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ALTERNATIVE OLIGOPOLISTIC STRUCTURES IN INTERNATIONAL COMMODITY MARKETS: PRICE OR QUANTITY COMPETITION?

by

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Abstract

It has been shown in new trade theory that trade taxes/subsidies may be optimal in the case of oligopolistic markets. This result has relevance for international commodity markets because there is growing evidence of imperfect competition in commodity trade. However, it has also been demonstrated that the optimal strategic trade policy depends on whether the market is distinguished by Bertrand (price) or Cournot (quantity) competition. We argue that commodity markets may be characterised by either form of imperfect competition and also by product differentiation. As an illustration, we present a set of models of the Japanese market for beef imports in which account is taken of various forms of strategic interaction between Australian and United States exports. The model which best fits the data is a Stackelberg model with price leadership by Australia. This result casts doubt on the approach taken in past empirical work on commodity markets in which quantity competition has been routinely imposed and it also suggests that if trade policy intervention is warranted, then export taxes may be preferred to export subsidies.

Key words: *strategic trade theory; imperfect competition; oligopolistic international commodity markets*

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1. Introduction

In new trade theory it has been suggested that there are possible reasons for government intervention in international markets based on either increasing returns or imperfect competition (Corden (1991); Baldwin (1992); Pomfret (1992)). Of all the elements of new trade theory, the one which generated the greatest interest was the profit-shifting strategic trade model of Brander and Spencer (1985). The result which Brander and Spencer obtained was that if the two exporting firms play a Cournot strategy with each other in a third-country market, then national welfare can be increased, relative to that with free trade, when one of the governments pre-commits to intervention and does so in the form of an export subsidy. This result was contrary to conventional thinking at that time, as the standard policy prescription for an exporting country with international market power was to impose an export tax as the welfare-raising form of intervention. Subsequently, it was shown by Eaton and Grossman (1986) that the Brander and Spencer conclusion was sensitive to the strategic variable used by the export firms. In particular, they showed that if the firms competed on price and played a Bertrand game, rather than a Cournot game, then an export tax was the optimal policy.[1]

The relevance of the counter-argument put forward by Eaton and Grossman to Brander and Spencer's policy prescription requires knowledge of the structure of the international market of interest. The empirical question of whether or not imperfectly competitive international markets are best characterised by either Cournot or Bertrand competition, or some other form of competition, is an interesting one that appears not to have received any attention. In addition, the important distinction between homogeneous and differentiated goods is often just ignored and homogeneity is assumed in empirical work. In particular, in the area of international commodity trade, there is little empirical evidence available on which to evaluate export policy intervention despite the early emphasis on imperfectly competitive market structures which pre-dated the new trade theory. Since at least the mid-1960s, research has been conducted on the competitive structure of the international wheat market. However, developments in new trade theory have enabled researchers to gain a better understanding of the nature of the strategic game being played in commodity markets. An understanding of strategic interaction is important if realistic models are to be developed with which to analyse international trade and trade policy in commodities; after all, products such as wheat, beef, wool, rice, vegetable oils, cheese and wine cannot be described as homogeneous, nor can international markets be described as being devoid of a few large trading entities. For example, Vanzetti and Kennedy (1989) argued that examples of market power can be found in international commodity markets such as those for wheat, meat and wine. It is also worth noting that export subsidies are a quite common feature for many of these commodities.

In this paper we argue that commodity markets may be characterised by either form of imperfect competition and, as an illustration, we present a set of models of the Japanese market for beef imports in which account is taken of various forms of strategic interaction between Australian and United States exporters. The model which best fits the data is a Stackelberg model with price leadership by Australia. This result casts doubt on the approach taken in past empirical work on commodity trade in which quantity competition has been routinely imposed and it also suggests that if trade policy intervention is warranted, then export taxes may be preferred to export subsidies.

2. Imperfect Competition in International Commodity Markets

Papers written in the 1960s and 1970s in which it was argued that the international grain market is imperfectly competitive were reviewed by Kolstad and Burris (1986).[2] They observed that there were more non-zero bilateral wheat trade flows than a perfectly competitive model would predict. Assuming wheat to be homogeneous and using a spatial equilibrium model, they then tested alternative hypotheses regarding market structures and concluded that a Canadian-U.S. duopoly model was the most appropriate market structure with which to characterise the international wheat market. In the spirit of new trade theory, Thursby (1988) developed a commodity model in which a statutory marketing board in one country and private exporters in a second, were Cournot rivals in a third. She attempted to determine whether or not Brander-Spencer type export subsidies could be welfare improving, given the nature of imperfect competition that exists in international commodity markets. She demonstrated theoretically that the optimal trade policy for the home country changes from an export subsidy to an export tax when there is more than one exporting firm.[3] Thursby considered the implications for United States' wheat policy and concluded that an export tax would make more sense than an export subsidy. In an empirical exercise, Anania, Bohman and Carter (1992) also considered the applicability of the export subsidy argument to the United States' wheat market and concluded that a U.S. export subsidy for wheat would not lead to welfare gains for the United States.

There are some recent papers in which *new empirical industrial organisation* (NEIO) methods have been applied to global commodity markets. In these studies, the Cournot non-cooperative oligopoly model with homogeneous products has been employed as the standard approach (Karp and Perloff (1989 and 1993), Buschena and Perloff (1991), and Love and Murniningtyas (1992)). Key results from these four studies are reported in Table 1.

[Table 1 about here]

Karp and Perloff (1989) modelled the international rice market as a dynamic oligopoly, with China, Pakistan, and Thailand as oligopolists facing an exogenous fringe of other exporting nations. Their simulation model allowed them to distinguish between collusion, Nash-Cournot competition, and price taking. They found that the market structure is close to price taking but with some degree of imperfect competition. Rice output levels are found to be between 6 per cent and 14 per cent below pure price-taking levels. Buschena and Perloff (1991) estimated the degree of market power exercised by the Philippine coconut authority (a statutory marketing agency) in the world market for coconut oil. They allowed the degree of market power to vary over time as a function of institutional and legal changes. A three-equation dominant firm and competitive fringe model was used and they found that the Philippine exporting agency exercised a substantial amount of market power in the global market. The Lerner index (markup of price over marginal cost) was estimated to be 0.89 following the creation of the statutory agency. Love and Murniningtyas (1992) focused on Japanese buying behaviour in the international wheat market and measured the monopsony market power of the Japanese Food Agency. They estimated econometrically excess supply and demand functions, with nested hypotheses for testing market power and found that the Japanese Food Agency exercised a high degree of monopsony power in the world wheat market. Using a dynamic model similar to that in their rice paper, Karp and Perloff (1993) studied the world coffee market, with Brazil and Colombia modelled as potential oligopolists. The rest of the world's exporting countries were treated as a fringe. They found the market structure to be close to that of price taking, with some imperfect competition as coffee exports are 6 per cent to 13 per cent below that expected if Brazil and Colombia were pure price takers. If the results presented in Table 1 are accepted as being plausible, then what do they imply for strategic trade policy? In each of the studies, the market structure is assumed to be characterised by quantity competition and thus the findings of less than perfect competition imply that export subsidies may be optimal (except in the case of Japanese wheat imports).

In these recent applications of the NEIO literature to commodity trade it has been assumed routinely, with little justification, that quantity-setting behaviour exists. The quantity-setting assumption is more convenient than the alternative of price setting because imperfect competition in prices implies differentiated products, if the Bertrand paradox is to avoided. However, assuming that there exist oligopolistic international markets for some commodities, it is difficult to know, *a priori* , whether these markets are characterised by firms adopting a price- or a quantity-setting strategy. Theoretically, there are reasons to expect either type of behaviour, depending on market and cost conditions. For example, in some markets, such as the Japanese market, commodity imports are not necessarily procured from the lowest cost supplier. For beef and wheat, it has been argued that there exist implicit bilateral import quotas, with the United States given the greatest share of the global quota (Alston, Carter and Jarvis, 1990). Wolak and Kolstad (1991) examined Japanese imports of coal and argued that Japan imports from a variety of countries in order to diversify risk and does not necessarily minimise the cost of imports. If the Japanese "manage" imports and pre-determine quantities to be imported from each source, then exporting firms would find it optimal to set prices rather than quantities. Alternatively, the use of price rather than quantity as the strategic variable might be determined by the nature of the commodity in question rather than the destination market. *Ceteris paribus*, it might be expected that there would be price competition for commodities which can be stored at relatively low cost (e.g. rice, wheat and coal) because there is no reason that current production need be sold during the current period. This outcome is especially true in the short-run. However, quantity might be the decision variable in those cases where a product is perishable and production is fixed in advance of sales (e.g. fresh flowers, fruits and vegetables). Similarly, if the production period covers a long time period (e.g. tree crops) or storage costs are exceptionally high (e.g. dairy products), then marketed quantity is more likely to be the decision variable.

3. The Model

It has been argued in the previous Section that the imposition, *a priori*, of Cournot competition is inappropriate. The strategic interaction between firms, including state trading agencies, will vary from commodity to commodity and from market to market. In this Section a model is specified for the Japanese market for imported beef, and evaluated statistically using methodology developed by Gasmi *et al.* (1992). In order to simplify the analysis, exports of beef from the United States and Australia are modelled, whilst exports from other sources, e.g. Canada and New Zealand, are ignored. This simplification is justified because the United States and Australia supply over 95 per cent of the market. Beef imports from these two sources are simplified further by assuming only two categories, namely, grain-fed beef from the United States and grass-fed beef from Australia. Therefore, Japanese beef imports are treated as a differentiated product. Quarterly data were used from 1973 through 1990, for a total of seventy-two observations. Japanese import volume and value data for total meat (including fresh, chilled and frozen beef) were obtained from "Japan Exports and Imports" published by the Japanese Ministry of Finance. All other data were obtained from the IMF "International Financial Statistics" or from the IMF "Supplements on Price Statistics". Japanese income and all prices are expressed in real terms.

The approach taken in what follows is to develop a general structural econometric model of the export duopoly and then to test for the type of strategic interaction which is consistent with the data. Each non-cooperative game structure investigated is nested in a general linear model through the use of cross-equation restrictions. However, the statistical testing of each type of strategic behaviour requires the use of a test for non-nested models because the models are non-nested with respect to each other. A suitable test for such models has been constructed recently by Vuong (1989) and its use demonstrated by Gasmi *et al.* It should be emphasised that the specified models ought to be regarded as illustrative and not definitive models of the Japanese market for imported beef.

The six non-cooperative structures chosen for investigation can be divided into those based on price as the strategic variable and those based on quantity. The three price-based models are Bertrand, and Stackelberg in prices with leadership by either the United States or Australia. The three quantity-based models are Cournot, and Stackelberg with quantity leadership by either country. There are, of course, many other forms of non-cooperative models which could have been specified as well as cooperative models involving collusive behaviour. However, it was assumed that it would be unlikely for export firms in Australia and the United States to collude in the Japanese market and, thus, collusive models were not specified. The standard approach in the NEIO literature is to specify a structural econometric model of the duopoly which comprises demand functions for each firm and the first-order conditions for profit maximisation under the appropriate strategic interaction. This approach has been employed in specifying the following models.

3.1 Price Models

Assume initially that the strategic variable is price. Let the export demand function facing the United States (u) and Australia (a) be:

$$q_i = \beta_{i0} + \alpha_{ii} p_i + \alpha_{ij} p_j + \beta_{i1} y, \quad i, j = u, a, \ i\_j, \qquad (1)$$

where q_i is the quantity of beef exported to Japan from country i, p_i is the price in Yen of country i's exports, y is Japanese per capita income, and β_{ik} ($k = 0, 1$) and the α s are unknown parameters.

Each exporter's total cost function is taken to have the simple form:

$$C_i(q_i) = c_i q_i, \quad i = u, a, \tag{2}$$

where c_i represents the marginal/average cost of the i^{th} exporter. In the econometric model presented below, c_i is expanded to include terms involving specific exogenous variables which account for costs of production.

The profit function for exporter i is given by:

$$\Pi_i(p_i) = (p_i - c_i)q_i, \quad i = u, a. \tag{3}$$

The conditions for profit maximisation depend on the strategic structure of the game. For the Bertrand-Nash equilibrium, (p_u^b, p_a^b), the first-order conditions for profit maximisation are given by:

$$(p_i^b - c_i)\alpha_{ii} + q_i = 0, \quad i = u, a. \tag{4}$$

The Stackelberg leader equilibrium, (p_u^{su}, p_a^{su}), in which the United States is assumed to be the leader, is obtained by substituting the reaction function for Australia, $p_a = R_a(p_u)$, into the profit function for the United States and maximising with respect to p_u. The equilibrium for Australia, as the follower, is derived as in the Bertrand-Nash case. Hence, the profit-maximising conditions for the Stackelberg equilibrium with price leadership by the United States is given by:

$$(p_u^{su} - c_u)\left(\alpha_{uu} - \frac{\alpha_{ua}\alpha_{au}}{2\alpha_{aa}}\right) + q_u = 0 \tag{4.1}$$

$$(p_a^{su} - c_a)\alpha_{aa} + q_a = 0. \tag{4.2}$$

For the case in which Australia is the price leader, the equilibrium is of the same form but with the subscript $a(u)$ replacing u (a).

3.2 *Quantity Models*

Assume now that the strategic variable is quantity exported. Then let the inverse demand function for each country be

$$p_i = \gamma_{i0} + \delta_{ii} q_i + \delta_{ij} q_i + \gamma_{i1} y, \quad i, j = u, a, \quad i\_j, \tag{1'}$$

where p and q are as defined above, and the γ s and δs are unknown parameters. Each exporter's profit function is now:

$$\Pi_i(q_i) = (p_i - c_i)q_i, \quad i = u, a, \tag{3'}$$

and the unique Cournot-Nash equilibrium, (q_u^c, q_a^c), is

$$(p_i - c_i) + \delta_{ii} q_i^c = 0, \quad i = u, a. \tag{4'}$$

The Stackelberg leader equilibrium, (q_u^{su}, q_a^{su}), in which the United States is assumed to be the leader, is obtained by substituting the Australian reaction function, now defined in terms of quantity, into the profit function for the United States and maximising with respect to q_u. The equilibrium for Australia, as the follower, is derived as in the Cournot-Nash case. Hence, the Stackelberg equilibrium with the United States as the quantity leader is given by:

$$(p_u - c_u) + \left(\delta_{uu} - \frac{\delta_{ua}\delta_{au}}{2\delta_{aa}} \right) q_u^{su} = 0 \tag{4.1'}$$

$$(p_a - c_a) + \delta_{aa} q_a^{su} = 0. \tag{4.2'}$$

When Australia is the Stackelberg leader in quantity, the equilibrium has the same form but the subscript *a(u)* replaces the subscript *u(a)*.

These six alternative models, namely, Bertrand [equations (1) and (4)], Stackelberg in price [equations (1), (4.1) and (4.2)], Cournot [equations (1') and (4')], and Stackelberg in quantity [equations (1'), (4.1') and (4.2')], can now be consolidated and presented in a general linear simultaneous equation econometric model of the following form:

$$\begin{bmatrix} \lambda_{11} & \lambda_{12} & \lambda_{13} & \lambda_{14} \\ \lambda_{21} & \lambda_{22} & \lambda_{23} & \lambda_{24} \\ \lambda_{31} & 0 & \lambda_{33} & 0 \\ 0 & \lambda_{42} & 0 & \lambda_{44} \end{bmatrix} \begin{bmatrix} q_{ut} \\ q_{at} \\ p_{ut} \\ p_{at} \end{bmatrix} - \begin{bmatrix} \theta_1 \\ \theta_2 \\ \lambda_{33} c_u \\ \lambda_{44} c_a \end{bmatrix} = \begin{bmatrix} u_{1t} \\ u_{2t} \\ u_{3t} \\ u_{4t} \end{bmatrix}, \tag{5}$$

where the terms u_{it}, $i = 1, 2, 3, 4$, are the assumed jointly normally distributed error terms with covariance matrix Σ. The cross-equation restrictions imposed on the λs by each model are given in the Appendix.

In order to investigate the identification of this general model, equation (5), identification of which is sufficient for identification of each of the six nested models (Gasmi *et al.*, 1992), it is necessary to complete the specification of the variables θ_i, i = 1, 2, and to make the marginal cost functions, c_u and c_a, explicit. For simplicity, let

$$c_i = \eta_{i1}G_i + \eta_{i2}I_i, \; i = u, a,$$

where G_i is the price of corn in country i and I_i is the interest rate. θ_i , $i = u, a$, represents the intercepts and the demand shift variable in equation (1), namely, $\beta_{i0} + \beta_{i1}y$ for the price models, and $\gamma_{i0} + \gamma_{i1}y$ in equation (1') for the quantity models.

To select among the six models which are implicit in equation (5), the test proposed by Vuong (1989) is used to provide pair-wise comparisons for the fifteen non-nested hypotheses. This test is based on the likelihood ratio (LR) principle but it has been formulated in such a way that in the pair-wise comparison, neither model needs to be correctly specified for the results of the test to be valid (Gasmi *et al.*, 1992, p.286). For each of the fifteen pairs of comparisons, (f, g), the likelihood ratio is calculated as $2(L_f - L_g)$ and normalised by

$$n^{-\frac{1}{2}}\hat{\omega}_n = \frac{1}{2}\left[\sum_{t=1}^{n}(\hat{u}'_{ft}\hat{\Sigma}_f^{-1}\hat{u}_{ft} - \hat{u}'_{gt}\hat{\Sigma}_g^{-1}\hat{u}_{gt})^2\right]^{\frac{1}{2}},$$

where L_s is the log likelihood and u_s and Σ_s are the estimated residuals and covariance matrix for model s, $s = f, g$. Under the null hypothesis that each model fits the data equally well, the normalised LR is asymptotically distributed as a standard normal variable. The decision rules for the test are: first, if the absolute value of the normalised LR statistic is less than the appropriate critical standard normal value, at some level of significance, then it is not possible to discriminate between the two models; and second if the test statistic is less (greater) than the appropriate negative (positive) critical value, then it is concluded that model M_g (M_f) is significantly better.

4. Results

Equation (5) was estimated for each of the six models using quarterly data for the period 1973:1 to 1990:4. The estimator used was the full information maximum likelihood (FIML) option in TSP which permitted the necessary cross-equation restrictions to be imposed (as shown in the Appendix). The results for the price models are shown in Table 2 and those for the quantity models in Table 3. It should be noted that there were no *a priori* sign restrictions imposed on the parameter estimates.

For the *Bertrand* model (Table 2), the signs in both of the demand functions are those to be expected, the own-price coefficients are significantly different from zero and there is a significant income effect for meat from the United States, although not from Australia. For the cost terms in the first-order conditions the signs are correct, because the negative signs imply that the η s are positive as they have to be if increases in the price of feed inputs or interest rates are to raise marginal costs.. Similar results, with respect to the slope coefficients, are obtained for the Stackelberg model with leadership by the United States The log likelihood statistics are very similar. The own-price elasticities of demand for United States and Australian meat, at the point of means, are -3.0 and -2.6, respectively, for the Bertrand model, the corresponding estimates for the Stackelberg model with United States leadership are -3.3 and -1.7 and for Australian leadership are -12.7 and -10.3. For the *Stackelberg* model with price leadership by Australia, the results are not as satisfactory in a qualitative sense as those for the Bertrand model. However, the likelihood function has a smaller absolute value. The estimated income elasticities of demand for United States beef from the three models are 8.7, 7.6 and -29.3, respectively, and for Australian beef, the corresponding estimates are 1.7, 0.3 and 15.9.

[Table 2 about here]

Overall, the results for the *Cournot* model (Table 3) do not make as much economic sense as do those of the price models. Although the signs of the parameter estimates for the quantity variables in the demand functions are correct, the sign on the income term is not. In the cost equations, the sign on the feed cost coefficient is correct and significantly different from zero but the sign on the interest rate variable in both equations is incorrect. In comparing the Cournot results with those of the Stackelberg equation with leadership by the United States, there are substantial changes to the orders of magnitude of some of the coefficients. For example: the own-quantity coefficient changes from -2.47 to -75.9 and becomes statistically insignificant; the income term in both demand equations changes sign and order of magnitude; and the sign on the interest rate variable also alters to be correct and it becomes significant. The comparisons between the results for the model in which Australia is the Stackelberg quantity leader with those of the other two models are also mixed. Finally, the likelihood statistics for the Cournot and US Stackelberg models are equal and smaller in absolute value than the likelihood statistics for the Australian Stackelberg model.

[Table 3 about here]

The values of the normalised likelihood ratio statistics are shown in Table 4. The statistics have been calculated as the model in the row minus the model in the column. Hence, a negative sign implies that the column model is preferred to the row model. Using a level of significance of 0.05 and a two-sided test, the critical values of the standard normal variable are -1.96 and 1.96. Amongst the price models (*M1* - *M3*), the Bertrand model is significantly inferior to the Stackelberg model with leadership by the United States which, in turn is significantly inferior to the Stackelberg model with price leadership by Australia. Amongst the quantity models (*M4* - *M6*), there is no significant difference between the Cournot model and the Stackelberg model with leadership by the United States. However, both of these models are significantly better than the Stackelberg model with Australian leadership. Finally, the best of these models is the Stackelberg model with price leadership by Australia. Using a two-sided test, this model is significantly better than all of the other models at a level of significance of 0.05, with the exception of the comparison with model *M4* in which it is significantly better at a level of significance of 0.10.

[Table 4 about here]

5. Conclusion

In new trade theory it has been shown that it matters considerably whether an oligopolistic market is characterised by price or quantity setting. One purpose in this paper was to relate these findings to trade in international commodity markets where there is some evidence of imperfect competition. However, it was obvious that in most empirical work on oligopolistic competition in global commodity markets the importance of theoretical findings in new trade theory has been overlooked. In past empirical papers in which the degree of international competitiveness has been tested, the assumptions of homogeneous products and quantity competition have been routinely imposed. Any evidence of imperfect competition thus implies that commodity export subsidies may be optimal trade strategies.

We have argued that the assumptions of product homogeneity and quantity competition may be inappropriate for some commodity markets. Using the Japanese market for imported beef as an illustration, we tested the competing hypotheses of price versus quantity setting. Six, non-collusive and non-nested models were specified for which the strategic variable was price in three of the models and quantity in the remaining three. On the basis of the statistical test used, it was found that amongst these models, the one which best fitted the data was a Stackelberg model with price leadership by Australia. The optimal trade strategy would then be an export tax rather than an export subsidy.

Table 1: Summary of Studies of Market Power in International Commodity Markets

Study	Commodity	Key finding
Karp and Perloff (1989)	rice	Thailand, Pakistan and China are close to price takers
Buschena and Perloff (1991)	coconut oil	Philippines exercises substantial market power
Love and Murniningtyas (1992)	wheat	Japan exerts monopsony power
Karp and Perloff (1993)	coffee	Brazil and Colombia are close to price takers

Table 2: Parameter Estimates for the Price Models

	Bertrand		Stackelberg leader			
			US		*Australia*	
Parameter[a]	Estimate	t- statistic	Estimate	t- statistic	Estimate	t- statistic
β_{10}	-575.15	-1.67	-555.27	-1.20	1788.40	1.47
α_{11}	-0.28	-2.02	-0.31	-2.11	-1.21	-3.20
α_{12}	0.17	0.35	0.37	0.84	3.96	1.45
β_{11}	3.87	2.30	3.38	1.49	-13..06	-1.19
β_{20}	89.43	0.13	41.42	-0.05	-2294.42	-0.42
α_{21}	0.30	0.60	0.45	1.33	1.29	0.43
α_{22}	-0.89	-3.53	-0.57	-3.14	-3.52	-0.36
β_{21}	1.66	0.31	0.30	0.06	15.18	0.39
$\lambda_{33} \cdot \eta_{11}$	-37.63	-1.27	-42.22	-1.45	-333.61	-3.07
$\lambda_{33} \cdot \eta_{12}$	-6.89	-1.13	-4.48	-0.96	-17.87	-1.20
$\lambda_{33} \cdot \eta_{22}$	-26.00	-2.75	-11.00	-1.35	-3.26	-0.68
Log likelihood	-1774.72		-1770.59		-1739.48	

Note: a - In the Australian marginal cost function, the price of corn variable was omitted and, therefore, the parameter η_{21} was set to zero. In addition, the individual parameters, η_{11}, η_{12} and η_{22}, in the cost functions were not estimated separately, although estimates of their values and standard errors can be recovered.

Table 3: Parameter Estimates for the Quantity Models

	Cournot		Stackelberg leader			
			US		*Australia*	
Parameter[a]	Estimate	t- statistic	Estimate	t- statistic	Estimate	t- statistic
γ_{10}	51.46	0.02	-31380	-0.44	-503.25	-0.19
δ_{11}	-2.47	-1.64	-75.93	-0.47	-4.05	-3.27
δ_{12}	33.73	0.75	12.48	0.82	9.15	0.67
γ_{11}	-27.32	-0.58	171.07	0.43	-0.16	-0.01
γ_{20}	-5469.37	-0.69	2702.78	0.42	-536.42	-0.66
δ_{21}	-13.38	-0.72	7.19	0.50	-0.02	-0.06
δ_{22}	-3.84	-3.09	-1.64	-5.41	-1.61	-0.32
γ_{21}	37.52	0.85	-11.53	-0.32	6.73	0.84
η_{11}	327.06	9.04	280.60	7.54	204.72	3.34
η_{12}	-25.25	-1.14	-9.52	-0.53	-2.41	-0.09
η_{22}	-18.94	-0.84	18.18	3.62	15.82	1.11
Log likelihood	-1745.75		-1746.23		-1768.05	

Note: *a* - See Note *a* for Table 2.

Table 4 Normalised LR Statistics

	M2[a]	*M3*	*M4*	*M5*	*M6*
M1	-2.69	-6.24	-6.14	-8.30	-3.50
M2		-6.17	-5.80	-7.29	-1.72
M3			2.00	1.69	5.18
M4				0.21	5.14
M5					7.07

Note: a --The models are: *M1* - Bertrand; *M2* - Stackelberg with US price leadership; *M3* - Stackelberg with Australian price leadership; *M4* - Cournot; *M5* - Stackelberg with US quantity leadership; and *M6* - Stackelberg with Australian quantity leadership.

Appendix

The six, non-collusive models differ with respect to the cross-equation restrictions which they impose on the parameters of the four endogenous variables of the models. The general model is presented in equation (5) in which the matrix of λs represents the parameters for the endogenous variables of the models nested within it. The structure of that matrix is shown for each model in the following Table.

[Appendix Table here]

Appendix Table 1

λ	*M1*[a]	*M2*	*M3*	*M4*	*M5*	*M6*
λ_{11}	1	1	1	$-\delta_{uu}$	$-\delta_{uu}$	$-\delta_{uu}$
λ_{12}	0	0	0	$-\delta_{ua}$	$-\delta_{ua}$	$-\delta_{ua}$
λ_{13}	$-\alpha_{uu}$	$-\alpha_{uu}$	$-\alpha_{uu}$	1	1	1
λ_{14}	$-\alpha_{ua}$	$-\alpha_{ua}$	$-\alpha_{ua}$	0	0	0
λ_{21}	0	0	0	$-\delta_{au}$	$-\delta_{au}$	$-\delta_{au}$
λ_{22}	1	1	1	$-\delta_{aa}$	$-\delta_{aa}$	$-\delta_{aa}$
λ_{23}	$-\alpha_{au}$	$-\alpha_{au}$	$-\alpha_{au}$	0	0	0
λ_{24}	$-\alpha_{aa}$	$-\alpha_{aa}$	$-\alpha_{aa}$	1	1	1
λ_{31}	1	1	1	δ_{uu}	$\delta_{uu} - \delta_{au}\delta_{ua}/2\delta_{aa}$	δ_{uu}
λ_{33}	α_{uu}	$\alpha_{uu} - \alpha_{ua}\alpha_{au}/2\alpha_{aa}$	α_{uu}	1	1	1
λ_{42}	1	1	1	δ_{aa}	δ_{aa}	$\delta_{aa} - \delta_{au}\delta_{ua}/2\delta_{uu}$
λ_{44}	α_{aa}	α_{aa}	$\alpha_{aa} - \alpha_{ua}\alpha_{au}/2\alpha_{uu}$	1	1	1

Note: a --The models are: *M1* - Bertrand; *M2* - Stackelberg with US price leadership; *M3* - Stackelberg with Australian price leadership; *M4* - Cournot; *M5* - Stackelberg with US quantity leadership; and *M6* - Stackelberg with Australian quantity leadership.

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Endnotes

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1 Dixit (1987) pointed out that the policy implications found in this literature may also be relevant for small countries, especially in those cases where market power exists because of product differentiation. The specific nature of the international strategic interaction, (e.g. whether an oligopolistic market is characterised by price or quantity competition), is particularly important because small countries are poorly placed to play quantity-setting games but may be well placed for Bertrand price-setting games. He also argued that the ideal situation for a small country is one in which there is a large country that can act as a price leader (i.e. there is an asymmetry between countries or firms). In this type of Stackelberg game the leader knows the response of the follower and chooses a price to which the follower reacts.

2 See McCalla and Josling (1981) for further evidence of imperfect competition in commodity trade.

3 This is an important limitation of the Brander-Spencer argument, namely that the optimal policy may shift from being an export subsidy to being an export tax if there is more than one exporter in the home country. There are other limitations identified once some general equilibrium structure is imposed.

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