STATE TRADING ENTERPRISES IN A DIFFERENTIATED ENVIRONMENT: THE CASE OF GLOBAL MALTING BARLEY MARKETS

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ABSTRACT

The lack of transparency in the pricing and operational activities of State Trading Enterprises (STEs) has generated concerns that certain countries’ STEs are circumventing Uruguay Round commitments on export subsidies, domestic support, or market access. Critics argue that STEs pursue activities that mask export subsidies or import tariffs and that STE’s exclusive purchase/sell rights in domestic country or world market may be used to create monopsonist/monopolist opportunities.

The purpose of this study is to examine the market structure of the differentiated world malting barley market in which two STEs (the Canadian Wheat Board and Australian Barley Board) maintain jointly a very large share of the export market. In particular, this study focuses on the exclusive procuring and pricing policies used by both STEs to test if these intra-country mechanisms can generate leadership and shift rent from other exporting countries. A conceptual and empirical framework is also provided to test if STEs set their initial payments at optimal levels.

The empirical approach proceeded in two stages: an output stage analysis and a precommitment stage in which STEs endogenously set their respective purchase price. Empirical results from the output stage indicate that the CWB, the ABB, and other export sectors do not react to each other’s output choices and thus are in Cournot equilibrium. Empirical results from the precommitment stage show that both STEs do not set their initial payments low enough to achieve leadership status.

The study suggests that some distortionary impacts from the STE prepayment systems are possible, but even if significant benefits are available, it does not appear to be a tool either STE seems to effectively use. Perhaps political realities about lowering the initial payments constrain the system. Perhaps enough product differentiation exists that there are simply other strategies better suited for this market. Regardless of the plausible reasons, the STE prepayment systems cannot be seen as a distorting factor in the global malting barley market.
Introduction

As early as 1947, the General Agreement on Tariffs and Trade (GATT) acknowledged State Trading Enterprises (STEs) as legitimate participants in international trade. The World Trade Organization (WTO) defines STEs as “government and nongovernmental enterprises, including marketing boards, which have been granted exclusive or special rights or privileges, including statutory or constitutional powers, in the exercise of which they influence through purchases or sales the level or direction of imports or exports” (see Economic Research Service 1997). Because STEs may be privately owned, the defining consideration is thus not governance, but exclusive privileges. State trading is more prevalent in agriculture than in other economic sectors. In 1995 and 1996, 32 countries notified the WTO of 96 agricultural enterprises or organizations as STEs. STEs operate in a broad range of agricultural commodities. However, they have been most active in grains and dairy products.

The Australian Barley Board (ABB) has made strong claims of net public benefits emanating from its single desk status. It claimed to have gained between $19 million and $41 million per year in demonstrable market premiums between 1985/86 and 1994/95, and could price discriminate among countries. The single desk of the ABB also had the potential to extract premiums and economic rents as a monopoly seller to domestic maltsters. The Center for International Economics (CIE) examined the claims of the ABB. They found no evidence of any price premiums in export markets for malting barley exported by the ABB. The CIE also pointed out that the claims of the ABB were overstated, because the ABB did not consider other effects, such as different qualities of barley and services, different time of sale and shipping times, etc, in its analysis.

Given the exclusive or special rights of STEs, the potential to exert considerable influence on the world markets is certainly possible. Controversial issues such as price pooling strategies and single desk marketing functions of several large agricultural based STEs [Canadian Wheat Board (CWB); the Australian Wheat Board (AWB), and the ABB] have been major concern in the U.S. over the past decade (GAO, 1995). Moreover, with increasing commitments toward free trade, the functions of STEs have come under greater scrutiny. The fundamental question is whether or not STEs could maintain and/or advance a distortionary market presence while the rest of the world made significant commitments to free, undistorted trade via tariffication of quotas, scheduled tariff reductions and a real, or at least perceived, loss of national autonomy through the WTO trade dispute process.

The U.S. Congress commissioned the General Accounting Office (GAO) to conduct two studies investigating STE behavior (GAO, 1995, 1996). In these studies, although STEs were shown to use policy tools that have reasonably clear WTO compliance rules (including price supports and export subsidies), several other STE activities seem more problematic under WTO law, such as export licenses, tax advantages, transportation subsidies, and delayed producer payments, etc. The delayed payment system was recognized by the GAO as a source of pricing flexibility because the initial payments are set before export marketing is realized. Typically, the STEs pay upstream producers a below-market initial payment, and then provide a lump-sum reimbursement after proceeds are generated in the downstream international markets. As a result, the prepayment approach is capable of creating a credible marginal cost advantage for the STEs in the international market and generating essentially the same precommitment effect as an export subsidy (Brander and Spencer, 1985). In the case of STEs, Hamilton and Stiegert (2000) established the formal equivalence between the delayed producer payment system and these more familiar forms of precommitment. The purpose of the research in this study is to evaluate STE behavior in the international malting barley market.

A key point from the seminal article by Brander and Spencer (1985) was that rent-shifting is only possible when markets are imperfect and there exists some form of a
precommitment stage. Brander and Spencer demonstrated that this precommitment can occur when governments set a credible export subsidy in advance of the quantity decision by firms. Other forms of rent-shifting are certainly possible. Fershtman and Judd (1987) demonstrate rent-shifting through intra-firm incentive systems. Bensaii and Gary-Bobo show that rent-shifting can occur through union contracts.

The delayed payment system utilized by STEs has the potential to create a credible marginal cost advantage because STEs make below market initial payments in acquiring exportable products, which provides similar effects as an export subsidy. Indeed, Hamilton and Stiegert (2002) found that CWB initial payment structure to durum producers provided a precommitment to shift rent in most of the years since 1973. The market for malting barley is quite different however. Malting barley markets operate with two STE’s both of which maintain a similar initial payment structure. Malting barley maintains a sensitive product quality structure and much of what is planted for malting markets ends up as a lower priced feed barley. Thus, the challenges in this paper include extending the model by Hamilton and Stiegert (2002) to include a market structure for two STE’s and move toward an estimating model that properly accounts for product differentiation while testing for rent shifting.

Literature

Previous empirical research offers a mixed view regarding the influence of international grain STE’s. Dixit and Josling (1997) show that distortions are possible under current WTO rules by using traditional tariff equivalents and the corresponding export subsidy equivalents. But many circumstances are not so simple as to be represented as tariff/export subsidy equivalents, especially for STEs. They pointed out that exclusive purchasing/selling rights could enhance the market power and rents available to STEs and encourage price discrimination across export markets. Brooks and Schmitz (1999) tested whether the CWB could price discriminate among international feed barley markets by straightforward comparisons of differences between market prices. The CWB realized an average price difference of $20.73/ton between Japan and the rest of the world over the 1980/81 to 1994/95 period. Lavoie found support for price discrimination behavior by the CWB by first controlling for the theoretical factors that explain competition and second evaluating a set of variables that reject pure competition.

Several other studies could not substantiate claims that STEs distort the market. Carter (1993) found no evidence of price discrimination for CWB barley and suggested that the CWB did not exercise market power in the barley export market. He concluded that price variation was more likely linked to export service and grain quality factors. He also found that lack of competitive disciplines in the selling process resulted in excessive handling costs for the CWB and the lack of market signals to producers resulted in the misallocation of resources. In rebuttal, Schmitz, Gray, Schmitz, and Storey (1997) argued that some of the costs addressed by Carter were not unique to CWB grain marketing and would be incurred by producers and governments in the absence of the CWB. Carter, Loyns, and Berwald (1998) showed that even if the CWB somehow earned a large premium in world markets, it did not pass the premium on to producers. The costs of protein overdelivery, excess handling charges, demurrage, and over-cleaning under the CWB’s monopoly rights over the supply of marketing services to farmers extracted the surplus that farmers would have in a competitive environment.

Empirical market power research under the assumption of product heterogeneity is relatively sparse and neither as extensive nor refined as homogeneous product industry research (Vickner and Davies, 1999). Baker and Bresnahan (1985) pioneered the application of residual demand analysis to brewing firms with differentiated products. The residual demand curve is the relationship between firms’ prices and quantities, taking the reactions of all other firms into account. By comparing the changes in residual demand elasticities, they determined the changes
in the firms’ market power after merging. Since the residual demand elasticities depend both on the structural demand elasticities and on the reaction function elasticities, only the total effect, not the individual effect, is identified.

Subsequently, Carter, MacLaren, and Yilmaz (1999) estimated the residual inverse demand elasticities, which are viewed as a measure of the degree of competition, for each of the three exporting countries (US, Canada, and Australia) for the Japanese wheat market. They found that the U.S. had a price leadership role and Australia and Canada competed in the fringe market. But their non-nested tests did not support the above result and they could not discriminate between the monopsony and competitive models.

**Conceptual Model**

The essence of Brander and Spencer’s (1985) study is that the government’s prior action in setting an export subsidy changes the domestic firm’s set of “credible actions” (its reaction function) in the output competition with its rival. If firms are not cooperative, then the Nash-equilibrium is changed in favor of the domestic firm. As introduced before, initial payments for commodities brokered by the CWB and the ABB are usually set at substantially below-market prices. Consequently, the delayed payment approach has the potential of creating a credible marginal cost advantage because STEs pay less on acquiring exportable products and thus has the same effect as an export subsidy. Moreover, in the case of STEs, the final payment in a delayed producer payment system, which is typically delivered in a lump-sum fashion, provides an explicit method of transfer back to the input supplier that rationalizes the system. Therefore, the delayed producer payment structure is equivalent in this regard to a policy of direct export subsidization. Under noncooperative competition, the export subsidy is able to shift rent from the rival and move the domestic firm to the position of Stackelberg leader. In a method similar to Brander and Spencer (1985)’s analysis, STEs are able to act first and set subsidy levels (or initial payment levels) before output levels, with their understanding of how export subsidies would influence the output equilibrium. Firms take as given export subsidy levels and decide their output levels in the second stage. This could be expressed by a subgame perfect equilibrium in a two-stage model in which governments set subsidy levels in the first stage and then firms decide output levels in the second stage.

The analysis in this study will be conducted on global malting barley markets. Several specific issues arise immediately. Agronomic practices, soil characteristics, and climatic conditions determine barley varieties grown in different regions, and downstream brewers have specific quality requirements in terms of acceptable varieties, protein, plumpness and germination. In addition, products are also differentiated by consumers due to geographical origin, personal taste, and suppliers (who vary in terms of their credit policies, delivery date, and ancillary services). Therefore, the malting barley market is considered to consist of imperfect substitutes. We begin with a theoretical model that proposes endogenous control of an upstream supply in that STEs choose the initial prices of their principal raw commodity and then compete in an international market of imperfect substitutes (see figure 1). We presume throughout that STEs and producers are vertically aligned and that the government grants the STE exclusive purchase rights of the raw commodity. The vertical structure analyzed here consists of two stages solved by backward induction. The first stage is a precommitment stage, in which both STEs simultaneously choose their initial payments for the material input. In this stage, we employ a subset of the output-stage results to characterize the value of the trade policy parameter associated with the optimal degree of rent-shifting, which is consistent with the previous assumption that the government sets a subsidy level with the understanding of how it influences the output equilibrium. The second stage is an output stage, in which the STEs and other exporting firms maximize profits by choosing quantities and maintain the ability to either store non-optimal
supplies or downgrade the quality of non-optimal supplies for sale to a residual feed barley market. We estimate the output stage by considering STE trade policy as a given shift parameter in the domestic marginal cost function.

Let \( x_1, x_2, \) and \( x_3 \) represent total sales of malting barley to the world market by the CWB (1), ABB (2), and the other malting barley-exporting countries (3), respectively, and denote the downstream inverse demand functions of malting barley marketed by the CWB, the ABB, and Other Exporting Countries as \( P_1, P_2, \) and \( P_3, \) respectively. The country specific inverse demand functions of malting barley are as follows:

\[
P_1 = P_1(x_1, x_2, x_3; \Phi_1) \tag{1}
\]

\[
P_2 = P_2(x_1, x_2, x_3; \Phi_2) \tag{2}
\]

\[
P_3 = P_3(x_1, x_2, x_3; \Phi_3) \tag{3}
\]

where \( \Phi_1, \Phi_2, \phi_3 \) are exogenous variables. If barley varieties were perfect substitutes or homogeneous, all the prices would be equal except for transport costs; if barley varieties were imperfect substitutes, each demand change could have a different impact on each price.

In the output stage, the STEs and the firms in other exporting countries choose their outputs to maximize profits by

\[
\max_{x_1} \pi_1(x_1) = P_1x_1 - w_1x_1 \tag{4}
\]

\[
\max_{x_2} \pi_2(x_2) = P_2x_2 - w_2x_2 \tag{5}
\]

\[
\max_{q} \pi_3(q) = P_3q - c_3q \tag{6}
\]

where \( w_1 \) and \( w_2 \) are initial payments set in the precommitment stage by the CWB and the ABB, respectively, and \( c_3 \) is the price received by farmers of other exporting countries. Here, we assume that there are \( n \) symmetric firms in the other exporting countries and thus \( q = (1/n)x_3 \). We chose outputs as the strategic variable because STES and other exporting firms have the ability to either store non-optimal supplies or downgrade the quality of non-optimal supplies for sale to a residual feed barley market.\(^1\)

Under Cournot competition, exporters do not react to competition quantity changes, implying that all quantity derivatives with respect to other quantities are zero. Maximization of equations (4), (5) and (6) with respect to \( x_1, x_2, \) and \( q, \) respectively yield the first order conditions:

\[
P_1 + x_1P_{11} - w_1 = 0 \tag{7}
\]

\[
P_2 + x_2P_{22} - w_2 = 0 \tag{8}
\]

\[
P_3 + x_3P_{33} - c_3 = 0 \tag{9}
\]

where \( P_{11} = \partial P_1/\partial x_1, \) \( P_{22} = \partial P_2/\partial x_2, \) and \( P_{33} = \partial P_3/\partial x_3. \) The second order conditions yield necessary stability conditions (Novshek, 1985):

\[
2P_{11} + x_1P_{111} \leq 0 \tag{10}
\]

\[
2P_{22} + x_2P_{222} \leq 0 \tag{11}
\]

\[
2P_{33} + x_3P_{333} \leq 0 \tag{12}
\]

where \( P_{iii} = \partial^2 P_i/\partial x_i^2. \)

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\(^1\) As we move from purely homogeneous products to highly differentiated products, the consequences of choosing the incorrect choice variable diminishes. At the extreme, products are not related and each firm offering a single product would behave as separate monopolists. (Friedman, 1983).
Let \( x_i(w_1, w_2; \Psi_i) \) represent the equilibrium levels of sales from country \( i \) in the output stage, given initial payments of \( w_1 \) and \( w_2 \). In the precommitment stage, the STEs select transfer prices, \( w_1 \) and \( w_2 \), so as to

\[
\text{Max } \pi_{1p} = P_1(x_1(w_1, w_2; \Psi_1), x_2(w_1, w_2; \Psi_2), \ldots, x_i(w_1, w_2; \Psi_i))x_i(w_1, w_2; \Psi_i) - c_c x_i(w_1, w_2; \Psi_i) - F_1
\]

(13)

\[
\text{Max } \pi_{2p} = P_2(x_1(w_1, w_2; \Psi_1), x_2(w_1, w_2; \Psi_2), \ldots, x_i(w_1, w_2; \Psi_i))x_i(w_1, w_2; \Psi_i) - c_a x_i(w_1, w_2; \Psi_i) - F_2
\]

(14)

where \( \pi_{1p} \) and \( \pi_{2p} \) are the profit of producers under the CWB and the ABB, respectively. The variables, \( c_c \) and \( c_a \), are the marginal production costs for producers in Canada and Australia, respectively. For simplification of the problem, production costs are assumed to be constant. The variable, \( \Psi_i \), is an exogenous variable affecting supplies. \( F_1 \) and \( F_2 \) are fixed costs that could include marketing and administration costs incurred by the CWB and the ABB, respectively.

Let \( w_i^* \)'s denote the optimal initial payments. The first order conditions of equations (13) and (14) are

\[
P_1 \left( \frac{\partial \xi_1}{\partial w_1} + x_1 \left( \frac{\partial P_1}{\partial x_1} \frac{\partial x_1}{\partial w_1} + \frac{\partial P_1}{\partial x_2} \frac{\partial x_2}{\partial w_1} + \frac{\partial P_1}{\partial x_3} \frac{\partial x_3}{\partial w_1} \right) - c_c \frac{\partial x_1}{\partial w_1} \right) = 0
\]

(15)

\[
P_2 \left( \frac{\partial \xi_2}{\partial w_2} + x_2 \left( \frac{\partial P_2}{\partial x_1} \frac{\partial x_1}{\partial w_2} + \frac{\partial P_2}{\partial x_2} \frac{\partial x_2}{\partial w_2} + \frac{\partial P_2}{\partial x_3} \frac{\partial x_3}{\partial w_2} \right) - c_a \frac{\partial x_2}{\partial w_2} \right) = 0
\]

(16)

Using backward induction from (7) and (8) and substituting \( P_i = P_i x_i = w_i \) into (15) and (16), the optimal upstream prices set by the STEs are:

\[
w_1^* - c_c = -x_1 \left( \frac{\partial x_2}{\partial w_1} + P_{12} \frac{\partial w_1}{\partial x_1} + P_{13} \frac{\partial w_1}{\partial x_3} \right)
\]

(17)

\[
w_2^* - c_a = -x_2 \left( \frac{\partial x_1}{\partial w_2} + P_{21} \frac{\partial w_2}{\partial x_1} + P_{23} \frac{\partial w_2}{\partial x_3} \right)
\]

(18)

where \( \frac{\partial x_i}{\partial w_j} \) (\( i = 1, 2, \) or \( 3; \) and \( j = 1 \) or \( 2 \)) may be derived by taking total differential of equations (7), (8), and (9).

\[
\frac{\partial x_1}{\partial w_1} = \frac{(P_{21} + x_2 P_{22}) (P_{31} + x_3 P_{33}) - (2P_{13} + x_3 P_{33}) (P_{21} + x_2 P_{22})}{(2P_{22} + x_2 P_{23} + x_3 P_{32})}
\]

\[
\frac{\partial x_2}{\partial w_1} = \frac{(P_{21} + x_2 P_{22}) (P_{31} + x_3 P_{33}) - (2P_{13} + x_3 P_{33}) (P_{21} + x_2 P_{22})}{(2P_{22} + x_2 P_{23} + x_3 P_{32})}
\]

\[
\frac{\partial x_3}{\partial w_1} = \frac{(P_{21} + x_2 P_{22}) (P_{31} + x_3 P_{33}) - (2P_{13} + x_3 P_{33}) (P_{21} + x_2 P_{22})}{(2P_{22} + x_2 P_{23} + x_3 P_{32})}
\]
\[
\frac{\partial x_1}{\partial w_2} = \frac{(P_{13} + x_1 P_{113}) (P_{32} + x_3 P_{332}) - (2 P_{33} + x_3 P_{333}) (P_{12} + x_1 P_{112})}{(2 P_{11} + x_1 P_{111}) (2 P_{33} + x_3 P_{333}) - (P_{13} + x_1 P_{113}) (P_{31} + x_1 P_{331})}
\]

\[
\frac{\partial x_2}{\partial w_2} = \frac{(P_{12} + x_1 P_{112}) (P_{31} + x_3 P_{331}) - (2 P_{11} + x_1 P_{111}) (P_{32} + x_3 P_{332})}{(2 P_{11} + x_1 P_{111}) (2 P_{33} + x_3 P_{333}) - (P_{13} + x_1 P_{113}) (P_{31} + x_1 P_{331})}
\]

\[
\frac{\partial x_3}{\partial w_2} = \frac{(P_{11} + x_1 P_{111}) (P_{31} + x_3 P_{331}) - (2 P_{11} + x_1 P_{111}) (P_{32} + x_3 P_{332})}{(2 P_{11} + x_1 P_{111}) (2 P_{33} + x_3 P_{333}) - (P_{13} + x_1 P_{113}) (P_{31} + x_1 P_{331})}
\]

\[
\begin{align*}
\frac{\partial x_1}{\partial x_1} + x_1 (P_{11} + P_{12} \frac{\partial x_2}{\partial x_1} + P_{13} \frac{\partial x_3}{\partial x_1}) - w_1 &= 0 \quad (19) \\
\frac{\partial x_2}{\partial x_2} + x_2 (P_{21} \frac{\partial x_1}{\partial x_2} + P_{22} + P_{23} \frac{\partial x_3}{\partial x_2}) - w_2 &= 0 \quad (20) \\
\frac{\partial x_3}{\partial x_3} + x_3 (P_{31} \frac{\partial x_1}{\partial x_3} + P_{32} \frac{\partial x_2}{\partial x_3} + P_{33}) - c_3 &= 0 \quad (21)
\end{align*}
\]

Next, define \( M_2/M_1 = \gamma_{12}, M_3/M_1 = \gamma_{13}, M_1/M_2 = \gamma_{21}, M_1/M_3 = \gamma_{31}, \) and \( M_2/M_3 = \gamma_{32}. \) The \( \gamma_0 \) (i, j=1, 2, 3, and i \( \neq \) j) indicates firm i’s expectations about the reaction of firm j to a change in its quantity, or firm j’s best response to the change of firm i’s quantity change. For example, \( \gamma_{12} \) indicates the CWB’s expectation about the response of the ABB to a change in the CWB’s export quantity, or the ABB’s best response to the output change of the CWB.

Equations (19)-(21) can now be written

\[
\begin{align*}
P_1 + x_1 (P_{11} + \gamma_{12} P_{12} + \gamma_{13} P_{13}) - w_1 &= 0 \quad (22) \\
P_2 + x_2 (\gamma_{21} P_{21} + P_{22} + \gamma_{23} P_{23}) - w_2 &= 0 \quad (23) \\
P_3 + x_3 (\gamma_{31} P_{31} + \gamma_{32} P_{32} + P_{33}) - c_3 &= 0 \quad (24)
\end{align*}
\]
When products are imperfect substitutes, the conditions for different market models are different from those under a homogeneous product scenario. They not only depend on the best response from other firms, but they also depend on the cross-price effects. This means that the potential impact of market power depends on product differentiation. For example, for the CWB, if the term in the parentheses in equation (22) is equal to zero (i.e. if $P_{11}+\gamma_{12}P_{12}+\gamma_{13}P_{13}=0$), then the CWB is facing a competitive market. The value in the parentheses depends not only on the best response from other firms, but also on the cross-price effects. It is different from the homogeneous condition which only depends on the best response. For Cournot competition, $\gamma_{ij}=0$, each firm believes that the other firms’ choice is independent from its own and the conjecture parameters are the same as those under the homogeneous scenario. Note that (22)-(24) collapses to (7), (8), and (9) under the Cournot assumption. For collusive behavior, conjectures are positive and under total collusion or a cartel, firms cooperate to maximize the joint profits by simultaneously choosing quantities. If malting barley are imperfect substitutes, all direct or cross-price effects in equations (19)-(21) are negative and the mark up under collusion is greater than that under the Cournot assumption, and furthermore, greater than that under competition.

For the current analysis, we set profit maximization separately instead of considering a cartel to maximize joint profit. We make this choice because, as Varian (1992) analyzed, the cartel solution is not stable. If one firm believes that the other firms will stick to the agreed-upon cartel output, the one firm would find it beneficial to chisel other cartel members by increasing its own output in order to sell more at the high price. But if the firm does not believe that other firms will stick with the cartel agreement, then it will not be optimal for the firm to maintain the agreement. This strategic situation is similar to the Prisoner’s Dilemma and the final result will be a set of Nash equilibrium strategies, as long as the discount rate is not too high. Although Friedman (1971) showed that the cartel output is sustainable as a subgame perfect equilibrium in an infinitely repeated game as long as the discount rate is sufficiently small, the study is not limited by the separate maximizations of profits set up above. Instead, it is easy to tell if the firms are collusive by the estimated results from separate maximization of each firm’s profit. If in very few cases the firms are collusive, then the first order conditions for maximization of joint profit by simultaneously choosing outputs become

\begin{align}
    P_1 + x_1 P_{11} + x_2 P_{21} + x_3 P_{31} - w_1 &= 0 \quad (25) \\
    P_2 + x_1 P_{12} + x_2 P_{22} + x_3 P_{32} - w_2 &= 0 \quad (26) \\
    P_3 + x_1 P_{13} + x_2 P_{23} + x_3 P_{33} - c_3 &= 0 \quad (27)
\end{align}

Although firms simultaneously choose outputs and conjectures are also zero, it is easy to tell from the estimation results under separate maximizations of each firm’s profit whether it is Cournot or collusive. The reason is that the mark-ups ($P_i - w_i$) in (25)-(27), are bigger than the mark-ups in (22)-(24) with zero conjectures. Therefore, if firms are playing collusion instead of Cournot, the conjectures in (22)-(24) should be positive. Equations (25)-(27) cannot be reconstructed from the estimation results because they are derived from the maximization of joint profit. If the conjecture variations in (22)-(24) are positive, with the possibility of total collusive, We can set up the maximization of joint profit, derive the first order conditions, and test if it is total collusive. For simplification, this study first considers the maximization of profits only by figuring them separately.

Because the reaction of foreign marketing agents to a change in the quantity of domestic exports is endogenous in the pre-commitment stage, this implies that the conduct parameter associated with the domestic marketing agent is predetermined. Hence, the conduct of the domestic marketing agent could be estimated as a free parameter in the output stage. Expressing the optimal initial payments using conjectural variations yields:
\[ w_1^* - c_e = -x_1 [P_{12} \left( \frac{\partial w_1}{\partial x_1} - \gamma_{12} \right) + P_{13} \left( \frac{\partial w_1}{\partial x_1} - \gamma_{13} \right)] \] (28)

\[ w_2^* - c_a = -x_2 [P_{21} \left( \frac{\partial w_2}{\partial x_2} - \gamma_{21} \right) + P_{23} \left( \frac{\partial w_2}{\partial x_2} - \gamma_{23} \right)] \] (29)

where
\[
\begin{align*}
\frac{\partial x_1}{\partial w_1} &= \frac{(S_1 S_2 - S_3 S_4)}{|S|} = \frac{S_1 S_2 - S_3 S_4}{S_2 S_3 - S_3 S_4} \\
\frac{\partial x_1}{\partial w_2} &= \frac{(S_2 S_3 - S_4 S_5)}{|S|} = \frac{S_2 S_3 - S_4 S_5}{S_3 S_4 - S_4 S_5} \\
\frac{\partial x_2}{\partial w_1} &= \frac{(S_1 S_3 - S_2 S_4)}{|S|} = \frac{S_1 S_3 - S_2 S_4}{S_2 S_3 - S_2 S_4} \\
\frac{\partial x_2}{\partial w_2} &= \frac{(S_3 S_4 - S_1 S_5)}{|S|} = \frac{S_3 S_4 - S_1 S_5}{S_1 S_2 - S_1 S_2} \\
\frac{\partial x_3}{\partial w_1} &= \frac{(S_1 S_5 - S_2 S_6)}{|S|} = \frac{S_1 S_5 - S_2 S_6}{S_2 S_3 - S_3 S_4} \\
\frac{\partial x_3}{\partial w_2} &= \frac{(S_2 S_6 - S_1 S_7)}{|S|} = \frac{S_2 S_6 - S_1 S_7}{S_1 S_3 - S_1 S_3} \\
\frac{\partial x_3}{\partial w_3} &= \frac{(S_1 S_7 - S_2 S_8)}{|S|} = \frac{S_1 S_7 - S_2 S_8}{S_2 S_3 - S_3 S_4}
\end{align*}
\]

and \( S_i \)'s are the items in the matrix \( S \).

\[
S = \begin{pmatrix}
S_1 & S_2 & S_3 \\
S_4 & S_5 & S_6 \\
S_7 & S_8 & S_9
\end{pmatrix}
\]

\[
= \begin{pmatrix}
2P_1 + (\gamma_{12}P_2 + \gamma_{13}P_3) + x_1 (P_{11} + \gamma_{12}P_{21} + \gamma_{13}P_{31}) & P_3 + x_1 (P_{12} + \gamma_{12}P_{22} + \gamma_{13}P_{32}) & P_0 + x_1 (P_{13} + \gamma_{12}P_{23} + \gamma_{13}P_{33}) \\
P_2 + x_1 (\gamma_{21}P_1 + \gamma_{22}P_2 + \gamma_{23}P_3) & 2P_2 + (\gamma_{21}P_1 + \gamma_{22}P_2 + \gamma_{23}P_3) + x_1 (\gamma_{21}P_{21} + \gamma_{22}P_{22} + \gamma_{23}P_{23}) & P_3 + x_1 (\gamma_{21}P_{23} + \gamma_{22}P_{23} + \gamma_{23}P_{33}) \\
P_3 + x_1 (\gamma_{31}P_1 + \gamma_{32}P_2 + \gamma_{33}P_3) & P_3 + x_1 (\gamma_{31}P_{21} + \gamma_{32}P_{22} + \gamma_{33}P_{33}) & 2P_3 + (\gamma_{31}P_1 + \gamma_{32}P_2 + \gamma_{33}P_3) + x_1 (\gamma_{31}P_{31} + \gamma_{32}P_{32} + \gamma_{33}P_{33})
\end{pmatrix}
\]

In equations (22)-(24), the value of the \( \gamma_{ij} \)'s combined with the cross price effects gives an illustration of the market structure and the degree of competition. Specifically, the departure of the \( \gamma_{ij} \)'s from zero is a logically consistent test of whether the Cournot-Nash model provides an accurate description of the industry equilibrium. Under the Cournot hypothesis, the optimal initial payments of the CWB and the ABB in (28) and (29) will be in accordance with (17) and (18). The stability conditions from the second order conditions of (4)-(6) under the linear inverse demand functions are
To test the hypothesis that the CWB and the ABB strategically utilize their pre-payment systems and product differentiation to shift rents from other foreign firms, the following formulas need to be calculated.

\[
\frac{\partial \pi_i}{\partial w_j} = \sum_{k=1}^{3} \frac{\partial \pi_i}{\partial x_k} \frac{\partial x_k}{\partial w_j} 
\]  

(33)

In equation (33), if \(i=1\), then the first term equals zero by the first order condition of profit maximization (if \(i=2\), then the second term cancels). Therefore, we can write (33) separately as follows:

\[
\frac{\partial \pi_2}{\partial w_1} = \frac{\partial \pi_2}{\partial x_1} \frac{\partial x_1}{\partial w_1} + \frac{\partial \pi_2}{\partial x_3} \frac{\partial x_3}{\partial w_1} 
\]  

(34)

\[
\frac{\partial \pi_3}{\partial w_1} = \frac{\partial \pi_3}{\partial x_1} \frac{\partial x_1}{\partial w_1} + \frac{\partial \pi_3}{\partial x_2} \frac{\partial x_2}{\partial w_1} 
\]  

(35)

\[
\frac{\partial \pi_1}{\partial w_2} = \frac{\partial \pi_1}{\partial x_2} \frac{\partial x_2}{\partial w_2} + \frac{\partial \pi_1}{\partial x_3} \frac{\partial x_3}{\partial w_2} 
\]  

(36)

\[
\frac{\partial \pi_3}{\partial w_2} = \frac{\partial \pi_3}{\partial x_1} \frac{\partial x_1}{\partial w_2} + \frac{\partial \pi_3}{\partial x_2} \frac{\partial x_2}{\partial w_2} 
\]  

(37)

\(\partial x_j/\partial w_j\) has been defined earlier and \(\partial \pi_i/\partial x_j\) is as follows:

\[
\frac{\partial \pi_1}{\partial x_2} = \gamma_{21} (P_1 - w_1) + x_1 (\gamma_{21} P_{11} + P_{12} + \gamma_{23} P_{13}) 
\]  

(38)

\[
\frac{\partial \pi_1}{\partial x_3} = \gamma_{31} (P_1 - w_1) + x_1 (\gamma_{31} P_{11} + \gamma_{32} P_{12} + P_{13}) 
\]  

(39)

\[
\frac{\partial \pi_2}{\partial x_1} = \gamma_{12} (P_2 - w_2) + x_2 (P_{21} + \gamma_{12} P_{22} + \gamma_{13} P_{23}) 
\]  

(40)

\[
\frac{\partial \pi_2}{\partial x_3} = \gamma_{32} (P_2 - w_2) + x_2 (\gamma_{31} P_{21} + \gamma_{32} P_{22} + P_{23}) 
\]  

(41)

\[
\frac{\partial \pi_3}{\partial x_1} = \frac{1}{n} [\gamma_{13} (P_3 - c_3) + x_3 (P_{31} + \gamma_{12} P_{32} + \gamma_{13} P_{33})] 
\]  

(42)

\[
\frac{\partial \pi_3}{\partial x_2} = \frac{1}{n} [\gamma_{23} (P_3 - c_3) + x_3 (\gamma_{21} P_{31} + P_{32} + \gamma_{23} P_{33})] 
\]  

(43)

If \(\partial \pi_i/\partial w_1<0\) and \(\partial \pi_i/\partial w_1>0\) (i= 2, or 3), then by lowering its initial payments, the CWB could increase its profit and decrease firm i’s profits. In this case, the CWB strategically utilizes its pre-
payment system to shift rents from country i. Similar analysis could be applied to the ABB. Unlike in the homogeneous product market, rent shifting in the product differentiated market not only depends on the market structure, but also on cross-price effects, which indicate the degree of product differentiation.

Empirical Methods

To evaluate the degree of market power, it is necessary to identify $\gamma_{ij}$’s. Equations (22)-(24) are expanded and rearranged as:

\[ P_{t1} - w_{t1} = \lambda_{i2}(P_{12}x_{1t}) + \lambda_{i3}(P_{13}x_{1t}) - P_{i1}x_{1t} \]
\[ P_{t2} - w_{t2} = \lambda_{21}(P_{21}x_{2t}) + \lambda_{23}(P_{23}x_{2t}) - P_{22}x_{2t} \]
\[ P_{t3} - c_{t3} = \lambda_{31}(P_{31}x_{3t}) + \lambda_{32}(P_{32}x_{3t}) - P_{33}x_{3t} \]

The market power parameters in the above equations ($\lambda_{ij}$’s) are the negative counterparts of the conjectural variation parameters (i.e., $\gamma_{ij} = -\lambda_{ij}$). Much prior research has been done on market power and firm conduct using the conjectural variation approach. Commonly dubbed New Empirical Industrial Organization [NEIO] methodology, it infers market conduct and unknown cost parameters through the responsiveness of price to changes in demand elasticities and cost components (Genesove and Mullin, 1998). Based on the concept of conjectural variations, which was introduced by Bowley in 1924 (Perry, 1982) and extended by Iwata (1974), Bresnahan (1982) gave an outline of a methodology to identify econometrically the market power parameter by introducing an interaction term in the demand function. Love and Murniningtyas (1992) applied this method to the Japanese wheat market to measure the market power of an import STE, Japanese Food Agency (JFA), with the assumption that the rest of the world suppliers are competing. Deodhar and Sheldon (1997) applied the method to the world soymeal export market to estimate the degree of market power exerted by the exporters in developed countries. Another cornerstone of the NEIO methodology is to analyze firm or industry conduct through the estimation of conjectural elasticities, which is also based on conjectural variations. Representative papers include those by Appelbaum (1978) on the U.S. crude petroleum and natural gas industry, Appelbaum (1982) on the U.S. rubber, textile, electrical machinery and tobacco industries, Schroeter (1988), Stieger, Azzam, and Brorsen (1993) on the beef packing industry, Schroeter and Azzam (1990) on the meat industry, Koontz, Garcia, and Hudson (1983) on fed cattle markets, Wann and Sexton (1992) on the California pear processing industry, Gollop and Roberts (1979) on the U.S. coffee roasting industry, and Genesove and Mullin (1998) on the sugar industry.

To estimate the parameters ($\lambda_{ij}$’s) in this system, we choose to estimate the derivatives of prices with respect to quantities, which are $P_{12}$, $P_{13}$, $P_{21}$, $P_{23}$, $P_{31}$, and $P_{32}$. It is here that we empirically allow for some degree of product heterogeneity (i.e. imperfect substitutes). To identify the quantity derivatives of prices, we specified an input distance function for malt production and derived the inverse demand equations. From the inverse demand equations, which resulted from applying Gorman’s Lemma to the distance function, the derivatives of prices with respect to quantities can be identified directly. The aggregate input distance function of imported malting barley is given by

\[ D = D(Q, Y) = \max_{d} \{ d \mid F(Q/d) \geq Y \} \]

where $Q$ is a (n×1) vector of input quantities; $Y$ is a (1×1) scalar representing malt output; and $F(Q/d)$ is the production technology. The behavioral assumption is to rescale all the input levels that are consistent with a target output level. Specifically, $d$ is the largest scalar value that could be used to divide $Q$ and still produce $Y$. Similar to the analysis by Marsh and Featherstone (2003), the distance function is assumed to be weakly separable in inputs by partitioning inputs into two
subgroups of malting barley and other inputs. The properties of a distance function are: 1) homogeneous of degree one and concave in input quantities, 2) nondecreasing in input quantities, and 3) nonincreasing in output $Y$. Given the homogeneity property in input quantities, inverse demand equations for malting barley may be obtained by applying Gorman’s Lemma to the distance function $D$,

$$
\frac{\partial D(Q,Y)}{\partial Q} = P^*(Q,Y) = (P_1^*, P_2^*, P_3^*)
$$

(47)

where $P_i^*$ (i=1, 2, and 3) are cost normalized input prices, $P_i^* = P_i / \sum_{j=1}^{3} P_j x_j$.

To complete the model specification, the distance function is assumed to take the form of a normalized quadratic distance function (Marsh and Featherstone, 2003; Holt and Bishop, 2002). The normalized quadratic distance function is a flexible functional form, able to estimate flexibilities and interactions between input and output quantity. The normalized quadratic distance function is given by

$$
d^*(Q^*, Y) = b_0 + \sum_{i=1}^{2} b_i x_i^* + \frac{1}{2} \left( \sum_{i=1}^{2} \sum_{j=1}^{2} b_{ij} x_i^* x_j^* \right) + b_1 Y + \sum_{i=1}^{2} b_{iy} x_i^* Y + \frac{1}{2} b_Y Y^2
$$

(48)

where $d^*$ and $x_i^*$ are normalized distance and input quantities, $d^*=D/x_3$, and $x_i^*=x_i/x_3$, respectively. The normalized quadratic distance function is linear homogeneous and concave in inputs and continuously differentiable. The inverse demand functions are obtained using Gorman’s Lemma:

$$
P_1^* = b_1 + b_{11} x_1^* + b_{12} x_2^* + b_{1y} Y
$$

(49)

$$
P_2^* = b_2 + b_{22} x_2^* + b_{12} x_1^* + b_{2y} Y
$$

(50)

where $P_i^*$ is normalized input prices by cost, $P_i^* = P_i / \sum_{j=1}^{3} P_j x_j$. Consequently, the cost of producing the target level of output is unity. The third inverse demand function has been dropped to avoid singularity of the error covariance matrix. The derived inverse demand function is homogeneous of degree zero in inputs. Homogeneity is realized by the normalization process and symmetry is imposed by setting $b_{ij}=b_{ji}$.

Input demand flexibilities are given by

$$
f_{ij} = b_{ij} x_j^* / P_i^* \quad \text{for } i, j=1,2
$$

(51)

using the estimated $b_{ij}$ and predicted $P_i^*$. The flexibilities for the third input is recovered from the homogeneity condition, which is $\sum_{j=1}^{3} f_{ij} = 0$.

The derivatives of prices with respect to quantities ($dP_i/dx_j$) could be expressed by normalized input quantities and parameters in (49) and (50). Then equations (43)-(45) could be expressed as follows:

$$
P_1^* - w_1^* = (\lambda_{12} b_{12} - \lambda_{13} b_{11} x_1^* - \lambda_{13} b_{12} x_2^* - b_{11} x_1^*)
$$

(52)

$$
P_2^* - w_2^* = (\lambda_{21} b_{12} - \lambda_{23} b_{11} x_1^* - \lambda_{23} b_{22} x_2^* - b_{22} x_2^*)
$$

(53)

$$
P_3^* - c_3^* = -\lambda_{31} (b_{11} x_1^* + b_{12} x_2^*) - \lambda_{32} (b_{12} x_1^* + b_{22} x_2^*) - (b_{11} x_1^* + b_{12} x_2^*) x_1^* - (b_{12} x_1^* + b_{22} x_2^*) x_2^*
$$

(54)

where $w_i^*$ is the normalized initial payments by cost (See Appendix for derivation).
Data

Evaluating the international market for malting barley has been a challenge in much of the past research primarily because of rather severe data limitations. Unfortunately, international statistics, such as the FAO Yearbook and World Grain Statistics, report barley trade aggregately instead of separating it into feed and malting barley. Consistent data for malting barley export quantities and prices were only available for Canada and Australia.

From August 1975, as authorized by Order-in-Council, barley selected and accepted from producers for use in malting, pot or pearling, is set into a separate pool account by the CWB, which is labeled “Designated Barley.” Prior data were not available. The CWB reports its initial payments, operating cost and final payments per ton for each account and indicates its export quantity of malting barley in its annual reports. Realized prices of the CWB malting barley used in the study were recovered by adding operating costs to total payments to producers. The production cost of malting barley in 1991 was obtained from Chudleigh et al. (1998). The production cost for other years was derived from the production cost in 1991 and the farm input price index, which was obtained from Annual Statistics and Agricultural Statistics Profile. The ABB reports its initial payments and final realized prices for different grades of barley received from producers in its annual report. Initial payments and final realized prices for malting barley were weighted by quantities of different grades of malting barley received by the ABB from South Australia and Victoria. The ABB does not consistently report its barley exports in the separate categories of feed barley and malting barley. The Commodity Statistical Bulletin, which started in 1985, reports data on exports of malting barley by the ABB and Australia from 1980/81. Since 1995, the Commodity Statistical Bulletin has become the Australian Commodity Statistics. However, Australian Commodity Statistics 1997 does not report barley exports for the ABB. Nor does the Australian Commodity Statistics 1999 report barley exports for either Australia or the ABB. The ABB data of malting barley exports data from 1980/81 to 1991/92 were obtained from Commodity Statistical Bulletin; data from 1992/93 to 1994/95 were obtained from CIE, and data for 1995/96 to 1997/98 were obtained from ABB annual reports. Australian malting barley exports data from 1980/81 to 1996/97 were obtained from Commodity Statistical Bulletin and Australian Commodity Statistics. Australian malting barley export data for 1997/98 were obtained from Australian Food Statistics 2000.

Because malting barley export data for the ABB and Australia between 1975/76 and 1980/81 were not directly available, we estimated these levels using a straightforward set of assumptions. By referring to the ABB annual reports, Commodity Statistical Bulletin, which lists the destinations of Australian malting barley export between 1983/84 and 1991/92, and many other publications and research (Center for International Economics (CIE), Schmitz and Koo (1996), Agriculture and Agri-Food Canada, etc), the analysis and estimations were developed along several lines.

West Asia is a major barley importing region that includes Saudi Arabia, Iraq, and Kuwait. This region, especially Saudi Arabia, imports very large quantities of barley from the U.S., Canada, the EU, and Australia. North Africa, which includes Algeria, Libya, and Morocco, also imports a little barley from the U.S. and Europe. Due to religious and legal constraints on alcohol consumption, all barley imported into these regions was assumed to be feed barley.

Data from the Commodity Statistical Bulletin indicate that no malting barley was exported to Muslim countries between 1983/84 and 1991/92. Export data for ABB before 1980/81 were estimated from the information provided in ABB annual reports and Commodity Statistical Bulletin. Australia mostly exported malting barley to China, the EU, South America, South Africa, South Korea, Taiwan and Japan. Occasionally, it would have exported malting barley to the former Soviet Union. By referring to Commodity Statistical Bulletin, which lists Australian malting barley exports’ destinations between 1983/84 and 1991/92, it was found that
Australia only exported malting barley to the Soviet Union in two years. Based on the information obtained from ABB annual reports and Commodity Statistical Bulletin, it was assumed that exports of barley to China were totally malting barley.

One hundred percent of barley exports to South America, South Africa and the EU were malting barley. In addition to this, 4.62% (the average percentage of malting barley imports from Australia by Japan from 1983/84 to 1991/92) of barley exports to Japan and 28.13% (average percentage of malting barley imports from Australia by Taiwan from 1983/84 to 1991/92) of barley exports to Taiwan were malting barley.

Those rules were applied to both Australia and the ABB for the years between 1975/76 and 1980/81. Explicitly, the exports of malting barley by ABB were calculated by

$$X_{ABB} = X_{China} + X_{S. America} + X_{S. Africa} + X_{EU} + 0.462*X_{Japan} + 0.2813*X_{Taiwan}$$

Table 1 contains summary statistics of export quantities, realized prices, initial payments, and the differences between realized prices and initial payments for the CWB and the ABB as well as of export quantity and realized prices for the rest of the world (ROW).

Total malting barley exports from the other exporting countries were the sum of malting barley exports from the U.S, E.U., South America and the residual exports from Australia not under ABB authority. World malting barley export data for 1996/97 and 1997/98 were obtained from Bi-weekly Bulletin, and for 1990/91 to 1994/95, data were obtained from Schmitz and Furtan (2000). Prior to 1990/91, and for the year 1995/96, the aggregate data for the rest of the world were derived by calculating the sum of exports from each country and were estimated using several assumption similar to those used for Australia.

All exports to Muslim countries were assumed to be feed barley.

The malting barley export data after 1989/90 for the U.S. is available from the USDA. For the rest of the years, U.S. malting barley exports were approximated in the following fashion referred to in Schmitz and Koo (1996): all barley sold to China, South America, and Central America was assumed to be malting barley. Three percent of exports to Japan and 27 percent of exports to Taiwan were assumed to be malting barley. All exports to Europe before 1985 were assumed to be feed barley and after 1985 were assumed to be malt quality. All other exports were assumed to be feed barley.

Intra-EU malting barley trade was excluded. EU trade always included the current 15 countries for each year, even though the number of countries in the European Union changed over the period. EU barley exports were assumed to contain malting grade barley in the following proportion: 1) 2% as malting barley to Switzerland; 2) 3.5% to the former USSR; 3) 75% to the former Czech-Slovakia; 4) 18% to Turkey (Schmitz and Koo, 1996); 4) 100% to East Asia, which includes China (including Hong Kong and Taiwan), Japan, and South Korea; and 5) 100% to South America and Central America.

It was necessary to choose a price series for other exporting malting barley. Only the U.S. was an active exporter to Asia, South America, and Europe in most study years. Along with the issue of data availability, prices of malting barley in a principal US market (Minneapolis) were used as a substitute of that for other countries. They were obtained from the USDA (Figure 6.6). Malting barley exporting countries in South America only exported barley to the countries within South America. It was assumed that all barley trade within South America was for malting barley. Barley exports by each country from 1976 to 1990 were obtained from the USDA website and for 1995/96 were obtained from the Statistical Handbook, Canada.

The GDP deflator for each country was used to deflate the nominal variables for each country and was collected from the International Monetary Fund publication, *International Financial Statistics*. All price variables were subsequently converted to a U.S dollar equivalent. Malt production is a necessary data requirement in the distance model. Malt production was determined using the following accounting: (Domestic Malt Consumption) + (Malt exports)-
(Malt Imports). Malt import and export data were obtained from FAO. Domestic malt consumption was derived from beer production. Normally, to produce 1000 hectoliters of beer, the process requires about 147.7 kilograms of malt, and to produce 1 kilogram malt, the process requires 1.2 to 1.3 kilograms of malting barley. Data on beer production for those malting barley importing countries were obtained from FAO.

For the purpose of comparison, realized prices for the CWB, the ABB and the rest of the world were deflated with the GDP deflator where 1995=100. There is a general downward trend on the barley price in export markets. Summary statistics of deflated data are reported in Table 2.

Estimation Results and Discussion

The empirical estimation procedures were carried out according to the two distinct game theoretic stages described in figure 1. The global malting barley output stage estimation was conducted using a Bayesian inference framework with flexibility to allow parametric restrictions and imposition of general demand conditions (Geweke, 1986). The simulation approach was based on the Markov Chain Monte Carlo (MCMC) method and the Metropolis-Hastings algorithm, discussed by Griffiths et al (2000). This is followed by an empirical evaluation of the precommitment stage in which both STEs endogenously control the input price of the principal raw commodity. In particular, we used two methods: a bootstrap approach and the Wilcoxon signed rank test to test the null hypothesis that the optimal initial payment is not different from the observed initial payment. The bootstrap approach was also used to test the null hypothesis that STEs could not shift rent by using their prepayment systems.

Bayesian Approach

The Bayesian approach provides a formal framework for including the prior information. The process of estimating parameters is not to estimate the values of fixed parameters, but rather to continually update and sharpen the subjective beliefs about the “state of the world” (Greene, 2003). With the Bayesian approach, information about a parameter is expressed in terms of the posterior p.d.f. The posterior p.d.f. is a direct statement of the subjective probability of the parameter taking on particular values (Judge et al, 1988). In this study, we applied the Bayesian approach because of its advantage in drawing finite sample inferences concerning nonlinear functions of parameters and imposing economic restrictions.

The core of the Bayesian methodology is Bayes’ Theorem: for events A and B, the conditional probability of event A given that B has occurred is

\[ P(A | B) = \frac{P(B | A)P(A)}{P(B)} \]  \hspace{1cm} (55)

Applying this theorem to parameter estimation and viewing data as a fixed set of additional information in updating beliefs about the unknown parameters and covariance, the theorem becomes

\[ f(\beta, \Sigma | Y, X) \propto L(Y, X|\beta, \Sigma) p(\beta, \Sigma) \]  \hspace{1cm} (56)

where \(\propto\) means “is proportional to,” \(\beta\) is a vector of model parameters, \(\Sigma\) denotes the covariance matrix, and \(Y, X\) represent data observations. The posterior joint density function is \(f(\beta, \Sigma | Y, X)\) for \(\beta\) and \(\Sigma\), given observed random variables \(Y\) and \(X\), or revised beliefs about the distribution of \(\beta\) and \(\Sigma\) after observing the data; \(L(Y, X|\beta, \Sigma)\) is the likelihood function summarizing all the sample information; \(p(\beta, \Sigma)\) is the prior density function for \(\beta\) and \(\Sigma\) that summarizes the nonsample information about \(\beta\) and \(\Sigma\). Once the data are drawn, the joint posterior density is obtained and then it becomes the prior density function for drawing next data. This principle is one of continual accretion of knowledge about the parameters.

Under the assumption of multivariate normal residuals, the likelihood function is
\[ L(Y,X \mid \beta, \Sigma) \propto |\Sigma|^{-N/2} \exp[-0.5tr(R^*\Sigma^{-1})] \]  

(57)

where \( tr \) denotes trace, which is the sum of the diagonals of a square matrix; \( R \) is a symmetric estimated covariance matrix by substituting \( \beta \) into the function; and \( N \) is the number of observations.

The noninformative prior is chosen because it allows for better comparison of results with Nonlinear SUR results later on, although there is information available such as on concavity, symmetry, and theoretic bound. In addition, see Judge et al., 1998, the algebraic form of the prior density function is unchanged by the availability of this information, even though the region over which it is defined changes. This is also true of the posterior density. The non-informative prior used is given by:

\[ p(\beta, \Sigma) = p(\beta)p(\Sigma)I(\beta \in h_s) \]  

(58)

where \( h_s \) is the set of permissible parameter values when constraint information is \( (s=2) \) and is not \( (s=1) \) available. \( I(\cdot) \) is an indicator function that takes the value 1 if the argument is true.

Then the posterior density under the assumption of noninformative prior is

\[ f(\beta, \Sigma \mid Y, X) \propto \left[ |\Sigma|^{-(N+I+1)/2} \exp(-0.5tr(R^*\Sigma^{-1}))I(\beta \in h_s) \right] s=1, 2 \]  

(59)

Techniques of Markov Chain Monte Carlo (MCMC) simulation estimation and Metropolis-Hastings algorithm make the Bayesian estimation remarkably simple. The Metropolis-Hastings algorithm can draw samples from a marginal probability density indirectly without having to derive the density itself (Griffiths et al., 2000). The Metropolis-Hastings algorithm allows the imposition of curvature, stability, and bounds on market power parameters during the sample drawing process. After considering the characteristics of data generation process by the Bayesian method, we imposed constraints on each point-estimated price that they be positive. Unlike the method involving the Cholesky decomposition, which imposes curvature globally and forces some flexible functional forms to exhibit undesired properties by economic theory (Griffiths et al., 2000), the Metropolis-Hastings algorithm imposes curvature restrictions locally with computational advantages over importance sampling.

The empirical model linked to the theory consists of a system of 5 equations: two inverse demand equations (49) and (50), and three equations for estimating market power parameters (52), (53), and (54). The Metropolis-Hastings algorithm described by Griffiths et al (2000) is carried out according to:

Step 1: Specify an arbitrary starting value \( k^0 \) that satisfies the constraints of stability, curvature, and bounds on market power parameters and set iteration \( i=0 \).

Step 2: Given the current value \( k^i \), use a symmetric transition density \( q(k^i, k^c) \) to generate a value as the next candidate in the sequence.

Step 3: Use the candidate value \( k^c \) to evaluate the stability, curvature, and bounds as well as positive estimated prices on market power parameter constraints. If any constraints are violated, then set \( u(k^i, k^c)=0 \) and go to step 5.

Step 4: let \( u(k^i, k^c)=\min(g(k^c)/g(k^i), 1) \), where \( g(k) \) is the kernel of the marginal density \( f(k \mid Y, X) \). \( g(k) \) can be obtained by integrating \( \Sigma \) out of the posterior function (Judge et al., 2000):

\[ f(k \mid Y, X) \propto |R|^{-N/2} I(k \in h_2) = g(k) \]

Step 5: Generate an independent uniform random variable \( U \) from the interval [0, 1].

Step 6: set \( i=i+1 \) and go to step 2.

The above iteration process generates a chain, \( k^1, k^2, \ldots \), with the property that, for large \( i \), \( k^{i+1} \) is an effective sample from \( f(k \mid Y, X) \). \( f(k \mid Y, X) \) is the posterior joint density for \( k \) given \( Y \) and \( X \). The posterior density gives all the information about \( k \) after the sample \( Y \) and \( X \) has been observed. Consequently, the sequence \( k^{i+1}, \ldots, k^{im} \) can be regarded as a sample from \( f(k \mid Y, X) \) that satisfies the constraints of stability, curvature, bounds, and positive price estimates on market.
power parameters. In Step 3, the concavity constraint is evaluated by using the maximum eigenvalue of the estimated Hessian matrix. The burn-in period, $i$, is set at 300,000, which is big enough to ensure the elimination of the influence of the starting value and the convergence of the MCMC chain. How many sample observations are needed for accurate estimation is not certain. The sample size $m$ is set as large as 300,000.

The starting values were chosen arbitrarily, but within the prescribed economic constraints. The choice of transition density $q(k^i, k^c)$ is arbitrary. It is commonplace to use a multivariate normal distribution with mean $k^i$ and covariance matrix equal to unrestricted nonlinear Seemingly Unrelated Regression (SUR) estimators. In order to manipulate the rate at which the candidate $k^c$ is accepted as the next value in the sequence, a tuning constant was used to multiply the covariance matrix. A smaller tuning constant increases the acceptance rate, but at the same time, a smaller tuning constant makes new draws more like old ones, so this slows down the process (Greene, 2003). The tuning constant is set at 0.01 to make the acceptance rate of approximately 0.40. This constant is chosen by trial and error.

The bootstrapped confidence intervals for parameter estimates are constructed after the burn-in period. The 90% confidence interval for each parameter was constructed by the percentile method, which requires ranking the estimated parameters and then selecting the $15000^{th}$ (5% of total iterations) outcome as the lower critical value and the $285000^{th}$ (95% of total iterations) outcome as the upper critical value. If the bootstrapped confidence interval for a parameter estimate contains zero, then the parameter value is not considered significant from zero at the 10% level.

The bootstrapped parameter estimates, along with the upper and lower bounds of the 90% confidence intervals for the Bayesian system, are reported in table 3. Both $b_{11}$ and $b_{22}$ are significant at the 10% level and negative due to the curvature constraint set during the data generation process. Both output parameters ($b_{1y}$ and $b_{2y}$) are negative and only $b_{1y}$ is significant. This shows that output of malt has significant effect on the price of malting barley from the CWB and has insignificant effect on the price of malting barley from the ABB. However, the significant effect is very small.

As discussed above, market power parameters lie between -1 and 1. When the market power parameter ($\lambda_{ij}$'s) is equal to 1 or conjectural variation ($\gamma_{ij}$) is equal to -1, the firm believes that other firms will reduce their output by exactly 1 unit if it increases its output by 1 unit. However, in this study malting barley is modeled as an imperfect substitute across exporters, thus firms have some degree of market power and we should not observe the perfectly competitive outcome. When the market power parameter is negative or conjectural variation ($\gamma_{ij}$) is positive, STEs are found to be collusive.

Significance or insignificance of conjectural variation parameters describes the conduct of STEs and firms in the world malting barley market. If the conjectural variation $\lambda_{ij}$ is not significant, then country i does not consider country j’s output change when i makes its decision. If both $\lambda_{ij}$ and $\gamma_{ij}$ are not significant, then the two countries are in Cournot competition. The results show that all market power parameters are not significant, which suggests that CWB, the ABB, and the other exporting countries are in Cournot competition with each other. This outcome does not imply that the single stage Cournot equilibrium has been identified. However, the single stage result can be supported unless there is some compelling evidence for a precommitment mechanism that may shift the equilibrium to favor one exporter over the others.

The bootstrapped confidence intervals for flexibility estimates are also constructed after the burn-in period. Table 4 contains the bootstrapped flexibility estimates, along with the 90% confidence intervals for the Bayesian system. All own price flexibilities are negative (imposed by concavity in the data generation process), inflexible, statistically significant. An inflexible price is consistent with an elastic demand. Cross-price flexibilities between the ABB and the
other exporting countries were insignificant, which suggests a low level of substitutability and possibly a high level of product differentiation. Cross-price flexibilities between the CWB and the ABB, and those between the CWB and other exporting countries, were significant and positive, which indicates a complimentary effects were present across parts of the export market.

One possibility for the complimentary effects is the effect of geography. The distance between Canada and Australia is great. Each exporter has its own regular customers (e.g., U.S only imports malting barley from Canada). The purchases from these regular customers may disguise the substitution relationship of malting barley from the CWB and the ABB, which may be presented by non-regular and off-switching customers (like China, which imports malting barley from both markets). The other possibility is that in some crop years, production of a STE was very low due to bad weather, causing a decrease in world total supplies and a consequent price increase. But decreased supply from one STE resulted in increased demand for the other STE. Therefore, all world prices increased while demand for imports from one STE also increased.

Using equations (28) and (29), we tested each STE to see if they had set their initial payments at optimal levels. With linear inverse demand functions, all second derivatives of prices with respect to quantities are zero, which greatly simplifies the matrix $S$. By testing whether the optimal mark downs (right hand sides of equations (28) and (29) were equal to the true values of the mark downs, $w_i-c_i$, it could be determined statistically whether the CWB and the ABB set their initial payments at optimal levels. Table 5 contains the bootstrapped estimates of the differences between optimal initial payments and actual payments, along with the upper and lower bounds of the 90% confidence interval for the Bayesian system. Both the CWB and the ABB set their initial payments considerably higher than optimal levels. This implies that while some rent shifting was possible, it does not generate much support that the prepayment system is operating as an effective strategic tool.

A test of rent-shifting based on equations (40)-(43) was also conducted by the bootstrap method. Table 6 shows the test results of rent shifting. All values are insignificant. Therefore the hypothesis that STEs could not utilize their initial payments to shift rent cannot be rejected. Combined with the bootstrapped results from above, a fairly strong conclusion emerges. It does not appear that the prepayment system can be used to shift rent and even if it could, it is currently being heavily underutilized.

To see if the findings from the bootstrap procedures hold up to additional testing, the Wilcoxon signed rank test was conducted. The Wilcoxon signed rank test is a nonparametric method of testing whether two populations have equal locations. To perform the test, we first calculated the difference between the optimal and observed initial payments, $w_i-w_i$. Means of optimal initial payments were estimated by substituting the estimated parameters from the Bayesian method into (28) and (29). Then, we ranked the absolute values of the differences and calculated the sum of the ranks from the positive differences. When the null hypothesis that no difference in distributions is true, the mean and standard deviation of the Wilcoxon signed rank statistic, $W$, are given by $n(n+1)/4$ and $\sqrt{n(n+1)(2n+1)/24}$, respectively. For $n>12$, the distribution of $W/n(n+1)/4$ can be adequately approximated by the standard normal. With 23 pairs of observations of the ranked data, the Wilcoxon signed rank statistic were -4.19726 for both the CWB and the ABB. Therefore, the null hypothesis that there were no differences between optimal and observed initial payments should be rejected. Consequently, the left tail alternative that observed initial payments were higher than optimal levels could be accepted.
Therefore, the Wilcoxon signed rank test suggested that both STEs set their initial payments at higher than optimal levels.

The Bayesian output results show that all conjecture variations are insignificant and the world malting barley market can be characterized by a Cournot equilibrium. From the precommitment stage results, there is little, if any, support for the notion that the prepayment system is effective in shifting rent. Thus, it does appear the Cournot equilibrium we found is consistent with a single-stage Cournot outcome. The structure of the malting barley market for STEs is quite similar in nature to the model by Brander and Spencer (1985), in which governments are able to act first and set export subsidies (lowering the initial payments has the same effect as export subsidies), with the understanding of how these subsidies influence the output equilibrium. Then firms take the subsidy levels set by governments as well as the output levels set by rivals as given. The optimal export subsidy moves the industry equilibrium to what would, in the absence of the subsidy, be the Stackelberg leader-follower position in output space with the firm that has an export subsidy as the leader and the firm without an export subsidy as the follower.

The world malting barley market mostly diverges from Brander and Spencer’s in the nature of the product. In particular, Brander and Spencer assumed that products were perfect substitutes. In a product differentiated environment, the realization of rent shifting depends not only on the presupposition of Cournot competition, but also on the degree of product differentiation. The empirical results showed that all the rent shifting effects were insignificant. Thus, contrary to the results from a homogeneous product market, we cannot conclude that STEs were capable of shifting rents. However, with possible positive values occurring in rent shifting tests, there are signals to suggest that the two STEs could utilize their initial payment system as a pre-commitment strategy to shift rent from others. Although due to the degree of substitution, geographic and other effects (such as the influence of weather on supply), as well as competition in the precommitment phase, much of the benefits are lost, leaving only the possibility of a much smaller distortionary presence.

Summary and Conclusions

Under the Agreement on Agriculture in the Uruguay Round of multilateral trade negotiations completed in 1994, participating countries agreed to convert quotas and other quantitative import restrictions to tariffs and thus base agricultural protection on tariffs. Countries also committed to reducing tariffs and consequently reducing their support to agricultural producers. As a means to achieve policy objectives such as domestic price support, efficiency in agricultural marketing, a low-cost food supply, and stable farm prices, the existence of STEs makes the distortions implicit. Concerns are aroused by the lack of transparency, exclusive export/import rights, and some financial benefits for STEs. Critics of state trading argue that the lack of price transparency or financial benefits from the government could be used to mask export subsidies or import tariffs, and that exclusive purchasing/selling rights in the domestic or on the world markets may be used by an STE as a reason to act as a monopsonist/monopolist.

State trading will likely continue as a contentious issue for many years. It is important for trade and policy researchers to make clear STEs’ trade effects and consequently to strengthen WTO rules governing STEs that will impose the necessary discipline on STEs. Although there have been many studies examining the distortionary effects of STEs, such as price discrimination, economic efficiency, welfare redistribution efficiency, or market leadership exerted by STEs, the results are contradictory. Most studies examining the market power of STEs always separate one STE from other STEs. Furthermore, in most empirical work the important distinctions between homogeneous and differentiated goods are typically ignored.
The purpose of this dissertation was to examine whether a dual STE-structure generates Stackelberg leadership capabilities in a differentiated product market. We focused on exclusive procuring and pricing policies, and whether STEs could utilize these as strategies to shift rent from other exporting countries. A conceptual two-stage model and an empirical framework were developed to evaluate these market possibilities. In addition, the model provides a framework to test if STEs set their initial payments at optimal levels.

The theoretical model in the research of this dissertation proposed endogenous control of an upstream supply in that STEs chose the initial prices of their raw commodities given that they competed in a downstream market of imperfect substitutes. The decision sequence consisted of a precommitment stage in which STEs chose initial prices followed by an output stage that determines prices, quantities and trade flows for the two STEs and a group of other exporters. We estimated the output stage by considering STE trade policy as a given shift parameter in the domestic marginal cost function. In the precommitment stage, we employed a subset of the output stage results to characterize the value of the trade policy parameter. Under the assumption of Cournot competition, we developed the model to feature the optimal initial payment levels. Then, we extended it to a conjectural variations model to capture the reaction of firms to the quantity changes of other firms. Besides the construction of a framework to examine the optimal initial payment levels, we also set up a framework to test whether STEs could utilize their initial payments to shift rent from other firms under a product differentiated scenario.

A normalized quadratic distance function was used to derive inverse demand relationships to identify the derivatives necessary for the estimation of market power parameters in the conjectural variations models. We applied a Bayesian approach to jointly estimate the inverse demand and conjectural variation relationships. The data for this study were from 1976/7 to 1997/8. Because of the difficulty of obtaining f.o.b. prices for both the CWB and the ABB, the average pooled prices were used as substitutes. World malting barley export data were not directly available from any source and had to be constructed through a series of steps involving feed barley trade flows, assumptions about various importing regions, and other factors. Results from the Bayesian approach indicated that all market power parameters were not significant, suggesting that the CWB, the ABB, and the other exporting countries did not consider the output changes of their rivals. Because the output stage results could be consistent with a static Cournot equilibrium with or without a precommitment, it was important to examine further the precommitment stage for any evidence of rent shifting activity. Two independent analyses were conducted. First, the bootstrap test results showed that both the CWB and the ABB set their initial payments higher than the optimal levels. Second, using a Wilcoxen signed rank test of the optimal initial prices and the observed ones, we rejected the hypothesis for both STEs that the paired data were similar. Thus, a consistent conclusion emerges. It appears that while support for an imperfectly competitive market was found, there is no causal evidence linking the market structure to the prepayment systems in Canada or Australia.

To test robustness of the Bayesian results, a nonlinear SUR model was also estimated. Nonlinear SUR and the Bayesian results are similar in the sense that all conjecture variations are insignificant, optimal initial payments are lower than observed values, and rent shifting effects are insignificant. However, they differ in magnitudes and significance of some parameter estimates. As O’Donnell, Rambaldi, and Doran discussed about the similarity and differences between the results of least squares and Bayesian method, the similarity between the nonlinear SUR results and Bayesian results is due to the use of a non-informative prior, while the differences are due to the fact that the variance of the marginal posterior p.d.f.s is large and subsequently, the variance of the MCMC sample mean is also large.

To provide additional verification of Cournot competition, a normalized likelihood ratio (LR) test for non-nested models was conducted. The test results showed that the Cournot model
was significantly better than the CWB leading model. The test results also showed that the data did not enable me to discriminate among the Cournot model, the ABB leading model, and the CWB and the ABB collusive model. This result provided a support to the specification of market structure by both the Bayesian and nonlinear SUR methods.

In this study, a conceptual two-stage model and an empirical framework was developed to evaluate if a dual STE-structure generates Stackelberg leadership capabilities in a differentiated product market or if STEs use exclusive procuring and pricing policies as strategies to shift rent from other exporting countries. Parametric and semi-nonparametric methods provide consistent conclusions in the sense of providing the same economic findings on market structure, optimal initial payment tests, and rent shifting test. Consistency between the parametric and semi-nonparametric methods, as well as a myriad of other hypothesis tests, demonstrated robustness.

Based on the conceptual model framework, data, and subsequent empirical results, important conclusions were reached. First, the STEs did not have market leadership in the differentiated global malting barley market. Both STEs and other exporting countries were in Cournot competition. Hamilton and Stiegert (2002) also found that the CWB was in Cournot competition with the other export sector in a homogeneous market. But unlike this study, they found support for rent-shifting and leadership outcomes for the STE. With product differentiation, firms rationally ignore rival behavior more than when products are the same and we would naturally tend to observe the Cournot –Nash equilibrium in such cases. This result is also consistent with Varian’s game theory model that the unique subgame perfect equilibrium in the finitely-repeated quantity-setting game is the repeated one-shot Cournot.

Second, both STEs were not setting their initial payments at optimal levels and did not shift rent from other exporting countries by utilizing a prepayment system as a precommitment. Both STEs set their initial payments higher than profit maximization levels. In addition, the effect of rent shifting by lowering initial payments was not significant. This is different from results under the assumption of product homogeneity. In Cournot competition, under product differentiation, rent shifting effects also depends on cross-price effects. In the world malting barley market, due to product differentiation, geographic effect, and output shocks from weather condition, etc, the rent shifting effects by using initial payment as a precommitment tool were dampened. Therefore, there is no urgent need to impose disciplines on STEs’ prepayment system.

**Figure 1: Two-Stage Structure Used by STEs**

![Diagram of Two-Stage Structure Used by STEs]

- Precommitment Stage
  - $w_i$
  - Max Producer’s Profit: $\max_{\pi p} \Rightarrow w_i^*$
- Output Stage
  - STEs’ Profit: $\max_{\pi i} \Rightarrow x_i(x_1, x_2, \Psi_i)$
  - Backward Induction
Table 1: Summary Statistics of Data

<table>
<thead>
<tr>
<th></th>
<th>CWB</th>
<th>ABB</th>
<th>ROW</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Max</td>
<td>Min</td>
</tr>
<tr>
<td>Exports (000 tonnes)</td>
<td>551.4</td>
<td>1423.0</td>
<td>52.8</td>
</tr>
<tr>
<td></td>
<td>(435.7)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Realized Prices</td>
<td>169.1²</td>
<td>243.2</td>
<td>106.6</td>
</tr>
<tr>
<td></td>
<td>(34.2)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Initial Payments</td>
<td>143.5⁸</td>
<td>225.3</td>
<td>88.1</td>
</tr>
<tr>
<td></td>
<td>(32.7)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Differences between</td>
<td>25.6⁸</td>
<td>64.8</td>
<td>-16</td>
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<tr>
<td>Realized Prices and</td>
<td>(15.1)</td>
<td></td>
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</tr>
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</table>

² CN$/tonne
³ AUS$/tonne
⁴ US$/tonne
Table 2: Summary Statistics of Deflated Data

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<td></td>
<td>Mean</td>
<td>Max</td>
<td>Min</td>
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<tr>
<td>Exports (000 tonnes)</td>
<td>551.4</td>
<td>1423.0</td>
<td>52.8</td>
</tr>
<tr>
<td></td>
<td>(435.7)</td>
<td>(299.2)</td>
<td>(498.9)</td>
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<tr>
<td>Realized Prices ($/ton)</td>
<td>168.5</td>
<td>276.8</td>
<td>98.9</td>
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<td></td>
<td>(45.6)</td>
<td>(38.0)</td>
<td>(71.7)</td>
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<tr>
<td>Initial Payments ($/ton)</td>
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<td>197.1</td>
<td>80.9</td>
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<tr>
<td></td>
<td>(30.2)</td>
<td>(27.1)</td>
<td></td>
</tr>
<tr>
<td>Differences between Realized</td>
<td>27.8</td>
<td>117.3</td>
<td>-14.7</td>
</tr>
<tr>
<td>Prices and Initial Payments</td>
<td>(24.8)</td>
<td>(19.5)</td>
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</tr>
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</table>

5 Standard deviations are in parenthesis
6 1995 US dollar
Table 3 Estimations by Bayesian Approach

<table>
<thead>
<tr>
<th></th>
<th>Estimations</th>
<th>90% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Upper Critical Value</td>
</tr>
<tr>
<td>$b_1$</td>
<td>0.002497</td>
<td>0.004091</td>
</tr>
<tr>
<td>$b_2$</td>
<td>0.001855</td>
<td>0.003415</td>
</tr>
<tr>
<td>$b_{11}$</td>
<td>-0.000271</td>
<td>-0.000137</td>
</tr>
<tr>
<td>$b_{12}$</td>
<td>0.000104</td>
<td>0.000188</td>
</tr>
<tr>
<td>$b_{22}$</td>
<td>-0.000151</td>
<td>-0.000020</td>
</tr>
<tr>
<td>$b_{1y}$</td>
<td>-0.000112</td>
<td>-0.000015</td>
</tr>
<tr>
<td>$b_{2y}$</td>
<td>-0.000084</td>
<td>0.000031</td>
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<tr>
<td>$\lambda_{12}$</td>
<td>0.079667</td>
<td>0.922173</td>
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<tr>
<td>$\lambda_{13}$</td>
<td>0.243644</td>
<td>0.924215</td>
</tr>
<tr>
<td>$\lambda_{21}$</td>
<td>0.148368</td>
<td>0.922833</td>
</tr>
<tr>
<td>$\lambda_{23}$</td>
<td>0.113645</td>
<td>0.865411</td>
</tr>
<tr>
<td>$\lambda_{31}$</td>
<td>0.310498</td>
<td>0.928622</td>
</tr>
<tr>
<td>$\lambda_{32}$</td>
<td>0.210307</td>
<td>0.913470</td>
</tr>
</tbody>
</table>

Burn in period=300000. Sample size=300000.
Table 4 Flexibility Estimates for the Normalized Quadratic System with Bootstrapped 90% Percentile Confidence Intervals by Baysian Method

<table>
<thead>
<tr>
<th>Price Flexibilities</th>
<th>CWB</th>
<th>ABB</th>
<th>Others</th>
</tr>
</thead>
<tbody>
<tr>
<td>CWB</td>
<td>-0.375654</td>
<td>0.184540</td>
<td>0.128277</td>
</tr>
<tr>
<td>ABB</td>
<td>0.117519</td>
<td>-0.223369</td>
<td>0.015279</td>
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<tr>
<td>Others</td>
<td>0.258135</td>
<td>0.038829</td>
<td>-0.143556</td>
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</table>

<table>
<thead>
<tr>
<th>90% Confidence Interval</th>
<th>CWB</th>
<th>ABB</th>
<th>Others</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper Critical Value</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CWB</td>
<td>-0.269481</td>
<td>0.374614</td>
<td>0.217372</td>
</tr>
<tr>
<td>ABB</td>
<td>0.227182</td>
<td>-0.022769</td>
<td>0.034050</td>
</tr>
<tr>
<td>Others</td>
<td>0.378280</td>
<td>0.088843</td>
<td>-0.078087</td>
</tr>
<tr>
<td>Lower Critical Value</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CWB</td>
<td>-0.525619</td>
<td>0.005347</td>
<td>0.062732</td>
</tr>
<tr>
<td>ABB</td>
<td>0.005328</td>
<td>-0.405804</td>
<td>-0.004123</td>
</tr>
<tr>
<td>Others</td>
<td>0.139781</td>
<td>-0.017990</td>
<td>-0.224788</td>
</tr>
</tbody>
</table>
Table 5: Estimates for Hypothesis Test $H_0: w_i^*-w_i=0$.

<table>
<thead>
<tr>
<th></th>
<th>Mean ($/1,000$ tonnes)</th>
<th>90% Confidence Interval</th>
<th>Upper Critical Value</th>
<th>Lower Critical Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$w_1^*-w_1$</td>
<td>-986.20073</td>
<td>-520.834028</td>
<td>-1559.972451</td>
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<tr>
<td>$w_2^*-w_2$</td>
<td>-911.60901</td>
<td>-677.651146</td>
<td>-1238.587726</td>
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</tr>
</tbody>
</table>

Table 6: Hypothesis Test that STEs Could Shift Rents from Other Exporting Countries

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>90% Confidence Interval</th>
<th>Upper Critical Value</th>
<th>Lower Critical Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\partial \pi_2 / \partial w_1$</td>
<td>-136.598382</td>
<td>529.959885</td>
<td>-772.610211</td>
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<tr>
<td>$\partial \pi_3 / \partial w_1$</td>
<td>-367.176858</td>
<td>413.266564</td>
<td>-1220.533833</td>
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</tr>
<tr>
<td>$\partial \pi_1 / \partial w_2$</td>
<td>-256.966471</td>
<td>1266.988685</td>
<td>-1385.945852</td>
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</tr>
<tr>
<td>$\partial \pi_3 / \partial w_2$</td>
<td>-174.590446</td>
<td>1202.522449</td>
<td>-1614.541864</td>
<td></td>
</tr>
</tbody>
</table>

References


U.S. Department of Agriculture (USDA).


