Strategic Interaction in International Commodity Markets

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1. Introduction

International commodity markets have most commonly been analysed with the use of spatial equilibrium models, in which international trade is assumed to be perfectly competitive (Kolstad and Burris 1986, p. 28). The effects of government intervention, market intermediaries and market power are ignored or treated as exogenous. Yet, government trading agencies (for example wheat marketing boards in Australia, Canada and USSR) or government policies (in the European Community [EC], the United States and Japan) significantly influence world trade. Much commodity trade is conducted by large multinational companies, which may be able to influence prices. Furthermore, there exist relatively few traders on one or both sides of the market. In the grains trade, three or four countries supply the bulk of all exports.

While the influence of government has long been recognised, it is only recently that attempts have been made to identify the determinants of government action. One approach to endogenising government policy highlights domestic political factors, such as the relative bargaining strength of various pressure groups. Sarris and Freebairn (1983), for example, took this approach. A second method involves the assumption that governments act to coordinate consumers or producers so that they may exercise market power. In spite of recent theoretical developments in these areas, few empirical models have endogenised government's role in the price formation process.

By assuming competitive behaviour, market power is ignored. However, when a country possesses market power, it is unlikely that such power would go unused. It is also reasonable to suppose that some form of retaliation can be expected when the imposition of a trade policy harms other traders. An example of this is the use in recent years of export subsidies by the United States and the EC in their attempts to regain or retain market share of the world wheat trade[1]. Examples of retaliatory behaviour can also be seen in other commodity markets, such as meat, wine and steel.

Retaliation and other strategic trade policies cannot readily be analysed by competitive market models. Policies which appear to be welfare reducing may lead to a change in rival suppliers' policies and result in longer-run welfare gains. The few models that have incorporated retaliation are based on the assumption that traders do not expect that rivals will vary their policy (i.e. retaliate). In an earlier paper, (Vanzetti and Kennedy 1987) we examined the effects of retaliation assuming that traders did not expect rivals to retaliate. To explain the observed pattern of trade flows and prices, we derived and estimated weights for producer and consumers-taxpayer groups in an unequally weighted welfare function. In a forthcoming comment, (Vanzetti and Kennedy 1988) these results are expanded to include differential domestic prices (for consumers and producers) and welfare weights for three groups (with consumers and taxpayers treated separately). In the current paper it is assumed that, when setting a policy, traders do expect some retaliation. This expectation affects optimum policies, trade flows and welfare. It will be shown that models which assume zero expected retaliation (or zero conjectural variations) may result in incorrect estimates of tariffs and welfare losses.

The general objective of this paper is to present a framework for analysing strategic behaviour (including non-zero conjectural variations) in international trade. Of particular interest is the impact of conjectural variations on optimum policies - the direction and extent to which tariffs change when the expectations of retaliation change.

To assess the impact of various conjectures, a simple linear trade model is derived, with import tariffs and export taxes/subsidies as the policy instruments. First, a free trade solution, assuming zero tariffs, is calculated to provide a benchmark for later comparisons. Next a Cournot-Nash solution, assuming zero conjectural variations, is shown. From the observed tariff structure, conjectural variation estimates are obtained through the use of the implicit function theorem. Once estimated, these are used to derive optimum tariffs following an exogenous exchange rate change. This conjectural variations equilibrium is then compared to the corresponding (post depreciation) Cournot-Nash equilibrium. For illustrative purposes, the analysis is applied to a 21 region wheat trade model, using data for the base period 1978-79 to 1979-80.

Section 2 contains a review of the way in which other authors have tackled conjectural variations in trade models. In section 3 a derivation of a simple one-commodity linear trade model is presented. The optimum tariff and conjectural variations formulae are derived. The alternative Cournot-Nash and conjectural variations solution concepts and algorithms are described later in the section. Results and the implications of the analysis are discussed in sections 4 and 5.

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[1] Vanzetti and Kennedy (1987) discuss a number of instances of retaliation.

2. Previous Attempts to Model Conjectural Variations

Conjectural variations models are a more general version of the well-known Cournot and Stackelberg models of an industry which is imperfectly competitive. In the Cournot model, it is assumed that each firm expects that its rivals will not respond to a change in output. This is in spite of the fact that, contrary to expectations, rivals do retaliate. The model has been criticised for this somewhat naive, although simplifying, assumption. By contrast, the Stackelberg model is based on the assumption that one firm, a leader, has perfect knowledge of how the other firms will respond. This assumption is also unrealistic. In the conjectural variations model it is assumed that responses are not known with certainty, but that each firm makes a guess (or conjecture) as to how rivals will vary their output. By specifying different conjectures from -1 (perfect competition) through 0 (Cournot) to 1 (monopoly) many types of market structure can be modelled (see Nelson and McCarl (1984) for a discussion of this). The number of equilibria is infinite, in some ways a weakness of the theory. Conversely, conjectural variations estimates can be obtained from an observed market structure.

In the Cournot model as applied to industrial organisation, the decision variable is the quantity of output. If, instead, price are chosen as the decision variable, one firm could capture the whole market by lowering its price. Retaliation leads to prices being forced down to the perfectly competitive level. This is the so-called Bertrand model.

This conclusion does not hold in trade models. Although tariffs and taxes are the decision variables, they impinge predominantly on the domestic markets. The world price is influenced by all domestic prices, but once determined, all countries face the one border price (with zero transport costs). Hence, in international trade, retaliation does not lead to the abolition of tariffs.

An Historical Perspective

The concepts of strategic behaviour in industrial organisation can of course be related to the problem of retaliation in international trade. Scitovsky (1942) maintained that this relationship had hitherto not been generally accepted, due in essence to *'our supposed inability to draw community indifference curves'* (p. 89). Before Scitovsky, many economists believed it was impossible to choose among alternative trade policies, from a national perspective, due to an inability to assess the distributional impacts. This stemmed from the difficulty in making interpersonal utility comparisons (p. 89). As free trade had been shown to be best for the world as a whole, it was considered to be best for single countries as well. Following Kaldor's (1940) assertion that countries may gain from trade even in the presence of retaliation (depending upon relative import demand elasticities), Scitovsky developed the community indifference curve analysis to assess trade policies. He assumed that eventually countries will recognise their interdependence, and an indeterminate (cooperative) bargaining situation will prevail (p. 102). Without explicitly specifying his equilibrium, Scitovsky nonetheless concluded that *'every country will actually be impoverished as they all raise their tariffs'* (p. 109).

Johnson (1953-4) formalised Scitovsky's work, and by having traders respond in a Cournot fashion, outlined the special supply and demand conditions under which one country may be better off after a tariff war than at free trade. However, in the standard case, both countries would be worse off following retaliation. McMillan (1986) notes several refinements of Johnson's analysis, including the application of specific rather than *ad valorem* tariffs; the use of tariff revenue as the decision variable; and the conditions necessary for the existence of equilibrium.

This analysis was taken further by Rodriguez (1974), who showed that, whereas tariffs and quotas are equivalent under competitive conditions, this is not so in the presence of retaliation. Tower (1975) demonstrated that if quotas are used retaliation will always lead to zero trade.

These refinements did not address the problem of expectations of retaliation. Cournot solutions were found with various decision variables. Riezman (1982) dropped the Cournot assumption, introducing a strategic component. With each country assuming that rivals may retaliate, the ensuing game situation may be cast as a prisoners' dilemma[2]. Consider a two-player non-zero sum game without cooperation. Each player can set its tariff at zero (free trade) or at the optimum level. There are thus four pairs of outcomes, of which free trade is globally optimal, and both players lose if each sets a tariff. However, the first player can improve on the free trade solution if it sets a tariff and its rival does not respond. On the other hand, if its rival sets a tariff initially, its best response is a positive tariff. In the absence of communication (or trust), both parties choose policies which lead them both to be worse off then under a free trade regime.

Riezman goes on to analyse tariffs in a cooperative framework, concluding that in reality *'free trade may be difficult to obtain when countries behave strategically'* (p. 591). The tariff-ridden strategy dominates a free trade strategy if one player benefits from a trade war (the Johnson case) or if the gains from eliminating tariffs are unequally distributed (p. 592). Riezman suggests that this result helps explain the failure of multinational trade negotiations to lead to free trade.

Riezman introduced strategy into his analysis, but did not incorporate retaliatory expectations explicitly, as did Thursby and Jensen (1983). Using a static two-country, two-commodity model, they impose arbitrary conjectures and derive the resulting equilibrium; a variant of Cournot-Nash conditional upon given (constant) conjectures. They show that increased expectation of retaliation leads to lower equilibrium tariffs in both countries.

The work mentioned here so far did not adequately handle the problem of conjectures being inconsistent with observed responses. A trader observing its rivals over time should hold conjectures consistent with those observations. This implies that expected behaviour is equivalent to actual behaviour. Bresnahan (1981), Perry (1983) and others developed the notion in a duopoly context. Kamien and Schwartz (1983) generalised the model, showing the specific conditions (relating mainly to the functional form of the reaction function and

[2]This is often referred to as a prisoner's dilemma, but as both players face the dilemma, the term used here seems more appropriate.

demand and cost functions) necessary for this equilibrium. In addition to its intuitive appeal, a further attraction of consistent conjectural variations is that the number of possible equilibria is very much reduced. In spite of its intuitive appeal, the consistent conjectural variations equilibrium is restrictive (in the conditions required for a stable, unique solution) and mathematically cumbersome, especially when players have differing (asymmetric) cost functions. For these reasons this equilibrium is not used here.

Grain Trade Models

In the applied area a number of modellers of imperfect competition have imposed arbitrary or ad hoc assumptions regarding expected response. McCalla (1966), in his cooperative duopoly model, had each duopolist accurately predicting how others would react to its policies within a given price-quantity band. Taplin (1969) maintained that the USA followed the price leader Canada in its price setting. Constant market shares were assumed. A stable oligopoly solution resulted from a kinked demand curve.

Alaouze, Watson and Sturgess (1978) proposed a triopoly, with Australia as the third dominant party. Their model is based on the assumption of minimum acceptable market shares, and cooperative behaviour between the USA and the price leader, Canada. When market shares are threatened, a limited price war is initiated, forcing Australia to restrain its exports. The authors identified the conditions under which the triopoly might degenerate into a price war, without specifying the role of expectations in the price formation process.

Carter and Schmitz (1979) postulated that an EC-Japan duopsony determined trade and prices. Schmitz, McCalla, Mitchell and Carter (1981) have expounded this notion at greater length. In essence, large importers impose an optimum, or near optimum, tariff, which transfers resources from exporters to producers and taxpayers in the importing country. The model was tested empirically, and the authors concluded that importers could be acting in a tacit collusive fashion in order to function as an importing cartel. Exporters were assumed not to retaliate.

Models of cooperative behaviour introduce possibilities of cheating, deterrence and side-payments, and increases the number of possible solutions. The solution to these models depends more on the assumption regarding collusive behaviour than on the nature of retaliation.

Karp and McCalla (1983) develop a dynamic difference game model of the world corn market. This allows interaction between both exporters and importers, in contrast to some earlier models, and introduces time into the analysis. Reaction functions, showing how each country's tariff is influenced by other tariffs, are endogenously determined in the model. Traders adjust their policies over time depending on the behaviour of their rivals. However, this is not a conjectural variations model. Risk can also be incorporated (Karp 1987). Their analysis is limited by an inability to handle inequality constraints, and the need for a linear model.

Kolstad and Burris (1986) use a nonlinear complementarity programming approach to compute spatial equilibrium in oligopolistic or oligopsonistic markets. They show how conjectural variations estimates can be utilised; however, for their purposes they assume conjectural variations to be zero, the Cournot assumption.

Perhaps the most impressive attempt to incorporate conjectural variations is that of Paarlberg and Abbott (1986). They assume policymakers hold conjectures regarding the slope of the excess demand function (response function) and derive domestic and trade policies from these conjectures. The policies also reflect the strengths of various interest groups. This analysis utilises the Thursby and Jensen methodology, except that conjectures are determined endogenously, instead of imposed. In fact, their conjectures are a direct function of rivals' policies, as a long run equilibrium in which actual implemented policies relate to expectations of rivals behaviour is assumed. This is not necessarily a consistent equilibrium, as conjectures may be only weakly related to actual behaviour. A revealed preference methodology is used to estimate conjectures from observed policies and the first order conditions of the model. They also incorporate domestic as well as trade distortions. The analysis is applied to a seven-region wheat model. In spite of some counter-intuitive estimated conjectures, the model is a useful attempt to endogenise policy, and to assess the impact of oligopolistic rather than competitive behaviour.

In the model presented in this paper a revealed preference methodology is used to estimate, rather than impose, conjectures. This work compares to that of Vanzetti and Kennedy (1987) in which welfare weights were estimated assuming observed tariffs were at their Cournot equilibrium levels. Here, the Cournot assumption of zero conjectures is dropped, and conjectures are estimated from observed tariffs. However, each country is assumed to have a welfare function with all interest groups weighted equally.

3. Theoretical Framework

It is apparent from the previous section that there are a variety of game-theoretic approaches by which retaliation can be analysed. When formulating the problem, it is necessary to decide:

- the extent of cooperation between players;
- the static or dynamic nature of the game;
- the suitability of a deterministic versus stochastic game;
- the relevant decision variable; and
- the strategy followed by the players.

In contrast to some early attempts, it is assumed here that a non-cooperative game best represents international commodity trading. While there is evidence against this, international agreements are difficult to enforce and are therefore not binding. The limited success of the General Agreement on Trade and Tariffs (GATT) attests to this.

Static models are useful if there is little interest in the path to equilibrium. They can, of course, be more readily formulated. The Cournot-Nash solution is static, with firms making their decisions before they know their rivals' policies. By contrast, the conjectural variations approach, while remaining tractable, can be considered to be implicitly dynamic, as reactions cannot occur instantaneously. The dynamics are subsumed in the reaction function. This is an unusual interpretation which will be examined in more detail later.

Stochastic games are repeated games with an element of randomness, such as demand or supply uncertainty. While important in examining problems such as price stabilisation, stochastic games would contribute little here. A deterministic approach is used in this paper.

Much of the literature on tariff retaliation deals with the choice of decision variable. While theoreticians find the multiplicative properties of *ad valorem* tariffs useful, many empirical models use unit tariffs. The models presented in Karp and McCalla (1983) and Sarris and Freebairn (1983) are examples. This has the advantage that the unit tariff can represent a range of policy instruments which result in an additive differential between world and domestic prices. In this paper, following Sarris and Freebairn, it is assumed that prices received by producers may differ from prices paid by consumers. Each country thus sets two tariffs.

The theory of the optimum tariff postulates that if the border price of imports falls when a tariff is imposed, then it is possible, in the absence of retaliation, for an importer to increase welfare by imposing some positive tariff. For the exporter, an export tax is the optimal policy. This follows from Lerner's symmetry theorem. The tariff is optimal only in a national sense; global welfare decreases.

A further consideration is the strategy employed by decision makers. Rather than an ad hoc or empirically estimated reaction function, it is assumed here that policymakers attempt to maximise a welfare function by setting a tariff at the appropriate level.

A difficulty in analysing retaliation in practice is the possibility that if a country imposes a tariff on one commodity, other countries may retaliate by imposing tariffs on other commodities. This is clearly the case in some instances, and points to the need for a multi-commodity model. However, retaliation has tended to occur in the same market, and it is assumed here that the cross-commodity effects are insignificant.

Thus far in this section the nature of the game-theoretic model to be developed has been outlined. Next, a linear model is specified and equations for the optimum tariff for the Cournot and conjectural variations solutions are derived.

A Single-Commodity Linear Trade Model

Once demand and supply equations and equilibrium conditions are specified, a welfare function is derived for each trader. The solution method involves calculating the first order conditions to maximise these welfare functions. The reaction functions, showing how each country reacts to tariffs imposed by others, can then be derived. The functions can be solved simultaneously to obtain the equilibrium set of tariffs.

Consider an homogeneous product traded between n countries with linear demand and supply curves:

$$D_i = \alpha_i - \beta_i P_i^d, \tag{1}$$

$$S_i = \gamma_i + \delta_i P_i^s, \tag{2}$$

where D_i and S_i denote quantities demanded and supplied in country i; P_i^d and P_i^s denote the current price paid by consumers and received by producers respectively; and α_i, β_i, γ_i and δ_i refer to the usual intercept and slope parameters, which are all non-negative. To keep the algebra to a minimum, there are no additive disturbance terms in (1) and (2). It is argued later that this does not lead to a bias in the estimates of expected tariffs.

Assuming no change in stocks, and therefore market clearance:

$$\Sigma_i^n (D_i - S_i) = 0. \tag{3}$$

The market clearing free-trade price is:

$$P^f = \frac{\Sigma_i^n(\alpha_i - \gamma_i)}{BD}, \tag{4}$$

where

$$BD = \Sigma_i^n(\beta_i + \delta_i). \tag{5}$$

The introduction of differential prices for domestic producers (P^s) and consumers (P^d) allows for separate domestic and international prices. The market clearing tariff-ridden world price is now:

$$P^w = \frac{\Sigma_i^n(\alpha_i - \gamma_i - \beta_i t_i^d - \delta_i t_i^s)}{BD}, \tag{6}$$

where

$$t_i^d = P_i^d - P^w, \tag{7}$$

$$t_i^s = P_i^s - P^w. \tag{8}$$

With linear schedules, the total welfare function to be maximized for country i is:

$$W_i = CS_i + PS_i + TR_i, \tag{9}$$

with

$$CS_i = \frac{D_i^2}{2\beta_i}, \tag{10}$$

$$PS_i = \frac{S_i^2 - \gamma_i^2}{2\delta_i}, \tag{11}$$

$$TR_i = t_i^d D_i - t_i^s S_i. \tag{12}$$

CS_i, PS_i and TR_i refer to consumer surplus, producer surplus[3], and tariff revenue respectively. D_i and S_i now depend on t_j^d and t_j^s for all j.

The essence of the conjectural variations model is that each trader has expectations as to how rival traders will respond. Due allowance for the response is made when deriving the first order conditions. The Cournot-Nash equilibrium is a special case of the conjectural variations model, and therefore can also be derived from the following equations. The first order conditions are obtained by differentiating the welfare function with respect to the tariffs. The partial derivatives are then equated to zero, for an interior solution, and solved for the optimal tariff.

$$\begin{aligned}\partial W_i/\partial t_i^d &= \frac{2D_i}{2\beta_i}\frac{\partial D_i}{\partial t_i^d} + \frac{2S_i}{2\delta_i}\frac{\partial S_i}{\partial t_i^d} + D_i + t_i^d\frac{\partial D_i}{\partial t_i^d} - t_i^s\frac{\partial S_i}{\partial t_i^d},\\ &= D_i(F_i - 1) + S_i(-F_i) + D_i + t_i^d(F_i\beta_i - \beta_i) - t_i^s(-\delta_i F_i),\\ &= F_i(D_i - S_i + t_i^d\beta_i + t_i^s\delta_i) - t_i^d\beta_i, \end{aligned} \tag{13}$$

where

$$\begin{aligned} F_i &= (\beta_i + \Sigma_{j\neq i}(\beta_j Z_{ji}^{dd} + \delta_j Z_{ji}^{sd}))/BD,\\ Z_{ji}^{dd} &= \frac{\partial t_j^d}{\partial t_i^d},\\ Z_{ji}^{sd} &= \frac{\partial t_j^s}{\partial t_i^d}. \end{aligned}$$

From (1),(2),(4),(5),(6),(7) and (8) it follows that

$$\begin{aligned} D_i - S_i &= \alpha_i - \gamma_i - (\beta_i + \delta_i)P^f + t_i^d\beta_i e_i + t_i^s\delta_i e_i\\ &\quad + e_i\Sigma_{j\neq i}(\beta_j t_j^d + \delta_j t_j^s) - \beta_i t_i^d - \delta_i t_i^s, \end{aligned} \tag{14}$$

where

$$e_i = (\beta_i + \delta_i)/BD,$$

Equation (13) can now be rewritten as:

$$\partial W_i/\partial t_i^d = F_i(\alpha_i - \gamma_i - (\beta_i + \delta_i)P^f + e_i\Sigma_{j=1}^n(t_i^d\beta_j + \delta_j t_j^s)) - t_i^d\beta_i \tag{15}$$

Likewise, W_i can be differentiated with respect to t_i^s to obtain:

$$\begin{aligned}\partial W_i/\partial t_i^s &= \frac{2D_i}{2\beta_i}\frac{\partial D_i}{\partial t_i^s} + \frac{2S_i}{2\delta_i}\frac{\partial S_i}{\partial t_i^s} + t_i^d\frac{\partial D_i}{\partial t_i^s} - S_i - t_i^s\frac{\partial S_i}{\partial t_i^s}\\ &= G_i(\alpha_i - \gamma_i - (\beta_i + \delta_i)P^f + e_i\Sigma_{j=1}^n(t_i^d\beta_j + \delta_j t_j^s)) - t_i^s\delta_i \end{aligned} \tag{16}$$

[3]Equation (11) for PS_i assumes γ exceeds zero, as is the case for all data used here. If γ is negative, $PS_i = S_i^2/2\delta_i$. The difference, $-\gamma_i^2/2\delta_i$, is a constant which drops out upon differentiation.

where

$$\begin{aligned} G_i &= (\delta_i + \Sigma_{j\neq i}(\beta_j Z_{ji}^{dd} + \delta_j Z_{ji}^{sd}))/BD, \\ Z_{ji}^{ds} &= \frac{\partial t_j^d}{\partial t_i^s}, \\ Z_{ji}^{ss} &= \frac{\partial t_j^s}{\partial t_i^s}. \end{aligned}$$

Setting the partial derivatives of W_i with respect to t_i^d and t_i^s equal to zero, and solving gives:

$$t_i^d = \frac{-F_i(\alpha_i - \gamma_i - (\beta + \delta)P^f + e_i\delta_i t_i^s + e_i\Sigma_{j\neq i}(\beta_j t_j^d + \delta_j t_j^s))}{F_i e_i \beta_i - \beta_i}, \tag{17}$$

$$t_i^s = \frac{-G_i(\alpha_i - \gamma_i - (\beta + \delta)P^f + e_i\beta_i t_i^d + e_i\Sigma_{j\neq i}(\beta_j t_j^d + \delta_j t_j^s))}{G_i e_i \delta_i - \delta_i}. \tag{18}$$

These equations hold simultaneously for n countries. After rearrangement, they can be expressed in matrix notation as:

$$At = g \tag{19}$$

where:

$$\begin{aligned} t' &= [t_1, ..., t_j, ..., t_{2n}] \\ &= [t_1^d, t_1^s, t_2^d, t_2^s, ..., t_n^d, t_n^s] \end{aligned}$$

and

$$\begin{aligned} a_{jj} &= F_j e_j \beta_j - \beta_j & j &= 1, 3, ..., 2n-1, \\ &= G_j e_j \delta_j - \delta_j & j &= 2, 4, ..., 2n, \\ a_{jk} &= F_j e_j \beta_k & j &= odd,\ k = odd, \\ &= F_j e_j \delta_k & j &= odd,\ k = even, \\ &= G_j e_j \beta_k & j &= even,\ k = odd, \\ &= G_j e_j \delta_k & j &= even,\ k = even, \\ g_j &= -F_j(\alpha_j - \gamma_j - (\beta_j + \delta_j)P^f) & j &= odd, \\ &= -G_j(\alpha_j - \gamma_j - (\beta_j + \delta_j)P^f) & j &= even. \end{aligned}$$

Equation (19) can be solved by matrix inversion to provide equilibrium tariffs:

$$t = A^{-1}g \tag{20}$$

By varying the assumed conjectural variation (Z_{ji}), differing values of F_i and G_i, and hence different equilibrium solutions, can be obtained using the equations outlined here. These solutions will be examined in some detail.

First, note that if the intercept terms of the demand and supply equations (α_i and γ_i in (1) and (2)) were stochastic and independent, equation(19) would still solve for expected tariffs if the intercept terms on the right hand side were set at their expected values. This follows because the terms , which appear only in equations (15) and (16), do not interact. Thus, expected equilibrium tariffs can be determined without taking account of the variances of α_i and γ_i.

The Cournot-Nash Solution

In the traditional Cournot oligopoly model, each firm takes account of production levels set by it and other firms, although each (naively) expects no response from its rivals. The Cournot-Nash equilibrium is a point at which no trader (acting unilaterally) can do better than playing its optimal strategy, given that all other traders are playing their optimal strategies. Interaction between the traders results in convergence to an equilibrium from which none would want to move.

While the Nash equilibrium is inferior to the Pareto optimum, given a finite number of traders, it is in no agent's interest in this non-cooperative game to act differently, although it would be in their collective interest to attain the Pareto optimum. However, once there, or at any point other than a Cournot-Nash equilibrium, it would be in some agent's individual interest to act differently. Thus, there is an incentive to cheat on collective agreements.

The standard criticism of the Cournot-Nash solution is that traders' actions are assumed to be short sighted at best. Rivals are expected not to react, although this expectation is repeatedly found to be false, and the firms themselves do not behave as they assume their rivals do. However, an alternative view is presented by McMillan (1986 p. 12) who maintains that it is incorrect to view traders' behaviour as naive, and that this view comes from the notion that the model is dynamic. In fact the model is static, with actions occurring only once, and need not be based on a *dynamic* adjustment process. The time path to equilibrium is not specified. If there is a unique equilibrium, and if each agent knows its rivals' strategy, it knows that they will rationally choose the Cournot-Nash policy. Each agent plays its best strategy, given that its rivals are playing their best. The Cournot-Nash equilibrium may be seen as a very sophisticated, albeit static, equilibrium.

To obtain a Cournot-Nash solution, the model is run with

$$Z_{ji}^{dd} = Z_{ji}^{ss} = Z_{ji}^{sd} = Z_{ji}^{ds} = 0 \quad for\ j \neq i, \tag{21}$$

$$Z_{ii}^{ds} = Z_{ii}^{sd} = 0, \tag{22}$$

$$Z_{ii}^{dd} = Z_{ii}^{ss} = 1. \tag{23}$$

F_i and G_i are thus

$$F_i = \beta_i / BD, \tag{24}$$

$$G_i = \delta_i / BD. \tag{25}$$

In spite of the appeal of the Cournot-Nash equilibrium, as a point from which traders would not want to move, it does not incorporate expectations of retaliation. The more general conjectural variations solution is more useful.

The Conjectural Variations Solution

Undoubtedly, traders do have some notion of how rivals may respond, and trade models would be improved by the inclusion of such information. Responses take time, and although formally static (like the Cournot model) McMillan maintains that the model contains an implicitly dynamic adjustment process, and is in fact similar to a repeated game model. However, the dynamics are not specified. For example, there is no discounting in the model. The time period involved is captured in the elasticities. In this paper, long-run elasticities are used, reflecting the nature of policy setting in agriculture.

Before tackling the problem of measuring conjectures, it is useful to examine the solution procedure.

Assume that each trader has an expectation as to how each rival will respond to a policy change. Thus, each of n traders has $4(n-1)$ conjectures, given prices are set differently for producers and consumers, amounting to $4n(n-1)$ individual estimates. Equation (19) can be used to obtain a conjectural variations solution, with equation(21) no longer holding.

A limitation of this approach is that expectations of interactions between rivals are not taken into account (when n exceeds 2). For example, policymakers in country one know how countries two and three will respond, but they assume that the resulting change in country two's policy will not impinge on country three. Thus, not all interactions are incorporated into the analysis. This is because the conjectures are partial rather than total derivatives. However, total derivatives can be calculated from partial derivatives in the following fashion.

$$\frac{dt_j}{dt_i} = \Sigma_{k=1}^{n} \frac{\partial t_j}{\partial t_k}\frac{\partial t_k}{\partial t_i}. \tag{26}$$

For a totally interactive analysis, it is necessary to have values for all the partial derivatives (albeit that some may be zero). These conjectures may be given some arbitrary value, or they may be estimated. For example, Thursby and Jensen (1983) used arbitrary values in their two country analysis, by assuming that the terms of trade are to be maintained. Alternatively, policy statements (threats) may provide a basis for analysis. For counter-factual simulations, a range of different assumptions could be imposed. Estimation is constrained by the need for sufficient degrees of freedom. This essentially means having $(n-1)$ years observations $4n(n-1)$ conjectures for n countries.

However, for the conjectural variations model developed here, it is not necessary that each country should have conjectures about the responses of all other countries individually for the setting of optimal tariffs. As is shown by equations (17) and (18), all each country i has to estimate is F_i and G_i, (defined following equations (13) and (16)) which are the weighted sum of conjectures across all other countries. Alternatively, it is possible to deduce the implicit values of F_i and G_i from a set of observed tariffs. This approach is dependent on the strong assumption that policymakers set tariffs to maximise welfare; the estimated conjectures are those necessary to make the observed tariff a welfare-maximising set[4]. The expressions for F_i and G_i are derived from the first order conditions.

[4]A similar approach was used by Vanzetti and Kennedy (1987) to estimating weights on the surpluses going to producers, consumers and government in a weighted welfare function.

$$F_i = \frac{\bar{t}_i^d \beta_i}{\alpha_i - \gamma_i - (\beta + \delta)P^f + e_i \Sigma_{j=1}^n (\beta_j \bar{t}_j^d + \delta_j \bar{t}_j^s)}, \tag{27}$$

$$G_i = \frac{\bar{t}_i^s \delta_i}{\alpha_i - \gamma_i - (\beta + \delta)P^f + e_i \Sigma_{j=1}^n (\beta_j \bar{t}_j^d + \delta_j \bar{t}_j^s)}. \tag{28}$$

where $\bar{t}_i$ refers to observed tariffs.

A point of note is that the aggregated conjectures are based on partial rather then total derivatives. Total derivatives are necessary for a consistent conjectural equilibrium (in which expected responses equalled actual responses). Had such an equilibrium been found, it would provide an alternative means of finding conjectures.

The expressions for Z_{ji} and t_i can be manipulated to provide insights into the relationship between expected retaliation and optimal tariffs. Of interest is the effect on a given tariff when tariffs change in another country, and when expectations of that response change. It is also interesting to note the impact on estimated conjectures of changes in observed tariffs. These relationships can be expressed as follows.

$$\frac{\partial t_i^d}{\partial t_j^d} = \frac{-F_i e_i \beta_j}{F_i e_i \beta_i - \beta_i}, \tag{29}$$

$$\frac{\partial t_i^d}{\partial t_j^s} = \frac{-F_i e_i \delta_j}{F_i e_i \beta_i - \beta_i}, \tag{30}$$

$$\frac{\partial t_i^d}{\partial F_i} = \frac{-\beta_i(\alpha_i - \gamma_i - (\beta + \delta)P^f + e_i \Sigma_{j=1}^n (\beta_j t_j^d + \delta_j t_j^s))}{(F_i e_i \beta_i - \beta_i)^2}, \tag{31}$$

$$\frac{\partial F_i}{\partial \bar{t}_i^d} = \frac{\beta_i(\alpha_i - \gamma_i - (\beta_i + \delta_i)P^f + e_i(\Sigma_{j \neq i} \beta_j \bar{t}_j^d + \Sigma_{j=1}^n \delta_j \bar{t}_j^s))}{(\alpha_i - \gamma_i - (\beta + \delta)P^f + e_i \Sigma_{j=1}^n (\beta_j \bar{t}_j^d + \delta_j \bar{t}_j^s))^2}. \tag{32}$$

Equations (29) and (30) show that for a given F_i an increase in tariffs in an importing country will lead to an increase in all importers' tariffs. However, an increase in an export tax (which is expressed in the negative) will result in a decrease in all importers' optimum tariffs.

Equation (31) shows that the effect of an increase in expected retaliation depends upon the direction of trade. Expected higher export taxes lead to a decrease in optimal tariffs. Likewise, expected higher import tariffs lead to a decrease in optimal taxes.

Finally, an increase in observed tariffs results in higher estimated conjectures, which are positive or negative depending once more upon the direction of trade.

Once estimated, the conjectures can be used to assess how regions or countries are likely to respond to policy changes made by their rivals. The conjectures can be varied to determine the impact of a threat or other events which change countries' beliefs about how their rivals will respond.

Having derived conjectures from an observed set of tariffs, F_i and G_i can be recalculated according to equations (27) and (28), and equation (20) can then be solved for a conjectural variations equilibrium. However, the equilibrium set of tariffs will equal the observed set. (This is one way of testing the model.) For useful analysis, it is necessary to assume constant a given set of estimated conjectures, and to change some other aspect of the model, such as the elasticities or other parameters. Here, it is assumed the United States makes an exogenous exchange rate depreciation. This can be simulated by reducing the slopes of the demand and supply functions for all countries except the United States. Let

$$\beta_i' = \beta_i \rho, \tag{33}$$

$$\delta_i' = \delta_i \rho, \tag{34}$$

where the prime denotes the demand or supply coefficient following depreciation and ρ is the new US dollar rate as a proportion of the old. With a 20 per cent depreciation $\rho = 0.8$. The impact of this is compared assuming zero and non-zero conjectural variations. An application to the world wheat trade illustrates that, by accounting for retaliation, a different and hopefully more realistic equilibrium can be attained.

4. An Application to the World Wheat Market

The current world wheat market is characterised by substantial government intervention. Policies take a variety of forms, including export subsidies, tariffs, quotas, acreage controls, price supports and more direct means such as state trading. (Schmitz et al. (1981) illustrate the importance of state trading.) These policies are invariably aimed at achieving some domestic price objectives. The theoretical model outlined earlier can be used to assess the impact of policies which have the net effect of raising domestic prices above world price. This approach avoids the problems of modelling each policy separately.

Although the model outlined here abstracts from the real world of multicommodity trade, multiple instruments and multiple goals, it can be used to show how retaliation can change the impact of many policies. The simulations shown here illustrate how the equilibrium trade flows, prices and welfare vary under alternative policy scenarios and assumptions regarding the precise nature of the retaliation.

The Data

The data used here are derived from those used by Sarris and Freebairn (1983). They are presented in Table 1. The twenty one regions are similar (with some aggregations) to those of the USDA's grain-oilseeds-livestock model (Rojko et al 1978). The price and quantity data refer to an average of 1978-79 and 1979-80. Eastern Europe, the USSR, China, East Asia and the 'Rest of World' are treated as net trading entities. Supply function are not specified for these traders. Sarris and Freebairn used short-run elasticities and obtained short-run equilibria. Because a conjectural variations solution can most sensibly be interpreted as a long-run equilibrium, the elasticities used in Sarris and Freebairn have been multiplied by four[5] for use in this analysis. While there is a certain arbitrariness, the data appears suitable for illustrative purposes.

In the reference period, the world price is taken to be the United States price, i.e. US$158. Total trade volume is 68.23 mmt, and global welfare, with the long-run elasticities, amounts to US$58760m. Because of the linear nature of the model, the welfare levels are not very meaningful; they are included here to indicate the impact of policy changes.

The Results

The following tables show domestic consumer and producer tariffs (the difference between domestic and world prices), trade volume and welfare levels. Negative tariffs reflect a domestic price below the world price (export taxes or import subsidies). Negative trade volume reflects net exports, and positive values denote net imports. The model provides a disaggregation of welfare between consumers, producers and taxpayers, but this information is not shown here.

The free trade case, shown in Table 2, is a base equilibrium that would apply if all tariffs and taxes were removed, assuming the basic parameters remain unchanged. As well as indicating how the introduction of free trade would alter prices and trade flows, it provides a benchmark for further comparisons with tariff-ridden equilibria.

If all tariffs were removed, given the data used here, world prices would rise from the base price level of US$158/t to US$175.40/t. Total trade volume would be 80.82 mmt, higher than the 68.23 mmt observed in the base period[6]. Under free trade, welfare is improved for exporters. Most importers are worse off, although the EC is a notable winner.

The Cournot-Nash solution is shown in Table 3. It is notable that all importers impose a tariff, and all exporters maximise welfare by taxing their exports. Countries with the greatest market power (reflecting market share and relative elasticities) impose the greatest tariff or tax. It is for this reason that taxes on the export side tend to be greater than on the import side. It is also noteworthy that producer and consumer prices are the same in each case[7] although there are provisions in the model for discriminating between them. With the imposition of tariffs, the world price rises to US$177.57, marginally above the free trade level of US$175.40. Trade volume and global welfare are significantly below the free trade level. However, due to their market power, exporters have increased their welfare; importers have had theirs decreased, in spite of the optimum tariffs they have imposed.

[5]Sarris and Freebairn divided some of their long-run elasticities by four. (p. 221).

[6]In the short-run case, the free trade volume falls from its reference period level to 65.82 mmt, chiefly because the EC goes from net exports to a balanced trade (see Vanzetti and Kennedy (1987) and Sarris and Freebairn (1983)). With the long-run elasticities, the EC imports a substantial amount.

[7]This is an intuitively appealling result, reflecting equal welfare weights on consumers, producers and taxpayers. Unequal weights result in differential prices.

Table 1: Base Simulation Data 1978-79 to 1979-80.

Region	S (mmt)	D (mmt)	D - S (mmt)	$\bar{t}^s$ (US$/t)	$\bar{t}^d$ (US$/t)	Es	Ed	W (US$m)
United States	53.25	22.40	-30.85	0.00	0.00	0.60	0.60	7997
Canada	19.45	5.15	-14.30	0.00	0.00	0.68	0.40	3045
Australia	17.18	3.00	-14.18	0.00	17.00	0.40	0.40	2879
Argentina	7.95	4.35	-3.60	-35.00	-35.00	0.48	0.20	2207
South Africa	1.95	1.70	-0.25	0.00	17.00	0.48	0.28	794
EC	46.30	41.25	-5.05	63.00	63.00	1.40	0.80	8449
Other West Europe	10.15	10.30	0.15	63.00	63.00	1.40	0.80	2105
Japan	0.45	6.15	5.70	585.00	42.00	0.40	0.88	961
East. Europe	0.00	4.15	4.15	0.00	0.00	0.00	0.40	820
USSR	0.00	7.55	7.55	0.00	0.00	0.00	0.60	994
China	0.00	7.40	7.40	0.00	0.00	0.00	1.00	585
Brazil	2.60	6.70	4.10	53.00	-8.00	0.60	0.48	1239
Central & Other South America	3.75	9.85	6.10	12.00	12.00	0.60	0.68	1751
Egypt	1.90	6.96	5.06	-38.00	-38.00	0.48	0.68	595
Other North Africa & Middle East	25.60	35.39	9.79	42.00	42.00	0.16	0.48	12494
Other Africa	0.75	3.50	2.75	17.00	17.00	0.60	1.00	445
India	33.37	35.14	1.77	0.00	0.00	0.40	0.80	7688
Other South Asia	12.63	15.86	3.23	-34.00	-34.00	0.40	0.80	2372
South East Asia	0.10	1.40	1.30	-8.00	-8.00	0.40	0.40	264
East Asia	0.00	5.10	5.10	0.00	0.00	0.00	0.60	671
Rest of World	0.00	4.08	4.08	0.00	0.00	0.00	1.00	322
TOTAL			68.23					58680

Source: Sarris and Freebairn, 1983.

S denotes production; D - consumption; D-S - net imports; $\bar{t}^s$ - producer tariff; $\bar{t}^d$ - consumer tariff; Es - supply elasticity; Ed - demand elasticity; W - welfare.

Table 2: Tariffs, Trade and Welfare Under Free Trade.

Region	Tariff (US$/t)	Trade (mmt)	Welfare (US$m)
United States	0.00	-37.02	8588
Canada	0.00	-15.98	3309
Australia	0.00	-14.94	3132
Argentina	0.00	-5.60	2322
South Africa	0.00	-0.35	800
EC	0.00	15.13	8997
Other West Europe	0.00	4.78	2208
Japan	0.00	6.50	909
East. Europe	0.00	3.97	749
USSR	0.00	7.05	867
China	0.00	6.58	463
Brazil	0.00	3.82	1180
Central & Other South America	0.00	5.82	1645
Egypt	0.00	2.45	579
Other North Africa & Middle East	0.00	12.38	12356
Other Africa	0.00	2.74	397
India	0.00	-2.80	7697
Other South Asia	0.00	-4.12	2505
South East Asia	0.00	1.20	243
East Asia	0.00	4.76	586
Rest of World	0.00	3.63	255
TOTAL		80.82	59787

Table 3: Cournot-Nash Tariffs, Trade and Welfare.

Region	Tariff		Trade	Welfare
	Consumer	Producer		
	(US$/t)	(US$/t)	(mmt)	(US$m)
United States	-19.71	-19.71	-30.80	8600
Canada	-8.45	-8.45	-15.38	3340
Australia	-7.85	-7.85	-14.65	3163
Argentina	-2.96	-2.96	-5.57	2334
South Africa	-0.19	-0.19	-0.37	800
EC	7.39	7.39	10.90	8953
Other West Europe	2.38	2.38	4.32	2198
Japan	3.36	3.36	6.35	895
East. Europe	2.06	2.06	3.92	740
USSR	3.65	3.65	6.88	852
China	3.38	3.38	6.32	448
Brazil	1.96	1.96	3.70	1171
Central & Other South America	2.97	2.97	5.54	1633
Egypt	1.23	1.23	2.29	574
Other North Africa & Middle East	6.34	6.34	11.49	12327
Other Africa	1.40	1.40	2.66	391
India	-1.76	-1.76	-2.91	7703
Other South Asia	-2.31	-2.31	-4.10	2514
South East Asia	0.62	0.62	1.19	240
East Asia	2.46	2.46	4.67	575
Rest of World	1.86	1.86	3.53	247
TOTAL			73.77	59701

The Cournot-Nash solution following a 20 per cent depreciation of the US dollar is shown in Table 4. Compared to the previous Cournot-Nash solution, world price has risen from US$177.57 to US$214.23, and global welfare has increased by 24 per cent in US dollar terms. As expected, optimum taxes, trade flow and welfare for the United States and all importers have risen. American producers and taxpayers have benefitted at the expense of consumers. Competing exporters suffer reduced trade volume, but all groups have benefitted, in US dollar terms, from higher world and domestic prices.

The conjectural variation estimates are shown in Table 5 along with the post-depreciation conjectural variations solution. The conjectural variation estimates are prior to depreciation. $F_i - \frac{\beta_i}{BD}$ refers to changes in response to consumer prices. $G_i - \frac{\delta_i}{BD}$ refers similarly to producer prices. The estimates are not percentage changes; they are based on a unit change in t_i. They show the weighted change in rivals' tariffs in response to a unit change in each country's tariff consistent with welfare maximisation. In other words, for the observed tariffs to be optimal, each country must have the conjectures indicated.

In general, the estimates are very low, indicating that only a small change in expectations of retaliation is necessary to significantly alter the optimum tariff. In countries with observed tariffs of zero, such as the United States in this period, the conjectures are negative, indicating that a zero tariff policy is consistent only with the expectation that the weighted sum of other traders' tariffs would fall. This would result in a decline in world and United States export prices.

Table 5 can be compared with Table 4 to assess the impact of conjecturel variations on prices, trade flow and welfare. Assuming countries hold the same expectations of retaliation after depreciation as before, the resulting tariffs and trade flows are as shown in Table 5. Countries, such as the United States, which preferred zero tariffs have maintained that level. In general, where observed tariffs and taxes were non-zero, they have risen in US dollar terms. However, world price at US$178.28 is below the revised Cournot-Nash level of US$214.23. Global welfare at US$72661m is down 2.2 per cent on the Cournot-Nash equivalent. These results illustrate that non-zero conjectures can significantly influence perceived optimum price levels.

Australia's influence as a small exporter is minimal in a non-cooperative environment. Suppose Australia had observed consumer and producer tariffs at the Cournot-Nash level of -US$7.85. How would this effect the post-depreciation conjectural variations solution? Austrlia's estimated conjectures and optimum tariff would, of course, be zero. Trade volume would fall to 12.93 mmt, but welfare would rise to US$3340m. Other exporters would benefit through increased trade flow. Trade flow from the US would increase to 38.81 mmt. On the importing side, conjectures, tariffs and trade would increase but welfare would fall. For example, the EC's conjectures would rise from .338 and .663 (see Table 4) to .340 and .667, and its tariffs would rise by US$0.04. Trade flow would rise to 6.71 mmt, but welfare would fall to US$10300m.

Table 4: Cournot-Nash Equilibrium Following Depreciation.

Region	Tariff		Trade	Welfare
	Consumer	Producer		
	(US$/t)	(US$/t)	(mmt)	(US$/t)
United States	-31.65	-31.65	-39.57	10115
Canada	-9.72	-9.72	-14.84	4053
Australia	-9.18	-9.18	-14.37	3839
Argentina	-3.39	-3.39	-5.34	2874
South Africa	-0.20	-0.20	-0.32	998
EC	10.54	10.54	13.18	11307
Other West Europe	3.23	3.23	4.93	2785
Japan	4.12	4.12	6.52	1169
East. Europe	2.50	2.50	3.99	956
USSR	4.47	4.47	7.06	1119
China	4.22	4.22	6.61	612
Brazil	2.45	2.45	3.88	1494
Central & Other South America	3.76	3.76	5.87	2086
Egypt	1.65	1.65	2.58	737
Other North Africa & Middle East	7.98	7.98	12.13	15506
Other Africa	1.76	1.76	2.80	510
India	-1.09	-1.09	-1.51	9610
Other South Asia	-2.21	-2.21	-3.30	3112
South East Asia	0.76	0.76	1.21	310
East Asia	3.02	3.02	4.79	756
Rest of World	2.33	2.33	3.69	337
TOTAL			79.25	74285

Table 5: Conjectural Variations Equilibrium Following Depreciation.

Region	$F_i - \frac{\beta_i}{BD}$	$G_i - \frac{\delta_i}{BD}$	Tariff Consumer (US$/t)	Tariff Producer (US$/t)	Trade (mmt)	Welfare (US$m)
United States	-0.053	-0.168	0.00	0.00	-38.04	8696
Canada	-0.006	-0.042	0.00	0.00	-12.81	3546
Australia	-0.012	-0.022	20.08	0.00	-13.40	3336
Argentina	0.047	0.205	-38.56	-38.56	-3.17	2676
South Africa	-0.228	-0.003	7.39	0.00	-0.09	991
EC	0.338	0.663	102.22	102.22	-6.56	10314
Other West Europe	0.340	0.586	97.53	97.53	0.19	2638
Japan	0.149	0.020	55.66	775.24	6.04	1330
East. Europe	-0.005	0.000	0.00	0.00	4.31	1106
USSR	-0.014	0.000	0.00	0.00	7.99	1392
China	-0.023	0.000	0.00	0.00	8.12	880
Brazil	-0.050	0.087	-11.03	73.05	4.52	1634
Central & Other South America	0.051	0.017	16.80	16.80	6.83	2324
Egypt	-0.478	-0.092	-58.00	-58.00	6.18	793
Other North Africa & Middle East	0.209	0.050	58.49	58.49	10.[illegible]	15879
Other Africa	0.099	0.013	23.60	23.60	3.05	619
India	-0.089	-0.042	0.00	0.00	5.80	9683
Other South Asia	2.078	0.827	14.71	14.71	-1.12	3046
South East Asia	-0.025	-0.002	-10.49	-10.49	1.36	355
East Asia	-0.010	0.000	0.00	0.00	5.40	940
Rest of World	-0.013	0.000	0.00	0.00	4.48	485
TOTAL					75.19	72661

5. Implications

The results presented here confirm a number of well-known points and illustrate some of the theoretical points developed in section three. However, any conclusions relating to the wheat market are dependent upon the linear and static nature of the model, and the particular elasticities used.

These results confirm that if a country can influence the world price, and if welfare weights are equal, the optimal policy for an importer is a positive tariff, and for an exporter a positive tax. In the absence of domestic distortions, it will be optimal to maintain producer and consumer prices at the same level.

While taxes and tariffs may be welfare maximising for individual countries, even when retaliation exists, they are not optimum from a global point of view. Global welfare under free trade was found to exceed tariff-ridden welfare levels in every case. However, because losers are not compensated (there are no side-payments), some countries may prefer the non-cooperative trade war outcome to trade liberalisation. This supports the notion that a successful outcome to multinational trade negotiations may require side-payments, perhaps in the form of concessions on non-agricultural trade.

The impact of retaliation depends upon whether it occurs on the same side of the market. Retaliation between importers leads to increased tariffs, and a movement away from the free trade equilibrium. A similar result holds for exporters. However, if a change in tariffs leads only to changes in export taxes the resulting equilibrium will be closer to free trade. It is likely that both importers and exporters will respond. The combined effect is indeterminate, depending on the relative elasticties.

The impact of expectations of retaliation is similar. An importer which expects retaliation from a rival importer will raise tariffs beyond the level that is optimal with zero conjectural variations. With the expectations of all traders taken into account, the final equilibrium may be closer to free trade than the Cournot-Nash equilibrium.

From the perspective of the individual trader, there is some value in attempting to change other countries' conjectures by issuing threats or the occasional use of policies which may be welfare-decreasing in the short run. The use of export subsidies may possibly be seen in this fashion[8].

Australia has limited influence as a small exporting nation. Nonetheless if all other traders were playing their Cournot-Nash policy, its best policy would be a small export tax. An increase in this tax, perhaps due to a change in policymakers' preferences, would make it optimal for other exporters to increase their taxes, leading to a higher world price. Optimal tariffs would fall marginally.

[8]Vanzetti and Kennedy (1987) discuss the strategic use of export subsidies.

6. Concluding Comments

In this paper it has been shown how, using the Cournot-Nash equilibrium, the outcome of a trade war in which each region imposes its optimal policy can be found. The effects of non-zero conjectural variations on the equilibrium trade flows, prices, tariffs and welfare are discussed.

Estimates of conjectures are derived from an observed set of policies. Given welfare maximising behaviour, the conjectures are those that must hold to make the observed policies rational.

The analysis is applied to a 21 region wheat trade model. The estimated set of conjectures is used to obtain an equilibrium following a 20 per cent depreciation of the US dollar. This equilibrium is compared to the Cournot-Nash equivalent.

The present model contains a number of limitations. First, the analysis is essentially static, with no attempt to portray the path to equilibrium. While the conjectural variations model includes dynamics in an implicit manner, a more careful specification of the dynamics may be rewarding.

Second, retaliation can occur in different markets. The introduction of other commodities into the model would enable some of the interactive effects to be captured, although this would probably necessitate a reduction in the number of regions. Applying the model to more recent data or other commodities may also provide useful comparisons.

For the model derived here it is assumed that no cooperative or collusive behaviour occurs. While evidence of collusive behaviour in commodity markets is not strong, its inclusion in the model may lead to somewhat different results. Simple aggregation of countries into regions or blocs is straightforward, but the possibilities for cheating and deterrence make the analysis unwieldy when individual countries form a coalition.

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