ABARE CONFERENCE PAPER 92.10

Wheat export cartels

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36th Annual Conference of the Australian Agricultural Economics Society
Australian National University, Canberra
10–12 February 1992

Under general assumptions, global welfare is maximised if all countries follow a free trade policy. However, each country with the ability to influence the world price would increase its own welfare by imposing optimal trade taxes, at least so long as other countries did not do likewise. A number of exporters possess market power in the international wheat market. Game theory is here used to assess the scope for counteracting such policies by these exporters through cooperative behaviour among less powerful exporters.

A non-spatial, static, linear trade model, in which policies are set to maximise a welfare function, is used to examine the effects of various forms of wheat export cartel. In the welfare function, the weights attached the welfare of producers, consumers and taxpayers, can be varied. The results suggest that the optimal trade tax for any one country is only marginally affected by retaliatory action by other exporters, and hence that the scope for collective action is limited.

1 This research was carried out while the author was a visiting lecturer at the Department of Agricultural Economics, The University of Western Australia, Nedlands 6009, Western Australia. Financial assistance from the Grains Research and Development Corporation is gratefully acknowledged.

Project 8131.102

Introduction

Free trade is a policy more commonly espoused than adhered to. One reason for this is that, under certain circumstances, a trading nation can increase its own welfare by imposing trade barriers. For countries with the ability to influence world prices, positive trade taxes are an optimal policy if rivals do not respond by implementing their own barriers, and may also be optimal even if rivals do respond.

Global welfare is maximised if all countries follow a free trade policy. However, each country with the ability to influence the world price has an incentive to 'free ride' by setting optimal trade taxes. To provide assurance that all or most countries abide by an agreement on free trade policies cooperation is required, otherwise the outcomes will be undesirable for all countries. If it is not in any country's interest to reduce trade barriers unilaterally, even though the benefits of collective action are clear, then in the absence of enforceable and binding agreements a second-best global welfare outcome will result.

Issues of coordination, cooperation and strategic interactions can be analysed using game theory. The main objective in this paper is to assess, using game-theoretic techniques, the scope for cooperative behaviour to counterbalance market power in the international wheat market. Of particular interest is the potential for coordination at a regional level, through the formation of a cartel, to offset the market power of large traders.

The application is illustrative rather than definitive, because of the simplistic nature of the static, deterministic, linear model employed, excluding as it does the holding of stocks. Questions concerning the validity of the model limit the conclusions that can be drawn from the results. It is the qualitative results, rather than the specific magnitudes of welfare gains and losses, that provide the basis for policy conclusions.

To analyse cooperative behaviour, a non-spatial trade model is specified. Policies are set so as to maximise a welfare function in which varying weights can be attached to the welfare of producers, consumers and taxpayers. In setting policy, other countries' reactions are taken into account. The interdependence between policies is thus modelled. Different assumptions regarding the degree and nature of cooperation lead to different equilibrium solutions.

In the next section some game-theoretic concepts are introduced. Following a brief discussion of cartels, a mathematical model is described, and data and results are then presented. Policy implications and conclusions are drawn in the final section.

A game-theoretic framework

Cooperation and conflict can be analysed using game theory. Game-theoretic solutions or equilibriums take into account interdependencies between the actions of the various players. Such interdependencies occur when a change in one player's policy leads to a change in another player's payoff (welfare). For example, imposing a tariff or subsidy in one country not only changes other countries' welfare but may also change their optimum policies. Game theory takes these interdependencies into account. A review of the use of game theory in economics can be found in Schotter and Shwodiauer (1980). McMillan (1986) reviews applications of game theory to international economics.

Game-theoretic outcomes or equilibria depend on the assumptions adopted relating to player behaviour. A commonly used equilibrium is Cournot–Nash. This is defined as an equilibrium from which no player would want to move, given that all others are following their optimum strategies. Each player attempts to maximise the payoff taking as given the actions of the other players. Except at equilibrium, other players' actions do change, and a convergence towards the solution occurs. The Cournot–Nash equilibrium subsumes the dynamics involved in moving from one equilibrium to another.

There are a variety of alternative equilibria, of which the most popular are 'conjectural variations', in which each player has expectations (conjectures) concerning how its rivals will vary their policy, and the Stackelberg solution, which is characterised by a hierarchical structure and a leader which makes a decision after it has observed its rivals' decisions. The first alternative requires that the modeller specify or estimate the numerous conjectures. The second requires idendification of a leader. Both of these may be somewhat arbitrary.

A Cournot–Nash equilibrium may be illustrated in the case of a two-player, non-zero-sum, single-shot, bi-matrix game characterised by asymmetric payoffs. Suppose two players (*A* and *B*) can set either optimal (welfare maximising) tariffs (*T*) or follow a free trade strategy (*F*). Of the four possible outcomes (designated F_AF_B, F_AT_B, T_AF_B, and T_AT_B), the free trade solution, F_AF_B, is globally optimal. Assume that the various strategies lead to payoffs as shown in table 1, in which country *A*'s payoff is the first of each pair shown.

The asymmetric payoffs characterise players having unequal market power. The respective payoffs for countries *A* and *B* are 10 and 5 if both follow a free trade policy. *A*'s welfare-maximising policy is to set a tariff, increasing its payoff from 10 to 12 if *B* maintains a free

Table 1: Two-country asymmetric trade game

	Free trade (*B*)	Tariff (*B*)
Free trade (*A*)	10,5	8,6
Tariff (*A*)	12,1	11,2*

* Cournot–Nash equilibrium.

trade policy, and to 11 if *B* retaliates. Country *A*'s preferred ranking of policies can be represented as

$$T_AF_B > T_AT_B > F_AF_B > F_AT_B.$$

If country *A* sets a tariff, country *B*'s optimal response is to retaliate, thus improving its payoff from 1 to 2. Starting from a free trade position also, *B*'s best policy is to set a tariff, if it can assume that *A* will not respond. Thus both countries set tariffs, and each thereby makes the other worse off. The Cournot–Nash outcome, T_AT_B, is in this case a unique and stable equilibrium. Global welfare, the sum of the two payoffs, is of course reduced.

A feature of this game is the difficulty of attaining the cooperative solution F_AF_B. Any tariff imposed by *B* makes *A* worse off but *A* is still better off if it imposes a tariff than if it does not. In the case shown there is nothing that country *B* can do to influence country *A*'s strategy. This outcome is known as the 'Johnson case' in the trade literature, after its exposition by Johnson (1953-54), who showed that tariffs may be optimal even allowing for retaliation by trading partners.

Where two countries have similar market share, the outcome is more likely to be that of the familiar 'prisoners' dilemma', in which both parties gain if a cooperative outcome can be enforced. Repeated plays are likely to lead to a cooperative solution as players learn to trust one another. Such an outcome is not likely here, as country *A*'s tariff-enhanced payoff is superior to any benefits it would obtain if it chose free trade.

The illustration given here relates to just two countries and two possible decisions. The framework can be applied to any number of players with little increase in complexity so long as players act non-cooperatively. Likewise, players may be allowed to set trade barriers at three or more alternative levels, without changing the intrinsic nature of the game.

The asymmetric trade game is representative of the position of small countries, such as Australia, in the international wheat trade. There appears to be little Australia can do to influence the behaviour of the United States, and its influence over the European Community seems very limited. Furthermore, it appears that European policies are not greatly influenced by American behaviour. The US Export Enhancement Program (EEP), for example, does not appear to have reduced EC export subsidies or market share. US influence may eventually induce a policy shift within the European Community, as evidenced perhaps by the imposition of set-asides and by changes currently proposed as a result of the Uruguay Round, but the pace of change is slow and certainly not as was hoped when the EEP was instigated.

Cartels

Cartels have sometimes been suggested as a means of increasing the market power of a group of small countries (particularly following the apparent — at least in the short term — success of OPEC in controlling oil production), and as a response to the use of market power by large importers that restrict their imports (Schmitz, McCalla, Mitchell, and Carter 1981, p. 35). The management of a cartel presents a policy coordination problem. A successful export cartel requires agreement between the members on the appropriate total level of exports, a means of allocating these exports among the member countries, and a means of controlling or enforcing the agreement. Because the optimum level of aggregate exports and division between member countries are likely to be different from the standpoints of the different members, there will generally be incentives to cheat on any agreement reached. The incentives are particularly strong for producers that have low supply elasticity, lacking the ability to switch production to other commodities. Cheating may be relatively easy to detect when quantity of exports is the relevant variable. Agreements on other types of policy — to maintain a given level of protection of the exporting industry, for example — can be much more difficult to monitor.

Gardner (1987, p. 334) has noted several practical difficulties with cartels, apart from those of dividing the output and the detection of cheating. Stockholding is necessary to control output, and this too must be allocated (Schmitz et al. 1981, p. 129). Substitutability between commodities, both in production and consumption, may diminish the power of a cartel. If wheat only were controlled, the consequent increase in production of other grains might reduce the demand for wheat after a few years. Additionally, there must be some means of restricting non-member producers from entering the market in response to the increased world prices. Finally, importing countries may respond by setting up importer cartels to redress the balance of market power.

Cartels can take a number of forms. Producer cartels are concerned to maximise producer welfare, whereas government cartels may also (or instead) be concerned with the welfare of consumers and taxpayers (ABARE 1989, pp. 133–4). In this paper, government cartels are considered, with government-applied trade taxes as the policy instrument. Policy makers are assumed to consider the welfare of consumers and taxpayers, although they may attach greater weight to that of the producers. Two possible export cartels are assessed. The first includes Australia, Argentina and Canada; the second includes, in addition, the United States.

Trade model

In this section a simple non-spatial trade model is presented. The model is applied to the international wheat market in the following section to assess the possible impact of the two possible cartels on US and EC behaviour.

Consider *n* countries trading an homogeneous product with linear supply and demand curves:

$$D_i = \alpha_i - \beta P_i^d$$
$$S_i = \gamma_i + \delta P_i^s$$

where D_i and S_i are consumption and production in country *i*, P^d and P^s are prices paid by domestic consumers and received by producers, and α, β, γ and δ are non-negative demand and supply parameters. The parameters are derived from the quantity, elasticity (E_i^d, E_i^s) and price data (see table 2).

With no change in stocks, the market clearing equation is

$$\Sigma_i^n (D_i - S_i) = 0$$

The free trade price, at which P^d and P^s equals P^w, is

$$P^f = \Sigma_i^n(\alpha_i - \gamma_i) / \Sigma_i^n(\beta_i + \delta_i)$$

With trade taxes, the world price, P^W, becomes

$$P^w = P^f - \Sigma_i^n(\beta_i T_i^d + \delta_i T_i^s) / \Sigma_i^n(\beta_i + \delta_i)$$

where

$$T_i^d = P_i^d - P^w$$
$$T_i^s = P_i^s - P^w$$

National welfare for country i is the sum of consumer surplus CS_i, producer surplus PS_i, and tax revenue, TR_i, which may be either negative or positive. An export subsidy, for example, provides negative revenue. The various components can be weighted according to the preferences of policy makers. Welfare is therefore

$$W_i = w_{ic}CS_i + w_{ip}PS_i + w_{ig}TR_i$$

where w_{ic}, w_{ip} and w_{ig} are the welfare weights relating to consumers, producers and tax-payers respectively. The weighting of the welfare function in this manner is by now a common formulation, and examples of its use can be found in Sarris and Freebairn (1983) and Paarlberg and Abbott (1987).

The various components of welfare can be represented as

$$CS_i = D_i^2 / 2\beta_i$$
$$PS_i = (S_i^2 - \gamma_i^2) / 2\delta_i$$
$$TR_i = T_i^d D_i - T_i^s S_i$$

If policy makers are setting policies in order to maximise national welfare, the tax levels can be found by differentiating W_i with respect to T_i^d and T_i^s and setting the partial derivatives equal to zero. These first order conditions can be generated for each country. It is found that optimal taxes in country i are a function of parameters and taxes in all countries. By solving simultaneously, a set of Cournot–Nash equilibrium policies can be obtained. (A detailed explanation of the solution procedure is not necessary here. It can be found in Vanzetti and Kennedy (1988).) This is the outcome of a non-cooperative trade war, in which each country sets its policy so as to maximise its own welfare, taking into account the interactions with other countries' policies. A second type of solution is obtained by solving for each country separately, setting the taxes of all other countries at zero. This gives the optimal levels of tax in the absence of retaliation.

Conversely, from an observed set of taxes, assuming them to represent a Cournot–Nash outcome, welfare weights can be estimated by using the first order conditions to solve for the weights.

The international wheat trade model

For illustrative purposes, the analysis outlined in the previous section can be applied to a highly simplistic characterisation of the international wheat market. The numerical analysis presented here illustrates how the model works. Though the numbers are broadly indicative of the situation in the wheat trade in one particular year, the simplistic nature of the model limits its usefulness for policy prescription. Nevertheless, it may provide some guidance to the areas in which further refinement of the model may be profitably undertaken.

Following presentation of the data, a free trade solution for imports and exports is shown, which provides a baseline welfare position. Optimal taxes without retaliation are then presented for later comparison with the 'trade war' (non-cooperative) solution, in which retaliation is assumed. From the taxes actually applied in one recent year, revealed welfare weights are estimated. Using these weights, the non-cooperative equilibrium when there is a coalition of minor exporters is compared with the fully non-cooperative solution. Finally, the coalition is extended to include the United States. A comparison between the two coalition solutions illustrates the limited potential benefits of extending the cartel.

Data

The raw data are presented in table 2. Quantity data were obtained from ABARE (1991) and relate to the crop year 1988-89. Supply is equated to production plus opening stocks, and demand includes closing stocks. The summation of the exports shown will be taken as the measure of total trade, because, although there may also be exports from countries in the Rest of the World group, it is the trade of the major exporters that is of interest here. The taxes for the OECD countries in the analysis are derived from producer and consumer subsidy equivalents and refer to 1988 (OECD 1990). The taxes for Argentina were calculated from price data to be zero in this period. The world price is taken to be US$156/t, the US No. 2 hard red winter wheat (Gulf) price in 1988-89. Elasticities are the same as those used in Sarris and Freebairn (1983). The Rest of World elasticities are a weighted

Table 2: Base simulation data, wheat 1988-89

Region	Demand	Supply	Trade a	P^s	P^d	E^s	E^d
	Mt	Mt	Mt	US$/t	US$/t		
European Community	70	90	–20	189	214	.35	.20
United States	45	84	–38	172	156	.20	.15
Argentina	5	9	–4	120	120	.12	.05
Australia	5	17	–11	165	156	.10	.10
Canada	11	23	–12	197	144	.17	.10
Japan	6	0.7	5	377	203	.10	.22
Rest of World	433	349	84	156	156	.10	.15

World price US$156/t. a Imports shown positive.
Sources: Sarris and Freebairn (1983); OECD (1990); ABARE (1991).

average of those used in the Sarris and Freebairn study, which has 21 regions rather than the seven used here.

Results

Trade liberalisation

If all countries removed trade barriers, and producers received and consumers paid the world price, the resulting free trade equilibrium would be as shown in table 3.

The free trade world price is US$170/t, compared to a base value of US$156/t. Total trade (excluding trade between members of the Rest of World group) falls from 84 Mt to 81 Mt. Thus, liberalisation diminishes trade volumes. EC exports fall from 20 Mt to 14 Mt, while those of the remaining exporters, including Australia, actually rise marginally. These changes reflect the stimulation currently given to production by the high domestic prices in the European Community and, to a lesser extent, the United States, and the relatively low assistance provided in Australia.

The use of linear supply and demand curves leads to overestimation of the welfare changes in response to large policy shifts. Changes in welfare calculated for small changes in prices and quantities are a more useful indicator of the impact of a policy. The welfare figures shown merely serve as a benchmark for later comparisons.

Table 3: Free trade solution

Region	Demand	Supply	Trade	*CS*	*PS*	Welfare
	Mt	Mt	Mt	US$b	US$b	US$b
European Community	73	87	–14	40.777	12.410	53.187
United States	44	83	–39	22.875	12.766	35.641
Argentina	5	9	–4	0.578	1.459	7.239
Australia	5	17	–12	4.230	2.733	6.963
Canada	11	23	–12	7.487	3.562	11.049
Japan	6	1	6	3.029	0.110	3.139
Rest of World	428	352	76	220.363	56.639	277.002

World price US$170/t. Global welfare US$394.220 billion.

Optimal taxes

Optimal trade taxes without retaliation are shown in table 4. The components of welfare are given equal weights. The Rest of the World is here assumed to act as a unit. In practice, though the Rest of the World could certainly influence prices and policy if it acted in this way, the divergence of interests among its many importers would make policy coordination difficult.

Table 4: Optimal taxes without retaliation

Region	Consumer tax T^d	Producer tax a T^s
	US$/t	US$/t
European Community	–14	14
United States	–37	37
Argentina	–4	4
Australia	–11	11
Canada	–11	11
Japan	5	–5
Rest of World	110	–110

a Export tax.
Note: Unitary weights on welfare components. Negative signs indicate subsidies.

Two points are apparent here. First, the optimum tax structure involves setting the same price for consumers as for producers. This eliminates a source of domestic market distortion. Second, the welfare maximising policy for an exporting nation in which consumers, producers and taxpayers are treated equally is an export tax. This is the corollary of a tariff on the part of importers.

In either case, the tax is non-zero only if the country has some influence over world prices. The optimal taxes, although influenced by the supply and demand parameters, predominantly reflect market shares. Thus the United States has the highest optimal tax among the exporters. If the importers in the Rest of the World could coordinate their policies, they could optimally impose a substantial import tariff of $110/t.

Where market power exists, it is unlikely that retaliation would not occur. Furthermore, most traders would realise this and take it into account in setting policy. The effect of retaliation can be seen by calculating the Cournot–Nash solution. This is presented next.

A non-cooperative export trade war

Table 5 shows the optimal trade taxes following a trade war between exporters — that is, the Cournot–Nash solution (T^*). For simplicity, importers are assumed to follow a free trade policy. The Rest of the World is assumed not to set taxes or tariffs but to consist of

Table 5: Cournot–Nash equilibrium export taxes, and observed taxes

Region	T^* a	Observed T^d	Observed T^s
	US$/t	US$/t	US$/t
European Community	–15	58	–33
United States	–38	0	–16
Argentina	–4	–36	36
Australia	–11	0	–8
Canada	–11	–13	–40

Negative signs indicate subsidies. a Unitary weights on welfare components. Optimal taxes are therefore equal and opposite for consumers and producers; the negative signs indicate domestic price below world price.

independent, competitive price takers. The trade taxes actually in force in 1988 are shown for comparison (T^d and T^s).

The most interesting aspect of these results is that the assumption of retaliation from rival exporters has very little effect on the optimal tax. The international impact of a tax is exerted via the world price. The optimal taxes for each country have little impact on the world price and hence on the optimal taxes for other countries.

If it is assumed that the actual taxes are a Cournot–Nash solution, the implied welfare weights can be calculated. They are shown in table 6. If all countries set taxes at the optima shown in table 5, all the weights would be unity. Deviations from unity reflect policy preferences for or against particular groups. From tables 5 and 6 it is evident that levels of trade tax in a Cournot–Nash solution are highly sensitive to welfare weightings.

The observed taxes differ quite significantly from those which would be optimal with equal welfare weightings, and the calculated welfare weights reflect this. The weight on producer surplus is greater than unity for all exporters except Argentina, implying that producers are favoured by policy makers in these countries. Consumers and, to a lesser extent, taxpayers provide this support.

Table 7 provides more detail on the welfare and trade effects of the unitary-weighted Cournot–Nash solution for exporters in comparison with free trade (table 3). Domestic prices for exporters are in general lower than the free trade level (US$170/t) because of the export tax. The world price is higher, and as a result trade flows are down by about 7 per cent overall: by 10 per cent for the United States, but almost unchanged for Australia. As a result, welfare levels in exporting nations are increased, with consumers and taxpayers

Table 6: Exporters' estimated welfare weights

Region	w_c	w_p	w_g
European Community	.913	1.096	.990
United States	.951	1.057	.991
Argentina	1.020	.974	1.006
Australia	.992	1.010	.998
Canada	.986	1.029	.985

Table 7: Trade and welfare effects of Cournot–Nash export taxes, and comparison with free trade

Region	Price	Welfare	Changes relative to free trade: Trade	Changes relative to free trade: Welfare
	US$/t	US$b	%	%
European Community	163	53.293	–10.6	0.20
United States	141	35.887	–10.4	0.69
Argentina	174	7.278	1.1	0.54
Australia	168	7.062	–0.3	1.44
Canada	167	11.153	–0.6	0.94

Unitary weights on welfare components. World price US$179/t. Global welfare US$394.132 billion.

gaining at the expense of producers. Importers' welfare (not shown) is lower and global welfare is marginally lower, than under free trade. Note that this result has been obtained under the simplifying assumption of no retaliatory (or indeed, any) trade taxation by importers.

Cooperative solutions for exporters

Small traders have little bargaining power, by virtue of their low market share. This is reflected in the low optimal export taxes found for Argentina, Australia and Canada. To assess the scope for increasing market power by cooperating with other exporting countries, cooperative solutions were obtained by horizontally aggregating demand and supply curves across a number of countries and treating that bloc as one trader. Aggregating the supply curves is straightforward, but a simple addition of individual country demand schedules results in a kinked demand curve unless they coincidentally share the same price intercept. This creates a problem, because it is not possible to estimate optimal taxes using the method described here if the demand curve is nonlinear. To circumvent this problem, the quantity intercept parameter, α, for the bloc was set at the simple summation of the individual αs, and a slope parameter β was found (by numerical iteration) such that the consumer surplus for the bloc is the sum of the consumer surpluses of the individual members.

Three-member cartel

Australia, Argentina and Canada are assumed to cooperate and behave as a cartel, while relations between the United States, the European Community and the cartel remain non-cooperative, and importers impose no trade taxes. The Cournot–Nash cartel solution with equally weighted welfare components is shown in table 8.

In this solution, trade volumes decrease and exporter welfare increases in comparison with free trade. As would be expected, although the trade volume changes are quite significant, the welfare gains are comparatively small. Global welfare falls.

Welfare weighted solution

The unitary weighted cartel solution presented in table 8 is quite different from an outcome in which policy makers have preferences as to sectoral welfare. Such a solution, using the inferred weights given in table 6, is shown in table 9. For the cartel, the weights are aggregated across member countries. The weight on consumer surplus is an average of the individual w_Cs weighted by consumption; similarly, that on producer surplus is an average weighted by production. The weight on taxpayers welfare is a residual derived from the condition that the three weights sum to three.

The results are very dependent on the these cartel welfare weights. The procedure of averaging welfare weights highlights the difficulty of allocating benefits among the various cartel members, for each of whom an alternative policy would be more appealing. In 1988, for example, Canada had a high weighting for producers whereas Argentina gave a high weighting to consumers.

Table 8: Cournot–Nash solution with three-member cartel, and comparison with free trade

		Changes relative to free trade	
Region	T^* a	**Trade**	**Welfare**
	US$/t	%	%
European Community	–15	–9.5	0.23
United States	–38	–10.1	0.79
Cartel	–27	–3.1	1.00

Unitary welfare weights. World price US$179/t. Cartel welfare US$25.502 billion. Global welfare US$394.123 billion. a Negative sign indicates domestic price below world price.

Table 9: Three-member export cartel solution with weighted welfare functions

Region	T^d	T^x	Changes relative to free trade	
			Trade	Welfare
	US$/t	US$/t	%	%
European Community	57	–33	49.0	–0.61
United States	–1	–15	0.4	–1.08
Cartel	–33	1	–3.4	–1.08

World price US$160/t. Cartel welfare US$22.977 billion. Global welfare US$394.053 billion.

Given policy makers' preferences favouring producers, an export tax of $1/t (rather than the export subsidies now prevalent) is optimal for the cartel. The cartel's exports are 27 Mt, marginally higher than the aggregate of the individual member countries in the non-cooperative trade war solution. Cartel welfare measured in conventional terms (with the components equally weighted) falls 1 per cent from the free trade benchmark. By contrast, cartel welfare under a policy which is itself based on unitary weights is 1 per cent above the free trade level. This indicates the welfare costs, measured in conventional terms, of following preferential rather than non-discriminating policies.

Four-member cartel

A three-member cartel among the less powerful exporters thus appears to have little impact on the welfare accruing to the member countries. An alternative possibility is a cartel which includes the United States. This is effectively a trade bloc opposing the European Community. The four-member cartel solution tariffs with unitary weights are shown in table 10.

The addition of the United States to the cartel does not appear to strengthen its position. The cartel now imposes an export tax of US$65/t, compared to US$27/t for the three-member cartel, and its welfare is 1.03 per cent higher than the free trade benchmark, compared to 1.00 per cent in the three-member case. Cartel welfare is marginally higher, at US$61.502 billion, than that of the three-member cartel plus the United States (US$61.424 billion). Clearly, the distribution of welfare gains between the various member countries is important.

Table 10: Four-member export cartel solution, and comparison with free trade

Region	T^*	Changes relative to free trade: Trade	Welfare
	US$/t	%	%
European Community	–17	–2.5	0.40
Cartel	–65	–14	1.03

Unitary welfare weights. World price US$185/t. Cartel welfare US$61.520 billion. Global welfare US$393.903 billion.

Sensitivity analysis has been performed with respect to elasticities, but is not reported here. Because of the linear nature of the model, changing the elasticities affects the magnitudes of the optimal taxes and welfare levels. It does not, however, qualitatively affect the results. This conclusion holds even for the most sensitive parameter, the Rest-of-the-World import demand elasticity.

Implications and conclusions

Several implications can be drawn from the above theoretical and numerical results. First, because of the conflicts involved in trade relations, game theory is a suitable method of analysis for international trade issues. Both multilateral and regional negotiations lend themselves to this form of analysis.

Contrary to the commonly observed policy of export subsidies, the optimal policy for exporting nations with the ability to influence world prices is to tax exports. Taxes, rather than subsidies, are the counterpart of tariffs on imports in that they push the world price in the direction favourable to the trader.

Trade taxes and subsidies have relatively small effects on overall welfare, from a national perspective, but have significant distributional effects. Producers are made worse off by export taxes. To obtain producer support for such a policy, some form of compensation or side payment may be necessary.

Although free trade is globally optimal, some countries gain from trade barriers, even when other countries retaliate. Thus, international trade, in wheat at least, appears to conform more closely to the asymmetric type of game for which there is no cooperative solution. Retaliation, in the form of other exporters setting optimal taxes, has little impact on the tax that would be optimal for any one country. This result would not necessarily hold if importers also impose taxes, rather than following a free trade policy as has been assumed here. A multi-commodity analysis would also modify these results, as countries with market power in one commodity do not have it in all.

Cooperation is necessary for the optimal functioning of a free trade system, as many countries have incentives to 'free ride' by imposing disguised trade barriers. Intervention measures therefore need to be transparent, to ease the negotiation of their reduction.

The numerical results need to be interpreted with some care, given the simplistic nature of the model and its application to just one year's data. The conclusions derived from the numerical analysis may not necessarily be readily transferable to other years or commodities. Perhaps the main conclusion implied by the analysis is that the formation of a cartel is unlikely to bring substantial benefits to small exporters such as Australia. This applies even to a cartel including large exporters such as the United States. Furthermore, within a country the distributional impacts of an export cartel are detrimental to producers. Some of the possible benefits to the cartel members would also be dissipated by dynamic effects ignored in this analysis — in particular, an increase in supply by non-member countries in response to higher world prices.

Espousal of free trade is a means of encouraging other participants to move toward a cooperative outcome. One such approach involves attempting to change the weights which other countries' policy makers attach to the components of their welfare functions. Australia has taken this approach by showing that EC and US policy objectives could be achieved in a more efficient manner (BAE 1985; ABARE 1989).

In this paper it has been shown that trade conflicts and strategic interactions can be analysed using game-theoretic models. The use of variable welfare weights provides a workable rationale for export subsidies, allowing the apparent preferences of policy makers to be measured. Optimal policies were found to be only marginally affected by retaliation, and hence the formation of various coalitions between non-EC exporters is unlikely to have a significant impact on the policies of the major players.

References

ABARE (Australian Bureau of Agricultural and Resource Economics) (1989), *US Grain Policies and the World Market*, Policy Monograph No. 4, AGPS, Canberra.

—— (1991) *Commodity Statistical Bulletin*, AGPS, Canberra.

Bureau of Agricultural Economics (BAE) (1985), *Agricultural Policies in the European Community: Their Origins, Nature and Effects on Production and Trade*, Policy Monograph No. 2, AGPS, Canberra.

Gardner, B. (1987) *The Economics of Agricultural Policies*, Macmillan, New York.

Johnson, H.G. (1953-54), 'Optimum tariffs and retaliation', *Review of Economic Studies* 21(2), 142-53.

McMillan, J. (1986), *Game Theory in International Economics*, Harwood, London.

OECD (1990) *Agricultural Policies Markets and Trade: Monitoring and Outlook 1990*, Paris.

Paarlberg, P.H. and Abbott, P.C. (1987), 'Collusive behaviour by exporting countries in world wheat trade', *North Central Journal of Agricultural Economics* 9(1), 13–27.

Sarris, A.H. and Freebairn, J. (1983) 'Endogenous price policies and international wheat prices', *American Journal of Agricultural Economics* 65(2), 214-24.

Schotter, A. and Schwodiauer, G. (1980), 'Economics and the theory of games: a survey', *Journal of Economic Literature* 18(2), 479-527.

Schmitz, A., McCalla, A.F., Mitchell, D.O. and Carter, C. (1981) *Grain Export Cartels*, Ballinger, Cambridge, Massachusetts.

Vanzetti, D.M. and Kennedy, J.O.S. (1988) 'Endogenous price policies and international wheat prices: comment', *American Journal of Agricultural Economics* 70(3), 743-46.