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NORTH AMERICAN MALTING BARLEY TRADE: IMPACTS OF DIFFERENCES IN QUALITY AND MARKETING COSTS

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Highlights

Differences between U.S. and Canadian marketing policies in malting barley have been identified as potential sources of trade distortions. Most important are issues related to quality control, yield differentials between feed and malting varieties, and differences in handling costs. This study analyzes effects of changes in selected marketing policies on trade flows and prices in the North American malting barley sector using a mathematical programming model. Simulation results illustrate impacts of relaxed variety release requirements, increased selection rates for malting barley, reduced Canadian handling costs and the effect of increased Canadian exports of malting barley to offshore markets. The results quantify effects of these strategic issues on both the United States and Canadian barley sectors.

NORTH AMERICAN MALTING BARLEY TRADE: IMPACTS OF DIFFERENCES IN QUALITY AND MARKETING COSTS*

William W. Wilson and D. Demcey Johnson**

Both the United States and Canada are surplus producers of barley and, therefore, potential competitors. Until recently, cross-border barley flows were negligible. That situation changed in the early 1990s, with a dramatic increase in Canadian barley exports to the United States. The surge in barley trade, coinciding with higher U.S. wheat imports, became a source of bilateral trade tension. In Canada, it also precipitated debate over liberalization of barley marketing in North America. Proponents of a *continental barley market* urged an end to Canadian Wheat Board (CWB) control over barley exports to the United States, arguing that a competitive marketing system would facilitate Canadian penetration of the U.S. barley market.

A number of studies addressed broader marketing and policy issues associated with the North American barley trade.[1] Several important market regulations and institutional differences between Canada and the United States were identified. Regulations on variety development and release, it was suggested, have limited Canada's potential for serving the U.S. market. Selection rates for malting barley (i.e., the proportion of a crop chosen for malting, instead of feed use) are unduly restrictive. Canadian handling costs are higher than those in the United States, effectively reducing effective returns to Canadian producers (Carter 1993a; Johnson and Wilson 1995a).

Analysis of the barley market is complicated by the heterogeneity of supply and demand. Brewers, the end-users of malting barley, have specific quality requirements, e.g., in terms of acceptable varieties, protein, plumpness and germination. Producing regions grow feed and malting varieties in different proportions, and crop quality conditions vary substantially by region. Previous studies of the North American barley market have noted these complexities, and have speculated on effects of changes in the spatial distribution of barley supplies, without detailed quantitative analysis of the type presented here.

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[1]These include: Carter (1993a, 1993b); Schmitz et al. (1993); Gray et. al.; Canadian Wheat Board (1992); Brooks; Veeman; and Johnson and Wilson (1995a, 1995b).

This study develops a spatial equilibrium model of the North American barley market to analyze effects of several aspects of Canadian supply--including quality factors, yield differentials, and handling costs. Each of these have been focal points of recent debates over the continental barley market. Results of the model are used to analyze impacts of potential changes in Canadian regulations and constraints on barley trade flows and producer prices.

Marketing Issues in North American Malting Barley

Numerous institutional and marketing practices affect malting barley production and trade flows. Each of these factors is discussed as background to the model development and specification of alternative simulations.

Malting Barley Quality: Brewer Demands

U.S. and Canadian brewers have different malt quality requirements. These include variety specifications and quantitative restrictions on quality characteristics, which influence the selection rate for malting barley. Variety type has an important impact on extraction rates and taste (Schmitz et al p. 36). In general, U.S. brewers make extensive use of malt produced with 6-rowed white (6RW) aleurone barley, while Canadian beers rely more heavily on 2-rowed (2R) varieties and, to a lesser extent, 6-rowed blue aleurone (6RB) varieties. These requirements also vary by brewer. Malt requirements for individual brewers were identified through discussions with industry representatives and are shown in Table 1.[2]

Table 1. Malt Requirements of North American Brewers

Company	6-rowed White		6-rowed Blue	2-rowed
	------------------ percent -----------------			
Anheuser-Busch	70			30
Miller	80-100			0-20
Coors				100
Other U.S.	90-100		0-10	
Labatts*	50	or	50	50
Other Canadian				100

[2]These values are widely known among industry participants. Those listed for Labatts, one of the principal Canadian brewers, reflect their intention to make greater use of 6RW beginning with the 1994 marketing year.

In the world market excluding North America, malt demand consists almost entirely of 2R varieties. Consequently, world malting barley exports are largely of this type, and trade is dominated by European countries.

Regulations Affecting the Supply of Malting Quality Barley

The supply of malting quality barley has an important spatial dimension, with direct implications for North American trade flows. Breeding programs, agronomic practices, soil characteristics, climatic conditions, and expected price differentials determine varietal types grown in different regions. Various regulations affect the malting barley supply, and have been subject to criticisms on both sides of the border. For marketing purposes, barley is classed into feed or malting varieties. The latter are further divided into 2R and 6RW and 6RB varieties, for which brewer demands differ.

To illustrate the components of supply, let M_{ih} denote the supply in region I of malting type h (6RW, 6RB, or 2R), A_i denotes the total planted acreage in region I; V_{ih}, the fraction of acres planted to malting type h; G_i, the fraction of production grading as malting; and Y_i is the average (planted) yield. Regional supplies of malting quality barley are given by

$$M_{ih} = A_i \cdot V_{ih} \cdot G_i \cdot Y_i$$

The value of A_i is determined by market conditions, subject to farm program provisions in such as the Acres Reserve Program (ARP) and Conservation Reserve Program (CRP) in the case of the United States. Other supply components are affected by regulations and marketing practices which differ by country. Feed barley supply is calculated as the residual of total barley production in a region less malting barley.

Variety Release Mechanisms and Production: Institutional differences in the United States and Canada affect the spatial distribution of varieties. In the United States, malting varieties are those that the American Malting Barley Association, Inc. (AMBA) recommends for malting in specific states. Other varieties are classified as barley and are produced and sold for non-malting use. Producers plant malting varieties in hopes of meeting malting quality standards (for example, for plumpness and protein), which are determined by the industry. If barley is of an approved variety, but fails to meet malting standards, it is sold as feed barley or stored. Virtually all malting barley planted in the United States are white aleurone.

The variety approval process differs in Canada. Most important is that the Canada Grain Commission under authority from the Canada Grain Act (1971), determines a list of registered varieties for each grade (6R malting, 2R malting, and 6R and 2R feed). Variety registration is determined by a committee comprising representatives from industry, government, and universities who jointly consider agronomic, pathological, and quality characteristics of proposed new varieties. To be marketed as any of these grades, the variety must be registered.

If a variety is not registered, it is assigned the lowest grade in its class. Other varieties may be produced but only under special contracting programs. Since malting varieties cannot be registered unless they are visually distinguishable from feed varieties, a blue aleurone was incorporated into breeding programs for 6R malting varieties. This regulation has sparked much controversy within the Canadian grain industry. Gibney and Furtan identified the economic losses for barley producers due to the criteria for licensing new barley varieties. And Carter (1993a, p. 9) blamed regulators for eliminating 6RW from breeding programs, thereby inhibiting exports to the United States, which is primarily a 6RW market.

In the United States, malting varieties are grown predominantly in the Midwest, with 6RW and 2R malting varieties accounting for approximately 55% and 12% of the acres grown respectively in 1992. Western states typically plant less than 50% to malting varieties. Two-rowed varieties dominate barley production in western states and provinces, with 2R area typically exceeding 80% of the malting barley total. Midwest states exclusively plant 6RW aleurone varieties, but only small amounts of 6RW are produced in the western states.

Traditionally, all varieties approved for malting in Canada have been either 2R or 6RB. Six-rowed blue is grown exclusively in Canada, and predominately in Manitoba. Other 6RW varieties are grown under contract, the value of which potentially reflects market clearing quantities. The amount of land planted to 6RW in Canada has grown from nil, prior to 1991, to an estimated 440,000 acres in 1993, with up to 500,000 acres expected to be planted in 1994. Since 6RW is grown mainly for the U.S. beer market, an important question is: At what production level does Canadian 6RW become surplus, i.e., incapable of further penetration into the U.S. malting market? This is addressed in our empirical model.

Selection Rates: The other component of malting barley quality affected by various regulations and marketing practices is the selection rate, or G_i. This is the percentage of malting-variety production that is selected for malting purposes. Again, trade practice and regulations differ between the U.S. and Canada. Marketing practices in both countries have the effect of preserving the identity (including variety, origin etc) of malting barley within the marketing system, however the mechanisms by which this is accomplished differ.[3]

The Federal Grain Inspection Services (FGIS) is the agency in the United States that establishes standards and factor limits for barley. These grade standards use a conventional "least factor approach." However, these are not restrictive. In all transactions, values for grade and non-grade factors (e.g. plumpness, protein, germination, and varietal purity)[4] are contract terms, with specified premiums and discounts providing incentives to participants. Grades and

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[3]Carter (1993a, pp. 9-10) discusses factors affecting variety planting decisions.

[4]See Wilson, Scherping, Cobia, and Johnson for a detailed discussion of this system.

factors serve a purely descriptive function; contract terms govern barley characteristics in individual shipments.

Due to these trade practices, data do not exist in the United States on the proportion of a crop sold for malting purposes. However, data exist on the proportion grading as No. 2, the usual minimum threshold for malting-quality barley. On average this is about 70% of the crop in the Red River Valley, and 50% in the rest of the Midwest production region. In western areas this percentage is substantially greater due to the more controlled environment under irrigation.

Standards and selection rates are substantially different in Canada, where the marketing system entails delivery quotas, domestic market premiums, and export licensing. Because of these restrictive features, it is alleged that Canada has substantially more malting-quality barley than historical selection rates would indicate. Ultimately, this surplus malting-quality barley enters the feed market at a lower price. Carter (1993a) likened the Canadian marketing system to a lottery with a high payoff for winners. He assumed selection rates of 15%, increasing to 22.5% under a liberalized marketing environment.

Data reported in Carter (1993a, p. 10), showing deliveries of malting barley by region in 1988-92, confirmed that the percent sold for malting in regions not contiguous to malt plant locations is relatively low, averaging around 10-15%. Combining this data with regional production figures indicates that, on average, 21% of the production of malting varieties was selected for malting. Thus, historical selection rates for the Prairies appear to be much less than comparable rates for U.S. producing regions.

Historical selection rates should be distinguished from potential selection rates. Both Carter (1993a) and Schmitz et al. indicated that with a more open and competitive marketing system in Canada, selection rates would increase. Impacts of greater selection rates in Canada on North American barley flows are analyzed in the empirical analysis.

Feed/Malting Yield Differentials

A critical aspect of variety choice is the yield differential between feed and malting varieties. Ulrich et al. found that the yield gap between the feed and malting varieties remains large relative to the United States and likely results from private sector influence on Canadian breeding programs. Direct comparisons between feed and malting varieties are difficult to make, for various reasons.[5] Available state and provincial data show some interesting trends in

[5]Crop average data would clearly be inappropriate. Data from experimental test plots would also misrepresent actual yield differentials, which reflect different fertilization rates for feed and malting varieties. Excessive fertilization can raise protein levels, making barley unsuitable for malting.

yields. North American yields increased by about 40% in the past two decades. Yields in Alberta have generally kept pace with those elsewhere in North America, while yields in Saskatchewan (where malting acreage and selection rates are relatively high) have lagged behind.

Carter (1993a) suggests the yield gap between feed and malting barley is about 20% for 6R barley in Canada, but only about 5% for 2R. His analysis assumed that the yield for feed varieties in Canada would increase by 15% under a liberalized marketing and regulatory environment, giving a 25% yield advantage over malting varieties. However, Schmitz et al. indicate that with exception of central Alberta and other small areas in Manitoba, there are no areas in the Prairies that can enjoy more than a 10% increase in yields by switching to feed varieties. Brooks also questioned these differentials and indicated that AMBA data suggests a yield advantage for feed of only 5%. Veeman suggested that a 15% yield differential for feed barley might not be attainable.

This is an area of conflicting evidence and opinion, reflecting different *a priori* assessments of possible changes in Canada's institutional environment. Higher feed yields in Canada would surely effect continental barley flows. To put some perspective on the importance of this problem, our empirical analysis simulates the impact of alternative yield differentials in Canada.

Marketing Cost Differentials

In terms of grain handling and transportation, there are important structural differences, as well as differences in regulatory environments, between the United States and Canada. Most notable, and hotly contested in the North American trade, are the Western Grain Transportation Act (WGTA) rail rates and the related subsidy mechanism. Johnson and Wilson (1995a) analyze the impacts of these policy changes on North American barley flows.

Differences also exist in handling costs between these two countries with those in the United States being lower.[6] The Canadian Grain Commission establishes handling regulations for licensed elevators and maximum tariffs for each function (e.g., storage, country handling, cleaning, fobbing). In contrast, a multitude of competitive forces in the United States determine rail rates and handling costs.

Carter (1993a, p. 3) indicated "The current system does not encourage competition in grain handling . . . and that total elevation charges (primary and terminal) in Canada are at least four times as high as in the United States." These sharp inefficiencies within the Canadian

[6]See Agriculture Canada (*Grains and Oilseeds: Regulatory Review*) for a discussion of these issues.

marketing system could be corrected through greater exposure to U.S. competitive pressures. It is the total shipping cost, including handling, transport and other related costs, which affects the spatial distribution of commodities. Though Canada's rail subsidy has been a focal point of recent disputes over bilateral grain trade, it should be recognized that the advantage provided to Canadian shippers by rail subsidies (for applicable movements) is partially offset by higher handling costs.

Handling differentials could affect the spatial distribution of barley flows in a freer North American barley market. Most important is whether Canadian barley can bypass the first-handler, i.e., be shipped directly by truck from farms to end-users. Schmitz et al. discounted this as impractical, due to logistical and other commercial considerations: many US end-users prefer to deal with commercial dealers capable of procuring larger volumes and providing a steady supply. Carter (1993a) assumed that elevator handling costs would be avoided completely by trucking directly to end-users; this was criticized as highly unrealistic. Another possibility, as reflected in our model, requires commercial handling some place in the marketing system, either the U.S. or Canada, exactly as has occurred during recent crop years.

Malting Barley Export Demand

An important but subtle aspect of this debate is the impact of growth in beer demand worldwide on offshore exports. Though the North American beer market and, therefore, malting barley demand has been declining, beer consumption elsewhere in the world is growing rapidly. Most of the world growth is concentrated in Asian markets which have a clear preference for 2R varieties.

Exports of malting barley from the United States typically are less than 7% of total barley exports, at about .15 mmt. This compares to Canadian malting barley exports which have averaged more than .60 mmt in recent years. Canadian malting barley exports are concentrated in China, the United States, and Colombia. China is a major importer and potential growth market for malt and/or malting barley. As is true for virtually all malt importers, China has a strong preference for 2R varieties.

The CWB has projected that malting barley exports could double by the year 2001 from the average during the period 1985-1989 (Canadian Wheat Board, 1994, p. 3). The impact of expanded exports of malting barley offshore has important implications for North American barley trade, particularly exports from Canada to the United States. Two-rowed varieties are preferred internationally; Canada has surplus production of 2R varieties, and the United States is in relatively short supply of this barley type. Thus, from a Canadian perspective, there is potential competition between expanded sales to the United States and expanded offshore exports. Expanded offshore exports of Canadian 2R varieties are simulated in our empirical analysis.

Overview of the Spatial Equilibrium Model[7]

A spatial equilibrium model was developed using mathematical programming to analyze potential impacts of the above marketing system issues on North American barley trade. In the simulations we seek to analyze impacts of changes in these selected parameters on spatial equilibrium in the North American market for barley, malting barley and malt. We recognize that the dimensions of some of the changes described in the previous section are uncertain. Thus, we are not prescribing the precise values of the potential change; but merely recognize differences identified in other studies.

The United States and Canada are divided into different producing and consuming regions; export markets for barley and malt are also included. The objective is to maximize the sum of producer and consumer surplus in feed barley markets less the cost of satisfying fixed regional demands for malt. Feed barley prices and quantities fed (by region) as well as exports are determined endogenously while malt demands are assumed perfectly inelastic. All barley demand is for current use, either for feed or malt production. The model is specified to assure competitive spatial equilibrium conditions are satisfied.

Mathematical Specification

Formally, the model is specified as a quadratic programming problem. Let X_{ijk} denote a shipment ('000 mt) from producing region I to feed demand region j. The index k denotes barley type (feed, 6RW, 6RB, and 2R malting). The four types are perfect substitutes in feed demand; however, only malting types are shipped to malt plants. For notational convenience, we use the index h to refer to the subset of malting types. Barley shipments from producing regions to malt plants ('000 mt) are denoted Y_{imh}, where m identifies the malt plant location. Malt shipments ('000 mt) to beer production regions are denoted Z_{mnh}, where n identifies the malt destination and h the malt type. The objective function is defined:

$$W = \sum_j \int_0^{Q_j} (\alpha_j - \beta_j Q_j)\, dQ_j \quad - \sum_i \sum_j \sum_k X_{ijk} Tx_{ij}$$
$$- \sum_i \sum_m \sum_h Y_{imh} Ty_{im} \quad - \sum_m \sum_n \sum_h Z_{mnh} Tz_{mn}$$

where Q_j is total barley feed use in region j;

[7]See Johnson and Wilson (1993) for complete model details, data sources and data values.

$$Q_j = \sum_i \sum_k X_{ijk} \qquad \forall j$$

α_j and β_j are regional feed demand parameters; and Tx_{ij}, Ty_{im}, and Tz_{mn} are transportation cost parameters ($/mt). The latter include freight costs, handling margins, applicable import tariffs, and export subsidies. Because barley supplies are fixed, total producer and consumer surplus is represented by the area under regional demand schedules less transportation. The objective function is maximized subject to constraints on: barley supplies, malt plant capacities, movements from selected malt plants to breweries due to vertical integrated operations where applicable; and malt requirements both in terms of volume and type at beer production regions.

The model does not include producer prices *per se*; producer prices are computed as a weighted average of the shadow prices associated with supply constraints in barley producing regions. Similarly, malting barley and malt prices are shadow prices associated with demand constraints at different points in the marketing system. These reflect the opportunity cost of malting barley (i.e., in terms of its alternative feed use) in addition to transportation and handling costs.

Barley Supply and Demand

Supply Barley supplies include four types: feed barley (varieties not suitable for malting), 6RW malting; 6RB malting, and 2R malting. These were defined for each producing region based on recent production history and quality factors. Quality differences are important because demand requirements vary across brewers, as discussed above.

Demand Feed barley demand functions were synthesized from optimization models of state and province-level feed sectors. Specifically, we used a least-cost feed model developed by (Johnson and Varghese, 1993), which combines diet formulations for several classes of livestock in a single linear-programming problem.[8] Using 1992 livestock inventories as scaling factors, least-cost feed models were formulated for individual states and provinces. Synthetic demand schedules were derived by varying prices incrementally, holding other prices constant. These demand schedules were linearized for insertion in the spatial model.

Export demand schedules were based on econometric estimates. Separate models were estimated for countries which were recipients of Export Enhancement Program (EEP) bonuses (i.e., the subsidized market), and non-EEP countries. An inverse demand equation was

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[8]Data does not exist at state or provincial levels on barley fed and therefore it was not possible to estimate these demand functions econometrically.

estimated for North American barley exports to these subsidized markets. Annual data from 1973-91 were used to estimate the following regression (t-statistics in parentheses):

$$ABP = 15.29 + .9021\,\dot{P}C - .0129\,QX \qquad \text{Adj. R-sq: .902}$$
$$(.947) \quad (6.651) \quad (-5.959) \qquad \text{DW: 1.796}$$

where ABP is the adjusted barley price (Portland price, adjusted for average EEP bonuses in 1986-91), PC is the export corn price, and QX is the volume of North American barley exports ('000 metric tons) to countries that received EEP subsidies during 1986-91. For the non-subsidized export market we used Carter's elasticity (-1.9) for Canadian exports to Japan.[9] Exports from the U.S. to non-subsidized markets have been virtually nil over this time period.

The purpose of deriving elasticities as described above was to capture important differences which become particularly critical in spatial competition. These are shown in Table 2 for comparisons along with the prices and quantities at which the linear inverse demand was evaluated.[10] Results demonstrate there are drastic differences in elasticities within North America largely reflecting price of alternative feed ingredients, and the composition and size of livestock inventories. It is also important that offshore demand elasticities are generally less than domestic.

Malt Demand and Other Market Characteristics There were 24 malt demand regions identified in North America. Demand quantities are based on annual beer production. Different conversion factors apply for malt usage by Canadian and U.S. brewers. In Canada, each barrel of beer requires 39.5 lbs of malt; in the United States, each barrel requires 24 lbs of malt due to greater use of adjuncts. U.S. and Canadian brewers also have different malt quality requirements and we used the types shown in Table 1 along with brewery ownership to define malt demand by state, province or region. For each region, malt requirements reflect market shares of individual brewers. There are 19 malt plant locations in North America with different capacity constraints. Vertical integration constraints are imposed at selected locations, reflecting brewer-owned malt plants. There are also two export markets for malt.

The model reflects another feature of the current policy regime affecting exports. EEP bonuses ($32 per metric ton under the base-case) were applied to all U.S. shipments to the subsidized export market. Canada's export price to the non-EEP market is constrained to be no greater than the Portland price, mimicking strategic pricing of the CWB in its offshore sales.

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[9]Historical trade volumes were used to convert this elasticity to demand parameters.

[10]Values are not shown for Arizona and Quebec because barley quantity fed was nil.

Table 2. Elasticities of Feed Barley Demand, North American and Offshore Markets*

Region	Price Elasticity of Demand	Evaluated at:	
		Price ($/mt)	Quantity ('000 mt)
Midwestern States			
Minnesota	-49.7	80.7	510.5
North Dakota	-296.6	81.2	6.9
South Dakota	-30.2	83.5	444.3
Western States			
California	-17.6	121.6	1,768.2
Colorado	-104.5	98.0	137.0
Idaho	-7.4	101.1	364.4
Montana	-3.8	85.8	453.0
Nevada	-17.2	121.6	45.0
Oregon	-5.2	102.3	839.7
Utah	-19.3	104.9	186.9
Washington	-4.3	101.1	518.5
Wyoming	-14.6	93.0	82.1
Provinces			
Alberta	-3.0	77.0	3,217.8
British Columbia	-3.4	89.5	411.8
Manitoba	-10.9	79.0	526.3
Ontario	-41.9	95.7	232.0
Saskatchewan	-5.2	74.7	1,151.0
Offshore Markets			
EEP	-3.3	82.3	1,903.4
Non-EEP	-1.4	99.6	2,694.7

* Prices and demand quantities correspond to the base-case.

Transport and Handling Costs

Transport and handling costs are based on 1993 truck and rail rates, and handling margins at U.S. and Canadian elevators. For individual origins and destinations, movements by truck, rail, or truck/rail combinations were allowed. Least-cost movements were identified and incorporated in the analysis. In particular, the model allows prairie-border-crossing trade, an alternative to traditional Canadian movements.

Table 3 defines cost components used in this study and specifies those included in alternative movements.[11] C_c and C_e are Canadian country and export elevation costs, respectively, U_c and U_e are the same for U.S. elevators. An *Administrative charge*, A_F, is applied for all shipments direct from Canadian farms, F_c, to U.S. shipping points. This is intended to reflect merchandising charges under the *ex-farm-truck* program introduced in early 1993. Specifically, this is an intake fee charged by accredited exporters to execute these transactions. Trucking is allowed directly from Canadian farms to U.S. shipping points, T_{FU}, and from Canadian elevators to U.S. destinations, T_{AD2}. The shipper portion of rail rates from Canadian origins were used and defined as R^s. Gathering rates for U.S. movements are defined as R^{usg}, and the proportional rail rate for eastern U.S. shipments are R^{usp}. R^{us} is used to refer to a direct point-to-point rate.

Alternative transport and handling regimes for Canadian shipments were defined and are illustrated, using this notation. The alternative most reflective of current and past marketing practices includes Min(T, R^1). This assumes that the CWB controls exports via licenses, and likely results in a lesser amount shipped to (via) the United States. However, to allow for prairie-border-crossing movements we defined the shipping matrix as Min(T, R^1, TR). This implies that the routing allows for either direct rail, using the R^s; an all-truck movement; or a truck/rail combination via U.S. shipping points. A different configuration of handling costs exists, depending on the routing. In most cases, particularly for the central and northern regions, R^1 is the optimal routing. However, TR applies in some southern origins, implying shipments by truck through the U.S. marketing system.

[11]Details on data sources and transformations on all shipping tariffs are shown in Johnson and Wilson, 1993.

Table 3. Elements of Shipping Costs for Exports from Canadian Origins to U.S. and Third Countries

Movement	U.S. Shipments East	U.S. Shipments West	Third Countries
T: All Truck	C_c+T_{AD2}	C_c+T_{AD2}	$C_c+T_{AD2}+C_e$
R[1]: Rail (Rail Subsidized)	$C_c+R^s+R^{usp}$	C_c+R^c	$C_c+R^s+C_e$
TR: Truck/Rail	$A_F+T_{FU}+U_c+R^{usg}+R^{usp}$	$A_F+T_{FU}+U_c+R^{us}$	$A_F+T_{FU}+U_c+R^{us}+U_e$

Base-case Assumptions

The base-case assumptions are described here briefly. Policy assumptions were made that were consistent with a more liberalized Canadian marketing system. Specifically, we assumed: 1) quantitative restrictions do not apply to cross-border flows of barley or malt, i.e., Canada does not regulate either imports or exports through the granting of permits; 2) current U.S. tariffs apply to imports of barley and malt from Canada; 3) Canadian rail rates reflect current WGTA subsidies; and 4) cross-border truck/rail shipments are allowed to U.S. barley destinations.

Barley acreage and yields, by region, reflect 1989-92 averages. However, the distribution of malting varieties in Canada is based on 1993 data. Thus, the increased acreage planted to 6RW varieties that has occurred in the past few years is reflected in our base-case. The model incorporates a proposed shift in malt requirements by one of the major Canadian brewers beginning with the 1994 marketing year (see Table 1). Selection rates are based on 1987-91 data, with adjustments to ensure that 2.5 mmt of Canadian barley are available for malting.[12] Yields of malting and feed varieties are assumed to be identical. Existence (or magnitude) of a yield differential is an area of much uncertainty as described earlier, and the assumption of identical yields is simply a starting point for analysis. Departures from this and other base-case assumptions are made in alternative simulations reported below.

[12]Selection rates vary by region, but average 30% nationally in the base-case. In other words, 30% of Canada's production of malting varieties is selected for malting. This is moderately higher than the historic average, but well below comparable rates for U.S. producing regions.

Regional demand schedules in the model were developed using market data (prices of substitutes, U.S./Canada exchange rate, etc.) from April 1993, a period during which domestic feed wheat prices were abnormally cheap. To calibrate the model we adjusted regional feed demand parameters. Specifically, intercepts in the provincial demand schedules were shifted upward by an amount sufficient to reduce Canada's net barley exports to the U.S. (feed and malting) to 1.3 million mt. This procedure was used given that we had no means to statistically evaluate the parameters of the provincial demand functions. By adjusting feed demand parameters to replicate actual flows, the results more accurately depict the effects of potential changes in quality factors, variety selection etc.

RESULTS

Base-case Simulations

Base-case results are summarized in Tables 4, 5a and 5b, with comparisons to alternative simulations. Under base-case assumptions the U.S. exports a relatively small amount of malting barley to Canada, a result not foreseen by previous studies. This flow is from a northern U.S. producing region to an eastern prairie malt plant. The U.S. origin had the lowest transport and handling cost to serve this particular market, and a large surplus of malting barley. Canada exports feed barley, malting barley, and malt to the United States. The malt exports consist primarily of 6RW (66%) and 2R (28%), and are mainly from prairie malt plant locations to California and Texas.

Review of capacity utilization rates under the base-case indicates that Canadian malt plants are 100 percent utilized. The U.S. plants which are at less than capacity are located in the Wisconsin region, and one West Coast plant. Shadow prices associated with plant capacity were greatest near the U.S. malting barley production region, at 25$/mt (measured in barley units). Shadow prices for Canadian malt plants were in the range of US $17-24/mt, and most of the other plants had shadow prices in the $8-11/mt range. These results indicate that the most valuable additional malt capacity would be in the U.S. production region, and in Canadian provinces. These values do not change drastically in alternative simulations discussed below.

Table 4. Base-case Simulation Results: Trade Flows and Producer Prices

	United States	Canada
Bilateral trade flows (TMT)		
Exports		
Feed barley	0	883
Malting barley	97	504
All barley	97	1,289
Malt	0	188
Net bilateral trade (exports-imports)		
Feed barley	-883	883
Malting barley	-407	407
All barley	-1,289	1,289
Malt	-188	188
Off-shore feed barley exports (TMT)		
Subsidized markets	1,903	0
Nonsubsidized markets	0	2,759
Domestic use (TMT)		
Feed use	5,356	5,539
Malting use	871	2,759
Avg. producer price (US $/MT)	83.46	73.81

†(See Johnson and Wilson, 1993 for details.)
‡Intercepts for Canadian demand schedules increased by US $16/mt.

Table 5a. Results from Alternative Simulations: Canada

Variable	Base-case	Increased Canadian 6-Row Acres	Higher Canadian Selection Rates	20% Higher Yields for Feed Varieties in Canada		Equal Marketing Costs: Canada and U.S.	1 mmt Off-shore Exports of Canadian Malting Barley
				No Acreage Shift	Acreage Shift		
Barley Production (mmt)	10.59	10.59	10.59	11.05	11.39	10.59	10.59
Of Malting-Quality (mmt)	2.49	2.49	3.98	2.49	1.99	2.49	2.49
% 2-rowed	69.50	69.50	68.89	69.50	69.50	69.50	69.50
% 6-Rowed White	4.95	15.25	4.89	4.95	4.95	4.95	4.95
% 6-Rowed Blue	25.54	15.25	26.22	25.54	25.54	25.54	25.54
Imports (mmt)	0.10	0.10	0.10	0.09	0.09	0.09	0.16
Domestic Feed Use (mmt)	5.54	5.42	5.47	5.91	5.97	5.24	5.15
All Barley Exports (mmt)	4.28	4.40	4.35	4.48	4.64	4.57	4.73
To Off-shore Markets	2.89	2.88	2.89	2.94	2.95	3.04	3.66
To United States	1.39	1.52	1.46	1.54	1.69	1.53	1.07
Average Producer Prices US $/mt	73.81	74.18	73.99	72.64	72.54	77.72	76.12

Table 5b. Results from Alternative Simulations: United States

Variable	Base-case	Increased Canadian 6-Row Acres	Higher Canadian Selection Rates	20% Higher Yields for Feed Varieties in Canada		Equal Marketing Costs: Canada and U.S.	1 mmt Off-shore Exports of Canadian Malting Barley
				No Acreage Shift	Acreage Shift		
Barley Production (mmt)	8.78	8.78	8.78	8.78	8.78	8.78	8.78
Of Malting-Quality (mmt)	3.63	3.63	3.63	3.63	3.63	3.63	3.63
Imports (mmt)	1.39	1.52	1.46	1.50	1.69	1.53	1.07
For Malting Use (mmt)	0.50	0.65	0.59	0.57	0.55	0.57	0.24
% 2-Rowed	83.84	68.25	81.64	85.79	87.11	91.87	63.53
% 6-Rowed White	9.40	28.01	11.65	8.27	6.86	2.18	19.91
% 6-Rowed Blue	6.76	3.74	6.71	5.94	6.03	5.94	16.55
Domestic Feed Use (mmt)	5.36	5.47	5.43	5.47	5.64	5.50	5.07
All Barley Exports (mmt)	2.05	2.07	2.06	2.05	2.07	2.06	2.02
To Off-shore Markets	1.95	1.97	1.96	1.96	1.98	1.96	1.87
To Canada	0.10	0.10	0.10	0.09	0.09	0.09	0.16
Average Producer Prices US $/mt	83.46	83.27	83.35	83.31	83.15	83.33	84.07

Malting Barley Variety Restrictions and Distribution

Canada's barley breeding programs and regulations on variety release have limited planting of 6RW varieties in Canada. Although 6RW varieties dominate U.S. malting demand, the potential for Canadian penetration in this market (given current volumes of U.S. malting barley production) depends on numerous factors affecting spatial competition. To evaluate potential effects of increased production of 6RW in Canada, simulations were conducted in which Canadian producing regions are assumed to shift 6R malting area from blue to white aleurone varieties. Under the base-case, 15% of Canada's 6R malting acres are planted to 6RW varieties, and 85% are planted to 6RB varieties. In alternative simulations, these proportions are changed. However, the total area planted to 6R varieties was unchanged.

The results shown in Tables 5a and 5b illustrate effects of the 6R area being split equally between 6RW and 6RB varieties. This represents a shift of 6RW malting barley area from 4.95% of the total malting barley area in the base-case to 15.25 percent. In this case, production of 6RW increases by .51 mmt and exports of feed and malting barley to the United States increase from 1.39 mmt to 1.52 mmt, or by 9.4 percent. Not all of the increases in Canadian 6RW production enter U.S. malting channels. The composition of U.S. malting barley imports shifts from 9% 6RW in the base-case, to 28% with expanded 6RW acres in Canada.

In other simulations, the share of 6RW is incrementally increased to 85% of Canada's total 6R malting acres (see Figure 1). Results indicate that increasing the percentage of 6RW translates into expanded Canadian penetration of the U.S. malting barley market. Exports of all malting barley to the United States increases by about 150-200 thousand mt. Exports of 6RW increase relatively fast in early stages of the acreage shift, with 6RW acres going from 15% to about 40-45% of total 6R acres. Thereafter, successive increases in 6RW acres results in smaller increases in Canada's 6RW exports. The location of U.S. malt plants vis-a-vis U.S. production regions, capacity constraints, and limited scope for expanded 6RW use by U.S. brewers make it increasingly difficult for Canadian 6RW to displace U.S. malting barley. At these levels much of the expanded Canadian production of 6RW enters feed channels, domestic and export.

Canadian Selection Rates

Selection rates for malting barley have been one of the focal points of controversy surrounding debate over the Continental Barley Market. Proponents have argued that with liberalization of the Canadian marketing system, and relaxation of current quality standards, a larger fraction of Canada's barley production could be sold for malting.

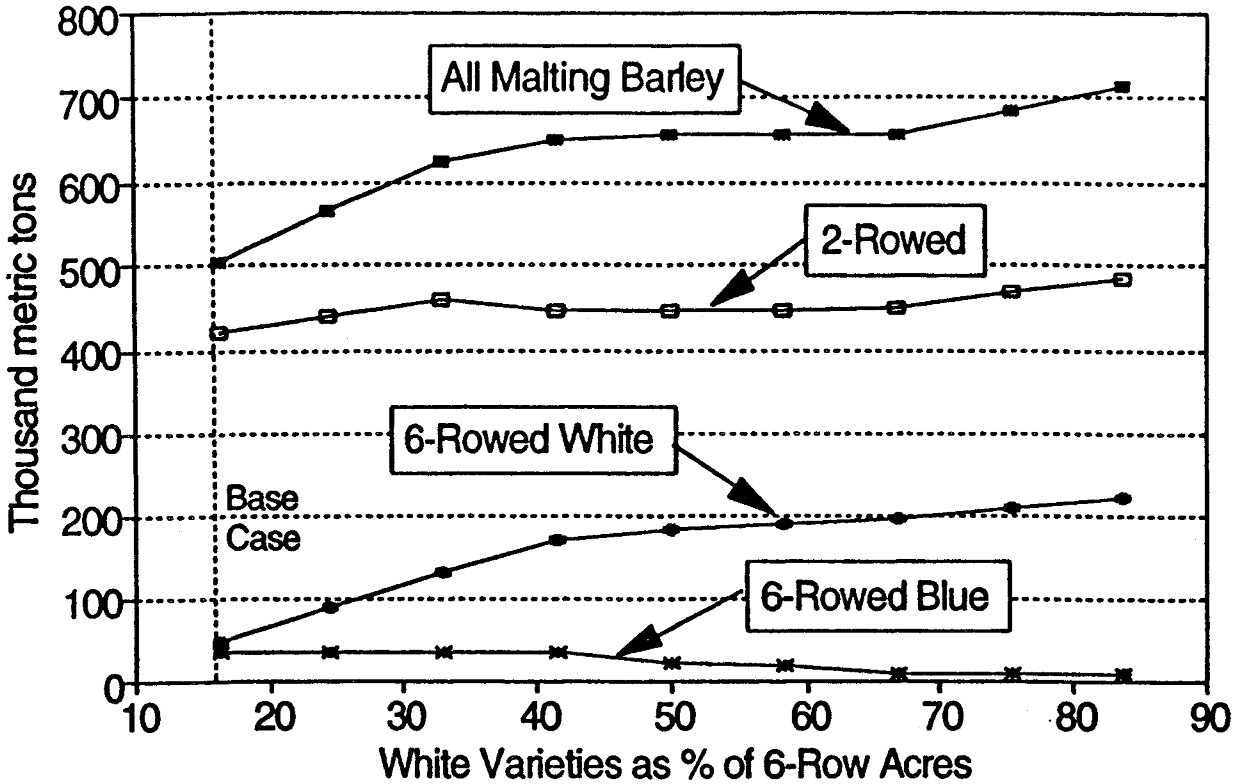

Figure 1. Impact of Canadian Acreage Shift on Malting Barley Exports to United States

Canadian selection rates in the base model are based on historical data, with adjustments to ensure a specified national volume of malting-quality barley. Let s_i represent the historical acceptance rate (%) for Canadian region i, and let MV_{ih} represent the availability of malting-variety barley (type h) in region i. The adjusted rate, g_i, is given by[13] $g_i = s_i + \theta(90 - s_i)$, where $0<\theta<1$ and

[13]Ninety percent is taken as a realistic maximum for the acceptance rate. Adjustments in each region are proportional to $(90-s_i)$; hence they are larger, in percentage terms, for regions where historical selection rates have been low. However, traditional supply regions (where s_i values are high) retain a quality advantage.

$$\sum_i \sum_h (g_i / 100)\ MV_{ih} = V$$

V is the total volume of malting-quality barley, 2.5 million mt in the base-case. In alternative simulations, V was varied between 2.0 and 5.0 million. Equivalently, the (weighted-average) Canadian selection rate was varied between 24 and 60 percent.

Figure 2 illustrates the impact of various selection rates on bilateral trade flows. Tables 5a and 5b provide detailed results for a 48% selection rate, which raises the quantity of malting-quality barley available in Canada by 60 percent. As a result of this assumed change, Canada's exports to the United States increase by 4 percent and equilibrium producer prices increase by less than 1 percent. Figure 2 illustrates that the rate of export penetration increases for selection rates between 45 and 55 percent, and changes are primarily in 2R malting barley exports.

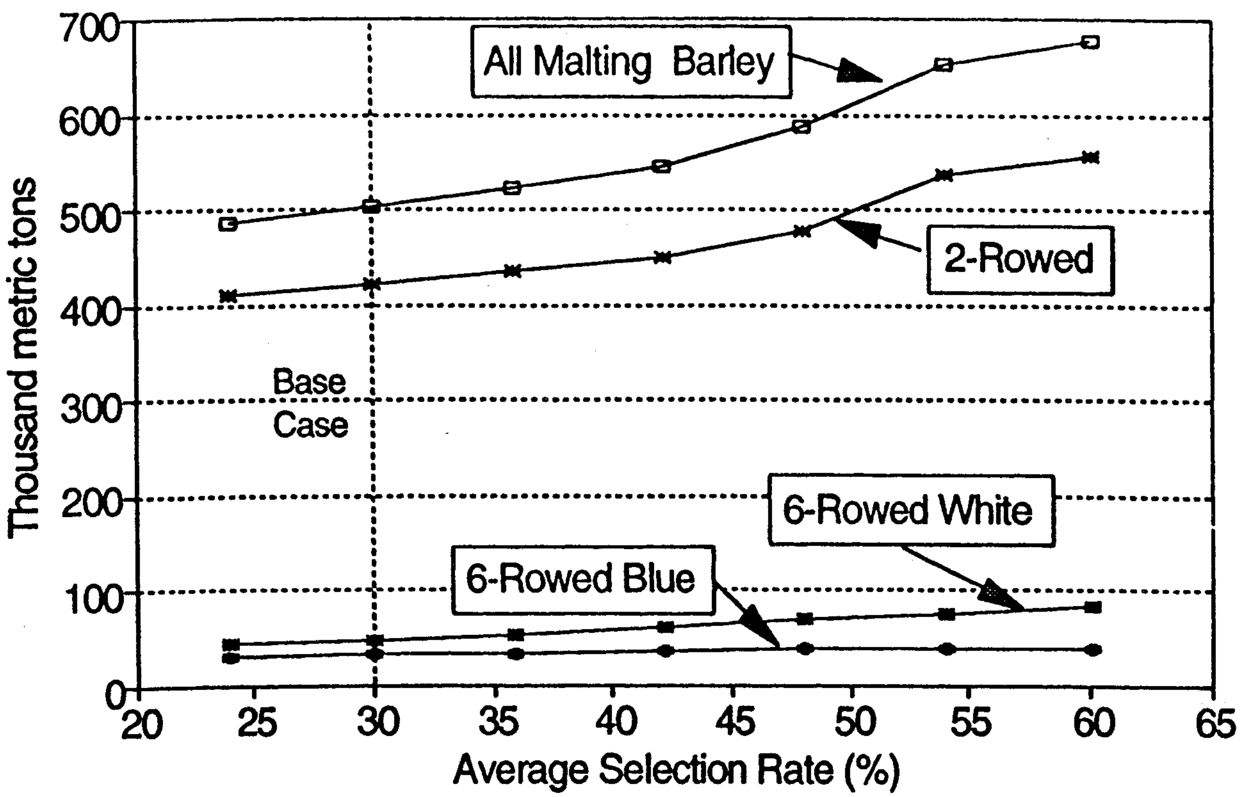

Figure 2. Impact of Canadian Selection Rates on Exports of Malting Barley to United States

Though there has been much discussion in Canada about the restrictive nature of selection criteria for malting barley, these results indicate that increases in selection rates would have positive, but modest impacts on malting barley exports to the United States. If the supply of malting quality barlèy were increased by 1.5 mmt, Canada's total exports would increase by only 70 thousand mt, an amount largely offset by lower domestic feed use.

Higher Yields for Canadian Feed Barley

In debates over Canadian marketing policies, it has been argued that production of feed barley would be substantially higher if there were fewer restrictions on the release and adoption of new varieties. Carter (1993a) suggested that Canadian feed barley yields could increase by as much as 15% in a liberalized marketing and regulatory environment. Additional simulations were conducted to quantify the effects of higher feed barley yields. Results are shown in Tables 5a and 5b for the case of a 20% higher yield for feed varieties in Canada. Equilibrium prices are reduced, domestic feed use increases, and exports to both the U.S. and off-shore markets increase by 16% and 1%, respectively. The effects of higher feed yields are mitigated by the relatively small fraction of Canadian acres planted to feed varieties in the base-case. This was an important concern identified by Carter (1993a).

For this reason we conducted an additional simulation, shifting 20% of Canada's planted area from malting to feed varieties. Results in this case indicate further increases in domestic feed use and exports. Again, increased exports would be primarily to the United States feed market. These results confirm that the major impact of higher yields would be in terms of increased feed barley exports, and depends critically on the amount of land shifted from malting to feed varieties.

Handling Costs Differentials

In base-case simulations, elevation costs are substantially higher in Canada than in the United States. For purposes of domestic feeding within the prairie provinces, we impute half the usual country handling costs. The implicit assumption is that barley is fed on farms, the effect being to avoid country elevation. Handling costs at Canadian country and export elevators are 19c/b (U.S.) and 14c/b (U.S.) respectively. These compare to costs of 8c/b for U.S. country and export elevators. In addition, an administrative charge of 9c/b (U.S.) was added on direct cross-border shipments from Canadian farms (applied under the *ex-farm-truck* program). With further liberalization in the Canadian marketing system and a rise in competitive pressures, Canadian handling margins are expected to decrease. Simulations were performed to assess the implications of existing cost differentials. As example, Canadian elevation costs were set equal to those for the U.S. industry. In addition, we eliminated the administrative charge for *ex-farm-truck* movements.

The results are particularly interesting. Compared to the base-case solution, equal marketing costs would have the effects of: decreasing Canadian domestic on-farm feeding; increasing Canadian exports to both off-shore and U.S. markets; increasing the proportion of 2R in Canada's malting barley exports to the U.S.; and raising Canadian producer prices by approximately the change in marketing costs. The logic of these simulations is that, as a result of lowering marketing costs, it becomes more attractive for barley to enter the commercial marketing system. In so doing, exports to both the U.S. and off-shore markets expand, and prices increase. As a result of the higher prices associated with commercial marketing, movement occurs along provincial feed demand schedules, reducing domestic feed use in Canada.

It is important to recognize that barley shipped in the marketing system competes with on-farm feeding. Marketing costs for feeding purposes are less than for barley entering commercial marketing channels. In the base-case, high handling costs in Canadian elevators induce cross-border truck movements to U.S. elevators, particularly in border regions. However, much of Canada's barley production is situated at greater distances from the border, making such truck movements uneconomic. In these regions, lowering of handling costs induces larger movements through commercial channels, including for export, and away from on-farm feeding.

Growth in Canadian Malting Barley Exports to Off-shore Markets

Development of off-shore markets for malting barley may have important potential consequences for continental trade flows. Canada is surplus of 2R, and off-shore malting barley demand is essentially 2R, while U.S. demand is for both 2R and 6RW. Expanding Canadian exports to off-shore markets must compete with increased sales opportunities within North America, specifically the United States. Exports of malting barley to off-shore markets are taken as exogenous in the base model; they are all 2R and assumed at 200 thousand mt. In an alternative simulation, Canada's exports of 2R malting barley to off-shore markets were increased from the base-case level to 1.0 mmt.

Impacts of expanded off-shore sales of malting barley are shown in Tables 5a and 5b. Increased off-shore Canadian exports of malting barley decreases domestic feed use, decreases exports to the United States, and raises equilibrium prices. In particular, at 1.0 mmt of off-shore Canadian malting barley exports, equilibrium barley exports to the United States decrease by 320 thousand mt.

There are several important forces affecting this result. One is that the off-shore market is restricted to 2R malting barley, the type which dominates the international market. Second, this is the type that Canada has conventionally exported to the United States, and under freer trade would be that type most likely exported to the U.S. in larger quantities, given the locations of production and U.S. malt demand. Specifically, the composition of U.S. malting barley imports changes, with less 2R under this scenario (Table 5b).

These results illustrate that one of the important strategic issues concerning exports of malting barley from Canada is the dynamics and composition of demand in the United States and world market. Given the current composition of supply, increased sales to one market must be offset by reduced sales to the other market.

Summary and Discussion

Barley trade between the United States and Canada has traditionally been negligible. However, recent changes in the policy, institutional and competitive environment have resulted in increased trade and increased tensions within and between these countries. Of particular interest for the evolving North American marketing system are differences between U.S. and Canadian marketing policies. Most important are issues related to quality control, yield differentials between feed and malting varieties, and differences in handling costs. Realization of these differences, largely due to the regulatory and policy environment, has sparked much controversy within the Canadian marketing system. Changes in some of these have major strategic implications for participants in both the Canadian and U.S. industries.

This study analyzed effects of changes in selected marketing policies on trade flows, prices and price differentials. A mathematical programming model was developed to analyze North American barley flows and identify potential impacts of changes in selected marketing policies. In the base-case, Canada exports feed and malting barley (primarily 2R, and minor amounts of 6RW and 6RB), and malt to the United States. There is also bilateral trade, with the United States exporting small amounts of 6RW to Canada.

The model was used to simulate changes in selected marketing policies. Availability of 6RW has been identified as a restriction on the ability of Canadian malting barley to penetrate the U.S. market. Relaxed variety release requirements, or increased contracting to allow greater production of 6RW, would allow increased Canadian penetration of the U.S. market and increase grower's prices. The results confirm that restrictions on the distribution of malting barley varieties in Canada have limited Canadian penetration of the U.S. market, notably the 6RW segment. Increased 6RW acreage in Canada would have important implications for the U.S. malting barley sector in terms of increased import competition, and reduced prices. However, the U.S. is the only significant market outlet for North American 6RW varieties, which means that excess Canadian production of this barley type must be sold as feed barley.

Selection rates for malting barley have been much lower in Canada than in contiguous U.S. producing regions. Other studies have indicated that under freer trade within North America, selection rates in Canada would increase. Simulation results indicate those increases in selection rates to levels comparable to the U.S. would have a positive, but modest impact on malting barley exports to the U.S.

An alternative to producing and marketing barley for malting purposes is feed barley. Canadian yield differentials for feed versus malting varieties have allegedly been restrained by restrictions on and funding for variety development. Simulation results are dependent on assumptions about switching from malting to feed barley varieties. With existing acreage allocations, higher yields on Canadian feed barley would have minimal impact. However, assuming a 20% shift in area from malting varieties to feed would increase exports, primarily to the U.S. feed market, and decrease prices relative to the base-case.

Handling tariffs differ between U.S. and Canada, due to different structural and regulatory environments in grain handling. This affects the flow of barley through their respective marketing systems, and aggregate trade volumes. Reduced Canadian handling costs would make it more attractive for barley to enter the marketing system; exports to the United States and elsewhere would expand, and domestic feed use would be reduced.

Finally, beer production is increasing faster in the rest of the world than in North America, raising the long-term importance of off-shore markets for malting barley. However, quality requirements differ to some extent between the U.S. and off-shore markets, a fact which sharpens Canada's strategic choices in terms of production and trade. Simulation results indicate that increased malting barley exports to offshore markets would decrease exports to the United States. Thus, Canada is confronted with the choice of whether to shift its planted acres to 6RW to penetrate the stagnant U.S. market, or to pursue off-shore exports.

Numerous pressures are being exerted on the North American barley market. Ultimately, these stem from policies and marketing institutions that have evolved independently in the United States and Canada; and are somewhat more restrictive in Canada. These have led to price distortions within North America and pressures to make changes in policies and regulations governing selected functions in the Canadian marketing system. In some cases these changes have important implications for the U.S. malting barley sector, primarily in terms of increased import competition and lower prices.

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