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# PRICE DISCRIMINATION IN THE CONTEXT OF VERTICAL DIFFERENTIATION: AN APPLICATION TO CANADIAN WHEAT EXPORTS

NATHALIE LAVOIE

The ability of the Canadian Wheat Board (CWB) to price discriminate in wheat exports is examined. The conceptual model shows that the CWB's ability to exploit cost differences in pricing depends on the extent of differentiation between Canadian and U.S. wheat. This model is implemented using monthly confidential price data for exports to four markets from 1982 to 1994. The empirical results support the conclusions that (1) the CWB has market power emerging from product differentiation, (2) the CWB price discriminates across export markets, and (3) Alchian–Allen effects are important in pricing in markets valuing quality such as Japan and the United Kingdom.

*Key words:* Canadian Wheat Board, marketing board, price discrimination, quality, state-trading enterprise, trade, product differentiation, wheat.

In microeconomics textbooks the wheat industry is often used to illustrate an industry characterized by perfect competition, and thus product homogeneity. This study challenges this view by investigating the presence of price discrimination in a differentiated-product wheat industry. Different wheat “classes” are used in flour destined for the production of raised breads, flat breads, noodles, cookies and cakes, pasta, etc. Not only do wheat classes differentiate wheat, but within those classes, wheat is also differentiated by quality. As emphasized in the studies conducted by Mercier, and Stephens and Rowan, Canadian and Australian wheat are often considered by

importers to be of better quality than U.S. wheat.

With product differentiation, the potential exists for a large seller to exercise market power through price discrimination. Interestingly, both Canada and Australia export wheat through a single-desk seller, also known as a state-trading enterprise (STE).

STEs are controversial institutions that have been challenged internationally and domestically. Internationally, the criticisms focus on the ability of STEs to engage in unfair trade practices and distort worldwide trade (GAO). In fact, under the current World Trade Organization (WTO) negotiation, the United States hopes to end the exclusive export rights and government financial backing of STEs (Miner). Domestically, STEs' benefit to wheat producers has been questioned in both Canada and Australia (Barracrough and Jones, Carter and Wilson).

In the context of those challenges, prior research has sought to examine the benefits and costs of the Canadian Wheat Board (CWB) (Kraft, Furtan, and Tyrchniewicz (KFT); Carter and Loyns) and of the Australian Wheat Board (AWB) (Piggott; Ryan; Booz, Allen, and Hamilton). KFT and Ryan have examined whether the CWB and AWB, respectively, can market wheat at a premium over the price of comparable wheat from competitors. They found that the CWB and AWB obtained a premium in the world market due

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to their ability to price discriminate. However, it is unclear to what extent the measured price premia could also be attributed to the higher quality of Canadian and Australian wheat. Critics of the CWB have argued that it over-delivers on protein content and uses "other lucrative contract terms which utilize discriminatory pricing and are the equivalent of export subsidies" (North Dakota Wheat Commission [NDWC]). The over-delivery of protein is viewed, alternatively, as an inefficiency (Carter, Loyns, and Berwald) or a form of predatory pricing (NDWC).

The above arguments underline the importance of considering wheat heterogeneity when evaluating the performance of organizations such as the CWB and the AWB. The literature on wheat trade has addressed separately wheat quality differentiation among countries and noncompetitive behavior of exporting countries.<sup>1</sup> This study integrates the two literatures by examining the ability of the CWB to price discriminate in a manner that maximizes producer surplus, while treating wheat as a vertically differentiated intermediate good.

The literature on wheat trade is expanded by modeling jointly the presence of imperfect competition, product differentiation, and a STE competing against private firms. Moreover, the model of quality differentiation for consumer goods developed by Mussa and Rosen is modified to accommodate the realities of import demands for bread wheat, an intermediate input.

Imperfect competition can be identified in export markets by exploiting the effect of variables causing a price wedge between the exporters' and importers' price such as ocean freight rates, import duties, export subsidies, and exchange rates on the prices set by the CWB. Thus, these variables can be used as "instruments" of price discrimination. The conceptual model isolates the effect of various instruments of price discrimination and demonstrates that the CWB's ability to exploit fluctuations in those instruments in pricing depends on the extent of the differentiation between Canadian and U.S. wheat. The empirical analysis of price discrimination uses CWB confidential price data on bread wheat exports.

## Canadian and U.S. Wheat Industries

The United States and Canada export the bulk of high-protein hard wheat, the type of wheat used in raised-bread production. Whereas most of the Canadian wheat production consists of Canada Western Red Spring (CWRS) wheat, a class of high-protein hard wheat, the United States produces a larger number of wheat types. Two other important differences between the Canadian and U.S. wheat industries are their marketing and variety control systems.

A few multinational firms dominate the exporting of U.S. wheat. In contrast, all Western Canadian wheat going for export or for domestic processing is marketed by the CWB. The CWB markets wheat and barley on behalf of farmers and returns to them the sales' revenues, minus operating and administration costs, as a pooled price. Its stated objective is to market "quality products and services to maximize returns to western Canadian grain producers" (CWB 2001).

Canadian wheat is subject to a variety control system. Varietal standards are included in grade definitions and "kernel visual distinguishability" is required. For example, the Neepawa variety is the standard for CWRS wheat. For a new CWRS variety to be registered and marketed, it must be of equal or better quality than Neepawa and be visually different from wheat in other classes. Western Canadian farmers are not allowed to grow non-registered and indistinguishable wheat varieties for milling purposes. This system enables wheat to be segregated by classes reflecting different end-use purposes and ensures a minimum intrinsic wheat quality.

In contrast to Canada, the U.S. varietal development and release system is unregulated. New varieties are developed and released by both public and private firms. According to Dahl and Wilson, this difference in variety control policy has resulted in twice as many releases of new hard red spring (HRS) wheat varieties in the United States as in Canada. American wheat producers are free to choose among available varieties on the seed market. Because different varieties within each class have different end-use and agronomic quality, such as high yield, disease resistance, etc., producers may not always choose varieties with good end-use quality. The difference in the variety control system between Canada and the United States contributes to the higher quality

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<sup>1</sup> Those two literatures are reviewed in Lavoie. A review of the wheat differentiation literature can also be found in Stiegert and Blanc.

recognition of Canadian wheat relative to U.S. wheat.

### **Wheat Quality**

Quality and quantity of flour produced from a given quantity of wheat depend on the physical and intrinsic quality of the wheat kernels. Protein content is the single most important predictor of the end-use potential of wheat (Williams). For raised-bread baking, protein level directly impacts loaf volume and crust and crumb texture. Up to about 13% protein is beneficial for raised breads, because higher protein will result in complications in mixing and fermentation (Williams). Wheat with more than 13% protein is normally used in blends with wheat of lower protein content. Protein quality is just as important as protein quantity. If two flours, milled from two different wheat varieties with the same protein content, produce two different loaf volumes, everything else constant, their protein is said to be of different quality (Tweed).

Two surveys of bread wheat importers (Mercier, Stephens and Rowan) show that important wheat quality attributes differ by importing country and importer. However, consistency in physical and intrinsic quality, especially the level and consistency of protein quantity and quality, emerges as an important attribute in general. Protein quantity was rated the most important attribute in wheat purchasing decision, followed by gluten (protein) quality, moisture content, and the quantity of nonmillable material. Canada and Australia have been recognized to export higher overall quality (physical and intrinsic) than the United States (Mercier). The main concern with U.S. bread wheat is the variability in protein quality within and between shipments and the difficulty of the United States “to provide the level of protein that buyers expect” (Mercier, p. 19). U.S. wheat protein quality is also a concern for U.S. millers (Lambert and Wilson).

### **Conceptual Model of Trade of a Vertically Differentiated Intermediate Good**

Price discrimination takes place when different markups exist for sales to different consumers. In an oligopoly setting, as is the case for international wheat trade, price discrimination is usually explained by horizontal product differentiation (Katz, Borenstein 1985).<sup>2</sup> In

<sup>2</sup> There are two types of product differentiation. Products are “horizontally” differentiated when they possess different charac-

teristics, for example, a blue car versus a red car. Not all consumers agree on which car is preferred because they have different preferences for color. Products are “vertically” differentiated when they differ by the level of characteristics, where more of a given characteristic is better. Under vertical differentiation, all consumers would choose the higher quality good if it was sold at the same price as the lower quality good. For example, a car with more fuel efficiency is preferred to an identical car with less fuel efficiency.

Quality differentiation has not been explicitly taken into account in studies examining price discrimination by the CWB in wheat and barley exports. Schmitz et al. and Brooks and Schmitz find evidence of price discrimination in feed barley exports by testing whether the prices between any market pair are statistically different. Other authors used the pricing-to-market (PTM) approach (Krugman, Knetter 1989), which is based on the idea that an exporter with the ability to price discriminate can exploit changes in the equilibrium caused by movements in exchange rates whereas a perfectly competitive firm cannot.<sup>3</sup> Using this method, Pick and Carter, Carew, and Carew and Florkowski find evidence supporting imperfect competition of Canadian wheat exports. Carter does not find evidence of PTM in Canadian barley exports. Not taking into account product differentiation could potentially explain findings of price discrimination (Sexton and Lavoie).<sup>4</sup>

A related approach (Goldberg and Knetter 1999) uses exchange rates to identify the residual demand elasticity in each destination market. Price discrimination is indirectly demonstrated upon the finding of different elasticities in the various markets. While product differentiation is allowed in this approach, it is not modeled explicitly.

This study develops a reduced-form test of price discrimination, which accounts for a vertically differentiated intermediate good within a system of import demands and supply relationships. Import demand systems for

teristics, for example, a blue car versus a red car. Not all consumers agree on which car is preferred because they have different preferences for color. Products are “vertically” differentiated when they differ by the level of characteristics, where more of a given characteristic is better. Under vertical differentiation, all consumers would choose the higher quality good if it was sold at the same price as the lower quality good. For example, a car with more fuel efficiency is preferred to an identical car with less fuel efficiency.

<sup>3</sup> Krugman coined the term “pricing-to-market,” while Knetter (1989) developed the empirical model. Other useful references include Marston, Knetter (1993), Knetter (1995), Gagnon and Knetter, and also Goldberg and Knetter (1997).

<sup>4</sup> PTM studies, such as these, typically use export unit values as prices—the next best alternative when confidential data cannot be obtained. Unit values are calculated as the ratio of value to volume of exports by product category and destination country. Product categories contain differentiated products. Lavoie and Liu demonstrate that using unit values aggregating differentiated products results in false detection of PTM even when the law of one price holds.

differentiated agricultural goods have been the topic of recent literature (MacLaren; Davis and Jensen; Davis; Koo, Mao, and Sakurai). Import demands in most studies are derived from utility theory, but agricultural products, such as wheat, are often intermediate goods. Obtaining import demand systems consistent with profit maximization or cost minimization for differentiated intermediate goods is challenging because knowledge of the production process is required and varies by industry. In this study, the vertical differentiation model of Mussa and Rosen is modified to accommodate the realities of the high-protein wheat market. The model generates a demand system for a vertically differentiated intermediate good, which is then used to (1) understand the role of quality differentiation in price discrimination and (2) devise a reduced-form test of price discrimination on the basis of movements in variables causing a wedge between the export and import price.

On the supply side, the specific objective of the CWB is modeled, as well as competition with U.S. sellers. Empirically, insights are used from the PTM approach and a reduced-form equation is estimated containing relationships present only in imperfect competition. A detailed discussion of the model can be found in Lavoie.

### *Demand Side*

Assume that two countries (Canada and the United States) export a differentiated commodity—wheat—to two markets (a and b). Wheat is differentiated by quality only. Wheat quality can be represented by various attributes such as moisture content, presence of dockage and foreign material, kernel size, color, protein quantity and quality, etc. For the purpose of this article, quality is modeled as consisting of a quality index. Thus, Canada produces wheat of high quality  $k_C$  and the United States produces wheat of lower quality  $k_U < k_C$ . Wheat is imported for processing into an end-product, for example, flour. Moreover, it is assumed that an importing country  $m$  ( $m = a, b$ ) produces wheat domestically of quality  $k_d^m$ , which is lower than the quality of both foreign wheats. Millers, in each country, differ according to their desired end-product qualities,  $k^m$ . Millers in market  $m$  are distributed uniformly according to  $k^m \in [s_m, K_m]$ , where  $s_m$  can be viewed as a minimum quality standard in market  $m$ , and  $K_m = s_m + 1$ .

In both markets, the maximum desired end-product quality ( $K_m$ ) is higher than the quality

of the domestic wheat (in end-product quality equivalent terms), but lower than the quality of foreign wheat. That is,  $k_d^m < K_m < k_U < k_C$ . If the desired end-product quality of a miller is higher than the domestic wheat quality ( $k_d^m < k^m$ ), wheat of quality  $k_C$  or  $k_U$  must be imported for blending in the production of the end-product. This situation applies well to bread wheats. Most importing countries produce wheat that is not high enough in protein content to produce flours used in raised-bread production. As a result, domestic wheat must be blended with Canadian or U.S. wheat with higher protein content. Wilson and Preszler (1992), and Wilson and Preszler (1993) convey this point about the United Kingdom market. Japan blends both Canadian and U.S. high-protein hard wheat (CWRS and HRS wheat, respectively) with domestic and lower-protein U.S. wheat.

Following Brorsen et al., the output (say flour) is produced using wheat and other inputs (labor, capital, energy, etc.) according to a Leontief production function. More specifically:  $y = \min[x, h(\mathbf{S})/\gamma]$ , where  $y$  is the quantity of flour,  $x$  is the quantity of wheat,  $\mathbf{S}$  is a vector of other inputs, and  $\gamma$  is the ratio of other inputs to wheat inputs. While there is a fixed ratio between wheat and other inputs,  $h(\cdot)$  may exhibit variable proportions. The wheat input consists of domestic and foreign wheat, which are blended according to their respective characteristics and the desired characteristics of the end-product. Domestic and foreign wheat are blended in fixed proportion ( $\alpha$ ) based on the level of the quality characteristic according to  $x = \min[q_i/\alpha, q_d]$ , where  $q_i$  is the quantity of imported wheat  $i$  ( $i = C, U$ ) and  $q_d$  is the quantity domestic wheat.<sup>5</sup> Both the ratio of foreign to domestic wheat ( $\alpha$ ) and the ratio of other inputs to wheat input ( $\gamma$ ) depend on the quality of the domestic and foreign wheat, as well as the desired output quality, that is,  $\alpha(k_i, k_d^m, k^m)$  and  $\gamma(k_i, k_d^m, k^m)$ . To facilitate exposition,

<sup>5</sup> Typically, wheat is blended on the basis of more than one characteristic and millers have a range of desired end-product quality. As such, wheat of different characteristics can be combined in multiple ways to achieve a given output specification. This aspect of flour milling is modeled in more detail in Wilson and Preszler (1992), and Wilson and Preszler (1993). Because this article focuses on the quality differentiation aspect of wheat, modeling is greatly simplified by considering quality as a summary index of a product's characteristics (Bresnahan). Using a quality index is a reasonable assumption when consumers (millers in this case) generally rank the differentiated products in the same order of quality. This ranking seems to be valid for bread wheat according to the surveys conducted by Mercier and by Stephens and Rowan, where many countries agree that Canadian wheat is of better quality than U.S. wheat.

assume that these ratios can be expressed as  $\alpha(\cdot) = k^m/k_i k_d^m$  and  $\gamma(\cdot) = (k^m)^2/k_i k_d^m$ . The ratio  $\alpha(\cdot)$  reflects the essential feature that less foreign wheat is required as the desired quality of the end-product decreases, and the quality of the foreign or domestic wheat increases.<sup>6,7</sup> The functional form for  $\gamma(\cdot)$  indicates that the quantity of processing inputs increases at an increasing rate as the end-product quality ( $k^m$ ) increases.<sup>8</sup> The production function for flour, thus, takes the following functional form:

$$y = \min \left\{ \min \left[ \frac{q_i}{\alpha(\cdot)}, q_d \right], \frac{h(\mathbf{S})}{\gamma(\cdot)} \right\}.$$

Assume that flour millers in market  $m$  each have a contract for  $y^{*m}$  quantity of flour to be delivered. Moreover, each miller produces a different end-product quality or, said differently, a different type of flour. The flour miller must choose between wheat C and wheat U to minimize costs subject to a technology constraint. The miller therefore faces the following problem:

$$(1) \quad \min_{q_i, q_d, \mathbf{S}} p_i^{m\$} e^m q_i + p_d q_d + \mathbf{wS} \text{ s.t. } y^{*m} \\ = \min \left\{ \min \left[ \frac{q_i}{\alpha(\cdot)}, q_d \right], \frac{h(\mathbf{S})}{\gamma(\cdot)} \right\} \\ \text{for } i \in (C, U)$$

$$C_i^m(\cdot) = \begin{cases} y^{*m} \left( p_d + p_C^{m\$} e^m \frac{k^m}{k_C k_d^m} + g^m(\mathbf{w}) \frac{(k^m)^2}{k_C k_d^m} \right) & \text{if buys wheat C} \\ y^{*m} \left( p_d + p_U^{m\$} e^m \frac{k^m}{k_U k_d^m} + g^m(\mathbf{w}) \frac{(k^m)^2}{k_U k_d^m} \right) & \text{if buys wheat U} \\ y^{*m} \left( p_d + g^m(\mathbf{w}) \left( \frac{k^m}{k_d} \right)^2 \right) & \text{if buys no foreign wheat} \end{cases}$$

<sup>6</sup> Wheat C and wheat U are considered perfect substitutes in this formulation even though wheat C is of greater quality than wheat U. Wheat C is of higher quality because it is more "productive" in the production of the output, i.e., a lower quantity of wheat C is required to achieve the desired end-product quality.

<sup>7</sup> The functional form of the ratio implies that wheat quality increases the end-product quality linearly. Such relationship exists between, for example, the level of wheat protein and the level of flour protein, test weight and flour yield, and ash content and flour yield (Dexter). The specific functional form was chosen for convenience and does not affect the qualitative effect of wheat quality on quantity demanded in the conceptual model.

<sup>8</sup> For example, as the end-product quality increases, there may be greater and greater requirements for labor inputs to monitor the various processing steps and insure that the standard is met. The functional form also describes a negative relationship between wheat quality and other inputs. Such a relationship exists between, for example, wheat cleanliness and cleaning inputs, protein quantity and vital gluten supplement, and wheat alpha-amylase content and enzyme supplement (Sarkar). The specific functional form was chosen for convenience and does not affect the qualitative effect of wheat quality on quantity demanded in the conceptual model.

where  $p_i^{m\$}$  is the landed price of wheat  $i$  in U.S. dollars in market  $m$ .  $p_C^{m\$}$  is equal to  $p_C^m + T^m + (D^m/e^m)$ , where  $p_C^m$  is the f.o.b. price of wheat C to market  $m$ ,  $T^m$  is the ocean freight rate to market  $m$  (in U.S. dollars),  $D^m$  is an import duty in market  $m$  (in domestic currency), and  $e^m$  is the exchange rate for market  $m$  (domestic currency per U.S. dollar). In addition,  $p_U^{m\$}$  is equal to  $p_U + T^m + (D^m/e^m) - \text{EEP}^m$ , where  $p_U$  is the f.o.b. price of wheat U, and  $\text{EEP}^m$  is the Export Enhancement Program (EEP) bonus offered to market  $m$  in U.S. dollars.<sup>9</sup> The variable  $p_d$  is the domestic wheat's price and  $\mathbf{w}$  is a vector of other inputs' prices. Separate data on freight rates for Canada and the United States are not available and it is assumed that Canadian and U.S. ocean freight rates to any given country are the same. This assumption is reasonable because bread wheat is produced in adjacent Canadian and U.S. areas and exported through adjacent ports.

Given their end-product quality  $k^m$ , millers in market  $m$  will use the lowest-cost wheat. Thus, solving the cost minimization problem in equation (1), the cost function obtained is

where  $g^m(\mathbf{w})$  is the marginal processing cost. Some millers may choose to purchase none of wheat C or U. In this case, they would use only domestic wheat in the production of the output.<sup>10</sup>

<sup>9</sup> EEP bonuses are export subsidies allocated to specific countries chosen by the U.S. government. U.S. exporting firms agree on the sales price and potential EEP bonuses with importers. U.S. firms then submit EEP bids to the Commodity Credit Corporation of the USDA. The exporter with the lowest bid receives the subsidy. Thus, importers indirectly receive the subsidy through U.S. exporting firms. EEP subsidies were used in U.S. wheat exports until 1995. Wang and Sexton provide a detailed explanation and analysis of the EEP bonus allocation mechanism.

<sup>10</sup> Allowing for a firm to use only domestic wheat is similar to having an "outside good" in the standard discrete choice model. The outside good guarantees a decrease in consumption if the price of both wheat C and U increases in the same proportions. The outside good could also be another wheat class produced domestically or imported. It will become apparent later that only the demand for

Let  $k_{CU}^m$  denote the miller in market  $m$  indifferent between buying wheat C and wheat U. In other words,

$$k_{CU}^m = \frac{(p_C^{m\$} e^m k_U - p_U^{m\$} e^m k_C)}{g^m(w)(k_C - k_U)}$$

and is the value of  $k^m$  that solves  $C_C^m(\cdot) = C_U^m(\cdot)$ .<sup>11</sup> Millers with  $k^m \geq k_{CU}^m$  will buy wheat C because it is cheaper to use than wheat U.

The demand for wheat C in market  $m$  can be found by adding the quantity purchased by millers with  $k^m \geq k_{CU}^m$  and corresponds to

$$(2) \quad D_C^m(p_C^{m\$}, p_U^{m\$}, e^m, \mathbf{w}, K_m, k_C, k_U, k_d^m, Y^m) \\ = \frac{Y^m}{2k_C k_d^m} \left( (K_m)^2 \right. \\ \left. - \left( \frac{(p_C^{m\$} e^m k_U - p_U^{m\$} e^m k_C)}{g^m(\mathbf{w})(k_C - k_U)} \right)^2 \right)$$

where  $Y^m$  ( $m = a, b$ ) is the sum of output quantity contracted by each miller in market  $m$ . The demand for wheat U can be obtained similarly by finding the miller indifferent between buying no foreign wheat and wheat U. The above model is appealing in many respects. The demand equations show how the qualities of the domestic and foreign wheat, as well as the end-product quality, interact to determine the quantity demanded. Moreover, a demand system for a vertically differentiated intermediate good is generated for each market.

### Supply Side

On the supply side, it is important to model the specific objective function of the CWB and U.S. firms because their wheat marketing systems differ. Prior research on the competitiveness of U.S. wheat exports does not provide strong evidence of the exercise of market power in bread wheat exports.<sup>12</sup> For that reason

and simplicity, profit-maximizing firms in the United States are assumed to engage in price competition. Moreover, each U.S. firm sells a product that is nondifferentiated from other U.S. firms as a result of their inability to fully internalize the benefits from higher wheat quality (Larue and Lapan). Therefore, as long as there is more than one firm selling wheat of quality  $k_U$ , the price at which wheat U is exported to both markets is the price  $p_U$  corresponding to the intersection of the total demand for wheat U with the residual supply. In other words,  $D_U^a(p_C^a, p_U) + D_U^b(p_C^b, p_U) = Q_U(p_U)$ , where  $D_U^m(\cdot)$  and  $Q_U(p_U)$  are the demand of market  $m$  and the residual supply of wheat U, respectively. Solving for  $p_U$  we obtain

$$(3) \quad p_U = p_U(p_C^a, p_C^b).$$

Wheat C is exported by the CWB—an STE. Because the STE sells a product that is differentiated from that of its competitors, it can charge prices that are different from competitors' prices and has the ability to price discriminate between the two markets. We seek a Nash equilibrium in prices where the marketing board is also assumed to engage in price competition with U.S. sellers. Following the recent literature on marketing boards and STEs (Thursby and Thursby; Alston, Gray, and Sumner; Alston et al.; Schmitz et al.), the CWB is modeled as maximizing producers' surplus by choosing f.o.b. prices to each market subject to the constraint that the amount shipped cannot exceed the harvested quantity ( $Q_C$ ) of wheat:

$$\max_{p_C^a, p_C^b} \text{PS} = (p_C^a - C_C^a) D_C^a(p_C^{a\$} e^a, p_U^{a\$} e^a; \delta^a) \\ + (p_C^b - C_C^b) D_C^b(p_C^{b\$} e^b, p_U^{b\$} e^b; \delta^b) \\ + \lambda(Q_C - D_C^a(p_C^{a\$} e^a, p_U^{a\$} e^a; \delta^a) \\ - D_C^b(p_C^{b\$} e^b, p_U^{b\$} e^b; \delta^b)).$$

The cost of marketing wheat to market  $m$  is denoted as  $C_C^m$  and corresponds to  $C_C^m = c + c_C^m$ , where  $c$  is the cost that is not specific to a market (e.g., the costs of elevation, storage, etc.), and  $c_C^m$  is the cost that varies by destination (i.e., the costs of wheat transportation to export position in Canada);  $D_C^m(\cdot)$  is as described in equation (2),  $\delta^m$  is a vector of

Canadian wheat is of interest in the study of the ability of the CWB to price discriminate. Thus, this generalization of the model plays no role in the subsequent empirical analysis.

<sup>11</sup> It is assumed that  $k_{CU}^m < K_m$  so that a positive quantity of high-quality wheat is imported in each market.

<sup>12</sup> For the period 1962/63–1983/84, Thursby finds evidence that is “at least suggestive of market power in wheat” (p. 98). Patterson and Abbott's results indicate that market power has only a small impact on the price-cost markups. Similarly, Arnade and Pick find some evidence of market power, but conclude that U.S. firms behave in a competitive manner given the low magnitude of the market power coefficients. Thus, prior research suggests that market

power is not an economically important factor in explaining U.S. pricing behavior in wheat exports.

other exogenous variables for market  $m$  (i.e.,  $Y^m$ ,  $K_m$ ,  $k_C$ ,  $k_U$ ,  $k_d^m$ ,  $g^m(\mathbf{w})$ ), and  $\lambda$  is the Lagrange multiplier.<sup>13</sup> It is assumed that wheat is produced once a year and there is no year-to-year storage.

Note that the CWB sells on an f.o.b. basis whereas importers' demand is a function of the landed price. The variables causing a price wedge between the landed price and the f.o.b. price are key elements of the test of price discrimination developed next. Using logic similar to the PTM model, these variables identify relationships that are present only in imperfect competition. I argue that exchange rates can be used as a tool to price discriminate because they create a wedge between the exporter's price and the price paid by the importer. Thus, other variables, such as transportation costs and government policy instruments (taxes, import quotas, import duties, export subsidies, etc.), also create a wedge between the two prices and can be used for price discrimination. I call these variables "instruments" of price discrimination.<sup>14</sup>

The first-order conditions of the CWB problem, together with equation (3), can be used to solve for the equilibrium price in each market (Lavoie). The equilibrium price of high-quality wheat in market  $m$  is a nonlinear expression of four terms, that is,

$$(4) \quad p_C^{m*} = f\left(C_C^m + \lambda^*, \left(\frac{k_C - k_U}{k_U}\right) \times \left(T^m + \frac{D^m}{e^m}\right), \frac{k_C}{k_U} \times (p_U^* - EEP^m), \left(\frac{k_C - k_U}{k_U}\right) \times \left(\frac{K_m g^m(\mathbf{w})}{e^m}\right)\right).$$

For estimation purposes, equation (4) is specified in a linear form, and the difference in price between two destinations,  $p_C^a - p_C^b$ , is taken. Expressing the difference in price has the advantages of eliminating variables common to

the two price equations (Borenstein 1989, and Arnade and Pick), which is especially convenient for empirical purposes. The resulting expression is

$$(5) \quad p_C^{a*} - p_C^{b*} = \theta_1 + \theta_2(c_C^a - c_C^b) + \theta_3\left(\frac{k_C - k_U}{k_U}\right)(T^a - T^b) + \theta_4\left(\frac{k_C - k_U}{k_U}\right)\left(\frac{D^a}{e^a} - \frac{D^b}{e^b}\right) - \theta_5\frac{k_C}{k_U}(EEP^a - EEP^b) + \theta_6\left(\frac{k_C - k_U}{k_U}\right) \times \left(\frac{K_a g^a(\mathbf{w})}{e^a} - \frac{K_b g^b(\mathbf{w})}{e^b}\right)$$

where the  $\theta_i$  are coefficients.

The outcome of the conceptual model is of interest because it shows that if the CWB has market power, can price discriminate, and markets a high-quality product, relative movements in ocean freight rates ( $T^m$ ), duties ( $D^m$ ), EEP subsidies ( $EEP^m$ ), exchange rates ( $e^m$ ), marginal processing costs ( $g^m(\mathbf{w})$ ), and quality standard ( $K_m$ ), explain changes in the relative prices. However, if the state-trader does not have market power, with or without a differentiated product, the only factor that affects the difference in f.o.b. price is a difference in the cost of marketing wheat to these two destinations ( $c_C^a - c_C^b$ ). In perfect competition, the f.o.b. price to two markets should differ only by the difference in marginal cost of serving the two markets.

When the state-trader has market power, an increase in the difference in freight rates, import duties, or processing costs between two markets causes an increase in the f.o.b. price difference between them.<sup>15</sup> Similarly, an increase in EEP bonus in market b results in an increase in the price difference between markets a and b. This confirms the general perception that the CWB had to decrease prices in EEP markets to make sales. To understand

<sup>13</sup> Because the marginal cost of marketing wheat is constant in this formulation, producer surplus maximization corresponds to net revenue maximization.

<sup>14</sup> These instruments are consistent with the factors the CWB takes into account in setting prices: "the price of competitive wheats offered by other exporting countries, changes in import levies and export subsidies used by other grain-trading countries, total exportable supplies of grain available in Canada, variations in ocean freight rates and fluctuations in foreign exchange rates" (CWB, 1993, pp. 465-66).

<sup>15</sup> The last term of equation (5) can be interpreted as a measure of difference in processing cost between two countries, where higher end-product quality raises processing costs. This term contains elements impacting the cost savings in processing high-quality wheat relative to low-quality wheat. Recall that  $g^m(\mathbf{w})/e^m$  is the marginal processing cost of wheat in market  $m$  expressed in U.S. dollars. Using the high-quality wheat reduces processing costs and this effect is more important the greater are marginal processing costs,  $g^m(\mathbf{w})$ .



the effect of those variables on the price difference, note that wheat C is purchased if it is cheaper than wheat U or if:

$$\frac{(p_C^m + T^m)e^m + D^m + g^m(\mathbf{w})k^m}{(p_U + T^m)e^m - EEP^m + g^m(\mathbf{w})k^m} < \frac{k_C}{k_U}.$$

The left-hand side represents the cost ratio of milling with wheat C versus U. An increase in ocean freight rate, import duty, processing cost, or a decrease in the EEP bonus will cause this ratio to decrease, making wheat C cheaper relative to wheat U. When wheat C becomes cheaper relative to wheat U, more millers in the affected market prefer wheat C, thus raising the demand for wheat C in that market. This result is akin to the theorem developed by Alchian and Allen.<sup>16</sup>

The importance of the Alchian–Allen effect is determined by the factor  $(k_C - k_U)/k_U$  (or  $k_C/k_U$  for the EEP bonus), that is, by the extent of product differentiation. Transportation costs, processing costs, duties, and EEP bonus are levied per unit of volume. As these per-unit charges increase, it enhances the desirability of importing the high-quality wheat because less is needed to produce a given finished product. Thus, the greater the quality difference between Canadian and U.S. wheat, the more the CWB can price discriminate.

When  $k_C = k_U$ , equation (5) reduces to  $p_C^{a*} - p_C^{b*} = \theta_2(c_C^a - c_C^b) - \theta_5(EEP^a - EEP^b)$ . In other words, when Canadian and U.S. wheat are identical and the CWB has market power, Canadian price differences adjust to EEP bonus differences. A price discriminating CWB can react strategically to a trade policy established by another country, such as the U.S. EEP subsidy, by allocating wheat to EEP- and non-EEP markets to maximize producer surplus. Thus, both wheat quality differences and U.S. trade policy may allow the CWB to price discriminate.

In summary, equation (5) makes two points regarding price discrimination in quality-differentiated wheat exports. First, product differentiation enables a STE with market power to take advantage of a number of price discrimination instruments through an Alchian–Allen effect. Second, U.S. policy instruments, such as the EEP bonus, provide another basis for price discrimination. Equation (5) is

appealing because it isolates the bases for price discrimination and demonstrates that the ability of the CWB to exploit cost differences in pricing depends on the extent of the differentiation between Canadian and U.S. wheat.

## Empirical Model

An empirical test of price discrimination based on equation (5) involves estimating the difference in the f.o.b. price of Canadian wheat to two markets as a function of difference in the values of the instruments of price discrimination, quality differences between Canadian and U.S. wheat, and difference in EEP bonus. Statistical significance of the price discrimination instruments indicates that the CWB has market power and price discriminates in wheat exports.

For estimation purposes, equation (5) must be extended to incorporate important elements of wheat production and trade that were omitted from the conceptual model. CWRS wheat can be purchased on the basis of grade and fixed protein content increments. Wheat of a lower grade (higher grade number) and higher protein content is sold at a higher price *ceteris paribus*. Thus, the variables GRADEa, GRADEb, PROTa, and PROTb are added to account for grade and protein differences of Canadian wheat shipped to market a versus b.<sup>17</sup> Those variables enter separately (as opposed to as a difference) in the model because importing countries may place different values on a grade or protein increase. The squared value of protein content (SQPROT $m$ ,  $m = a, b$ ) is also included to account for nonlinearities in the protein price schedule.

To estimate equation (5), empirical measures of the conceptual variables must also be chosen. A variable is needed to represent the quality of Canadian and U.S. wheat, that is,  $k_C$  and  $k_U$ . Canadian and U.S. wheat can be differentiated on the basis of multiple characteristics. Because protein quality was listed as an important quality differences between Canadian and U.S. wheat in the importers' surveys and one of the most important factors in bread making, it was chosen as quality index. More

<sup>16</sup> The Alchian–Allen theorem states that adding the same per unit charge, such as transportation cost, to the price of two substitute goods will decrease the relative price of the higher priced (higher quality) good, thus increasing its relative consumption.

<sup>17</sup> Canadian wheat sales contract specify the grade and protein level. Other intrinsic quality attributes such as ash and color, which were shown by Stiegert and Blanc to affect wheat prices are not included. While these attributes affect the level of wheat prices in any given year, prices do not vary across destination markets according to those factors.

specifically, loaf volume is used as a measure of protein quality.<sup>18</sup>

In the empirical model,  $LOAF_m = (LOAF_C^m - LOAF_U^m) / LOAF_U^m$  represents the relative difference in loaf volume of wheat shipped by Canada and the United States to market  $m$  ( $m = a, b$ ), where  $LOAF_C^m$  is the loaf volume of CWRs wheat and  $LOAF_U^m$  is the loaf volume of HRS wheat shipped to market  $m$ . In equation (5), the relative difference in quality is assumed to be the same for different destination markets. However, loaf volume varies with wheat grade and protein content, and these attributes may be different for Canadian and U.S. wheat exported to any given market and month. Thus, in the empirical specification,  $LOAF_m$  is interacted with price discrimination variables by market. Taking transportation cost as an example,  $((k_C - k_U) / k_U)(T^a - T^b)$  in equation (5) becomes  $(LOAF_a \cdot T^a - LOAF_b \cdot T^b)$  in the empirical specification.

The data for  $LOAF_C^m$  are reported in the Canadian Grain Commission's (CGC) *Quality of Western Canadian Wheat*. It consists of the yearly average loaf volume of CWRs wheat at harvest by grade and protein content for western and eastern Canada prairie composites. Yearly average of U.S. loaf volume for HRS wheat are collected at harvest and for export cargoes, and published in the U.S. Wheat Associates (USWA), *Crop Quality Report*. Unlike the Canadian data, U.S. harvest data are not gathered for each grade and protein content combinations. Because loaf volume varies with protein content, USWA data were supplemented with protein content of HRS wheat shipments from grain inspection data obtained from the USDA Grain Inspection and Packers Stockyard Administration (GIPSA) to generate a comparable data set as used for  $LOAF_C^m$ . See Lavoie for more details on the computation of  $LOAF_U^m$ .

The conceptual model includes CWB's marketing costs that vary by destination markets such as storage, elevation, and inland transportation costs. These handling costs are available from a Canadian mid-prairie point (Sintaluta, SK) to the port of embarkment for each market. DCOST represents the difference in handling cost to two markets. Manufacturing wage in each market measures

processing costs.<sup>19</sup> DWAGE designates the difference in wage rate between two destination markets. Transportation cost between the Canadian export port and the import market port is represented by ocean freight rates. DOCEAN denotes the difference in ocean freight rates to two markets. DDUTY represents the difference in import duties between destination markets and takes a value of 0 for all markets except the United Kingdom. The data for the EEP subsidy consist of the monthly average EEP bonus for HRS wheat. The variable takes a value of 0 for Japan and the United Kingdom, which never received the subsidy. DEEP denotes the difference in this subsidy to two markets. To follow the PTM model, where exchange rates are instruments of price discrimination, an exchange rate index is added as a separate variable (DXRATE). See table 1 for further details on the above variables, their units of measurements, and their source. Descriptive statistics are presented in table 2.

#### *Description of the Price Data*

The CWB provided a confidential data set consisting of monthly average price and total quantity of CWRs wheat of grade 1 and 2 sold, as recorded in CWB contracts from November 1982 to July 1994. Those two grades are primarily used for milling and bread making. The data were obtained for four markets: Japan, the United Kingdom, and two aggregate markets consisting of sales to all other countries. Rest-of-the-World west coast (ROW-WC) comprises all sales shipped via the west coast of Canada, except to Japan. Rest-of-the-World east coast (ROW-EC) comprises all sales shipped via the east coast of Canada, except to the United Kingdom.

The data are disaggregated by protein content. Wheat is sold at 0.5% increments from 11.5% to 14.5% protein. Monthly sales are recorded according to the sales contract date for a total of 1,405 observations. All prices are expressed on an f.o.b. basis at the port of export in U.S. dollars/metric ton. An observation consists, for example, of the January 1985 sales

<sup>18</sup> Loaf volume is the volume of a loaf of bread baked from wheat samples taken as wheat is loaded into cargoes. Similar results were obtained with other protein quality measures (wet gluten content and farinograph absorption).

<sup>19</sup> This variable performed better than a variable constructed as an interaction of a proxy for the importing countries' quality standard ( $K_m$ ) with manufacturing wages. Following Arnade and Pick, the proxy used for  $K_m$  was real GDP per capita. This variable may be a poor proxy for the quality consciousness of millers and consumers, which would explain its poor performance. Manufacturing wage consists of an average of all industries' "manufacturing earnings" by country. Other elements of processing cost (e.g., energy prices) could not be included due to unavailable data.

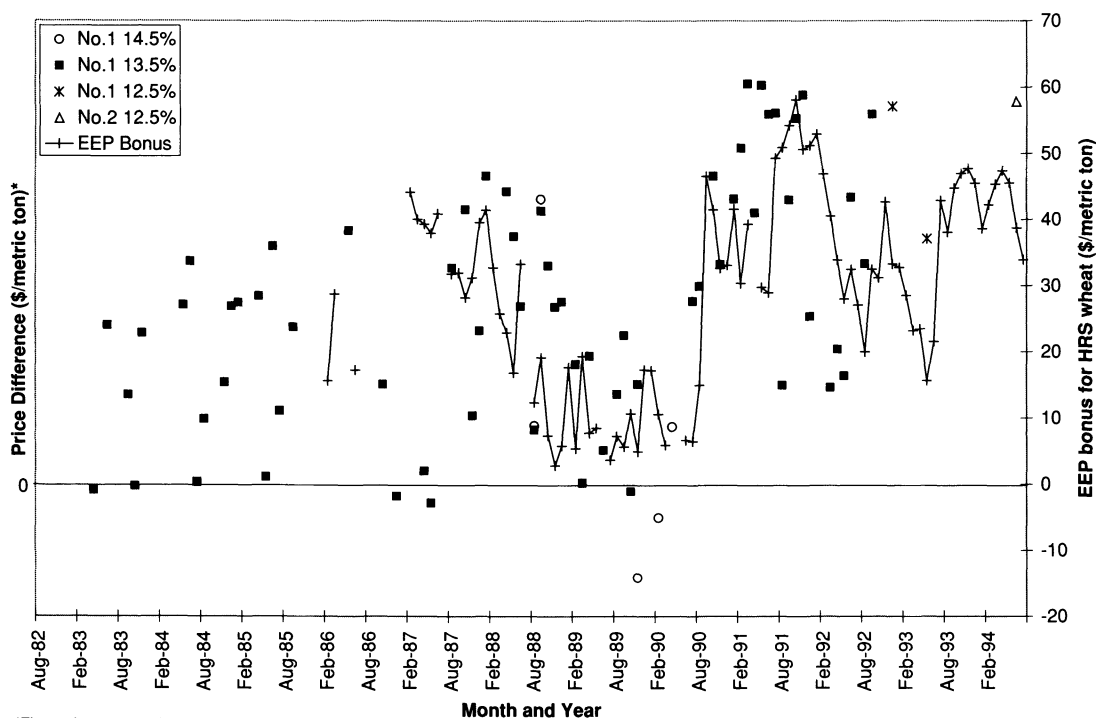
**Table 1. Description of the Variables Used in the Estimation**

Variable	Calculation <sup>a</sup>	Units	Definition and Source
DPRICE	$p_C^a - p_C^b$	Real 1990 U.S. \$/metric ton	$p_C^m$ is the price of Canadian wheat sold to market $m = a, b$ (CWB)
DCOST	$c_C^a - c_C^b$	Real 1990 U.S. \$/metric ton	$c_C^m$ is the handling cost of bringing wheat from a Canadian mid-prairie point (Sintaluta, SK) to the port of embarkment of wheat for market $m = a, b$ (CGC, <i>Canadian Grain Exports</i> )
GRADE $m$		No units, grade = 1, 2 <sup>a</sup>	Grade of Canadian wheat sold to market $m = a, b$ (CWB)
PROT $m$		Percentage of protein	Protein content of Canadian wheat sold to market $m = a, b$ (CWB) <sup>b</sup>
SOPROT $m$		Percentage of protein squared	(PROT $m$ ) <sup>2</sup> , ( $m = a, b$ )
DWAGE	$\frac{WAGEa}{e^a} - \frac{WAGEb}{e^b}$	Thousands of real 1990 U.S. \$/month	WAGE $m$ is the real manufacturing earnings in $m = a, b$ (United Nations, <i>Statistical Yearbook</i> ). $e^m$ is the exchange rate of market $m$ in domestic currency per U.S. dollar (United Nations, <i>Statistical Yearbook</i> )
DWAGEL	$LOAFa \cdot \frac{WAGEa}{e^a} - LOAFb \cdot \frac{WAGEb}{e^b}$	Thousands of real 1990 U.S. \$/month	
LOAF $m$	$\frac{(LOAF_C^m - LOAF_U^m)}{LOAF_U^m}$	No units	LOAF $m$ is the loaf volume (in cm <sup>3</sup> ) of the grade and protein content of CWRS wheat shipped to market $m = a, b$ (CGC, <i>Quality of Western Canadian Wheat</i> ). LOAF $m_U$ is the loaf volume of the subclass, grade, and protein content of HRS wheat shipped to market $m$ (USWA, <i>Crop Quality Report</i> , and GIPSA) $T^m$ is the ocean freight rates to market $m = a, b$ (International Wheat Council, <i>World Grain Statistics</i> )
DOCEAN	$T^a - T^b$	Real 1990 U.S. \$/metric ton	
DOCEANL	$LOAFa \cdot T^a - LOAFb \cdot T^b$	Real 1990 U.S. \$/metric ton	$D^m$ is the EU import duty (Home-Grown Cereals Authority, <i>Cereal Statistics</i> )
DDUTY	$\frac{D^a}{e^a} - \frac{D^b}{e^b}$	Real 1990 U.S. \$/metric ton	
DDUTYL	$LOAFa \cdot \frac{D^a}{e^a} - LOAFb \cdot \frac{D^b}{e^b}$	Real 1990 U.S. \$/metric ton	
DEEP	$EEP^a - EEP^b$	Real 1990 U.S. \$/metric ton	EEP $m$ is the monthly average U.S. Export Enhancement Program bonus for HRS wheat in market $m = a, b$ (CWB)
DEEPL	$LFa \cdot EEP^a - LFb \cdot EEP^b$	Real 1990 U.S. \$/metric ton	$LFa = \frac{LOAF_C^a}{LOAF_U^a}$ , $LFb = \frac{LOAF_C^b}{LOAF_U^b}$
DXRATE	$XRATE^a - XRATE^b$	No units	XRATE $m$ is an index of exchange rate in market $m = a, b$ . Real 1990 domestic currency to U.S. dollar exchange rate measured in index form (January 1990 = 1)

<sup>a</sup> A, negative (positive) sign on GRADE $a$  (GRADE $b$ ) reflects the effect on the price difference of a grade decrease from grade 1 to grade 2.  
<sup>b</sup> PROT $m = 11.5, 12.0, 12.5, 13.0, 13.5, 14.0, 14.5$ .

**Table 2. Descriptive Statistics**

Variable	Japan-United Kingdom		Japan-ROW-EC		Japan-ROW-WC		United Kingdom-ROW-EC		United Kingdom-ROW-WC		ROW-EC-ROW-WC	
	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
DCOST	-22.23	1.53	-22.03	1.47	0.00	0.00	0.00	0.00	22.09	1.45	21.89	1.35
GRADEa	1.01	0.09	1.01	0.10	1.02	0.14	1.02	0.13	1.01	0.10	1.56	0.50
GRADEb	1.01	0.11	1.57	0.50	1.64	0.48	1.57	0.49	1.62	0.49	1.63	0.48
PROTa	13.56	0.46	13.50	0.49	13.48	0.51	13.99	0.51	13.98	0.52	13.27	0.87
PROTb	13.96	0.52	13.28	0.84	13.05	0.89	13.32	0.80	13.12	0.87	13.06	0.91
SOPROTa	184.04	12.60	182.59	13.38	181.84	13.85	196.07	14.24	195.79	14.47	176.95	22.72
SOPROTb	195.28	14.48	177.11	21.97	170.99	23.12	178.06	21.13	172.81	22.69	171.46	23.69
DWAGE	1.04	0.37	1.98	0.47	2.37	0.49	0.87	0.22	1.19	0.21	0.29	0.14
WAGEa	2.26	0.56	2.39	0.54	2.47	0.52	1.25	0.24	1.29	0.24	0.39	0.11
WAGEb	1.23	0.23	0.41	0.11	0.10	0.10	0.39	0.10	0.09	0.09	0.10	0.09
DWAGEL	0.03	0.15	0.04	0.17	0.03	0.21	0.02	0.10	0.02	0.11	$-3.13 \times 10^{-3}$	0.04
DOCEAN	14.68	2.31	7.53	2.50	1.28	3.83	-7.09	2.73	-13.96	3.00	-5.84	4.21
T <sup>a</sup>	24.79	2.97	25.25	2.82	25.46	2.74	10.18	2.23	10.38	2.34	18.34	3.32
T <sup>b</sup>	10.10	2.27	17.72	3.55	24.18	2.31	17.27	3.59	24.34	2.37	24.18	2.22
DOCEANL	0.48	1.63	0.65	1.70	1.06	2.22	0.25	1.52	0.68	2.21	0.47	2.49
DDUTY	-159.01	61.71	0.00	0.00	0.00	0.00	162.06	62.26	165.03	59.03	0.00	0.00
D <sup>a</sup>	0.00	0.00	0.00	0.00	0.00	0.00	162.06	62.26	165.03	59.03	0.00	0.00
D <sup>b</sup>	159.01	61.71	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
DDUTYL	-5.30	16.65	0.00	0.00	0.00	0.00	3.08	16.78	1.77	16.64	0.00	0.00
DEEP	0.00	0.00	-19.69	18.26	-20.47	17.52	-18.35	18.87	-18.85	18.19	0.00	0.00
EET <sup>b</sup>	0.00	0.00	19.69	18.26	20.47	17.52	18.35	18.87	18.85	18.19	22.35	18.19
DEEPL	0.00	0.00	-18.98	17.42	-19.51	16.64	-17.89	18.26	-18.04	17.36	0.26	3.38
DXRATE	$-5.95 \times 10^{-3}$	0.15	-471.14	852.69	-0.36	1.08	-431.49	809.93	-0.14	0.77	722.25	955.76
LOAFa	0.03	0.07	0.02	0.08	0.02	0.08	0.03	0.09	0.02	0.09	-0.02	0.10
LOAFb	0.04	0.09	-0.01	0.10	-0.03	0.10	0.00	0.10	-0.02	0.10	-0.04	0.10
LFb	1.04	0.09	0.99	0.10	0.97	0.10	1.00	0.10	0.98	0.10	0.96	0.10



\*The scale is removed to preserve data confidentiality

**Figure 1. Price difference between Japan and ROW-WC for CWRS wheat (f.o.b. west coast) in relation to the EEP subsidy for HRS wheat**

price and quantity for No. 1 CWRS wheat with 12.5% protein for exports to Japan.<sup>20</sup>

Figure 1 plots the prices to Japan minus the prices to ROW-WC for CWRS wheat of the same grade and protein level sold during the same month. Most points are positive indicating that the prices to Japan are higher than prices to ROW-WC.<sup>21</sup> The pattern of price differences between Japan and ROW-WC is related to the size of the monthly average U.S. EEP bonus for HRS wheat (expressed in dollar value on the right vertical axis of this graph). The export subsidy was offered to some countries in ROW-WC, but not to Japan. In months

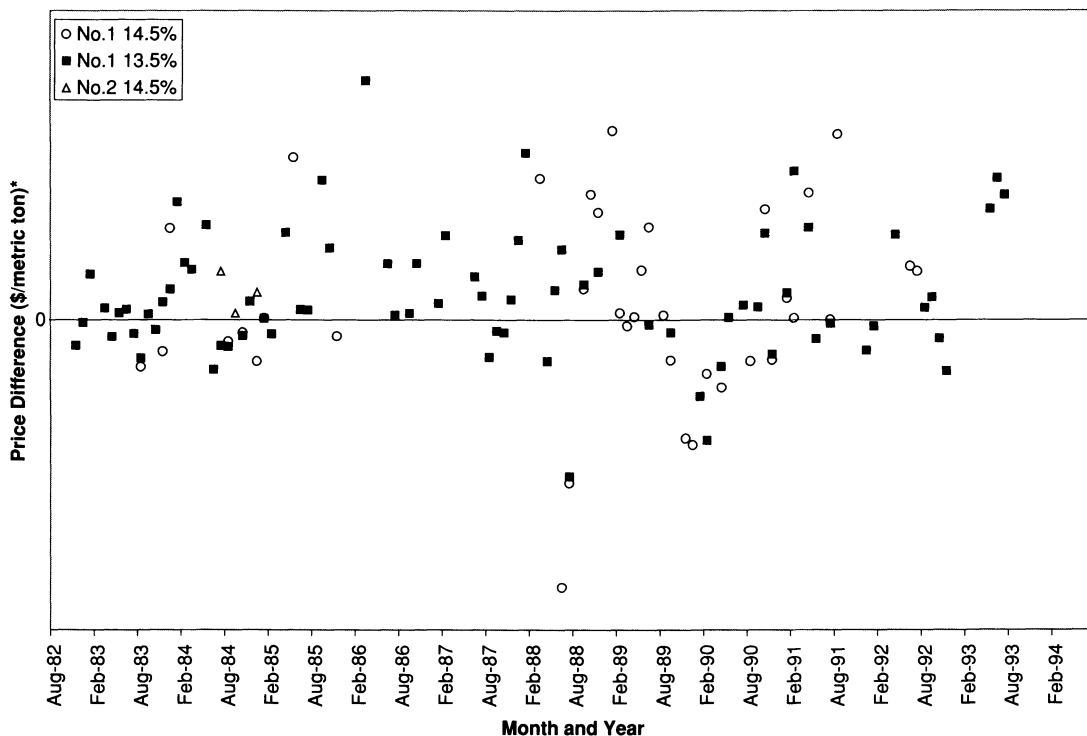
where the EEP subsidy is large, as in 1988 and 1991, the price difference between Japan and ROW-WC is also large, indicating a large degree of price differentiation. However, when the EEP bonuses are small, as in 1989, there is less price differentiation.

Figure 2 shows the price differences for CWB sales to the United Kingdom relative to sales to ROW-EC. While some markets in ROW-EC have also received the EEP subsidy, the price differences between the United Kingdom and ROW-EC are smaller than those between Japan and ROW-WC. Some data points show that ROW-EC prices are higher than U.K. prices.

Figures 1 and 2 demonstrate the ability of the CWB to charge different prices for the same wheat quality. Yet, it is also clear that these differences are by no means constant, may not be representative of the complete data set, and are not evidence that those prices maximize producer surplus. However, they do provide evidence that markets are segmented—a necessary condition for price discrimination. The empirical model will provide further insights regarding the ability of the CWB to price discriminate in a manner consistent with producer surplus maximization.

<sup>20</sup> The observation obtained from the CWB consists of an average when there are more than one sale of a given grade and protein content to one market in a given month.

<sup>21</sup> Note that Japan imports wheat through an STE—the Japanese Food Agency (JFA). The argument that Japan maintains stable market shares for political reasons has been debated in the literature (Alston, Carter, and Jarvis; Chen and Brooks; Koo, Mao, and Sakurai). In the context of this study, stable market shares imply a very inelastic Japanese demand schedule and may be one reason why the CWB can price discriminate and charge a high price in that market. Other researchers (Love and Murniningtyas) have found that Japan, through its STE, exercises monopsony power in wheat imports. These aspects of wheat trade with Japan do not affect the ability of the CWB to price discriminate in the context of this study (i.e., to exploit movements in the price discrimination variables) because the market institution, namely the JFA, is present throughout the period of analysis.



\* The scale is removed to preserve data confidentiality.

**Figure 2. Price difference between the United Kingdom and ROW-EC for CWRS wheat (f.o.b. east coast)**

## Results

The equation estimated as a test for the ability of the CWB to price discriminate is

### (6) DPRICE

$$\begin{aligned}
 = & \beta_0 + \beta_1 \text{DCOST} + \beta_2 \text{GRADEa} \\
 & + \beta_3 \text{GRADEb} + \beta_4 \text{PROTa} \\
 & + \beta_5 \text{PROTb} + \beta_6 \text{SQPROTa} \\
 & + \beta_7 \text{SQPROTb} + \beta_8 \text{DWAGE} \\
 & + \beta_9 \text{DWAGEL} + \beta_{10} \text{DOCEAN} \\
 & + \beta_{11} \text{DOCEANL} + \beta_{12} \text{DDUTY} \\
 & + \beta_{13} \text{DDUTYL} + \beta_{14} \text{DEEP} \\
 & + \beta_{15} \text{DEEPL} + \beta_{16} \text{DXRATE} \\
 & + \beta_{17} \text{LOAFa} + \beta_{18} \text{LOAFb} + \varepsilon
 \end{aligned}$$

where  $\varepsilon$  is the error term. Variable names starting with “D” indicate the difference in the value of the variable between two markets. Names ending with “L” indicate variables interacted with the relative loaf volume difference between Canadian and U.S. wheat exports, as prescribed by the conceptual model

in (5) and detailed in table 1. Note that the difference in loaf volume between Canadian and U.S. wheat enters the equation both additively (i.e., LOAFa and LOAFb) and multiplicatively with the price discrimination instruments. This equation is a combination of two model specifications: (1) a specification where the relative difference in loaf volume between Canadian and U.S. wheat to two destinations was introduced multiplicatively, as specified in the conceptual model and (2) a specification where the relative difference in loaf volume was introduced additively. Two nonnested tests, the *F*-test and the *J*-test, were performed to determine the preferred specification. Results of both tests suggested that there is explanatory power to be gained by combining the two models. In other words, a hybrid model (equation (6)) with loaf volume entering the model multiplicatively and additively was preferred.

Ordinary least squares regressions were run for each of six possible market pairs: Japan–United Kingdom, Japan–ROW-EC, Japan–ROW-WC, United Kingdom–ROW-EC, United Kingdom–ROW-WC, and ROW-EC–ROW-WC. The dependent variable is the f.o.b. price difference of CWRS wheat sold

during the same month to the two markets. In any given month, there may be more than one type (grade and protein content) of wheat sold to any given market. Thus, there may be more than one observation per month. For example, there are six observations for the Japan–United Kingdom market pair if three types of CWRS wheat are sold to Japan (e.g., grade no. 1 with 13.5% and 14.5% protein, and no. 2 with 13.5% protein) and two wheat types to the United Kingdom (e.g., No. 1 13.5% and 14.5% protein) during the month of interest. Monthly observations for a given market pair are stacked to obtain a time series for the estimation.

For variables interacted with the relative loaf volume difference between Canadian and U.S. wheat exports, the variable's coefficient represents the effect of a unit increase in the difference of the quality-adjusted variable on the price difference between the two markets. For example, suppose the price difference between Japan and ROW-EC is examined. The coefficient for DOCEANL represents the effect of an increase of \$1/metric ton in the quality-adjusted freight rate difference between Japan and ROW-EC on the price difference between these two markets.

Table 3 presents the estimation results. The variables can be divided and examined in three categories: those that explain the price difference in perfect competition only (DCOST, GRADEa, GRADEb, PROTa, PROTb, SQPROTa, and SQPROTb), those that create an Alchian–Allen effect (DWAGE, DWAGEL, DOCEAN, DOCEANL, DDUTY, DDUTYL, DEEP, and DEEPL), and other variables added in the empirical model (DXRATE, LOAFa, and LOAFb). The fit of the models, as expressed by the adjusted  $R^2$ , varies between 0.40 and 0.50.

The variables that would be present in the model under perfect competition behave as expected. The coefficient for GRADEm ( $m = a, b$ ) represents the effect of decreasing the grade from grade 1 to grade 2 to market a on the price difference of wheat sold to two markets. The coefficients on GRADEa and GRADEb are not expected to be equal because different countries may value a grade decrease differently. Except for the sign on DCOST for ROW-EC–ROW-WC, the coefficients have the anticipated sign and are significant at the 10% level. The sign on the coefficients of SQPROTa is consistent with a concave protein schedule for the

Japan–U.K., Japan–ROW-WC, and ROW-EC–ROW-WC market pairs. The signs on SQPROTb indicate a concave protein schedule, except for the Japan–U.K. market pair.

Given the interaction of most other variables with loaf volume and the nonlinearity of the protein variable, marginal effects (expressed in U.S. dollars) on the price difference are computed at the mean value of the variable using the coefficients in table 3. The results and expected signs are reported in table 4 for the variable associated with one of the markets in the price difference. The  $t$ -statistics are calculated from each regression's variance–covariance matrix at the mean of the variables, which are assumed to be nonstochastic.

The results in table 4 indicate that on average Japan, United Kingdom, ROW-EC, and ROW-WC are willing to pay \$7.39, \$5.59, \$6.59, and \$9.07, respectively, for a 1% increase in protein level.<sup>22</sup> The coefficients are significant at the 10% level for most market pairs. The United Kingdom, which imports the highest level of protein, has the lowest willingness to pay for a 1% increase. Recall that there are optimal protein levels for baking and exceeding those levels can be detrimental.

The variables having an Alchian–Allen effect in general performed well. Variables that are significant and have the expected sign indicate that the CWB utilizes their fluctuations to price discriminate. An increase in the ocean freight rate to market a ( $T^a$ ) has the expected effect, to increase the price difference for four market pairs (Japan–United Kingdom, Japan–ROW-EC, Japan–ROW-WC, and United Kingdom–ROW-EC). This effect is statistically significant for two of those market pairs (Japan–United Kingdom, Japan–ROW-EC). The coefficient indicates that a \$1/metric ton increase in the ocean freight rate to Japan resulted on average during the period of study in a \$1.46/metric ton increase in the price difference between Japan and the United Kingdom, everything else held constant. The wage (WAGEa) variable performs well for Japan–United Kingdom and Japan–ROW-EC, but does not have the anticipated sign for the other market pairs. This variable represents the overall country's manufacturing wage and may be an imprecise measure of changes in

<sup>22</sup> It is expected that the impact of a protein increase to one market has the same impact on all price differences involving that market. Thus, the average impact of a protein increase to Japan is calculated as the average of the coefficients for PROTa in the three market pairs involving Japan.

**Table 3. Estimation Results for the Hybrid Model**

	Japan— United Kingdom	Japan— ROW-EC	Japan— ROW-WC	United Kingdom— ROW-EC	United Kingdom— ROW-WC	ROW-EC— ROW-WC
INTERCEPT	-1,339.89 (-1.03)	1,341.78* (3.50)	-1,114.92* (-2.16)	3,801.89* (3.60)	561.89 (0.40)	81.64 (0.73)
DCOST	3.99* (5.17)	0.62 (1.00)			1.84* (2.12)	-0.36 (-1.04)
GRADEa	-21.09* (-2.84)	-30.15* (-4.75)	-10.86* (-2.08)	-12.37* (-2.72)	-13.12* (-1.92)	-14.33* (-18.83)
GRADEb	9.07 (1.58)	15.18* (12.50)	6.17* (4.20)	16.12* (14.42)	7.98* (6.01)	6.72* (8.48)
PROTa	183.56* (2.54)	-135.84* (-2.54)	226.56* (3.07)	-515.94* (-3.39)	-28.46 (-0.14)	13.88 (1.09)
PROTb	20.93 (0.12)	-54.90* (-2.50)	-54.12* (-2.50)	-25.84 (-1.24)	-57.15* (-2.70)	-24.68* (-2.16)
SQPROTa	-6.38* (-2.43)	5.12* (2.59)	-8.06* (-2.99)	18.54* (-3.40)	1.24 (0.17)	-0.19 (-0.38)
SQPROTb	-1.02 (-0.16)	1.78* (2.13)	1.68* (2.02)	0.85 (1.08)	1.86* (2.31)	0.62 (1.43)
DWAGE	30.15* (4.56)	10.35* (4.16)	-7.81* (-2.25)	-26.67* (-3.48)	-19.88* (-3.17)	1.37 (0.30)
DWAGEL	34.31 (1.04)	109.42* (4.16)	138.04* (4.64)	121.51* (2.90)	-222.82* (-4.40)	200.61* (6.43)
DOCEAN	1.35* (3.26)	1.46* (4.18)	0.18 (0.60)	0.56 (1.43)	-0.79* (-2.81)	-0.48* (-3.92)
DOCEANL	3.60 (0.97)	-8.71* (-3.71)	-7.85* (-2.14)	-10.40* (-5.04)	3.31 (1.18)	-10.44* (-9.87)
DDUTY	0.05* (1.76)			0.04* (2.43)	0.10* (3.76)	
DDUTYL	0.50* (3.71)			-0.11 (-0.74)	0.22 (1.27)	
DEEP		-1.15* (-2.59)	-0.92* (-1.90)	-1.28* (-3.18)	-1.51* (-3.56)	
DEEPL		1.03* (2.25)	0.73 (1.46)	1.15* (2.76)	1.49* (3.33)	
DXRATE	45.05* (4.15)	0.004* (4.03)	-10.25* (-5.22)	-0.01* (-4.04)	-7.22* (-4.47)	0.001 (0.83)
LOAFa	-130.04 (-1.26)	-90.04 (-1.06)	-135.23 (-1.20)	16.67 (0.36)	231.22* (4.18)	98.46* (4.16)
LOAFb	159.13* (3.19)	-84.81* (-2.11)	-190.55* (-1.99)	-171.00* (-4.52)	37.94 (0.51)	-271.39* (-9.73)
Adjusted R <sup>2</sup>	0.45	0.50	0.43	0.41	0.40	0.42
N	240	597	560	824	730	2,128

Note: Numbers in parentheses are *t*-statistics.

\*Indicate variables that are significant at the 10% level.

wheat milling costs. These Alchian–Allen effects appear to be more effective in markets that value quality, such as Japan and the United Kingdom, which are well known for having high standards.

An increase in the import duty in the United Kingdom causes an increase in the price of Canadian wheat through an Alchian–Allen effect as evidenced by the sign on the marginal effects for  $D^a$  and  $D^b$ . The coefficients are statistically significant for all market pairs concerned. The impact of an increase in the duty

on the price difference is small. For example, the marginal effect of a \$1/metric ton increase in the duty is an increase in the price difference between the United Kingdom and ROW-WC by \$0.10/metric ton on average from 1982 to 1994.

The impact of a \$1/metric ton increase in the EEP subsidy to market b is positive as expected and varies between \$0.06/metric ton for the UK–ROW-WC market pair and \$0.21/metric ton for the Japan–ROW-WC market pair. An increase in the subsidy is only partly matched



**Table 4. Effect of an Increase of One Unit in a Variable on the Price Difference for Each Market Pair**

Variable	Calculation	Expected Sign	Japan-United Kingdom	United Kingdom-ROW-EC	Japan-ROW-WC	United Kingdom-ROW-EC	United Kingdom-ROW-WC	ROW-EC-ROW-WC
DCOST	$\beta_1$	+	3.99* (5.17)	0.62 (1.00)			1.84* (2.12)	-0.36 (-1.04)
GRADEa	$\beta_2$	-	-21.09* (-2.84)	-30.15* (-4.75)	-10.86* (-2.08)	-12.37* (-2.72)	-13.12* (-1.92)	-14.33* (-18.83)
GRADEb	$\beta_3$	+	9.07 (1.58)	15.18* (12.50)	6.17* (4.20)	16.12* (14.42)	7.98* (6.01)	6.72* (8.48)
PROTa	$\beta_4 + 2\beta_6$ -PROTMa	+	10.53* (3.00)	2.33 (0.87)	9.30* (2.31)	2.98 (1.53)	6.18* (3.03)	8.95* (8.49)
PROTb	$\beta_5 + 2\beta_7$ -PROTMb	-	-7.60* (-4.22)	-7.70* (-3.94)	-10.41* (-4.31)	-3.13* (-1.69)	-8.40* (-4.16)	-8.40* (-8.81)
WAGEa	$\beta_8 + \beta_{10}$ -LOAFMa	+	31.26* (4.74)	12.41* (5.30)	-5.64 (-1.64)	-23.45* (-2.98)	-24.01* (-3.78)	-2.06 (-0.46)
T <sup>a</sup>	$\beta_{10} + \beta_{11}$ -LOAFMa	+	1.46* (3.53)	1.29* (3.63)	0.06 (0.17)	0.28 (0.75)	-0.73* (-2.49)	-0.30* (-2.52)
D <sup>a</sup>	$\beta_{12} + \beta_{13}$ -LOAFMa	+					0.10* (3.94)	
D <sup>b</sup>	$-\beta_{12} - \beta_{13}$ -LOAFMb	-	-0.07* (-2.59)					
EEP <sup>b</sup>	$-\beta_{14} - \beta_{15}$ -LFMb	+		0.12* (2.39)	0.21* (3.53)	0.13* (2.87)	0.06 (0.99)	
DXRATE	$\beta_{16}$	-	45.05* (4.15)	0.004* (4.03)	-10.25* (-5.22)	-0.01* (-4.04)	-7.22* (-4.47)	0.001 (0.83)
LOAFa	$\beta_9$ -WAGEa + $\beta_{11}$ -Ta + $\beta_{13}$ -Da + $\beta_{17}$	+	36.78 (1.44)	-48.73* (-2.24)	6.12 (0.20)	45.49* (2.62)	15.22 (-49.83* (-2.37)	-13.76 (-1.36)
LOAFb	$-\beta_9$ -WAGEb - $\beta_{11}$ -Tb - $\beta_{13}$ -Db - $\beta_{15}$ -EEPb + $\beta_{18}$	-	1.63 (0.11)	4.80 (0.24)	-29.94 (-1.13)	-59.44* (-3.25)		-39.75* (-3.91)

Note: Numbers in parentheses are *t*-statistics.  
\* Indicate coefficients that are significant at the 10% level.

by the CWB. In fact, those results indicate that the CWB decreased its price less in response to EEP than did the European Community, based on results reported by Haley.

The exchange rate (XRATE) is statistically significant for all market pairs, except ROW-EC-ROW-WC. It has the expected sign for three market pairs (Japan-ROW-WC, United Kingdom-ROW-EC, and United Kingdom-ROW-WC). The sign on the Japan-UK and Japan-ROW-EC market pairs indicate that the CWB adjusts prices upward to amplify the effect of a depreciation of the yen. This effect makes sense in a dynamic context when future market shares depend on current ones and exchange rate changes are expected to be temporary (Froot and Klemperer). The size of the estimates is small for market pairs involving ROW-EC. ROW-EC includes the Former Soviet Union, which endured large fluctuations in exchange rate during the period of interest.

Finally, an increase in the relative loaf volume difference between Canadian and U.S. wheat shipped to market a (LOAFa) causes an increase in the price difference for Japan-United Kingdom, Japan-ROW-WC, United Kingdom-ROW-EC, and United Kingdom-ROW-WC. The coefficient indicates that increasing the loaf volume of Canadian relative to U.S. wheat by one unit (essentially, doubling the Canadian loaf volume) results in an increase in the U.K.-ROW-EC's price difference of \$45.46/metric ton.

An *F*-test was performed to test whether the variables accounting for imperfect competition significantly add predictive power to the model. The null hypothesis for this test is that the coefficients for DWAGE, DWAGEL, DOCEAN, DOCEANL, DDUTY, DDUTYL, DEEP, DEEPL, and DXRATE are jointly equal to 0. According to the *F*-statistics, the model of perfect competition is rejected for all market pairs, indicating that the imperfect competition variables add significant explanatory power to the model. However, not all of these variables add significant explanatory power for all market pairs. This fact makes it difficult to conclude that the CWB price discriminates to maximize the producer surplus from a given harvest.

However, because some of the explanatory variables are imprecisely measured, I conclude that the results largely support the predictions of the conceptual model. Two instruments of price discrimination perform particularly well: the European Union (EU) duty ( $D^a$ ,  $D^b$ ) and the EEP bonus. The statistical signif-

icance and expected sign of their marginal effects across equations indicate that the CWB uses fluctuations in duties and subsidies to price discriminate. Data quality is not as good for manufacturing wages and ocean freight rates. Average manufacturing wages may not measure well millers' processing costs. Ocean freight rates were not available for all countries in the two ROW markets. Thus, the aggregation necessary to obtain a weighted average of freight rates for those markets may not be perfectly accurate, as the data to the nearest available country were used. However, WAGEa and  $T^a$  perform well in terms of sign and statistical significance for the Japan-UK market pair where the above problems are absent and wheat quality is valued.

In addition to data quality issues, the CWB may be pursuing a dynamic pricing strategy and may be reluctant to adjust prices in response to every movement in variables such as ocean freight rates and import duties to avoid alienating customers. Thus, results that apparently do not support the predictions of the model may simply indicate that the CWB's pricing strategy is more complex and dynamic than the prescription for static optimization derived in this study.

## Conclusion

Previous literature on wheat trade has examined separately wheat differentiation and imperfect competition. Moreover, the trade and new empirical industrial organization literatures have focused primarily on horizontally differentiated consumer goods. This study develops conceptual and empirical models to examine whether the CWB, an STE, can price discriminate in exports of high-protein wheat—a vertically differentiated intermediate good. The conceptual model isolates the bases of price discrimination and demonstrates that the CWB's ability to exploit cost differences in pricing depends on the extent of the differentiation between Canadian and U.S. wheat. Confidential price data provided by the CWB surmount difficulties that plagued many prior studies of imperfect competition in wheat trade that have used export unit values. In fact, testing for price discrimination, while also accounting for the difference in wheat quality, is not possible using publicly available data.

This study presents evidence residing between the polar perspectives of prior debates on the performance of the CWB, such as KFT

versus Carter and Loyns. Specifically, inspection of the data indicates that the CWB does price discriminate by charging different f.o.b. prices to different countries for wheat of the same grade and protein content. Moreover, the result of *F*-tests on the price discrimination hypothesis supports the conclusion that the CWB has market power emanating from product differentiation and uses it to price discriminate across export markets. Finally, consistent with the conceptual model, the CWB is shown to take advantage of price discrimination instruments through Alchian–Allen effects especially for markets that value quality (Japan and United Kingdom). Because not all variables have the expected signs and some are not statistically significant, it is difficult to conclude that the CWB maximizes producer surplus in price discrimination. However, data quality is a plausible explanation for the lack of performance of some variables. In addition, results that apparently do not support the predictions of the model may simply indicate that the CWB is not fully utilizing the instruments of price discrimination at its disposal to maximize producer surplus or is pursuing a more complex optimization strategy than the static (annual) optimization problem modeled in this article.

Results from this study, along with recent trade negotiations, illuminate the current STE debate and the request by the United States for their elimination. From 1985 to 1994, the United States and the EU were using targeted export subsidies as a tool to price discriminate in wheat exports. Export price differences were not fully arbitrated because either the exports or export subsidies from the major wheat exporting countries were controlled by one entity, that is, an STE or the government, respectively. In other words, the lack of competition within and among exporting countries enabled price discrimination to occur in world wheat exports.

In 1994, the Uruguay round of the WTO negotiations required the phasing out of export subsidies. While the United States and the EU lost their price discrimination tool at that point, Canada and Australia did not. This study shows that an STE with market power can use another exporter's export subsidy as an instrument of price discrimination. However, it is not the only tool *if* the STE markets a differentiated product from its rivals. While the elimination of the EEP subsidy reduced the ability of the CWB to price discriminate, having a differentiated product enabled the CWB to rely on other price discrimination instruments to sell

wheat at different prices to various importers. Thus, this study also provides insights into the U.S. concerns regarding the CWB and demonstrates the importance of considering quality differentials in the examination market power in wheat trade.

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## References

- Alchian, A.A., and W.R. Allen. *University Economics*. Belmont, CA: Wadsworth, 1964.
- Alston, J.M., C.A. Carter, and L.S. Jarvis. "Discriminatory Trade: The Case of Japanese Beef and Wheat Imports." *Canadian Journal of Agricultural Economics* 38(1990):197–214.
- Alston, J.M., C.A. Carter, R. Gray, and D.A. Sumner. "Third-Country Effects and Second-Best Grain Trade Policies: Export Subsidies and Bilateral Liberalization." *American Journal of Agricultural Economics* 79(1997):1300–10.
- Alston, J.M., R. Gray, and D.A. Sumner. "The Wheat War of 1994." *Canadian Journal of Agricultural Economics* 42(1994):231–51.
- Arnade, C., and D. Pick. "Alternative Approach to Measuring Oligopoly Power: A Wheat Market Example." *Applied Economic Letters* 6(1999):195–97.
- Barraclough, J., and R. Jones. *An Economic Perspective of the Rationale for Single-Desk Selling*. Economic Policy Report No. 3, Economic Services Unit, NSW Agriculture, Orange, Australia, 1993.
- Booz, Allen, and Hamilton. "Milling Wheat Project." *Consultant's Report to the Australian Grains Council*. Canberra, 1995.
- Borenstein, S. "Hubs and High Fares: Dominance and Market Power in the U.S. Airline Industry." *Rand Journal of Economics* 20(1989):344–65.
- . "Price Discrimination in Free-Entry Markets." *Rand Journal of Economics* 16(1985):380–97.
- Bresnahan, T.F. "Competition and Collusion in the American Automobile Industry: The 1955 Price War." *Journal of Industrial Economics* 35(1987):457–82.
- Brooks, H., and T.G. Schmitz. "Price Discrimination in the International Grain Trade: The Case of Canadian Wheat Board Feed Barley Exports." *Agribusiness* 15(1999):313–22.
- Brorsen, B.W., J.-P. Chavas, W.R. Grant, and L.D. Schnake. "Marketing Margins and Price Uncertainty: The Case of U.S. Wheat Market." *American Journal of Agricultural Economics* 67(1985):521–28.

- Canadian Wheat Board. "Canadian Wheat Board Sales." *Grains and Oilseeds: Handling, Marketing, Processing*, 4th ed, pp. 463–90. Winnipeg, MB: CIGI, Canadian International Grains Institute, 1993.
- . "CWB's Vision, Mission, and Goals." [WWW document]. URL <http://www.cwb.ca>, n.d./2001.
- Carew, R. "Pricing to Market Behavior: Evidence from Selected Canadian and U.S. Agri-food Exports." *Journal of Agricultural and Resource Economics* 25(2000):578–95.
- Carew, R., and W.J. Florkowski. "Pricing to Market Behavior by Canadian and U.S. Agri-food Exporters: Evidence from Wheat, Pulse and Apples." *Canadian Journal of Agricultural Economics* 51(2003):139–59.
- Carter, C.A. "The Economics of a Single North American Barley Market." *Canadian Journal of Agricultural Economics* 41(1993):243–55.
- Carter, C.A., and R.M.A. Loynes. *The Economics of Single Desk Selling of Western Canadian Grain*. Edmonton, AB, Canada: Alberta Agriculture, Food and Rural Development, 1996.
- Carter, C.A., R.M.A. Loynes, and D. Berwald. "Domestic Costs of Statutory Marketing Authorities: The Case of the Canadian Wheat Board." *American Journal of Agricultural Economics* 80(1998):313–24.
- Carter, C.A., and W.W. Wilson. "Emerging Differences in State Grain Trading: Australia and Canada." *Agricultural Economics* 16(1997):87–98.
- Chen, K., and H. Brooks. "State Trading and Non-price Discriminatory Trade: The Case of Japan's Wheat Imports." *Agribusiness* 15(1999):41–51.
- Dahl, B.L., and W.W. Wilson. *Factors Affecting the Supply of High Quality Spring Wheats: Comparisons between the United States and Canada*. Agricultural Economics Report No. 374. Fargo: Department of Agricultural Economics, North Dakota State University, 1997.
- Davis, G.C. "Product Differentiation and Representative Agent Import Demand Systems: A Reconsideration and Reconciliation." *Canadian Journal of Agricultural Economics* 43(1995):149–64.
- Davis, G.C., and K.L. Jensen. "Two-Stage Utility Maximization and Import Demand Systems Revisited: Limitations and an Alternative." *Journal of Agricultural and Resource Economics* 19(1994):409–24.
- Dexter, J.E. "Quality Requirements of Western Canadian Bread Wheats." *Grains and Oilseeds: Handling, Marketing, Processing*, 4th ed. Winnipeg, MB: CIGI, Canadian International Grains Institute, 1993, pp. 697–722.
- Froot, K.A., and P.D. Klemperer. "Exchange Rate Pass-through when Market Share Matters." *American Economic Review* 79(1989):637–54.
- Gagnon, J.E., and M.M. Knetter. "Markup Adjustment and Exchange Rate Fluctuations: Evidence from Panel Data on Automobile Exports." *Journal of International Money and Finance* 14(1995):289–310.
- GAO. *Canada, Australia and New Zealand: Potential Ability of Agricultural State Trading Enterprises to Distort Trade*. United States General Accounting Office, GAO/NSIAD-96-94, 1996.
- Goldberg, P.K., and M.M. Knetter. "Goods Prices and Exchange Rates: What Have We Learned?" *Journal of Economic Literature* 35(1997):1234–72.
- . "Measuring the Intensity of Competition in Export Markets." *Journal of International Economics* 47(1999):27–60.
- Haley, S.L. "The US Export Enhancement Program: Prospects under the Food, Agriculture, Conservation, and Trade Act of 1990." *Food Policy* 17(1992):129–40.
- Katz, M.L. "Price Discrimination and Monopolistic Competition." *Econometrica* 53(1984):1453–71.
- Knetter, M.M. "International Comparisons of Price-to-Market Behavior." *American Economic Review* 83(1993):473–86.
- . "Price Discrimination by U.S. and German Exporters." *American Economic Review* 79(1989):198–210.
- . "Pricing to Market in Response to Unobservable and Observable Shocks." *International Economic Journal* 9(1995):1–25.
- Koo, W.W., W. Mao, and T. Sakurai. "Wheat Demand in Japanese Flour Milling Industry: A Production Theory Approach." *Agricultural Economics* 24(2001):167–78.
- Kraft, D.F., W.H. Furtan, and E.W. Tyrczniewicz. *Performance Evaluation of the Canadian Wheat Board*. Winnipeg, MB, Canada: Canadian Wheat Board, 1996.
- Krugman, P. "Pricing to Market When the Exchange Rate Changes." *Real-Financial Linkages among Open Economies*, S.W. Arndt and J.D. Richardson, eds., pp. 49–70. Cambridge, MA and London: MIT Press, 1987.
- Lambert, D.K., and W.W. Wilson. "Valuing Varieties with Imperfect Output Quality Measurement." *American Journal of Agricultural Economics* 85(2003):95–107.
- Larue, B., and H.E. Lapan. "Market Structure, Quality and World Wheat Market." *Canadian Journal of Agricultural Economics* 40(1992):311–28.

- Lavoie, N. "Price Discrimination in the Context of Vertical Differentiation: An Application to Canadian Wheat Exports." Unpublished PhD dissertation, University of California, Davis, 2001.
- Lavoie, N., and Q. Liu. "Pricing-to-Market: Price Discrimination or Product Differentiation?" Working paper No. 11, University of Massachusetts, Amherst, MA, December 2004.
- Love, H.A., and E. Murniningtyas. "Measuring the Degree of Market Power Exerted by Government Trade Agencies." *American Journal of Agricultural Economics* 74(1992):546–55.
- MacLaren, D. "Implications of New Trade Theory for Modelling Imperfect Substitutes in Agricultural Trade." *Imperfect Competition and Political Economy: The New Trade Theory in Agricultural Trade Research*, C.A. Carter, A.F. McCalla, and J.A. Sharples, eds., pp. 113–33. Boulder, San Francisco, and Oxford: Westview Press, 1990.
- Marston, R.C. "Pricing to Market in Japanese Manufacturing." *Journal of International Economics* 29(1990):217–36.
- Mercier, S.A. *The Role of Quality in Wheat Import Decisionmaking*. Agriculture Economic Report No. 670. U.S. Department of Agriculture, Economic Research Service, 1993.
- Miner, W.M. "An Overview of the Issues and Positions of the Major Countries in the WTO Negotiations." *Estey Center Journal of International Law and Trade Policy* 2(2001):10–34.
- Mussa, M., and S. Rosen. "Monopoly and Product Quality." *Journal of Economic Theory* 18(1978):301–17.
- North Dakota Wheat Commission. "N.D. Wheat Commission to File Section 301 Against Canada." *News Releases*. September 7, 2000 [WWW document]. URL [http://www.ndwheat.com/in/news/news\\_detail.asp?ID=115](http://www.ndwheat.com/in/news/news_detail.asp?ID=115)
- Patterson, P.M., and P.C. Abbott. "Further Evidence on Competition in the U.S. Grain Export Trade." *Journal of Industrial Economics* 42(1994):429–37.
- Pick, D.H., and C.A. Carter. "Pricing to Market with Transactions Denominated in a Common Currency." *American Journal of Agricultural Economics* 76(1994):55–60.
- Piggott, R.R. "Some Old Truths Revisited." *Australian Journal of Agricultural Economics* 36(1992):117–40.
- Ryan, T.J., 1984. "Marketing Australia's Wheat Crop: The Way Ahead." *Review of Marketing and Agricultural Economics* 62(1994):107–21.
- Sarkar, A.K. "Flour Milling." *Grains and Oilseeds: Handling, Marketing, Processing*, 4th ed. Winnipeg, MB: CIGI, Canadian International Grains Institute, 1993, pp. 603–54.
- Schmitz, A., R. Gray, T. Schmitz, and G. Storey. *The CWB and Barley Marketing: Price Pooling and Single-Desk Selling*. Winnipeg, MB, Canada: Canadian Wheat Board, 1997.
- Sexton, R.J., and N. Lavoie. "Food Processing and Distribution: An Industrial Organization Approach." *Handbook of Agricultural Economics*, B. Gardner, and G.C. Rausser, eds., pp. 863–932. Amsterdam: North-Holland, 2001.
- Stephens, D.G., and F.T. Rowan. "Procurement Systems of International Buyers and Changing Marketing Systems and Policies of International Competitors." Research Program, Western Grain Marketing Panel, The Exchange Consulting Group, Winnipeg, MB, 1996.
- Stiegert, K., and J.-P. Blanc. "Japanese Demand for Wheat Protein Quantity and Quality." *Journal of Agricultural and Resource Economics* 22(1997):104–19.
- Thursby, M.C. "Strategic Models, Market Structure, and State Trading: An Application to Agriculture." *Trade Policy Issues and Empirical Analysis*, NBER Conference Report Series, E. Baldwin, ed., pp. 79–105. Chicago and London: University of Chicago Press, 1988.
- Thursby, M.C., and J.G. Thursby. "Strategic Trade Theory and Agricultural Markets: An Application to Canadian and U.S. Wheat Exports to Japan." *Imperfect Competition and Political Economy: The New Theory in Agricultural Trade Development*, C.A. Carter, A. McCalla, and Sharples, eds., pp. 87–111. Boulder and Oxford: Westview Press 1990.
- Tweed, A.R. "Breadmaking Technology." *Grains and Oilseeds: Handling, Marketing, Processing*, 4th ed. Winnipeg, MB, Canada: CIGI, Canadian International Grains Institute, 1993, pp. 655–96.
- Wang, H., and R.J. Sexton. "The Cost Effectiveness of the U.S. Export Enhancement Program Bonus Allocation Mechanism." *American Journal of Agricultural Economics* 86(2004):375–88.
- Williams, P. "Variety Development and Quality Control of Wheat in Canada." Paper presented at the International Japanese Conference on Near-Infrared Reflectance, 1997. Also available at <http://www.cgc.ca/Cdngrain/VarietyDev/variety1-e.htm>
- Wilson, W.W., and T. Preszler. "End-Use Performance Uncertainty and Competition in International Wheat Markets." *American Journal of Agricultural Economics* 74(1992):556–63.
- . "Quality and Price Competition in International Wheat Trade: A Case Study of the United Kingdom Wheat Import Market." *Agribusiness* 9(1993):377–89.