FOREIGN SUBSIDIES, DUMPING AND OPTIMAL TRADE POLICIES: THE CASE OF THE UK FERTILISER MARKET

STEVE McCORRISTON AND IAN SHELDON*

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*Agricultural Economics Unit, University of Exeter, and Department of Agricultural Economics and Rural Sociology, The Ohio State University, respectively.

Abstract

Recently the EC Commission has imposed trade restrictions on imports of fertilisers into the Community. Under competitive conditions there is no basis for such a policy. However, developments in international trade theory indicate that when markets are characterised by imperfect competition, there may be a case for intervention. Using a theoretical model originally suggested by Dixit (1988) and applying a simulation technique also developed by Dixit (1987), this paper derives optimal tariffs and subsidies for the fertiliser industry, with the UK market taken as an example. The optimal adjustment of these policies in the face of foreign export subsidies and dumping is also considered.

The theoretical and simulation results show the following: first, there is a normative case for government to use tariffs and domestic production subsidies in the fertiliser industry, and whilst the welfare-enhancing effects of these policies are low, the distributional effects are substantial. Second, in the case where only a tariff or a subsidy is used, the welfare-maximising policy would be one where the government counters the competitive distortion in the domestic fertiliser industry by using a subsidy on fertiliser production. Third, in face of foreign dumping, protection of the fertiliser industry should be reduced rather than increased.

1. INTRODUCTION

In recent years, in response to increased competitive pressure from third-country imports, the European Community (EC) has begun to implement protectionist trade policies covering the EC fertiliser market. Standard international economic theory provides little first-best justification for the use of such policies. However, recent analysis of trade policy in the presence of imperfect competition suggests that the protection of a domestic industry may be desirable, since domestic firms can capture rents from foreign firms (see Brander and Spencer, 1985 and Eaton and Grossman, 1986). Given the imperfectly competitive nature of the various national fertiliser markets within the EC, the objectives of this paper are to derive optimal import tariffs and domestic production subsidies for fertilisers and to calculate the optimal adjustment of such policies in the face of foreign export subsidies and dumping, using the UK fertiliser market as an example. This analysis is based on an application of a simulation model originally outlined by Dixit (1987).

The outline of the paper is as follows: Section 2 highlights the basic structural changes that have been occurring in the world and EC fertiliser industries; Section 3 outlines the rationale for government intervention and derives the optimal levels of policy, based on a theoretical model suggested by Dixit (1988), whilst Section 4 reports the results of a simulation exercise, using data from the UK fertiliser market as an example. The technique of calibration used in the simulation exercise is described in an Appendix. It is interesting to note that, to date, Dixit's (1988) model has only been examined in an empirical context by Dixit (1987) and Laussel *et al* (1988), both studies focussing on the automobile sector. Therefore, analysis of the fertiliser market is interesting in that it provides both a different application of Dixit (1988)

and also an example of a market where there have been accusations of foreign dumping.

2. STRUCTURAL CHANGE IN THE WORLD FERTILISER MARKET[1]

Since the beginning of the 1980s, the world fertiliser market has been undergoing structural change which has had a significant impact upon the EC fertiliser industry. In particular, there has been a shift in the balance of supply away from developed Western countries to developing and Eastern bloc countries. Oil and gas-rich countries in both the Middle East and the Eastern bloc have substantially increased their exports of fertilisers[2], whilst China and India, who were both major importers of fertilisers, have brought their own production capacity on-stream. The net effect of this has been to increase the quantities of fertilisers on world markets, putting downward pressure on prices. In tandem with this change in supply structure, demand for fertilisers in developed countries has begun to stagnate. In particular, demand within the EC has levelled off since the mid-1980s, for technical, economic and environmental reasons[3].

The overall effect of these changes has been to place the EC fertiliser industry under a great deal of competitive pressure, particularly as cheap imports have penetrated the EC market in the mid-1980s[4]. As a consequence, the EC fertiliser industry has undergone a certain amount of rationalisation within national markets, in particular, ailing companies have been taken over by non-EC firms aiming to purchase market share. This re-structuring has tended to re-inforce the already imperfectly competitive nature of the EC fertiliser industry.

In face of these pressures, the influx of low-priced fertiliser imports has also resulted in demands for protection by EC producers. In particular,

anti-dumping actions implemented by the European Commission in 1987[5] have heralded a move to a more general system of protectionist trade policies in the form of quotas and price restraints (see Lancaster, 1989, for a full discussion). In the context of these developments vis-à-vis third-country imports, this paper explores two issues: first, is there a normative case for the UK government and EC Commission to restrict fertiliser imports; and, second, if trade intervention is justified, how should these policies change in response to both subsidies by foreign governments to their exporters and dumping by overseas firms?

3. RATIONALE FOR INTERVENTIONIST TRADE POLICIES

Under competitive market conditions, it is normally argued that there is no first-best justification for the use of countervailing and anti-dumping duties. Since an importing country's terms of trade are improved by foreign export subsidies or dumping, it is better to compensate factors of production in the import competing sector through the tax system rather than impose trade restrictions. However, in recent years, "rent-shifting" arguments for intervention have been developed. The basic intuition of this analysis is that, if markets are imperfectly competitive, there is a role for government to use trade policies in order to capture a greater share of supernormal profits, i.e. a country can gain by "shifting" profits away from its foreign competitors to its domestic industry. The central focus of much of this new theory has been on competition between firms in third-country markets, e.g. Brander and Spencer (1985) and Eaton and Grossman (1986). However, in the present context, the interest is in home-market effects, in particular the trade-off between consumer surplus and domestic firms' profits.

In order to examine trade policy in the context of the EC fertiliser market, this paper applies the theoretical work of Dixit (1988) to the UK fertiliser market[6]. The structure of the fertiliser industry is divided into two, where subscript 1 refers to the four dominant firms in the UK and subscript 2 refers to a group of firms, known as blenders, who are treated as import agents. It is assumed that there is no entry/exit of firms, the dominant firms face constant average and marginal operating costs and blenders have a constant price-cost mark-up. Also, domestically produced fertilisers and imports are treated as imperfect substitutes in agricultural production.

(a) Structure of the Demand System

The aggregate demand functions are given as:

$$Q_1 = A_1 - B_1 p_1 + K p_2 \tag{1}$$

$$Q_2 = A_2 + K p_1 - B_2 p_2 \tag{2}$$

where all the parameters are positive, $(B_1 B_2 - K^2) > 0$[7], p_1 and p_2 are prices, and Q_1 and Q_2 are quantities. The corresponding inverse derived demand functions are:

$$p_1 = a_1 - b_1 Q_1 - k Q_2 \tag{3}$$

$$p_2 = a_2 - k Q_1 - b_2 Q_2 \tag{4}$$

where all parameters are positive and $(b_1 b_2 - k^2) > 0$.

This demand system can be derived by maximising the following aggregate profits function:

$$\Gamma = f(Q_1, Q_2) - p_1 Q_1 - p_2 Q_2 \tag{5}$$

where the aggregate production function $f(Q_1, Q_2)$ for farmers is defined as:

$$f(Q_1, Q_2) = a_1 Q_1 + a_2 Q_2 - \tfrac{1}{2}(b_1 Q_1^2 + b_2 Q_2^2 + 2k Q_1 Q_2) \tag{6}$$

It is important to note that, for simplicity, the aggregate production function is of quadratic form, no inputs other than the two forms of fertilisers are considered, and farmers' output prices have been normalised to one.

(b) Firms' Behaviour

In this model, firms' reactions to one another are treated as a Nash equilibrium with conjectural variations[8], the latter being derived from firms' profits functions. The profits function π_1 of a typical dominant firm is:

$$\pi_1 = (p_1 - c_1 + s)q_1 \tag{7}$$

where q_1 is its output, p_1 and c_1 are its selling price and costs respectively, whilst s is a per unit production subsidy that it may receive from government. If profits π_1 are maximised with respect to q_1, the first-order condition is given as:

$$p_1 - c_1 + s + q_1 \delta p_1 / \delta q_1 = 0 \tag{8}$$

where $\delta p_1 / \delta q_1$ is the conjectural variations parameter, i.e. the firm's expectation of how market price p_1 will vary with changes in its output q_1. Therefore, if a firm plays Cournot, it believes rival firms will not change output in response to a change in q_1, hence $\delta p_1 / \delta q_1 = -b_1$, the slope of the inverse demand function. If the market were perfectly competitive, a change in one firm's output would have no effect on market price, hence $\delta p_1 / \delta q_1 = 0$. Thus a wide range of oligopolistic behaviour is captured in this term.

Expression (8) can be aggregated over the n_1 firms, the first-order condition being given as:

$$p_1 - c_1 + s - Q_1 V_1 = 0 \tag{9}$$

where V_1 is the aggregate conjectural variations parameter. For Cournot behaviour, $V_1 = -b_1 / n_1$ and as n_1 increases, the more competitive is the Cournot

outcome. For perfectly competitive behaviour, $V_1 = 0$. Similar expressions, inclusive of a per unit tariff t, can be derived for the blenders:

$$p_2 - c_2 - t - Q_2 V_2 = 0 \tag{10}$$

(c) Optimal Trade Policies

For the policymaker, economic welfare is defined as the sum of farmers' producer surplus Γ, the dominant firms' profits and government revenue[9] as given by:

$$W = \Gamma + Q_1(p_1 - c_1 + s) + (tQ_2 - sQ_1) \tag{11}$$

It should be noted that the profits of the blenders have been excluded from the welfare function, as the optimal policies are aimed exclusively at protecting the dominant firms and also the blenders are being treated as import agents.

The aim of optimal policy is to maximise welfare, as defined by (11), assuming that the firms' conjectures and the demand parameters are unaffected by government policies. In theory, the full optimum requires the government to use both a tariff and a subsidy, the object of the former being to capture a portion of the foreign firms' monopoly rents, whilst the latter is aimed at removing the domestic monopoly distortion. However, constrained optima can also be derived, where either the tariff or the subsidy are set equal to zero. In this case, the chosen policy assumes part of the role that the other policy takes in the full optimum, e.g. when only the tariff is used, its optimal level will be higher in order to encourage greater domestic output and hence reduce the domestic distortion. The case of a positive tariff and zero subsidy is probably the most relevant in that a production subsidy, whilst being the welfare-maximising policy, is unlikely to be a viable instrument.

In the case of the full optimum, (11) is maximised with respect to t and s such that:

$$dW = (p_1 - c_1)dQ_1 + (t - Q_2 V_2)dQ_2 \tag{12}$$

where the first-order conditions can be written as:

$$p_1 = c_1 \quad \text{or} \quad s = Q_1 V_1 \tag{13}$$

$$t = Q_2 V_2 \quad \text{or} \quad p_2 = c_2 + 2t \tag{14}$$

(13) indicates that the optimal subsidy removes the domestic market distortion, whilst the tariff in (14) captures half of the foreign firms' mark-up.

Since in (13), s is proportional to domestic output Q_1 and in (14) t is proportional to foreign output Q_2, solutions for t and s can be derived by utilising explicit expressions for Q_1 and Q_2, as given by:

$$\begin{bmatrix} Q_1 \\ Q_2 \end{bmatrix} = \frac{1}{\Delta'} \begin{bmatrix} b_2 + V_2 & -k \\ -k & b_1 + V_1 \end{bmatrix} \begin{bmatrix} a_1 - c_1 + s \\ a_2 - c_2 - t \end{bmatrix} \tag{15}$$

where $\Delta' \equiv (b_1 + V_1)(b_2 + V_2) - k^2$. (15) is derived from (3), (4), (9) and (10). The explicit solutions for the tariff and subsidy can be written as:

$$t = \frac{-(a_1-c_1)kV_2 + (a_2-c_2)b_1 V_2}{(b_2+2V_2)b_1 - k^2} \tag{16}$$

$$s = \frac{(a_1-c_1)V_1(b_2+2V_2) - (a_2-c_2)kV_1}{(b_2+2V_2)b_1 - k^2} \tag{17}$$

Expressions (16) and (17) indicate that both the optimal tariff and subsidy are affected by the relative cost levels of the home and foreign firms. Also, the potential for rent-shifting through the tariff varies positively in the value of the foreign firms' conjectural variations parameter V_2, whilst the pro-competitive effect of the subsidy varies positively with both the degree of monopoly distortion in the home market, as reflected in V_1, and the degree of imperfectly competitive behaviour exhibited by foreign firms, as shown by V_2.

In the case of the constrained optimum, the tariff is found by maximising (11) with respect to t, given s is set equal to zero, such that:

$$dW/dt = (p_1 - c_1)\delta Q_1/\delta t + (t - Q_2 V_2)\delta Q_2/\delta t \tag{18}$$

the expression for an optimal tariff being:

$$t = Q_2V_2 + (Q_1V_1 - s)k/(b_1 + V_1)$$ (19)

Compared to (14), expression (19) clearly indicates that in the constrained optimum the tariff is higher than for the full optimum. Substituting for Q_1 and Q_2 from (15), the explicit expression for the optimal tariff is:

$$t = \frac{(a_1-c_1)k(\beta_2V_1-\beta_1V_2)+(a_2-c_2)(\beta_1^2V_2-k^2V_1)}{\beta_1^2(\beta_2+V_2)-k^2(\beta_1+V_1)}$$ (20)

By a similar process, (11) can be maximised with respect to s, given that t is set equal to zero, such that the expression for an optimal subsidy is:

$$s = Q_1V_1 + (Q_2V_2 - t)k/(b_2 + V_2)$$ (21)

Again, compared to (13), it can be seen that for the constrained optimum, the subsidy is higher than for the full optimum. Substituting for Q_1 and Q_2 from (15), (21) becomes:

$$s = \frac{(a_1-c_1)(\beta_2^2V_1-k^2V_2)+(a_2-c_2)k(\beta_1V_2-\beta_2V_1)}{\beta_2^2(\beta_1-V_1)+k^2(V_2-\beta_2)}$$ (22)

As in the case of the full optimum, expressions (20) and (22) indicate how, in the constrained optima, the values of the tariff and subsidy will vary with the relative cost levels of the home and foreign firms and also the conjectural variations parameters.

(d) Adjustment of Policies

Whilst it is welfare maximising to implement these policies, it is important to establish by how much they should be altered in response to foreign export subsidies and dumping by foreign firms. This is particularly relevant in the context of the EC fertiliser industry, given the utilisation of anti-dumping regulations in 1987.

An increase in foreign subsidies is interpreted as a decrease in the foreign firms' costs. In the context of the model of the UK fertiliser market,

this is treated as a fall in the costs of the import agents, i.e. c_2. In the case of the full optimum, equations (16) and (17) are differentiated with respect to c_2, generating expressions for the optimal adjustment of the tariff and subsidy:

$$-dt/dc_2 = \frac{b_1 V_2}{(b_2 + 2V_2)b_1 - k^2} \tag{23}$$

$$-ds/dc_2 = \frac{-kV_1}{(b_2 + 2V_2)b_1 - k^2} \tag{24}$$

Expression (23) indicates that a foreign export subsidy should be partially countervailed by an increase in the optimal tariff, the response varying with both the degree of competitiveness of the foreign firms, i.e. V_2, and the substitutability of home produced goods and imports, i.e. k. Expression (24) shows that the production subsidy should be reduced as the lower cost of imports increases the competitive pressure on domestic firms, the extent of reduction depending on the competitiveness of home and foreign firms and the degree of product differentiation.

In the case of the constrained optima, (20) and (22) are differentiated with respect to c_2, generating the following expressions:

$$-dt/dc_2 = \frac{\beta_1^2 V_2 - k^2 V_1}{\beta_1(\beta_1 \beta_2 - k^2) + (\beta_1^2 V_2 - k^2 V_1)} \tag{25}$$

$$-ds/dc_2 = \frac{k(\beta_1 V_2 - \beta_2 V_1)}{\beta_2(\beta_2 \beta_1 - \beta_2 V_1 - k^2) + k^2 V_2} \tag{26}$$

Unlike the full optimum, the direction of change in the optimal tariff and subsidy in response to foreign export subsidies cannot be predicted unambiguously. This follows from the earlier argument that, in the constrained optimum, each policy assumes part of the role that the other takes in the full

optimum. Consequently, the right-hand sides of (25) and (26) can be either positive or negative depending on the size of V_2 relative to V_1, i.e. for a partial countervailing duty, the right-hand side of (25) will be positive, whilst the subsidy will be reduced if the right-hand side of (26) is negative.

Following Dixit (1988), dumping is treated as a reduction in the foreign firms' conjectural variations term V_2, i.e. more competitive behaviour on the part of the import agents. As V_2 falls, then the price p_2 will also fall[10], either below the foreign market price or their average costs of production[11]. In the case of the full optimum, expressions (16) and (17) are differentiated with respect to V_2, and combined with an expression for dp_2/dV_2, derived from (10) and (15), the expressions being:

$$dt/dp_2 = \left[\frac{b_1 b_2 - k^2}{(b_2 + 2V_2)b_1 - k^2}\right]\left[\frac{\beta^2_1(\beta_2 + V_2) - k^2(\beta_1 + V_1)}{2\beta_1(\beta_1 b_2 - k^2)}\right] \qquad (27)$$

$$ds/dp_2 = \left[\frac{kV_1}{(b_2 + 2V_2)b_1 - k^2}\right]\left[\frac{\beta_1^2(\beta_2 + V_2) - k^2(\beta_1 + V_1)}{\beta_1(\beta_1 b_2 - k^2)}\right] \qquad (28)$$

In the case of the constrained optima, the same process is followed using (20) and (22), the responses to dumping being:

$$dt/dp_2 = \frac{\beta_1(\beta_1 b_2 - k^2) + k^2 V_1}{2\beta_1(\beta_1 b_2 - k^2)} \qquad (29)$$

$$ds/dp_2 = \left[\frac{k[\beta_2(\beta_1 + V_1) + k^2 V_1 - k^2]}{\beta_2^2(\beta_1 - V_1) + k^2(V_2 - \beta_2)}\right]\left[\frac{\beta_1^2(\beta_2 + V_2) - k^2(\beta_1 + V_1)}{2\beta_1(\beta_1 b_2 - k^2)}\right] \qquad (30)$$

Whilst these equations are complex, (27)-(30) indicate that in both the full and constrained optima, the optimal tariff and subsidy should be reduced in the face of dumping[12]. The rationale for this is as follows: due to the aggressive nature of the exporters' policies, the import price p_2 falls. As this action

makes the domestic market more competitive, there are less super-normal profits to capture from the exporter, and hence the case for implementing a tariff declines. Similarly, since the market is more competitive, there is less need for a production subsidy to offset domestic monopoly distortions.

4. SIMULATION RESULTS

Given the previous analysis, it is useful to measure empirically the welfare effects of implementing optimal tariffs and subsidies. In order to do this, values for the policies can be derived by calibrating the demand system contained in equations (1) to (4), following a technique suggested by Dixit (1987), (see Appendix for a full discussion of the calibration). Based on data for the UK fertiliser industry in 1985, the simulated policy values for both the full and constrained optima are indicated in Table 1. In order to calculate the optimal response to foreign export subsidies and dumping, it was assumed that in both cases, c_2 and p_2 fall by £10/tonne and £35/tonne of fertiliser. The value of £10/tonne is used as a benchmark whilst the value of £35/tonne is used on the grounds that UK fertiliser import prices were observed to fall by this much in 1986.

Table 1 Simulated Policy Values for the UK Fertiliser Market, 1985 Values (£/tonne)

	Initial Policy Values	Response to Foreign Export Subsidies($-c_2$)		Response to Dumping($-p_2$)	
Full Optimum		£10	£35	£10	£35
t	8.30	9.12	11.17	3.30	-9.20
s	30.38	30.16	29.59	30.11	29.43
Constrained Optima					
t,s = 0	18.22	18.96	20.83	13.17	0.57
s,t = 0	31.80	31.71	28.74	30.59	27.58

In line with the theoretical analysis, the values for the tariff and subsidy are higher in the constrained optima than the full optimum. Also in response to foreign export subsidies, tariffs are increased whilst domestic subsidies fall, and for dumping, the optimal tariff is decreased and again subsidies fall. Importantly, in the case of dumping, when the decrease in p_2 of £35/tonne is simulated, the dumping margin is so high that, for the full optimum, the optimal tariff becomes an import subsidy, whilst for the constrained optimum, the tariff is virtually reduced to zero[13].

The intuition of the latter result is as follows: whilst p_2 exceeds c_2, there are rents to be captured and so the optimal tariff will be positive. Once p_2 falls below c_2, due to dumping by foreign firms, there are no longer rents to be "shifted". However, because of the competitive effect of imports, it is optimal for the importing country to provide a subsidy to foreign firms if p_2 falls sufficiently below c_2[14]. Effectively, the importing country subsidises the costs of foreign firms in order to maintain the competitive impact of low priced imports. In practical policy terms though, it is unlikely that an import subsidy would ever be a viable policy instrument, consequently, reductions in the value of the optimal tariff would probably be bounded at zero.

Using (11), the welfare effects of these policies can be simulated, given the no-policy value for welfare in 1985 as a benchmark. The results are shown in Tables 2 and 3, for the full and constrained optima respectively. Several comments can be made about these results. First, whilst there is a normative argument for initially implementing tariffs and subsidies, the actual welfare gains are small, a finding which is similar to Dixit's (1987) empirical results for the US car industry. Second, the distribution of the gains/losses is of interest; farmers' producer surplus unambiguously increases as the domestic

monopoly distortion is removed by the subsidy, whilst the dominant firms benefit from the tariff. Clearly there is a net loss to government revenue, dominated by payment of the subsidy. Also, in the case of the constrained optima, the subsidy proves to be the better policy. Third, welfare improves significantly in the presence of either foreign export subsidies or dumping, although the use of an import subsidy in the case of the full optimum clearly increases the net loss to government revenue.

Table 2   Simulated Welfare Effects for Trade Policies in the UK
Fertiliser Market, Full Optimum, 1985 Values (£million)

	No Policy	Initial Policy Values	Response to Foreign Export Subsidies($-c_2$)		Response to Dumping($-p_2$)	
			£10	£35	£10	£35
Producer Surplus	152.36	186.50	188.80	195.52	190.38	202.62
Firms' Profits(π_1)	32.97	45.03	44.36	42.71	44.10	41.82
Government Revenue	-	-42.85	-41.73	-38.76	-43.09	-45.60
Total	185.33	188.68	191.43	199.47	191.39	198.84

Table 3 Simulated Welfare Effects for Trade Policies in UK Fertiliser Market, Constrained Optima, 1985 Values (£million)

	No Policy	Initial Policy Values		Response to Foreign Export Subsidies$(-c_2)$				Response to Dumping$(-p_2)$			
		t	s	t		s		t		s	
				£10	£35	£10	£35	£10	£35	£10	£35
Producer Surplus	152.36	147.67	190.06	150.14	157.54	193.49	199.27	151.69	164.12	191.03	196.85
Firms' Profits(π_1)	32.97	33.51	45.67	33.26	32.63	44.47	40.99	33.11	32.09	44.80	41.47
Government Revenue	-	+4.86	-47.16	+5.55	+7.45	-46.68	-40.99	+4.07	+0.24	-44.80	-39.07
Total	185.33	186.04	188.57	188.95	197.62	191.28	199.27	188.87	196.45	191.03	199.25

5. SUMMARY

In the context of the EC fertiliser industry, this paper has examined the use of tariffs and subsidies as strategic policy instruments. Using Dixit's (1988) theoretical analysis, optimal tariffs and subsidies in the presence of imperfect competition have been derived. The adjustment of such policies in the face of foreign export subsidies and dumping has also been derived. Three important results follow from this analysis; first, there is a normative case for initially implementing tariffs and subsidies, and although the net increase in national welfare is small, important re-distributive effects can occur. Second, in the case of the constrained optima, a production subsidy is better than an import tariff. Third, due to the pro-competitive effects of dumping by foreign firms, the extent of protectionism should be reduced. In particular, given the large reduction in import prices observed in the UK fertiliser market in 1986, the results suggest that in the case of the full optimum, an import subsidy would have been optimal, whilst in the case of the constrained optima, the tariff would have been reduced almost to zero (see Table 1).

NOTES

1. Discussion of changes in the late-1970s and early-1980s is contained in, "EC Fertiliser Industry" (European Commission, 1988). A more recent analysis can be found in Lancaster (1989).

2. See Agra Europe (June 1987).

3. Optimal rates of fertiliser application in the EC have now been achieved at the same time as pressure has been placed on the Common Agricultural Policy (CAP) support system and the implementation of EC regulations on nitrate run-off.

4. Between 1985 and 1986, EC imports increased by three hundred per cent (Agra Europe, June 1987).

5. Following the 1985/1986 increase in imports, the EC Commission imposed a minimum import price in 1987.

6. A description of the UK fertiliser industry can be found in McCorriston and Sheldon (1987).

7. This condition implies the two types of fertiliser are imperfect substitutes, i.e. the own-price effects differ from the cross-price effects.

8. Whilst conjectural variations models of oligopoly can be criticised for being static, as Dixit (1986) has pointed out, a tractable dynamic solution is not available.

9. Throughout the analysis, it is assumed that the government applies equal weight to all interest groups.

10. p_2 could fall for reasons other than dumping by overseas firms; for example, increased competition in the foreign market.

11. As p_2 cannot fall below marginal costs, this is a weaker definition of dumping.

12. In the case of the full optimum, the tariff should be reduced by half the dumping margin, whilst for the constrained optimum, reduction of the tariff relative to the dumping margin lies between half and one.

13. Because the tariff is higher in the constrained optimum, p_2 will have to fall further below c_2 before the tariff becomes negative.

14. Sensitivity analysis indicates that whilst the optimal tariff and subsidy values alter, the direction of change in welfare remains the same.

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APPENDIX

In order to both derive the optimal trade policies and simulate their effects, it is necessary to have estimates of the parameters in the demand system. This is done by taking some of the parameter estimates from external empirical sources. The remainder are calculated by calibrating the theoretical model such that the parameters are consistent with equilibrium in the market in a given period. Focussing on equations (1) and (2), there are five unknown parameters A1, A2, B1, B2 and K. Since actual prices and quantities give two relations between them, three further relations are required to solve the system.

Following Dixit (1987), expressions for the price elasticity of demand and elasticity of substitution can be derived and then set equal to empirically observed values. In the case of the price elasticity of demand, since the products of the dominant firms and of the blenders are being treated as imperfect substitutes, it is interpreted as being the effect of an equiproportionate rise in the price of the two products on total fertiliser expenditure Q. Therefore, letting $p_1 = P_1^o P$ and $p_2 = P_2^o P$, where P_1^o and P_2^o are initial prices and P is the proportional change factor, the aggregate expenditure for fertilisers can be written as:

$$Q = P_1^o Q_1 + P_2^o Q_2 \qquad (A1)$$

Given that in the calibration p_1 and p_2 are the initial prices, and substituting equations (1) and (2) into (A1), the aggregate expenditure index can be re-written as:

$$Q = p_1 A_1 + p_2 A_2 - (B_1 p_1^2 + B_2 p_2^2 - 2K p_1 p_2)P \qquad (A2)$$

The total market elasticity of demand for fertiliser, ε, is then defined and evaluated at the initial point where the proportional change factor P equals

1. By differentiating (A2) with respect to P, and multiplying by P/Q, the elasticity is given as:

$$\varepsilon = - \frac{B_1 p_1{}^2 + B_2 p_2{}^2 - 2K p_1 p_2}{Q} \tag{A3}$$

The elasticity of substitution would normally be defined as :

$$\sigma = d\log(Q_1/Q_2)\big/ d\log(p_1/p_2) \tag{A4}$$

which gives a fourth relation between the parameters when set equal to the observed value for σ. However, as Dixit (1987) notes, equations (1) and (2) in general define the ratio Q_1/Q_2 as a function of the vector (p_1, p_2) and not in terms of the ratio p_1/p_2. In order for Q_1/Q_2 to be a function of p_1/p_2, at least locally, then the parameters must satisfy the following final relation:

$$p_1(A_1 K + A_2 B_1) = p_2(A_2 K + A_1 B_2) \tag{A5}$$

which implies homotheticity of the production function. Given the definition of σ in (A4) and using equations (1), (2) and (A5), the final expression for the elasticity of substitution can be derived as:

$$\sigma = \frac{\dfrac{p_1}{p_2}(B_1 B_2 - K^2)}{\left(B_1 \dfrac{p_1}{p_2} - K\right)\left(B_2 - K \dfrac{p_1}{p_2}\right)} \tag{A6}$$

The demand system in equations (1) to (4) was calibrated for the year 1985 using price, quantity and elasticity data as presented in Table A1. p_1 and p_2 are the average selling prices of the dominant firms and blenders respectively over the year 1985 based on reported prices in the UK farming press. Q_1 and Q_2 are derived from Fertiliser Manufacturer Association data and other farming and trade sources. The value of the elasticity of demand ε is based on an estimate made by Cowling and Metcalf (1967), although more recent estimates by Burrell (1989) suggests a similar value. No estimate of σ is available for the UK, so

a value of 2.00 was assumed, which compares with an Australian estimate made by Higgs (1986) of 1.7. c_1, the operating costs for the dominant firms are based upon reported cost levels in Challinor (1987) and the UK farming press, whilst c_2, the blenders' operating costs are assumed to be £10 below the selling price p_2.

Table A1 Calibration Data

p_1	126.00	(£/tonne)
p_2	120.00	(£/tonne)
Q_1	1,268,000	(tonnes)
Q_2	317,000	(tonnes)
ε	0.65	
σ	2.00	
c_1	100.00	(£/tonne)
c_2	110.00	(£/tonne)

Having calibrated the model, the parameter estimates shown in Table A2 are consistent with equilibrium in the UK fertiliser industry in 1985. Estimates of the conjectural variations parameters V_1 and V_2 are presented in Table A3. For the purposes of comparison, the Cournot-equivalent values of V_1 and V_2 are also shown. The values indicate that, given the assumptions made about firms' costs, the dominant firms were acting slightly more competitively than Cournot whilst the blenders were acting less competitively than Cournot.

Table A2 Demand Parameters

Aggregate Demand Functions		Inverse Demand Functions		
A_1	2,092,200	a_1		320
A_2	523,050	a_2		305
B_1	7,799	b_1	(10^{-4})	1.38
B_2	3,104	b_2	(10^{-4})	3.47
K	1,321	k	(10^{-5})	5.88

Table A3 Conjectural Variations Parameters

	Actual Values		Cournot-Equivalent Values	
V_1	(10^{-5})	2.05	(10^{-5})	3.45
V_2	(10^{-5})	3.15	(10^{-5})	1.74