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Single-Desk Selling of Canadian Barley: Price Pooling, Price Discrimination, and Systemic Costs

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Abstract

An optimization model is used to evaluate the implications of single-desk selling of Canadian barley for trade flows and producer welfare. Effects on U.S. imports and barley prices are also considered.

Key words: barley, Canadian Wheat Board, grain trade.

Executive Summary

The Canadian Wheat Board markets all Canadian barley for human consumption (malting) or export. Single-desk selling by the CWB has been a contentious issue in Canada, as well as a source of trade friction between Canada and the United States. Within Canada, debate has centered on whether single-desk selling works to the advantage of producers. The CWB claims to practice price discrimination in international barley markets and thereby raise average returns for Canadian producers. However, critics dispute the CWB's ability to exert market power in barley and point to various costs and inefficiencies associated with board control. The role of the CWB is also of interest to U.S. producers and policymakers, as Canada has exported increasing amounts of barley to the United States in recent years.

Most Canadian barley is consumed domestically as livestock feed and falls outside of direct CWB control. This makes the situation of barley somewhat different from that of wheat, the other grain marketed by the CWB. To attract barley into the price pooling system, the CWB must offer a prospective return that is competitive with the domestic feed market. Pool returns are essentially weighted averages of CWB sale prices, with deductions for marketing and transportation costs.

This paper uses a quantitative model to examine the trade and welfare effects of single-desk selling of Canadian barley. The model, adapted from Schmitz et al. (1997), is developed from the perspective of the CWB, which seeks to maximize board sales for three different types of barley (feed, 2-row malting, and 6-row malting) within a single marketing year. Revenues from CWB sales are pooled by barley type. Arbitrage conditions ensure that pool returns are at least as great as the domestic feed barley price. Barley demand is differentiated by type and region, and the CWB is assumed to practice price discrimination. Supply and demand parameters are representative of the 1991/92 marketing year.

The analysis is focused on two ongoing debates. The first concerns the ability of the CWB to extract additional revenue for Canadian producers through price discrimination in international markets. In the absence of the U.S. EEP program, which provided targeted export subsidies for barley, there may be much less scope for differential pricing by the CWB. This is an area of sensitivity analysis in model simulations. Bounds are placed on price spreads between regions; as these are tightened, the potential gains from Canadian price discrimination are reduced. The second debate concerns the alleged 'systemic inefficiencies' associated with board control. A marketing cost parameter, representing the extra costs incurred by producers because of single-desk selling, is varied in model simulations in order to illustrate the effects on trade flows and welfare.

Simulation results are reported for a range of parameter values, reflecting different assessments of single-desk selling. The base-case assumptions are most favorable to the CWB: no binding constraints on price spreads, and no extra marketing costs associated with board sales. Under these assumptions, which are identical to those of Schmitz et al. (1997), single-desk selling raises Canadian producer revenue by C$95.8 million relative to the multiple-seller (competitive) solution. However, under assumptions least favorable to the CWB —i.e., inability to price discriminate and extra marketing costs of $C16/mt—Canadian producers lose C$160 million

because of single-desk selling. That is consistent with the view of critics of the CWB, notably Carter and Loyns (1996), that Canadian producers would be better served by a competitive grain marketing system. Thus, conflicting views on single-desk selling are represented (or rationalized) by different values of two key parameters: bounds on price spreads, and CWB marketing costs.

From a U.S. perspective, an important question is whether single-desk selling has contributed to recent inflows of barley from Canada. It would be unwise to read too much into simulation results based one marketing year; however, the results are suggestive. Given market conditions in 1991/92, single-desk selling appears to have the effect of lowering U.S. feed barley prices while raising U.S. malting barley prices. If Canada were to adopt a competitive marketing system for barley, results indicate, larger amounts of malting barley would be exported to the United States.

Some qualifications should be mentioned. First, the analysis was restricted 1991/92, as relevant data for other marketing years were not available. Important changes have occurred in recent years, including the growth of feed demand in western Canada, the suspension of U.S. EEP subsidies for barley, and quality problems in the U.S. malting barley crop—all of which could be expected to change price relationships and trade patterns. Second, the model lacks the kind of regional detail that may be critical to an understanding of continental barley trade. Finally, while the study focuses on single-desk selling, it should be recognized that other features of the Canadian system have an important bearing on trade flows. Among these are the regulations concerning grain quality, grain transportation, and constraints on market access for U.S. grains in Canada.

Single-Desk Selling of Canadian Barley: Price Pooling, Price Discrimination, and Systemic Costs

D. Demcey Johnson*

1. Introduction

The Canadian Wheat Board (CWB) holds a pivotal position in Canada's barley sector as the organization responsible for selling all western-grown barley for malt or export. The Board's single-desk seller status has been a contentious issue in Canada, as well as a source of trade friction between Canada and the United States. Most U.S. barley is grown in states contiguous to the Prairie provinces. This has drawn attention to stark differences in market organization on either side of the border—differences that fuel, rightly or wrongly, U.S. concerns about 'unfair' Canadian practices.[1] Competition in U.S. markets ensures a continuous flow of price information between buyers and sellers, leaving little doubt about the value of U.S. barley at a given time and location. Pricing is quite different in Canada. Although barley sold for domestic feed use is priced competitively, the rest of Canadian barley (that controlled by the CWB) falls within a price-pooling system. The proceeds from CWB sales are pooled and, after deduction of marketing and transportation costs, returned to producers after the close of a marketing year. Effectively, Canadian producers receive an average price for barley marketed by the CWB, with adjustments for quality and distance from export points. From a producer perspective, pooling masks the 'true' value of barley in individual sale transactions, and can lead to anomalous price spreads between U.S. and Canadian barley.

The price-pooling system is linked to one of the putative advantages of the Canadian Wheat Board: its ability to practice price discrimination. Because it is the single-desk seller of barley for export or malting use, the CWB can offer different sale prices to different customers and thereby raise net sales revenue. (So claimed proponents of the CWB in advance of a 1997 plebiscite, in which Canadian barley producers were asked whether they wished to retain the current system or allow open marketing for all barley. The vote favored retention, but did not end strident criticism of the system by many Canadian farmers.) Pooling provides a mechanism for producers to share in the proceeds of sales at different prices.

Evidence supportive of the CWB was presented by Schmitz, et al. (1997). That study used a model of CWB barley marketing with price pooling to quantify the benefits of single-desk selling. Critics of the CWB, including Carter and Loyns (1996), question whether it is able to exert market power in U.S. or offshore markets. They also point to systemic inefficiencies in grain marketing, handling, transportation and logistics that are associated with CWB control; these reduce net returns to Canadian producers and may outweigh any gains from price discrimination.

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[1]For discussion, see Johnson (1998).

From a U.S. perspective, an important question is whether single-desk selling or other institutional factors have contributed to recent inflows of barley from Canada. Politicians from northern-tier states often blame the CWB for driving down U.S. prices, but it is not clear, *a priori*, that the situation would improve if Canada liberalized its barley marketing system. Indeed, brief experience of a 'continental barley market' in 1993 showed that exports to the United States could increase if the CWB were no longer in control. Economic theory suggests that, as price-discriminating seller, the CWB could 'undersell' or 'oversell' (relative to a competitive equilibrium) in individual markets, depending on the relevant elasticities of demand. With the U.S. barley market divided into 'feed' and 'malting' segments, and the latter divided into '6-rowed' and '2-rowed' malting, it is not easy to guess the net effect of Canada's single-desk selling on U.S. imports or welfare.

This paper uses a quantitative model to analyze welfare and trade issues associated with single-desk selling. The model, adapted from that of Schmitz et al. (1997), incorporates price discrimination, price pooling, and a set of arbitrage conditions linking the pool to Canada's domestic feed barley market, which lies outside of CWB control. Adaptations of the model are focused on two ongoing debates. The first concerns the ability of the CWB to practice price discrimination. Recent studies funded by the CWB, and making use of actual transaction data, support the assertion that single-desk selling earns higher average returns (measured at port) for Canadian grain producers, relative to a system with multiple sellers, because of price discrimination (Kraft et al., and Schmitz et al. 1997). However, much of the evidence is drawn from years when the U.S. Export Enhancement Program (EEP) was active. That program, it may be argued, made it possible, even necessary, for the Board to charge vastly different prices in subsidized and unsubsidized markets. In absence of EEP, the scope for differential pricing by the CWB may be substantially reduced. This is an area of sensitivity analysis for model simulations.

The second debate concerns what might be called 'systemic inefficiencies' associated with single-desk selling. Carter, Loyns, and Berwald (1998) argue that CWB control has contributed to inflated costs of marketing, grain handling and logistics. They estimate extra marketing costs of approximately C$16 per metric ton for barley; this reduces the net price received by producers and (they argue) more than offsets any benefit from single-desk selling. This is a highly contentious issue, partly because of disagreement about the Board's responsibility for specific costs (eg., high costs of elevation, grain cleaning, etc.) in the Canadian system. To the extent that extra marketing costs are associated with single-desk selling, that should be factored into an analysis of trade and welfare effects. The model presented here does so through inclusion of a 'marketing cost differential,' which is meant to reflect extra marketing costs associated with the board system. By varying this parameter, model simulations will illustrate the importance of cost differentials for trade patterns and welfare.

The paper is organized as follows. The second section provides some background on Canada's barley sector and institutional arrangements. The third section provides a complete specification of the trade model. Simulation results are presented in the fourth section. The paper concludes with a short summary and discussion of implications.

2. Background on Canada's Barley Sector

Barley has traditionally been one of the major crops grown in Canada's western provinces, with acreage exceeded only by wheat and (recently) canola. Harvested acres have oscillated from year to year (Figure 1), but averaged 11.2 million acres during the past two decades.[2] Barley yields grew by 0.7 bushels/acre per year, on average, during the same period (Figure 2). About 70 percent of total barley acreage is seeded to malting varieties, and the remaining 30 percent is seeded to varieties suitable for livestock feed only. Malting barley acreage is divided between two-row (two-thirds) and six-row varieties (one-third). (CWB, "Grains from Western Canada: 1997-98 Wheat and Barley," p. 16). Malt made from two-row varieties is preferred by most of the world's brewing industry, while malt from six-row varieties is more widely used in the United States (Johnson and Wilson, 1994).

Although most of Canada's barley acreage is planted to malting varieties, only a small fraction of production is sold for malting. Farmers wishing to sell their barley for malting (and earn higher pool returns) must submit a representative sample for evaluation by malt users (domestic maltsters) or CWB-accredited exporters. Samples are 'selected' for malting based on quality factors, but standards may vary through time depending on the availability of high-quality malting barley.[3] The overall selection rate (percentage accepted for malting) has averaged 11 percent in recent years; this compares to an average rate of 33 percent in the United States (Schmitz and Koo, p. 29).[4] The Canadian Wheat Board controls the overall selection rate through its marketing program by restricting the amount of malting barley available for export. Critics have questioned the 'fairness' of the selection process (which has been likened to a lottery), and suggested that Canadian producers are losing potential export revenue (especially in the United States) for malting barley.

Canadian production, consumption, and exports of barley are shown in Figure 3. In general, barley exports have closely followed year-to-year changes in production. However, recent years have also seen a marked increase in domestic consumption. This is the result of increased livestock feeding, especially in Alberta. With increased domestic consumption, smaller portions of the barley crop are available for export. Figure 4 compares exports with domestic utilization (feed and non-feed) during two three-year periods: 1985-87 and 1995-97. On average, domestic feed use accounted for 55 percent of barley utilization in the earlier period, and 75 percent of utilization in the latter.

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[2]For perspective, U.S. barley acres averaged 8.3 million acres during the same period. In the mid-1980s, U.S. and Canadian barley acres were roughly the same; since then, U.S. acreage has been trending downward. U.S. harvested acres fell below 6 million in 1998.

[3]Alberta Agriculture provides a useful summary of malting barley marketing in Canada. http://www.agric.gov.ab.ca/crops/barley/market02.html

[4]These rates compare utilization of barley for malting purposes to total barley supply. Using a different measure, Johnson and Wilson (1994) estimated the availability of malting-quality barley by region. This varies with the proportion of acres planted to malting varieties (higher in Saskatchewan than in Alberta).

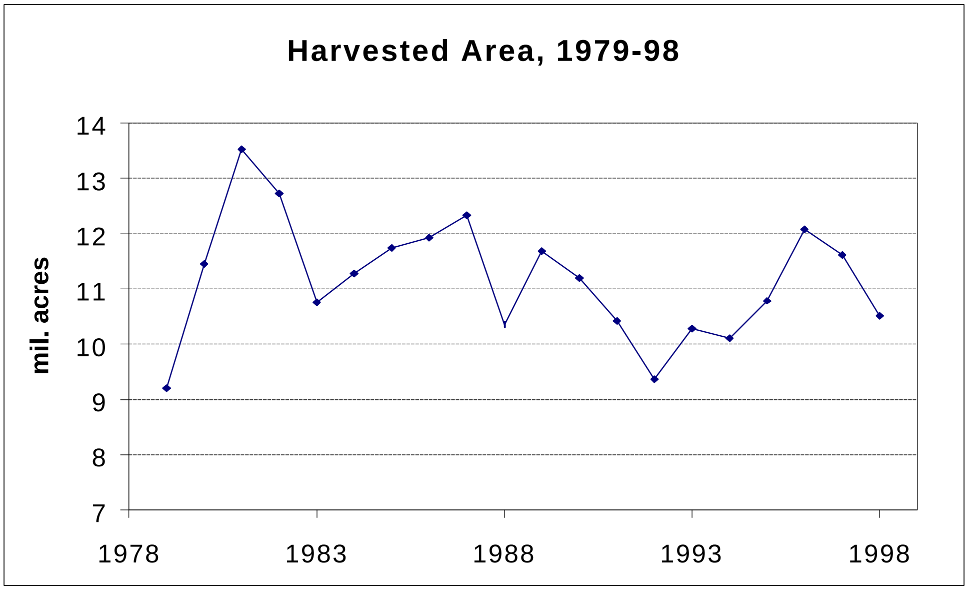

Figure 1. Harvested Barley Acres in Canada, 1979-98
Source: USDA/ERS.

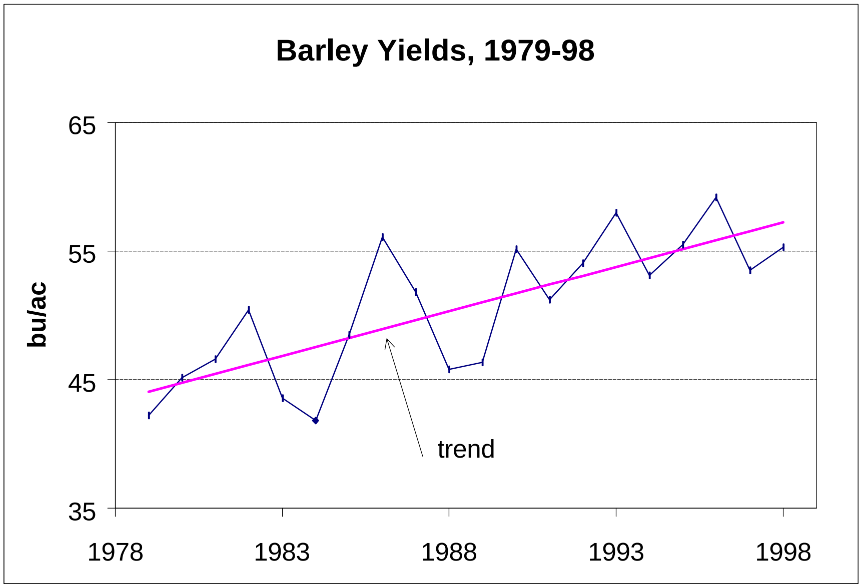

Figure 2. Canadian Barley Yields, 1979-98
Source: USDA/ERS.

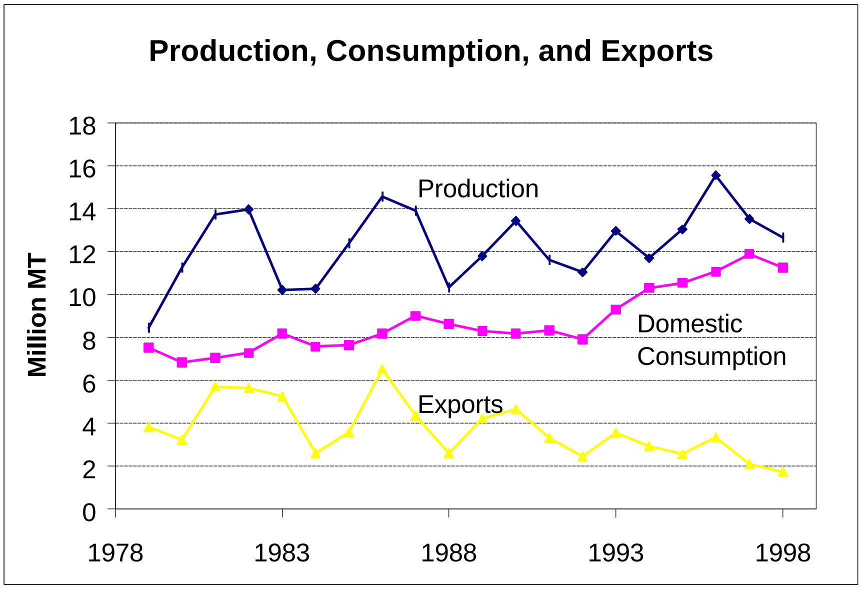

Figure 3. Canadian Barley Production, Consumption, and Exports, 1979-98

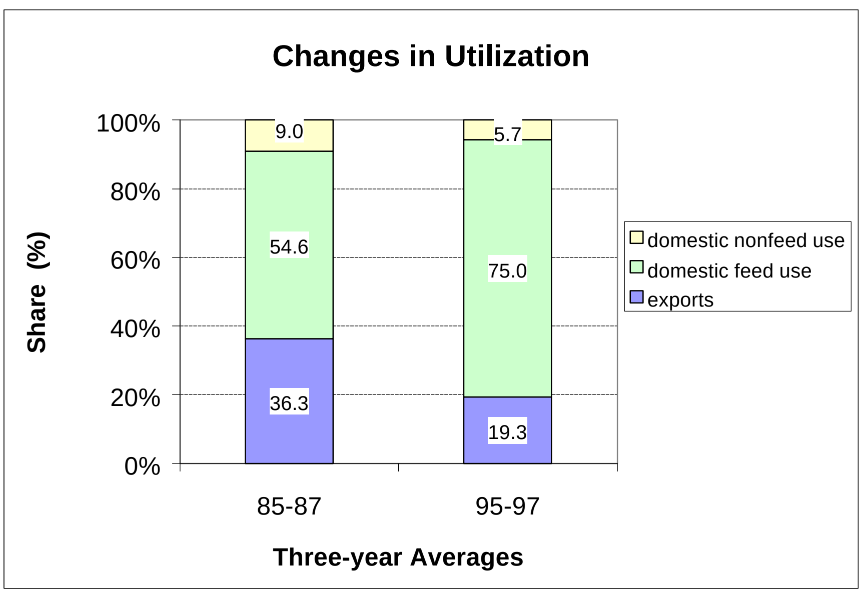

Figure 4. Changes in Canadian Barley Utilization

Although domestic feed use is now far larger than the level of exports, the CWB has continued to exert an influence on feed barley prices received by producers. That is due to arbitrage between board and non-board prices within Canada, and a lack of effective arbitrage with external (primarily U.S.) feed markets. Both points require some elaboration.

Canadian producers can either sell their barley through the CWB for export or domestic non-feed use, or in the domestic feed market; their choice depends on a comparison of prospective returns. In the case of pool returns, this is complicated by uncertainty about the timing of delivery and size of final payment. Producers who sell barley through the CWB must first apply for a permit book. This gives them the right to deliver under an acreage-based system from the start of the crop year until after harvest; thereafter, they can contract to deliver grain under one or more contract series (Series A, B, C, or D), which are staggered through the marketing year. The CWB issues delivery calls for contracted grain according to the requirements of its marketing program. Thus, producers are notified that some percentage of their contracted grain should be delivered by a specified date. Delivery calls are updated periodically based on sale commitments and logistical needs. It is also possible (although rare) for a contract series to terminate before deliveries have reached 100%. Upon delivery, producers receive an initial payment. Their final payment is received up to one-half year after the close of a marketing year, after settlement of the pool accounts. The final payment for a pool is unknown at the time of contract sign-up, but can be estimated from the CWB's own published forecasts. Nevertheless, selling barley through the CWB entails some additional risk and payment delays, which compare unfavorably to selling opportunities in the domestic feed market. In order to attract barley into the pooling system (and away from domestic feed), the CWB needs to offer a return sufficient to compensate producers for these extra costs. Arbitrage pressures provide a linkage between board and non-board prices for feed barley.

Figure 5 compares barley pool returns to the average price received for non-board sales (domestic feed) during 1986-95. Pool returns are measured at port (Vancouver or Thunder Bay), while the domestic feed price is a weighted average of interior locations.[5] Thus, transportation costs account for part of the observed spread between the feed barley pool return and the domestic feed barley price. Other year-to-year variation in this spread is likely due the timing of sales in individual marketing years.[6] Also shown are pool returns for select (malting) barley. Pool returns for malting barley were substantially higher than those for feed, especially in the late 1980s. Two-row select barley earned consistently higher returns than six-row select.

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[5]Data are from the *Canadian Grains Industry Statistical Handbook 97*, p. 163. Prices received by farmers for non-board grains are not available for years after 1995.

[6]The spread in 1995 was exceptionally high due to large premiums for Japanese sales early in the year (CWB 1995-96 Annual Report, p. 29).

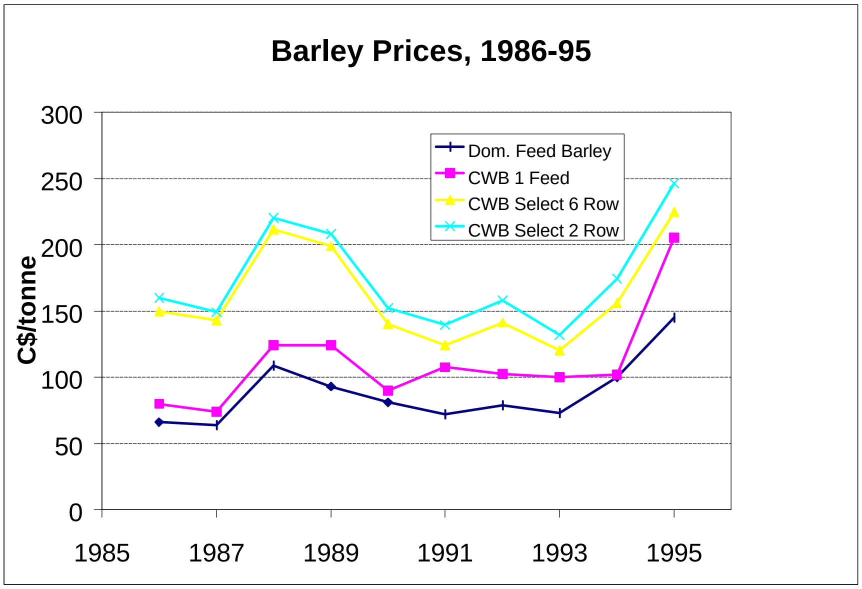

Figure 5. Domestic Feed Barley Price and Pool Returns, 1986-95
Source: Canadian Grains Council.

The single-desk authority of the CWB prevents direct arbitrage between external and domestic markets. As a result, Canadian barley prices bear no necessary relationship to prices in contiguous regions of the United States. This has been a source of frustration to growers who are positioned to ship barley directly into the United States—particularly during periods of high U.S. prices. Canada experimented with a 'continental barley market' in 1993, briefly removing the CWB's monopoly over North American sales.[7] This led to a surge of direct sales into the United States by Canadian producers, demonstrating the powerful effects of cross-border arbitrage in a liberalized marketing system. CWB control over barley was restored through court action in 1993 and confirmed by a producer plebiscite in 1997. Barley exports to both U.S. and offshore markets now seem likely to remain under CWB control, although debate continues within Canada about the costs and benefits of single-desk selling.

[7]Carter (1993) and Schmitz et al. (1993) presented conflicting views on the continental barley market. Carter argued for market liberalization, while Schmitz et al. projected welfare losses for Canadian producers due to lower malting premiums.

3. Model Specification

The price-pooling model is a modified version of that presented by Schmitz et al. (1997). The model adopts the perspective of the Canadian Wheat Board, seeking to maximize board sales revenue for three different types of barley (feed, 2-row malting, and 6-row malting) within a single marketing year. Revenues from CWB sales are pooled by barley type. Arbitrage conditions ensure that pool returns are at least as great as the domestic feed barley price. Barley demand is differentiated by type and region, and the CWB is assumed to practice price discrimination. Canadian barley supplies are taken as fixed, although quantities marketed by the CWB are endogenous. Supply and demand parameters are representative of the 1991/92 marketing year.[8]

Two modifications have been made to the model. First, an upper bound (D) is placed on price differences in CWB markets. This is motivated by the claim by Carter (1993), among others, that the CWB has limited ability to exert market power in international barley markets. Price discrimination by the CWB, in this view, was facilitated by the U.S. Export Enhancement Program. In the absence of EEP, it is questionable whether the CWB can charge substantially different prices in different foreign markets. By varying the size of the bound on price differences, the model can be used to simulate varying degrees of market power.

Second, a marketing cost parameter (M) has been introduced. This is intended to reflect higher costs of barley marketing associated with single-desk selling. Carter, Loyns, and Berwald (1998) have identified extra costs on the order of C$ 16/mt for barley.[9] This is disputed by the Canadian Wheat Board (1996), and, indeed, not all of the costs and inefficiencies identified by Carter et al. are due strictly to single-desk selling.[10] However, to the extent that extra marketing costs are borne by producers, the advantages of single-desk selling are diminished. This will also be illustrated through sensitivity analysis in model simulations.

There are ten barley markets in the model, indexed by i. Prices, quantities, and estimated elasticities for the 1991-92 marketing year are shown in Table 1. These were used to derive linear demand parameters. It should be noted that the elasticity estimates (with one exception) were not based on econometric analysis; rather, they were synthesized from a set of first-order conditions. Schmitz et al. assume that, as a price-discriminating monopolist, the CWB would allocate its sales so as to equate marginal revenues across markets. This is questionable, for reasons explained in the appendix; however, the same demand elasticities are used in this study.

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[8]As noted below, that is the only year for which complete data are available. A limitation of the following analysis is that it does not reflect current market conditions.

[9]This estimate includes the direct cost of CWB administration ($1.75/mt), and costs due to marketing inefficiency ($12.4 - 14.4/mt). It does not include costs of delayed varietal development or increased costs of farm management. See Carter, Loyns and Berwald, p. 319.

[10]For example, costs of handling and cleaning grain, grading standards, and variety licensing fall within the purview of the Canadian Grain Commission. However, there is a larger regulatory overlay for board grains than for non-board grains.

Table 1. Demand Data for 1991-92 Marketing Year*

Index (i)	Region	Barley Type	F.O.B. Price (C$/mt)	Quantity Sold ('000 mt)	Market Revenue (C$ mil.)	Demand Elasticity
0	Canada Domestic	Feed	117.18	7,229	847	−0.53
1	Japan	Feed	135.74	1,015	138	−3.69
2	United States	Feed	106.73	143	15	−13.80
3	Rest of World	Feed	104.21	1,336	139	−20.00
4	Canada Domestic	6-Row Malting	163.09	91	15	−1.96
5	United States	6-Row Malting	125.81	288	36	−2.74
6	Rest of World	6-Row Malting	127.39	83	11	−2.68
7	Canada Domestic	2-Row Malting	167.78	137	23	−1.91
8	United States	2-Row Malting	147.01	111	16	−2.19
9	Rest of World	2-Row Malting	138.93	804	112	−2.36

* Source: Schmitz et al. (1997), p. 32.

The CWB seeks to maximize its sales revenue net of marketing costs. Board net revenue (BR), the objective function value, is defined as follows:

$$BR = \sum_{i=1}^{9} (p_i - M) q_i \qquad (1)$$

where p_i is the price received (C$/mt) for sales in market i, q_i is the quantity sold ('000 mt), and M is the unit marketing cost associated with board sales. For simplicity, the same unit marketing cost is assumed to apply in all CWB markets. It should be emphasized that board net revenue, not producer revenue, is the value to be maximized. Board net revenue differs from total producer revenue by p_0q_0, the revenue from domestic feed barley sales.

Linear inverse demand schedules are specified for each market:[11]

$$p_i = a_i - b_i q_i \qquad (i=0,1,...,9) \qquad (2)$$

For board markets (i = 1,2,...,9), prices are measured FOB at export points (Vancouver or Thunder Bay). The price for the domestic feed market (p_0), by assumption, is also measured at

[11]Parameters are derived from information in Table 1. The intercept is given by $a_i = p_i (\eta_i - 1)/\eta_i$, where η_i is the demand elasticity, and the slope is given by $b_i = -p_i/(\eta_i q_i)$.

export points.[12] This allows arbitrage conditions to be specified without adjusting for spatial price differences.

There are three separate barley pool accounts. Let y_k denote the quantity of barley in a pool account (k = 'feed', '6-row', and '2-row'). Thus,

$$\begin{aligned} y_{feed} &= q_1 + q_2 + q_3 \\ y_{6\text{-}row} &= q_4 + q_5 + q_6 \\ y_{2\text{-}row} &= q_7 + q_8 + q_9 \end{aligned} \qquad (3\ a,b,c)$$

Total barley supplies are divided between the three pools and the domestic feed market:

$$Q = y_{feed} + y_{6\text{-}row} + y_{2\text{-}row} + q_0 \qquad (4)$$

where Q is the total quantity produced in a given year (11,238 thousand mt in simulations reported below). Returns to pool accounts are a weighted average of sale prices, with adjustment for marketing costs:

$$\begin{aligned} r_{feed} &= \sum_{i=1}^{3} (p_i - M) q_i \ / \ y_{feed} \\ r_{6-row} &= \sum_{i=4}^{6} (p_i - M) q_i \ / \ y_{6-row} \\ r_{2-row} &= \sum_{i=7}^{9} (p_i - M) q_i \ / \ y_{2-row} \end{aligned} \qquad (5\ a,b,c)$$

where r_k is the average return (C$/mt) for pool k.

Two arbitrage conditions link the pool return for feed barley and the domestic feed barley price. Equation (5) ensures that if domestic feed sales are positive ($q_0 > 0$), then the domestic feed price is at least as great as the pool return.

$$q_0 (p_0 - r_{feed}) \geq 0 \qquad (6)$$

Equation (6) ensures that if barley is attracted into the feed pool ($y_{feed} > 0$), then the pool return is at least as great as the domestic feed price.

[12] The domestic feed price in Table 1 is actually a weighted average of feed barley prices in export markets. See Schmitz et al. (1997), p. 31.

$$y_{feed}(r_{feed} - p_0) \geq 0 \tag{7}$$

In combination, (6) and (7) imply that if both quantities are positive, the domestic feed price equals the pool return. In that case, producers are indifferent between selling feed barley through the CWB and selling it in the domestic feed market.

Finally, an upper bound is placed on price differences:

$$p_i - p_{i'} \leq D \qquad \forall\ i, i' \in k \tag{8}$$

where i and i′ represent two markets in the same pool (either feed, 6-row, or 2-row malting). This bound may reflect arbitrage opportunities for international trading firms, or the existence of substitutes for Canadian barley—either of which would limit the size of potential market premiums. For example, (8) ensures that the price of Canadian feed barley sold to Japan (a 'premium' market) does not exceed the price of feed barley sold to the United States or offshore markets by more than D.

The CWB's optimization problem can now be stated. It is to maximize (1) subject to constraints (2) through (8). Note that if there are no additional marketing costs associated with single-desk selling (M=0), and if the bound on price differences (D) is sufficiently large that constraint (8) is non-binding for all relevant price pairs, then the model solution will be identical to that of Schmitz et al.

Alternative Models

For purposes of comparison, simulations will also be conducted with two alternative models. The first is what Schmitz et al. (1997) call the 'multiple seller' model, in which prices are equalized across markets. The multiple seller model represents a competitive market environment. This is posed as an optimization problem in which total producer revenue (including revenue from domestic feed sales) is the value to be maximized. Marketing costs are zero, and prices of malting barley (6-row and 2-row) are fixed at $C15/mt above the feed barley price.[13]

[13]According to Schmitz et al. (p. 33), the C$15/mt spread captures the average cost difference between growing feed barley and growing malting barley. This assumes that 2-row and 6-row malting varieties would trade at the same premium to feed in a competitive market environment. This is questionable, given the larger premiums for 2-row varieties that have been observed historically.

Formally, total revenue (TR) is maximized

$$TR = \sum_{i=0}^{9} p_i q_i \tag{9}$$

subject to demand equations (2) and constraints (10) through (12):

$$\sum_{i=0}^{9} q_i = Q \tag{10}$$

$$q_i (p_i - p_{i'}) \geq 0 \qquad \forall i, i' \in k \tag{11}$$

$$q_i [p_i - (p_0 + 15)] = 0 \qquad \forall i \in \{4,5,6,7,8,9\} \tag{12}$$

Constraint (10) allocates all barley to ten markets. Constraint (11) ensures that sales of a given barley type (k) to market i are made only if there are no higher priced markets. Constraint (12) ensures that if malting barley is sold to market i, then it is priced at the domestic feed price plus a fixed premium. In combination, these constraints force the equalization of prices (either feed or malting) in all markets where sales occur. The 'multiple seller' solution provides a natural benchmark for the evaluation of trade and welfare effects.

The second alternative represents the 'continental barley market'. This involves price equalization in North America only, with the CWB retaining control over all offshore exports of feed and malting barley. The objective to be maximized is:

$$RO = (p_1 - M) q_1 + (p_3 - M) q_3 + (p_6 - M) q_6 + (p_9 - M) q_9 \tag{13}$$

where RO denotes revenue from offshore markets. The maximization is subject to demand equations (2), and constraints (14) through (19):

$$\begin{aligned} y_{feed} &= q_1 + q_3 \\ y_{6\text{-}row} &= q_6 \\ y_{2\text{-}row} &= q_9 \end{aligned} \tag{14 a,b,c}$$

$$Q = y_{feed} + y_{6\text{-}row} + y_{2\text{-}row} + q_0 + q_2 + q_4 + q_5 + q_7 + q_8 \tag{15}$$

$$\begin{aligned} r_{feed} &= [(p_1 - M)q_1 + (p_3 - M)q_3]/\, y_{feed} \\ r_{6-row} &= (p_6 - M) \\ r_{2-row} &= (p_9 - M) \end{aligned} \tag{16 a,b,c}$$

$$\begin{aligned} q_0(p_0 - r_{feed}) &\geq 0 \\ q_4(p_4 - r_{6-row}) &\geq 0 \\ q_7(p_7 - r_{2-row}) &\geq 0 \end{aligned} \tag{17 a,b,c}$$

$$\begin{aligned} y_{feed}(r_{feed} - p_0) &\geq 0 \\ y_{6-row}(r_{6-row} - p_4) &\geq 0 \\ y_{2-row}(r_{2-row} - p_7) &\geq 0 \end{aligned} \tag{18 a,b,c}$$

$$\begin{aligned} p_0 &= p_2 \\ p_4 &= p_5 \\ p_7 &= p_8 \end{aligned} \tag{19 a,b,c}$$

In addition, for comparability with the single-desk seller model, an upper bound (D) is placed on price differences between offshore and continental markets. Along with the marketing cost parameter (M), this will be varied in model simulations.

4. Model Results

The model results in this section divide into two parts. First, results of base-case simulations are shown. These reflect specific parameter assumptions: no extra marketing costs are attached to board sales (M = 0), and the bound on inter-market price differences is sufficiently large (D = 40) that it is not constraining. With these assumptions, results for the single-seller and multiple-seller models are identical to those of Schmitz et al. (1997). Second, results of sensitivity analysis are shown. Values of marketing costs and price bounds are varied over a range so that their joint impact on welfare, trade volume, and prices can be assessed.

Base Case Results

Base-case results for the single-desk selling model are shown in Table 2. This is the same as the solution reported in Schmitz et al. (1997), p. 32. Of Canada's total barley supply, 7,229 thousand metric tons (64.3 %) are allocated to the domestic feed market, and the remainder (35.7 %) is sold by the CWB. Price premiums are especially high for 2-row malting varieties.[14] Feed barley prices are highest in Japan, and lowest in other offshore markets.

Results of the multiple-seller (free-trade) model are shown in Table 3. In this scenario, prices are equalized across markets and both types of malting barley are sold at a C$15/MT premium to feed. A larger quantity of barley, 7,487 thousand metric tons (66.7 % of total supply), is sold on the domestic feed market. This solution, representing a competitive market equilibrium, provides a benchmark for comparison with other simulation results. Interestingly, total U.S. import volume (543 thousand MT) is virtually the same as under single-desk selling, although there is a different distribution between feed and malting barley.

Table 4 shows base-case results for the continental barley market. In this scenario, board sales are limited to offshore markets (Japan and rest-of-world), while prices are equalized in the United States and Canada. It turns out that, because of arbitrage constraints linking off-board prices to pool returns, prices of malting barley are the same in offshore markets and North America. However, different prices apply in offshore feed barley markets, with Japan continuing to pay a small premium.

Table 5 compares welfare measures for three models under base-case assumptions. Total net revenue for Canadian producers is highest under single-desk selling and lowest under the multiple-seller model. Under the continental barley market, producer net revenue is lower by C$50 million (about 3 percent) due to the reduced opportunity for price discrimination. In terms of broader welfare measures, the differences between models are fairly small. Canada, as an exporter, experiences a net welfare gain due to single desk selling. Welfare effects for the United States reflect its position as an importer. The United States shows a welfare gain in the multiple-seller scenario because of larger sale volumes and lower prices, particularly for 2-row malting barley. However, as discussed below, a multiple-seller scenario would likely work to the disadvantage of U.S. barley producers.

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[14]For ease of comparison with Schmitz et al. (1997), all values are in expressed in Canadian dollars. The average exchange rate during the 1991/92 marketing year was 86 U.S. cents per Canadian dollar.

Table 2. Base-Case Solution for Single-Desk Seller*

	Canada	United States	Japan	Rest-of-World
Quantity ('000 MT)				
Feed barley	7,229	143	1,014	1,336
6-row malting	91	288	0	83
2-row malting	137	111	0	805
Price (C$/MT)				
Feed barley	117.2	106.7	135.8	104.2
6-row malting	163.1	125.8	-	127.4
2-row malting	167.8	147.0	-	138.9
Pool Accounts				
	Pool Quantity ('000 MT)		Pool Return (C$/MT)	
Feed barley	2494		117.2	
6-row malting	462		133.5	
2-row malting	1053		143.5	

*Assumes zero marketing cost differential (M=0) and no binding constraint on price differences (D=40). Model solution is identical to that of Schmitz et al. (1997), p. 32.

Table 3. Base-Case Solution for Multiple Seller Model*

	Canada	United States	Japan	Rest-of-World
Quantity ('000 MT)				
Feed barley	7,487	96	1745	34
6-row malting	133	298	0	88
2-row malting	205	149	0	1,004
Price (C$/MT)				
Feed barley	109.3	109.3	109.3	109.3
6-row malting	124.3	124.3	124.3	124.3
2-row malting	124.3	124.3	124.3	124.3

*Model solution is identical to that of Schmitz et al. (1997), p. 34.

Table 4. Base-Case Solution for Continental Barley Market Model*

	Canada	United States	Japan	Rest-of-World
Quantity ('000 MT)				
Feed barley	7,318	0	1508	670
6-row malting	128	265	0	79
2-row malting	197	140	0	933
Price (C$/MT)				
Feed barley	114.5	114.5	117.9	106.8
6-row malting	129.5	129.5	-	129.5
2-row malting	129.5	129.5	-	129.5
Pool Accounts				
	Pool Quantity ('000 MT)		Pool Return (C$/MT)	
Feed barley	2,178		114.5	
6-row malting	79		129.5	
2-row malting	933		129.5	

*Assumes zero marketing cost differential (M=0) and no binding constraint on price differences (D=40).

Table 5. Comparison of Welfare Measures in Three Models

Model	Producer Net Revenue (C$ Million)			Welfare* (C$ million)	
	Board	Non-Board	Total	Canada	United States
Single-Desk Seller	505	847	1,352	2,161	10.9
Multiple Seller	-	1,256	1,256	2,135	14.0
Continental Barley Market	380	932	1,312	2,151	11.5

* For Canada, welfare is the sum of producer net revenue and consumer surplus. For United States, welfare is measured as area beneath import demand curve and above price, summed over three barley types.

Sensitivity Analysis: Impacts of Marketing Costs and Price Bounds

Within Canada, much of the debate about single desk selling has concerned two issues: the ability of the CWB to exert market power; and the systemic costs and inefficiencies associated with board control. To provide perspective on these issues, two model parameters are varied incrementally. The first is the bound on inter-market price differences (D), and the second is the marketing cost parameter (M). Different parameter values can be taken to represent different views on the merits of single-desk selling.

Table 6 shows the impact of alternative values of M and D in the single-desk seller model. The upper panel shows the impact on Canadian producer revenue. Revenue impacts are expressed in terms of deviations from the multiple-seller solution. Thus, when M=0 and D=40, producer revenue is C$95.8 million higher with single-desk selling than under multiple sellers. These particular values correspond to Schmitz et al. (1997), and are most favorable to the single-desk selling. At the opposite (bottom right) corner of the panel are parameter values least favorable to the CWB. When M=16 and D=0, single-desk selling results in C$160 million lower revenue relative to a competitive marketing system. Values in the bottom right more closely reflect the view of Carter and Loyns (1996); they point to higher costs of board marketing and dispute the potential gains from price discrimination.

Other panels in Table 6 show the impacts of alternative parameter values on Canadian welfare, U.S. welfare, and the CWB share of barley supply under single-desk selling. Canadian welfare is highest if the board has most pricing discretion (D=40) and no extra marketing costs attach to the board system (M=0). Canadian welfare is lowest if the board cannot price discriminate (D=0) and marketing costs are high (M=16). Differential impacts on U.S. welfare are fairly small. Results indicate that U.S. welfare is enhanced, to a small extent, by the board's ability to price discriminate—although net effects are still negative relative to the multiple sellers scenario. The bottom panel shows the proportion of Canadian barley marketed by the CWB, given different parameter values. This varies between 35.7 % (base case) and 28.7 %. As expected, with higher marketing costs and smaller bounds on price differences, smaller amounts of barley enter the pooling system.

Table 7 presents results of sensitivity analysis for the continental barley market. As shown in the upper panel, Canadian producer revenue is negatively related to both the marketing cost parameter and the bound on price differences. (For some combinations of high marketing costs and low price bounds, model solutions were not feasible.) A comparison of Tables 6 and 7 reveals that, for marketing costs above C$8/MT, the continental barley market generates higher producer revenue than the single desk seller. Impacts of the continental barley market on U.S. welfare are mixed, depending on parameter values, but small in absolute magnitude.

Table 6. Sensitivity of Single-Desk Solution to Alternative Parameter Values

Extra Marketing Cost (M), $/MT	Maximum Price Difference (D), $/MT				
	40	30	20	10	0
	Canadian Producer Revenue: Deviations from Multiple Seller Solution (C$ Million)				
0	95.8	95.5	84.5	55.6	5.1
4	58.3	58.0	46.6	16.6	−36.1
8	21.1	20.8	9.0	−22.2	−77.4
12	−15.8	−16.1	−28.3	−60.8	−118.4
16	−52.4	−52.4	−65.3	−99.1	−160.0
	Canadian Welfare: Deviations from Multiple Seller Solution (C$ Million)				
0	25.9	26.4	25.6	20.7	10.5
4	12.1	12.6	11.8	−6.9	−3.2
8	−1.3	−0.8	−1.5	−6.3	−16.5
12	−14.2	−13.7	−14.5	−19.2	−29.3
16	−26.8	−26.3	−27.0	−31.7	−41.7
	U.S. Welfare: Deviations from Multiple Seller Solution (C$ Million)				
0	−3.1	−3.4	−4.0	−4.9	−5.9
4	−3.3	−3.6	−4.2	−5.1	−6.1
8	−3.4	−3.7	−4.3	−5.3	−6.3
12	−3.6	−3.9	−4.5	−5.4	−6.5
16	−3.7	−4.0	−4.6	−5.6	−6.7
	CWB Share of Total Barley Supply (%)				
0	35.7	35.7	35.3	34.5	33.0
4	34.7	34.7	34.4	33.5	31.9
8	33.8	33.8	33.4	32.5	30.8
12	32.9	32.9	32.5	31.5	29.8
16	31.9	31.9	31.5	30.5	28.7

Table 7. Sensitivity of Continental Barley Market Solution to Alternative Parameter Values

Extra Marketing Cost (M), $/MT	Maximum Price Difference (D), $/MT				
	40	30	20	10	0
	Canadian Producer Revenue: Deviations from Multiple Seller Solution (C$ Million)				
0	56.1	56.1	56.1	52.4	0.0
4	55.2	55.2	47.1	19.9	*
8	26.7	26.5	16.4	−12.1	*
12	−2.9	−3.1	−13.6	*	*
16	−31.7	−31.9	−48.9	*	*
	Canadian Welfare: Deviations from Multiple Seller Solution (C$ Million)				
0	16.1	16.1	16.1	15.0	0.0
4	15.2	15.2	12.8	4.9	*
8	6.2	6.2	3.3	−4.7	*
12	−2.8	−2.9	−5.8	*	*
16	−11.4	−11.4	−16.0	*	*
	U.S. Welfare: Deviations from Multiple Seller Solution (C$ Million)				
0	−2.5	−2.5	−2.5	−2.3	*
4	−2.5	−2.5	−2.1	−1.0	*
8	−1.3	−1.3	−0.9	0.5	*
12	0.0	0.0	0.6	*	*
16	1.5	1.5	2.5	*	*
	CWB Share of Total Barley Supply (%)				
0	28.4	28.4	28.4	28.2	*
4	28.4	28.4	28.0	26.6	*
8	27.0	27.0	26.5	25.0	*
12	25.5	25.5	25.0	*	*
16	24.1	24.1	23.3	*	*

* Solution infeasible.

Because the U.S. welfare measure is derived from import demand, it does not convey the impact of Canadian barley trade on U.S. producers. U.S. producer welfare cannot be directly measured in the context of the present model, which does not explicitly include U.S. barley supply. However, the model does generate information relevant for an assessment of likely welfare effects: import volumes, import values, and prices. Impacts of single-desk selling on these variables are shown in Tables 8 and 9.

Table 8 shows the effects of single-desk selling on aggregate U.S. barley imports. As shown in the upper panel, import volumes are highest under base-case conditions (D=40 and M=0). Import volumes are lowest when price differences are minimized and marketing costs are highest (D=0 and M=16). The negative relationship between marketing cost and U.S. import volume is not unexpected: higher marketing costs reduce CWB sales generally, and not just in the United States. It is less obvious why the bound on price differences is positively related to U.S. barley imports. The explanation lies in inter-market price spreads, especially for malting barley. U.S. malting barley prices are substantially lower than Canada's in the base case, and a narrowing of price spreads (lower value of D) requires withholding malting barley from the lower-priced market.[15] It is worth emphasizing that while single-desk selling has little impact on total U.S. import volume under base-case assumptions, the effect is to reduce U.S. imports if extra marketing costs are associated with board sales.

Additional detail on price effects can be found in Table 9. As shown in the upper panel, single-desk selling tends to lower the U.S. feed barley price. The impact is most pronounced for base-case parameter values (D=40, M=0). On the other hand, as shown in the middle and lower panels, U.S. malting barley prices are higher as a result of Canada's single-desk selling—and substantially so in the case of 2-row malting barley. This suggests that the CWB withholds malting barley from the U.S. market, thereby raising the price above what would be observed in a multiple seller environment.[16] The estimated price impacts vary with parameter assumptions. As the marketing cost parameter increases, so does the U.S. barley price.

These results provide a mixed message for U.S. producers. While single-desk selling by Canada appears to lower the U.S. feed barley price, it may also raise the U.S. malting barley price by restraining trade flows that would otherwise occur. And whatever the level of extra marketing costs associated with single desk selling (and absorbed by Canadian producers), their impact on U.S. barley prices is generally positive.

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[15]In this context, it should be noted that Canada now has fewer import barriers than in 1991/92, the base year for model simulations. The fact that most Canadian malt producers are now owned, wholly or in part, by U.S. parent companies may create additional pressure for lower malting barley prices in Canada. See Buschena, Gray, and Severson (1998) for discussion of integration in the North American malting sector.

[16]The magnitude of estimated price effects is influenced by assumptions underlying the multiple-seller (competitive) scenario; particularly the C$15/mt spread between malting and feed barley. To test the importance of this assumption, an additional simulation was performed in which 2-row malting barley was assumed to earn a C$30/mt premium to feed under multiple sellers. Using this as the base for comparison, simulation results for the single-desk selling model still show a net positive effect on U.S. malting prices.

Table 8. Impact of Single-Desk Selling on U.S. Barley Imports

Extra Marketing Cost (M), $/MT	Maximum Price Difference (D), $/MT				
	40	30	20	10	0
	U.S. Barley Import Volume: Deviations from Multiple Seller Solution ('000 MT)				
0	0.1	−6.8	−20.8	−44.2	−83.4
4	−8.4	−15.3	−29.4	−53.4	−93.9
8	−16.8	−23.7	−37.9	−62.4	−104.4
12	−25.0	−31.9	−46.3	−71.3	−115.0
16	−33.0	−39.9	−54.5	−80.0	−125.5
	U.S. Average Barley Import Price: Deviations from Multiple Seller Solution (C$/MT)				
0	3.5	4.1	5.1	6.9	9.5
4	4.0	4.6	5.7	7.5	10.2
8	4.5	5.1	6.2	8.1	11.0
12	5.0	5.6	6.7	8.7	11.7
16	5.5	6.1	7.2	9.3	12.5
	U.S. Barley Import Value: Deviations from Multiple Seller Solution (C$ Million)				
0	1.9	1.3	−0.2	−1.9	−5.8
4	1.1	0.5	−0.7	−2.8	−6.6
8	0.3	−0.3	−1.5	−3.7	−7.9
12	−0.5	−1.0	−2.3	−4.6	−9.0
16	−1.2	−1.8	−3.1	−5.5	−10.0

Table 9. Impact of Single-Desk Selling on U.S. Barley Prices

Extra Marketing Cost (M), $/MT	Maximum Price Difference (D), $/MT				
	40	30	20	10	0
	U.S. Feed Barley Price: Deviations from Multiple Seller Solution (C$/MT)				
0	−2.6	−2.6	−2.5	−2.3	−1.5
4	−2.2	−2.2	−2.2	−2.0	−1.1
8	−1.9	−1.9	−1.9	−1.6	−0.8
12	−1.6	−1.6	−1.6	−1.3	−0.4
16	−1.3	−1.3	−1.3	−1.0	−0.1
	U.S. 6-Row Malting Barley Price: Deviations from Multiple Seller Solution (C$/MT)				
0	1.5	2.6	4.5	7.2	11.5
4	1.8	2.9	4.8	7.6	12.0
8	2.1	3.2	5.1	8.0	12.6
12	2.4	3.5	5.4	8.3	13.1
16	2.7	3.8	5.7	8.6	13.6
	U.S. 2-Row Malting Barley Price: Deviations from Multiple Seller Solution (C$/MT)				
0	22.8	22.8	23.3	24.9	23.3
4	23.1	23.1	23.6	25.2	23.8
8	23.4	23.4	23.9	25.6	24.3
12	23.6	23.7	24.2	25.9	24.8
16	23.9	23.9	24.5	26.2	25.3

5. Conclusion

The role of the Canadian Wheat Board in the barley sector has been the subject of much analysis and debate in Canada. Some western growers, particularly in Alberta, have objected to the disproportionate influence of the CWB on feed barley prices, and the lack of effective arbitrage between U.S. and Canadian markets. About three quarters of Canadian barley is now utilized domestically as livestock feed, which renders the CWB something of a residual claimant. Yet so long as Canada remains a surplus producer of feed barley, prospective pool returns will affect values in the Canadian feed market. Single-desk selling and price pooling mean that Canadian barley values are disconnected from those in contiguous U.S. markets.

One of the purported advantages of the CWB is its ability to earn higher returns for malting barley compared to a multiple-seller environment. Schmitz et al. (1997) quantified the impact of single-desk selling on average prices received for malting barley: C$42/MT for 6-row varieties, and C$34/MT for 2-row varieties, based on model simulations for ten marketing years. Other studies, notably Carter (1993), have pointed to the low Canadian selection rates for malting barley, and questioned whether Canadian producers would be better served by a deregulated marketing system. In Carter's view, higher premiums for malting barley must be weighed against the cost of lost marketing opportunities, particularly in the United States.

Among economists, much of the debate about single-desk selling has revolved around two issues. The first concerns the ability of the CWB to exert market power and extract price premiums for Canadian barley in export markets. Carter (1993), for example, found demand for Canadian barley to be extremely elastic in major offshore markets. This would undermine the ability of the CWB to act a price discriminating monopolist. Schmitz et al. (1997) presented some empirical evidence on differences in CWB export prices. They found significant differences in fob prices paid for feed barley in Japan, the United States, and the rest of the world, lending support to the claim of CWB price discrimination. However, their results were strongest for the period when the U.S. Export Enhancement Program (EEP) was in effect. In the absence of targeted subsidies by competing exporters, the ability of the CWB to charge different prices in different markets may be severely circumscribed.

The second debate concerns the issue of systemic costs associated with single-desk selling. Carter and Loyns (1996), and Carter, Loyns and Berwald (1998) have identified numerous extra costs in the Canadian grain handling, transportation, and marketing system which, they argue, are directly or indirectly linked to the Canadian Wheat Board. Higher marketing costs—possibly as high as C$16/MT for barley— would lower the net return to Canadian producers and offset any advantages of single-desk selling. Defenders of the CWB dispute these estimates and the Board's responsibility for specific costs and inefficiencies. There may be no way to resolve this debate short of major reforms in the Canadian system.

These questions are of keen interest to U.S. producers and policymakers. Canadian barley exports to the United States have risen in recent years relative to historical averages, while U.S. barley acres have declined. It is natural to ask what effect single-desk selling of Canadian barley has had on U.S. barley prices. Northern-tier politicians have argued that the Canadian Wheat Board, as a state trading enterprise (STE), enjoys an unfair competitive advantage in U.S. and international markets. Their presumption is that the CWB must therefore work to the disadvantage of U.S. producers. But the brief experience of a 'continental barley market' in 1993 may have shown the opposite, as the suspension of CWB control allowed large volumes of Canadian barley to move south in response to price differentials. While the 1993/94 surge in U.S. barley imports was partly due to a short corn crop, it seems plausible that a competitive marketing system in Canada would actually facilitate exports to the United States.

The analysis in this paper is based on a model of single-desk selling by the Canadian Wheat Board. The model, adapted from that of Schmitz et al. (1997), includes both feed and malting barley, ten distinct markets, price pooling, and a set of arbitrage conditions linking pool returns to the domestic feed barley price. The model includes two additional features—a bound on inter-market price differences (D), and a marketing cost parameter (M)— which allow the diverse opinions on single-desk selling to be represented analytically. The benchmark for comparison is a 'multiple seller' model, in which prices are equalized (fob Canadian ports) across markets for each type of barley. Comparisons are also made to a 'continental barley market' model. Demand and supply estimates are based on the 1991/92 marketing year.

Results of the analysis may be summarized as follows. Under base-case assumptions, which are most favorable to the CWB (i.e., D=40 and M=0), single-desk selling of Canadian barley raises Canadian producer revenue by C$95.8 million, relative to the multiple-seller solution. However, if tighter bounds apply to price differences or extra marketing costs apply, the effect of single-desk selling is to lower Canadian producer revenue. Under parameter values least favorable to the CWB (D=0 and M=16), Canadian producers lose C$160.0 million because of single-desk selling.

Under base-case assumptions, the continental barley market generates lower net revenue for Canadian producers than single-desk selling. However, the continental barley market compares favorably to single-desk selling (in terms of Canadian revenue) if extra marketing costs of at least C$8/MT apply to board sales.

Impacts of single-desk selling on U.S. producers cannot be estimated directly from model results because U.S. supplies are not explicitly included in the analysis. However, the price effects of different scenarios are suggestive. Given market conditions for the base year, single-desk selling in Canada appears to have the effect of lowering U.S. feed barley prices while raising U.S. malting barley prices—both 6-row and (especially) 2-row varieties. This suggests that if Canada were to adopt a competitive marketing system for barley, larger amounts of malting barley would be exported to the United States. Based on sensitivity analysis, if marketing costs in Canada are inflated by single-desk selling, this would also lend some support to U.S. price levels.

Some qualifications should be mentioned. First, the analysis is based on results for one marketing year, as relevant data for other years (i.e., average CWB transaction prices and quantities, by market) were not available. Important changes have occurred in recent years, including the growth of feed demand in western Canada, the suspension of U.S. EEP subsidies for barley, and quality problems in the U.S. malting barley crop—all of which could be expected to change price relationships and trade patterns. Second, the model lacks the kind of regional detail that may be critical to an understanding of continental barley trade.[17] Canadian feed barley

[17]See Johnson and Wilson (1994) for a more fully developed spatial model based on competitive market equilibrium.

demand is centered in Lethbridge, while California represents the largest U.S. feed market. U.S. malting capacity is spatially dispersed, but with a concentration of plants in the Midwest. With or without the CWB, flows of Canadian barley into U.S. markets are likely to be determined by the costs of inter-regional grain movements, in addition to price spreads at Canadian ports.

While this study has focused on single-desk selling, it should also be recognized that other features of the Canadian system have an important bearing on trade flows. Among these are the regulations concerning grain quality, and constraints on market access for U.S. grains in Canada.[18] Some prospective policy changes—such as deregulation of Canadian rail rates for grain—could have significant long-term effects on continental barley trade. These issues, which may be only indirectly linked to Canadian Wheat Board, also warrant attention from U.S. analysts and policymakers.

[18]These issues were examined by the Canada-United States Joint Commission on Grains. For more background on reciprocal market access, see Wilson and Dahl (1998).

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Appendix

In the standard model of a price discriminating monopolist, profits are maximized by equating marginal revenues across markets (e.g., Henderson and Quandt, pp. 182-3). However, when the price difference between markets is limited—for example, by opportunities for trader arbitrage—this condition no longer holds. Following is a demonstration that marginal revenues for the monopolist are not, in general, equalized across markets when there is a binding constraint on price differences.

Consider a two market problem. A monopolist faces inverse demand functions of the form $p_i = a_i - b_i q_i$ (i = 1,2) and seeks to maximize revenue.[19] An upper bound, D, is placed on price differences. This might reflect the transaction cost for firms engaged in arbitrage between the two markets. The monopolist's problem is:

$$\max \sum_{i=1}^{2} [a_i - b_i q_i] q_i$$

subject to

$$(a_1 - b_1 q_1) - (a_2 - b_2 q_2) \le D$$

$$(a_2 - b_2 q_2) - (a_1 - b_1 q_1) \le D$$

or in lagrangian form,

$$\max L = a_1 q_1 - b_1 q_1^2 + a_2 q_2 - b_2 q_2^2$$
$$+ \lambda_1 [D - (a_1 - b_1 q_1) + (a_2 - b_2 q_2)]$$
$$+ \lambda_2 [D - (a_2 - b_2 q_2) + (a_1 - b_2 q_1)]$$

The first-order conditions are equations (1) through (8):

$$\frac{\partial L}{\partial q_1} = a_1 - 2b_1 q_1 + \lambda_1 b_1 - \lambda_2 b_1 \le 0 \tag{1}$$

$$q_1 \frac{\partial L}{\partial q_1} = 0 \tag{2}$$

$$\frac{\partial L}{\partial q_2} = a_2 - 2b_2 q_2 + \lambda_2 b_2 - \lambda_1 b_2 \le 0 \tag{3}$$

[19]We ignore production costs for simplicity. In the standard model, marginal revenue in each market equals the marginal cost of output as a whole.

$$q_2 \frac{\partial L}{\partial q_2} = 0 \tag{4}$$

$$\frac{\partial L}{\partial \lambda_1} = D - a_1 + b_1 q_1 + a_2 - b_2 q_2 \geq 0 \tag{5}$$

$$\lambda_1 \frac{\partial L}{\partial \lambda_1} = 0 \tag{6}$$

$$\frac{\partial L}{\partial \lambda_2} = D - a_2 + b_2 q_2 + a_1 - b_1 q_1 \geq 0 \tag{7}$$

$$\lambda_2 \frac{\partial L}{\partial \lambda_2} = 0 \tag{8}$$

Assume that $q_1 > 0$ and $q_2 > 0$. Then (1) and (3) are equalities, by complementary slackness conditions (2) and (4). Rearrange (1) to obtain

$$q_1 = \frac{a_1 + \lambda_1 b_1 - \lambda_2 b_1}{2b_1} = \frac{1}{2}\left(\frac{a_1}{b_1} + \lambda_1 - \lambda_2\right) \tag{9}$$

and rearrange (3) to obtain

$$q_2 = \frac{a_2 + \lambda_2 b_2 - \lambda_1 b_2}{2b_2} = \frac{1}{2}\left(\frac{a_2}{b_2} + \lambda_2 - \lambda_1\right) \tag{10}$$

Now assume that $p_2 - p_1 = D$, so that (7) holds as an equality. Then (5) is a strict inequality, and $\lambda_1 = 0$ by the complementary slackness condition (6). Combining $\lambda_1 = 0$ with (9), we obtain

$$q_1 = \frac{1}{2}\left(\frac{a_1}{b_1} - \lambda_2\right) \tag{11}$$

Combining $\lambda_1 = 0$ with (10), we obtain

$$q_2 = \frac{1}{2}\left(\frac{a_2}{b_2} + \lambda_2\right) \tag{12}$$

Substitute (11) and (12) into (7) (treated as equality)

$$D - a_2 + b_2\left[\frac{1}{2}\left(\frac{a_2}{b_2} + \lambda_2\right)\right] + a_1 - b_1\left[\frac{1}{2}\left(\frac{a_1}{b_1} - \lambda_2\right)\right] = 0 \tag{13}$$

and rearrange to solve for λ_2:

$$\lambda_2 = \frac{-2D + a_2 - a_1}{b_2 + b_1} \tag{14}$$

Using (14), we now replace λ_2 in equations (11) and (12) to express quantities in terms of demand parameters:

$$q_1 = \frac{a_1}{2b_1} + \frac{2D + a_1 - a_2}{2(b_2 + b_1)} \tag{15}$$

$$q_2 = \frac{a_2}{2b_2} - \frac{2D + a_1 - a_2}{2(b_2 + b_1)} \tag{16}$$

Marginal revenue in market 1 is given by

$$\frac{\partial p_1 q_1}{\partial q_1} = \frac{\partial}{\partial q_1}(a_1 - b_1 q_1) q_1 = a_1 - 2b_1 q_1$$

$$= a_1 - 2b_1 \left[\frac{a_1}{2b_1} + \frac{2D + a_1 - a_2}{2(b_2 + b_1)} \right]$$

$$= \frac{-2b_1 D - b_1(a_1 - a_2)}{b_2 + b_1} \qquad (17)$$

Similarly, marginal revenue in market 2 is

$$\frac{\partial p_2 q_2}{\partial q_2} = \frac{\partial}{\partial q_2}(a_2 - b_2 q_2) q_1 = a_2 - 2b_2 q_2$$

$$= a_2 - 2b_2 \left[\frac{a_2}{2b_2} - \frac{2D + a_1 - a_2}{2(b_2 + b_1)} \right]$$

$$= \frac{-2b_2 D - b_2(a_2 - a_1)}{b_2 + b_1} \qquad (18)$$

If marginal revenues in the two markets are equalized, then it must be true that

$$-2b_1 D - b_1(a_1 - a_2) = -2b_2 D - b_2(a_2 - a_1)$$

or rearranging terms,

$$D = \frac{(b_2 + b_1)(a_2 - a_1)}{2(b_1 - b_2)} \qquad (19)$$

Thus, if $p_2 - p_1 = D$, marginal revenues are equalized only in the special case that demand parameters satisfy (19).

The implication is that, if price spreads are constrained (e.g., by the presence of arbitragers, or availability of substitutes), a monopolist will not, in general, equate marginal revenues in different markets. This prompts two observations about Canadian barley and the price pooling model. First, price-setting by the CWB has surely been subject to constraints of this kind. In years when the U.S. EEP program was in effect, the CWB exported barley to both subsidized and unsubsidized markets. Price spreads between those markets, corrected for shipping cost differentials, were bounded by the size of EEP bonuses—something over which the CWB had no control. The second point concerns the price-pooling model of Schmitz et al. (1997). Demand parameters in that model were synthesized from a mixture of elasticities, CWB sales data, and first-order conditions from the single-desk seller's optimization problem. Those first-order conditions include equalization of marginal revenues across markets. Thus, the demand parameters reflect a dubious assumption: that CWB price differentials are not constrained by competitive conditions or subsidies of foreign suppliers. This suggests that the estimated net benefits of single-desk selling may be overstated for reasons unrelated to the debate over systemic costs.