Backward Implicit Contracts, Pre-commitment and Market Power in the International Durum Wheat Market

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Abstract

The Canadian Wheat Board (CWB) initially pays below market prices for grain and then reimburses producers later using a lump-sum transfer payment. We found empirically that this mechanism serves as credible threat to any competitor challenging the CWB's long run leadership status in the international durum market.

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For several decades, the behavior and role of nationally sanctioned grain marketing agents has been the focus of appreciable policy debate, the center of numerous trade disputes, and the subject of considerable economic analysis. The largest of these agencies, and perhaps the most prominent, is the Canadian Wheat Board (CWB), which controls marketing activities for Canada's hard wheat, durum wheat and barley exports. Many economists have suggested that the activities of national marketing agents are noncompetitive. McCalla (1966) was among the first to argue that the CWB acts as a price leader in the international wheat export market. Subsequently, Alouze Watson and Sturges (1978) provide evidence of a noncompetitive wheat export triopoly between the U.S., Canada, and Australia where, once again, the CWB was positioned as the price leader. Although other studies generate somewhat different conclusions about market power in CWB influenced markets (e.g., Sarris and Freebairn, Love and Murniningtyas, Paarlberg and Abbott, Thursby and Thursby), a vast literature has emerged to support the case of leadership positioning by the CWB. In international barley markets, Schmitz and Koo conclude that Canada and Australia act as dominant suppliers with other exporters behaving as a fringe.[1] Goodwin and Smith demonstrate that the CWB operates as the wheat export price leader and find that the board uses price discrimination between national and international markets to maximized export revenue. Smith and Holt examined U.S.-Canada wheat price dynamics and found that Canadian price volatility was five times more influential on U.S. prices than U.S. price volatility had on the variance of Canadian wheat prices. Using simulations, they predict that a Canadian price

increase tends to be fully matched by U.S. firms in the long run, while only about 43% of a U.S. price increase would be matched by Canada. The conclusions of these recent quantitative studies generally support the earlier models suggest that the CWB acts as the market leader in world wheat markets.

Despite the long and scrutinized history of the CWB, a clear, consistent argument has not been forwarded to explain the mechanism through which the CWB maintains a long-run leadership status. In the present paper, a formal test for Stackelberg leadership behavior is derived that relies on a critical and heretofore unrecognized feature that distinguishes the CWB from other marketing agents in the U.S. and the E.U. Specifically, the CWB pays Canadian farmers a below-market upstream price for grain then reimburses farmers with proceeds from downstream international grain sales. This payment system represents an implicit form of an export subsidy, which generates a marginal cost advantage for the CWB in the international market and subsequent leadership status (Brander and Spencer).

The model is applied to the durum wheat export market, in which Canada has typically maintained a 40-60% export market share (International Wheat Council). Unlike hard wheat and barley markets, the CWB does not compete with the AWB in durum wheat markets, and only limited substitution is possible for durum wheat in semolina flour and pasta formulas. These features provide the clearest approach to evaluate the prepayment system of the CWB as a mechanism to acquire leadership.

As in a standard model of strategic trade, the international equilibrium is determined as the outcome of a simultaneous-move game, while Stackelberg leadership is

[1] The Australian Wheat Board (AWB) controls and exports domestic hard wheat and barley markets in a manner similar to that of the CWB.

derived from previous price-commitment in the procurement market. That is, the CWB chooses implicitly its own marginal cost by setting the upstream transfer price of durum wheat at the farm gate. With sufficient market information, the CWB can identify the optimal procurement markdown to attain leadership status in the international market. Our empirical analysis employs estimates of the international market conditions to derive a confidence interval about the optimal procurement markdown and tests the hypothesis that CWB discounts can be used to acquire a leadership position.

The Model

The model presented here follows the more general framework developed by Hamilton and Stiegert. We consider a vertical structure comprised of two markets: an upstream market, in which farmers sell durum wheat to marketing agents in isolated domestic markets and a downstream market, in which marketing agents sell durum wheat to consumers in a single international market. In the Canadian upstream market, the CWB sets the upstream market price in a procurement contract for raw durum wheat. The CWB's trade competitors, by contrast, face legal challenge in the explicit control of upstream market prices. In the U.S., for example, Perloff, Rubinfeld and Ruud (1996) identify 13 major antitrust categories, several of which limit the ability of domestic marketing agents to control the pricing behavior of durum wheat suppliers.

Consider for analytic convenience the case in which farmers in the U.S., E.U., and Canada produce durum wheat at a constant marginal cost of c.[2] The durum wheat purchased by the marketing agents for the export market is then sold in an international market comprised of the CWB and an independent group of rival firms.

[2] Extension of the model to consider more general supply relationships is relatively straightforward. In the empirical model to follow, the results are quite robust to considerations of upward sloping supply relations.

Strategic interaction between the marketing agents is modeled as a three-stage game. In the first stage, the contract stage, the CWB writes an observable and non-renegotiable contract with Canadian farmers. The contract specifies the upstream (or wholesale) price of durum wheat, *w*, and a fixed transfer *F* to be paid from proceeds collected in the downstream international market. In the second stage, the acceptance stage, Canadian farmers either accept or reject the contract.[3] In the third and final stage, the CWB and rival marketing agents compete in quantities in an international oligopoly.

Throughout, we confine attention to the case in which marketing agents in the U.S. and E.U. operate under the auspices of antitrust authorities that do not allow the formation of procurement contracts in the upstream raw durum market. That is, the independent marketing agents are constrained to purchase inputs in the spot market at marginal cost *c*. In the remainder of this section, we refer to other marketing agents in the U.S. and E.U. as other exporters (OE).

Let Q represent total output of the final good and denote the downstream inverse demand function as *P(Q)*, which is assumed throughout to be strictly decreasing and twice continuously differentiable. Furthermore, it is assumed that

$$P'(Q) + QP''(Q) < 0, \tag{1}$$

which, as demonstrated by Novshek (1985), ensures the existence of equilibrium.

The model is solved using backward induction. Accordingly the output stage is solved first, followed by the acceptance and contract stages, respectively. Given that the

[3] In this stylized model, Canadian farmers are given the choice of whether or not to accept the CWB contract. In reality, participation in the CWB contract is mandatory; however, it is important for modeling reasons to consider an acceptance stage, albeit a degenerate one, to ensure that Canadian farmers are not made worse off by participating in the CWB selling system. That is, if a "participation constraint" is not met, in which each Canadian farmer is (at least weakly) better off through the actions of the CWB, then it is difficult to explain the persistence of the CWB as a viable national marketing channel.

contractual relationship is satisfactory to Canadian farmers in the acceptance stage, the objective function of the CWB in the output stage is

$$\pi_C(q_C, Q, w, F) = (P(Q) - w)q_C - F\,, \tag{2}$$

where π_C and q_C denote the level of profit and output for the CWB, respectively. Maximization of (2) with respect to q_C yields the first-order necessary condition:

$$P(Q) + q_C P'(Q) - w = 0\,. \tag{3}$$

In the OE downstream markets for durum wheat, let q_{U_i} represent the output of an individual OE marketing agent *i*. Then, if *n* denotes the number of OE marketing agents, the aggregate output of OE durum wheat is $q_U = \sum_{i=1}^{n} q_{U_i}$. For marketing agent *i*, the objective function in the output stage is

$$\pi_{U_i}(q_{U_i}, Q) = (P(Q) - c)q_{U_i}\,,$$

which yields the first-order condition

$$P(Q) + \delta_{U_i} q_{U_i} P'(Q) - c = 0\,, \tag{4}$$

where $\delta_{U_i} = dQ/dq_{U_i}$ is the conjectural variations parameter of OE marketing agent *i* in the output market. The output stage equilibrium in the international durum wheat market is completely characterized by simultaneously solving the *n+1* equations in (3) and (4).

To achieve greater analytic tractability, the remainder of the paper confines attention to the case of symmetric OE marketing agents, $q_{U_i} = (1/n)q_U$, and symmetric market conjectures in the downstream international market, $\delta_{U_i} = \delta$. For the symmetric case, the above system of equations may be simplified considerably by aggregating the *n*

first-order conditions (4), which yields the first-order condition for a representative firm

$$P(Q) + \lambda q_U P'(Q) - c = 0. \tag{5}$$

where $\lambda = \delta / n \in [0,1]$, with 0 representing competition and 1 representing monopoly.

The export volume of durum wheat for the U.S. and Canada and the level of total international output, denoted $q_i(w,c)$, $i = U, C$ and $Q(w,c)$ respectively, are obtained by solving (3) and (5) simultaneously. Totally differentiating these equations yield the ratio of comparative statics associated with the CWB's choice of *w*,

$$\frac{\partial q_U(w,c)/\partial w}{\partial q_C(w,c)/\partial w} = -\frac{P'(Q) + \lambda q_U P''(Q)}{(1+\lambda)P'(Q) + \lambda q_U P''(Q)}, \tag{6}$$

which is negative given stability condition (1).

In the acceptance stage, Canadian farmers accept the contract proposed by the CWB provided they receive a payment no less than the opportunity costs of producing durum wheat. Given that Canadian farmers are competitive, these opportunity costs can be normalized to zero without loss of generality. As a result, Canadian farmers accept the contract whenever the following participation constraint is satisfied

$$(w-c)q_C(w,c) + F \geq 0, \tag{7}$$

where F is the aggregate fixed transfer payment paid to Canadian farmers with international durum wheat revenues.

In the contract stage, the CWB chooses the contract terms to maximize profits in (2) subject to the participation constraint (7) and the output stage solutions above. Substituting the output stage solutions into (2) and (7), the contracting problem becomes:

$$\underset{w,F}{Max}\, \pi_C(w,F) = \big(P(Q(w,c)) - w\big)q_C(w,c) - F$$

$$s.t \qquad (w-c)q_C(w,c) + F \geq 0.$$

Substitution of the constraint results in the following unconstrained problem:

$$\underset{w}{Max}\,\pi_C(w) = \big(P(Q(w,c)) - c\big)q_C(w,c)\,. \tag{8}$$

Suppressing some of the output stage solution notation, differentiation of (8) with respect to *w* gives the necessary condition for a profit-maximizing contract,

$$\big(P(Q) - c\big)\frac{\partial q_C(w,c)}{\partial w} + q_C P'(Q)\frac{\partial Q(w,c)}{\partial w} = 0\,. \tag{9}$$

Manipulating (9), if q_U^* and Q^* represent the equilibrium levels of OE output and total industry output, respectively, then the CWB's equilibrium output level, q_C^*, satisfies

$$P(Q^*) - c + q_C^* * P'(Q^*)\left(1 + \frac{\partial q_U}{\partial q_C}(q_C^*, Q^*)\right) = 0\,, \tag{10}$$

where $\dfrac{\partial q_U}{\partial q_C}(q_C, Q) = \dfrac{\partial q_U(w,c)/\partial w}{\partial q_C(w,c)/\partial w}$ denotes the ratio of comparative statics given in (6).

Using expression (5), the equilibrium level of durum wheat output by the OE satisfies

$$P(Q^*) - c + \lambda q_U^* * P'(Q^*) = 0\,. \tag{11}$$

The equilibrium levels of output for the CWB and for OE marketing agents are thus obtained by substituting $Q^*=q_C^*+q_U^*$ into (10) and (11) and solving simultaneously.

To determine the optimal contract price for raw durum wheat, denoted w^*, substitute the ouput solution (10) into (3) to obtain

$$w^* - c = -q_C^* * P'(Q^*)\frac{\partial q_U}{\partial q_C}(q_U^*, Q^*) < 0\,, \tag{12}$$

where the inequality holds by (1) and (6). Thus, the profit-maximizing contract set by the CWB specifies that farmers sell durum wheat at a loss. The CWB compensates farmers later through the payment of a fixed transfer, *F*, that satisfies the participation constraint (7). Thus, it is optimal for the CWB to use contractual relations with upstream farmers to

achieve an output expansion in the final goods market by restructuring production costs between fixed and marginal cost components. The optimal upstream price to be specified in the contract (12) stipulates below-marginal cost prices for raw Canadian durum wheat, which pre-commits the CWB to an *ex post* beneficial output expansion.

An Empirical Test of Stackelberg Leadership Behavior

Suppose that the CWB is able to obtain a Stackelberg leadership role in the international durum wheat market through the choice of the procurement price discount (12). If this is the case, the model above yields a testable implication. In particular, suppose that international demand for durum wheat is specified by the isoelastic demand equation $P = \alpha Q^{1/\varepsilon}$, where ε is the price elasticity of demand. Making use of the fact that $QP'/P = 1/\varepsilon$ and $QP''/P' = (1-\varepsilon)/\varepsilon$ and substituting (6) into (12), the optimal markdown price set by the CWB, *M**, is given by:

$$M^* = c - w^* = \left(\frac{-PS_C^*}{\varepsilon}\right)\left(\frac{\varepsilon + \lambda S_U^*(1-\varepsilon)}{(1+\lambda)\varepsilon + \lambda S_U^*(1-\varepsilon)}\right), \tag{13}$$

where S_C^* is the market share of the CWB in the international durum wheat equilibrium and $S_U^* = \sum_{i=1}^{n}\left(q_{U_i}/q_U\right)$ is the sum of market shares of the individual marketing agents in other exporting nations (i.e., the OE share of the export market). For a given value of the demand elasticity, expression (13) yields a direct implication for leadership behavior.

To test the null hypothesis of Stackelberg procurement pricing, we proceed in two stages. First, the long-run export market demand elasticity and the conjectural variation parameter are estimated using the Bresnahan framework (see Deodhar and Sheldon). Using the parameter estimates and standard errors from the empirical model, a confidence interval is then established for the optimal procurement markdown, which is

used to test the null hypothesis that the observed markdown coincides with the Stackelberg leadership markdown in (13).

The export demand equation used for this study is specified as:

$$Q = \alpha_0 + \alpha_1 LQ + \alpha_2 P_D + \alpha_3 P_D P_R + \alpha_4 Z_1 + \varepsilon \qquad (14)$$

where Q is total world exports of durum wheat, LQ is exports lagged one period, P_D is Minneapolis real price of durum wheat, $P_D P_R$ is the product of the real price of rice, P_R, and the real Minneapolis durum price, and Z_1 is the per capita income in all nations other than the U.S. and Canada. The price interaction term, $P_D P_R$, is used to generate the standard demand rotation necessary to identify the market power parameter.

The marginal cost of durum exports, P_D, is determined simultaneously with demand in (14) and uniquely identifies the conjectural variation, or market power, parameter, λ. The marginal cost equation is specified as

$$P_D = \beta_0 + \beta_1 Q + \lambda\left(\frac{Q}{\alpha_1 + \alpha_3 P_R}\right) + \beta_2 Z_2 + \beta_3 T + \eta \qquad (15)$$

where, and Z_2 is a real price index for electricity, and T is a time trend.

Results

The above system was estimated using nonlinear three-stage least squares with annual crop year data from 1971 through 1994. The results appear in Table 1. Most of the parameter estimates are statistically significant and of the expected sign. The parameter associated with lagged quantity is in the theoretically prescribed range and indicates a reasonably quick adjustment process to short-term changes. The coefficient on own price demand is negative and highly significant. The short run mean demand elasticity was estimated at -0.812 and which adjusts to a long run [-0.812/(1-.24997)]

value of –1.08. The market interaction term is significant and indicates that rice is a substitute for durum wheat. The coefficient on world per capita income is positive and significant, which indicates that durum wheat is a normal good. The market power term is significant, indicating that the world durum market is, in fact, noncompetitive.

Table 2 compares the optimal and observed markdown prices by the CWB. The first column of Table 2 presents the optimal markdown price from (13) given the long-run demand elasticity estimate and the estimate of market power. The second column presents the observed markdown by the CWB, which is taken as the difference between the initial procurement price and final payments made to producers. The observations within a 95% confidence interval of the optimal M^* are signified with a †-symbol in the third column. For nine of the 25 years, we fail to reject of the hypothesis that the CWB used the prepayment mechanism to generate Stackelberg leadership. In three of these years (1972, 1973 and 1987), we find that the CWB exceeded the optimal markdown. In an average year, the CWB procures durum wheat with about half of the markdown that is sufficient to achieve Stackelberg leadership.

Although the results do not fully support the theoretical model in every year, there is considerable evidence that the pre-payment mechanism has been used to force other exporters to accept long-run follower status. To challenge the leadership position of the CWB would require a competing nation to have a similar long-run stable institutional feature. Given the ebb and flow of grain export policies in other nations, such institutional advantages have simply not been available. Thus, the flexibility of the CWB to fully utilize its pre-commitment tool is likely to be a sufficient deterrent to discipline other players in the market into a follower role without large procurement discounts. The

findings presented here do not dilute the notions that the CWB uses product differentiation and price discrimination tactics to increase market share. In fact, our conclusions rationalize such behavior. With a stable leadership role, a large market share, and economic profits that meet the participation constraint in (7), the CWB is more able to focus attention on improving crop quality and building customer networks that allow for price discrimination practices. Finally, the rational for the prepayment system employed in Canada motivated by reasons other than market control (i.e. budgetary concerns and/or cash flow constraints.) Nevertheless, once instituted, the pre-commitment mechanism would certainly not be underutilized by the CWB.

Conclusions

The purpose of this paper was to evaluate an important yet largely unrecognized strategic component of the Canadian grain marketing system. Specifically, we examined the strategic impacts of the CWB's practice of initially paying below market prices for grain and then reimbursing producers later using a lump-sum transfer payment. Our theory suggests the optimal markdown generates a strategic advantage leading to Stackelberg leadership status for the CWB. The empirical results for international durum markets indicated 9 of the 25 observed markdowns were not significantly different from the markdown required to generate leadership status. Therefore, it is reasonable to conclude that this mechanism serves as credible threat to any competitor that considers challenging the CWB's long run leadership status. The results also indicated that this institutional feature is an important reason explaining why the CWB has been able to exert and maintain its leadership status over the past 30 years.

Table 1: Model estimates for Durum Export Demand 1971-1994.

Parameter		Estimate	Standard Error
α_0	(intercept)	0.94325	20.815
α_1	(LQ)	0.24997**	0.1933
α_2	(P_D)	-4.71*	1.807
α_3	(P_D*P_R)	2124.6*	944.2
α_4	(Z_1)	6.33*	2.441
β_0	(intercept)	14.35*	7.329
β_1	(Q)	-0.34*	0.097
λ	(Market Power)	-.449**	0.267
β_2	(Z_2)	-1.58	5.75
β_3	(T)	0.188	0.169
Short-Run Demand Elasticity		-0.812	
Long-Run Demand Elasticity		-1.083	
R^2		.71	

* denotes significance at the 90% level. ** denotes significance at the 85% level.

Table 2: Stackelberg Markdown Versus Observed Markdowns by the Canadian Wheat Board. Durum Wheat: 1971-1994.

Year	M* (Stackelberg Markdown)	(M) Observed Markdown	(M/M*)%
1971	22.23	2.31	10.3
1972	28.117	41.89	147.2†
1973	78.91	87.85	110.3†
1974	81.23	73.89	89.8†
1975	56.66	18.3	31.9
1976	39.01	30.5	77.2†
1977	43.34	18.1	41.2
1978	39.61	20.24	50.5
1979	49.28	39.5	79.3†
1980	91.58	0.58	0
1981	60.87	25.84	41.9
1982	73.96	10.74	14.3
1983	80.43	21.83	26.7
1984	69.68	22.64	32.07
1985	43.72	19.09	43.2
1986	33.73	18.2	53.3†
1987	38.51	42.21	109.6†
1988	47.18	12.06	25.3
1989	50.49	11.47	22.4
1990	46.02	0	0
1991	38.10	35.37	91.8†
1992	39.83	36.61	90.9†
1993	81.99	45.38	54.6
1994	95.57	50.55	52.2
1995	104.95	24.55	23.4
AVG 75-84	58.92	29.58	53.8
AVG 85-95	57.05	26.86	51.4

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