

Export Subsidies and Countervailing Duties Under Asymmetric Information

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Trade policy is analysed in a setting in which the home government chooses its subsidy level first after which the foreign government chooses tariffs on its imports. Two setups are considered: (i) when home firm's costs are private information, (ii) when foreign firm's costs are private information. We show that a low-cost home firm has an incentive to misrepresent itself as high-cost in (i) while the foreign firm has an incentive to misrepresent itself as low-cost in (ii). Compared to complete information, home government sets a higher subsidy in the signalling case whereas foreign government sets same tariff in the first setup while tariff is lower in the second setup.

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1. Introduction

For the past two decades the use of export subsidies and countervailing duties has been on the rise. The General Agreement on Tariffs and Trade (GATT)¹ allows the use of duties on the subsidised imports if the relevant industry can show that it falls in the so-called 'unfair trade' category, i.e., if the exports are either being dumped in the importing country or are being subsidised. A response by the importing country is usually a countervailing tariff or a voluntary export restraint. The impact of these impositions on the importing country has been studied by several authors, notably Staiger and Wolak (1992, 1994), Reitzes (1993) and Qiu (1995).

Staiger and Wolak (1992, 1994) use empirical model to show that the antidumping duties against a foreign monopoly restrict foreign imports and increase the share of the import-competing domestic firms. Reitzes (1993) and Qiu (1995) use a two period game between the

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¹ World Trade Organisation (WTO) since 1 January 1995.

governments (and firms) and analyse the effect of a VER or a countervailing duty once export subsidy is provided by the foreign country. Reitzes shows that the use of antidumping duty improves the domestic welfare when firms compete a' la Cournot but with Bertrand competition the effect is welfare worsening. Qiu shows that the countervailing duties, when imposed under GATT constraints and with delayed reactions, have no effect on the welfare of the two countries.

None of the above mentioned papers, however, assumes asymmetric information between the firms and the governments. However, in oligopolistic industries it is unlikely that the government has full information about the costs and/or demand of the firms. In this setting the trade literature has used the tools of regulation theory to analyse the impact of asymmetric information on the optimal policies of competing governments. The informational asymmetry is quite important in determining the injury claimed by the domestic firms. For instance, the Department of Commerce in the United States initiates an investigation only from the information provided to it by the interested party (firm with foreign competition). Also, several International Trade Commission (ITC) commissioners have complained about the quality of information, provided by the firms, they have to rely upon in order to make decisions on countervailing and antidumping duty cases.

This paper addresses the information problem and adds to the existing literature of international trade under asymmetric information. Most of the studies in international trade using asymmetric information approach have been in the so called third-market models, thus extending the Brander and Spencer (1985) model to the case in which governments are uninformed about either the cost or the demand parameter.² Information asymmetry about marginal cost in the third-market setup has been analysed by Brainard and Martimort (1996, 1997), Collie and Hviid (1993), Qiu (1994), Maggi (2000) and Wright (1998), among others.³

Our paper extends Wright (1998) by considering a different setup in which the government is not only concerned with the protection of its industry but also about the welfare of its consumers. Furthermore, we assume both governments use trade policy to influence the outcome in their country as the usual assumption of a government adopting non-interventionist policy unilaterally is not real. Finally, unlike Wright, we consider two distinct cases of asymmetric information: (i) when the home firm's costs are private information, (ii) when foreign firm's costs are private information.

² One notable exception is Rosendorff (1996) who studies the use of VERs and CVDs when the government is incompletely informed about the electoral returns from the two policy parameters. Also see recent papers by Montado (2000), Cheng et al (2001) and Kolev and Prusa (2002).

³ Within the same setup, some papers also consider the alternative trade policy instruments, i.e., VERs, quantity/subsidy restrictions with different combinations between home and foreign governments etc (see Cooper and Reizman, 1989; Shivakumar, 1993 and Caglayan and Usman, 2004).

We develop a two-period game and analyse the effect of asymmetric information in which the home firm has private information about its costs which it signals to the foreign firm and both home and foreign governments by its choice of the first period output level. Based on some prior probability assessment, at the beginning of period 1 the home government chooses an optimal subsidy level after which the foreign government derives its optimal tariff. In the next stage both firms compete in quantities. At the end of period 1 both the governments and the foreign firm observe home firm's quantity and update their beliefs about the type of home firm they are facing, low or high cost. Given the updated beliefs, the home and foreign governments, in period 2, choose their respective policy instruments in the same sequence as in the first period. The two firms then choose their optimal quantities.

In the third-market set-up the two countries are *ex ante* identical and therefore it could be assumed, without loss of generality, that the cost is private with regard to either of the two exporting firms. In the framework of this paper, by contrast, the two countries are not identical since the output market is located only in one of them and the governments use different policy instruments. Therefore, here it is natural to also analyse the effect on the trade policy instruments when the foreign firm's costs are unknown. This is done in Section 4.

In both cases of information asymmetry, i.e., when home firm has private information and when the foreign has private information about its costs, the firms have an incentive to misrepresent themselves by distorting their outputs away from the profit maximising levels under complete information. In particular, we find that in the first case of asymmetric information (about home firm's costs) the home firm produces less in the presence of signalling than what it would produce when there is complete information. For the home government it is optimal to give a higher subsidy (or a lower export tax) in the first period. This is because signalling commits a high cost firm to a lower output level in the first period and hence a smaller tax is needed to reduce this distortion and improve domestic welfare. Furthermore, we find that the foreign government uses the same level of tariff whether the home firm has private information about its costs or not.

However, in the second case of asymmetric information (about foreign firm's costs) the foreign firm produces more in the presence of signalling than it would under complete information. Under such a setup, the home firm provides a higher subsidy in the first period whereas the same period tariff is lower.

The rest of the paper is organised as follows. Section 2 presents the benchmark case when there is complete information about both firms' costs. Sections 3 and 4 present the separating and pooling equilibria for the two cases of asymmetric information, i.e., when home and foreign firms' costs are unknown, respectively. Analysis of the comparison between two

information structures is presented in Section 5 and finally the last section concludes the paper.

2. Complete Information: The Benchmark Case

There are two countries, one foreign and one home, each with one firm producing a homogenous good for consumption in the foreign country. The inverse demand function is given by $p = a - (q + q^*)$, where q and q^* are the quantities produced by the home and foreign firms, respectively and a is a positive parameter. Both governments use trade policy instruments to protect their respective firms. In addition, the foreign government also takes into account the consumer surplus which is given by $V = Q^2/2$ where $Q = q + q^*$.

The structure of the game is as follows. At the beginning of period 1 the home government commits to a subsidy for the home firm. After observing the subsidy chosen by the home government, the foreign government imposes tariff on its imports. In the last stage of the game both firms choose their outputs to maximise their respective profits.⁴ Game is solved using backward induction.

The profits for the home and foreign firms are given as,

$$\pi = (a - q - q^* - c + s - t)q \quad (1)$$

$$\pi^* = (a - q - q^* - c^*)q^* \quad (2)$$

The first order conditions for the maximisation problem give the reaction functions of each firm. Solving the two first order conditions simultaneously gives home and foreign outputs:

$$q = \frac{1}{3}(a - 2c + c^* + 2s - t) \quad (3)$$

$$q^* = \frac{1}{3}(a + c - 2c^* - s + t) \quad (4)$$

Next we solve for import tariffs which the foreign government imposes as a countervailing duty to the export subsidy given by the domestic firm in the first stage. The foreign government maximises consumer surplus, firm profits and the tariff revenue,

$$G^* = V(p(q, q^*), q^*) + \pi^*(q, q^*) + tq$$

⁴ Collie (1994) also considers this structure under complete information. See Dixit (1988) and Collie (1991) for a comparison with a simultaneous move model.

Solving this yields the optimal tariff as a function of the domestic export subsidy, $t = \frac{1}{3}(a - c + s)$. At stage 1 the domestic government sets its subsidy to maximise domestic welfare realising that its subsidy will affect the optimal tariff set by the foreign government in stage 2. The home government therefore solves the following problem,

$$\max_s \{G = \pi(c, c^*) - sq(s, t)\}$$

The solution to this problem, taking account of the second stage tariff gives the optimal export subsidy,

$$s^C = -(a - 4c + 3c^*) / 40 \quad (5)$$

and the import tariff then is given by

$$t^C = (13a - 12c - c^*) / 40 \quad (6)$$

Faced with the prospect of a countervailing duty in the second stage, the optimal strategy for the domestic government is to use export tax in the first stage which will then result in a lower tariff.

Substituting the values of subsidy and tariff in (3) and (4) we get the optimal quantities for both firms.

$$q^C(c, c^*) = \frac{1}{10}(a - 4c + 3c^*) \quad (7)$$

$$q^{*C}(c, c^*) = \frac{1}{20}(9a + 4c - 13c^*) \quad (8)$$

Corresponding profits for home and foreign, respectively, are $\pi(c, c^*) = \left(\frac{a - 4c + 3c^*}{10}\right)^2$ and

$$\pi^*(c, c^*) = \left(\frac{9a + 4c - 13c^*}{20}\right)^2.$$

3. Incomplete Information about Domestic Firm's Costs

Given the structure of the game explained above, now we assume that in period 1 neither the home and foreign governments nor the foreign firm knows the cost of the home firm, though it is common knowledge that the costs are high (c^H) with probability δ and low (c^L) with probability $(1-\delta)$. Marginal cost of the foreign firm is common knowledge and is denoted by c^* . At the last stage of period 1 both firms make their output decisions simultaneously, to maximise profits. After observing the output levels of the home firm, the uninformed agents update their beliefs about the costs of the home firm.

Based on the updated beliefs $\delta(q_1)$, both governments set their respective policy instrument levels to maximise welfare in period 2. Given the subsidy and tariff levels chosen by the governments and given the updated beliefs of the foreign firm, both firms choose output levels to maximise their second period profits. For the second period, therefore, we can use the full information subsidies and tariffs (equations 5 and 6) as our benchmark levels.

Given the setup of the game, the equilibrium concept used is sequential equilibrium (Kreps and Wilson, 1982), which in this setting is a list of period 1 and 2 outputs for each type of each firm and a system of beliefs that are consistent with each other and satisfy sequential rationality at every information set. Two distinct types of equilibria are considered: separating and pooling. In the case of separating equilibrium the home firm either plays q^L or q^H . The foreign firm and both governments then form a posterior belief function about the home firm's costs and based on this belief function, the government chooses an optimal subsidy level s after which the foreign government responds with a countervailing duty.

In the case of pooling equilibrium the home firm uses the same output level regardless of its costs. In this case the foreign firm's and both governments' posterior beliefs are the same as their prior beliefs.

3.1 Separating Equilibria

Optimal Behaviour in Period 2

The choice of quantity in the first period in a separating equilibrium fully reveals the domestic firm's costs to the foreign firm and both governments. Given the first period cost information, the domestic government first chooses the subsidy level, s , after which the foreign government announces the level of its import tariff, t , and then both firms choose their outputs by maximising their respective profits, which are same as those obtained in the full information case except now we have for each type of firm, low cost and high cost. Based on these, maximisation of welfare results in the optimal subsidy and tariff:

$s_2^i = -(a - 4c^i + 3c^*)/40$ and $t_2^i = (13a - 12c^i - c^*)/40$, where $i = L, H$. Putting these in the profit function we obtain profits for both home and foreign firms:

$$\hat{\pi}_2^i(c^i, c^*) = \left(\frac{a - 4c^i + 3c^*}{10} \right)^2 \text{ and } \hat{\pi}_2^{*i}(c^i, c^*) = \left(\frac{9a + 4c^i - 13c^*}{20} \right)^2.$$

Optimal Behaviour in Period 1

In period 1 the marginal cost of the home firm is private information and is therefore unknown to the foreign firm and both policymakers, home and foreign. As before, at the beginning of the first period subsidy is chosen after which the tariff is decided and in the last stage both firms choose their respective output levels.

In separating equilibria either type of the home firm chooses different output levels, i.e., the high cost firm will play q^H while if it's a low cost firm then it will play q^L . Thus the foreign firm's posterior beliefs associated with the home firm's high cost signal are, $\delta(q^H) = 1$, and the posterior beliefs associated with the low cost signal are $\delta(q^L) = 0$ and it suffices for any other signal q_1^i to be associated with the belief $\delta(q_1^i) = 0$, $i = L, H$.

The optimal behaviour in period 1 must satisfy the following incentive compatible conditions

$$\pi_1^H(q_1^H, s_1, t_1) + \hat{\pi}_2^H \geq \pi_1^H(q_1^L, s_1, t_1) + \hat{\pi}_2^{H/L} \quad (9)$$

$$\pi_1^L(q_1^L, s_1, t_1) + \hat{\pi}_2^L \geq \pi_1^L(q_1^H, s_1, t_1) + \hat{\pi}_2^{L/H} \quad (10)$$

where $\hat{\pi}_2^{i/j}$ ($i = L, H$) are the profits when the actual costs are c^i but the home firm, via the output choice in first period, signals the costs as c^j , and is given by,

$$\hat{\pi}_2^{i/j}(c^{i/j}, c^*) = \left(\frac{a - 5c^i + c^j + 3c^*}{10} \right)^2.$$

Equation (9) means that the high cost firm would prefer to produce q^H in period 1 and be perceived as high cost in period 2 rather than be perceived as low cost in period 2 and be forced to produce q^L in period 1. Note that tariff and the export tax (since optimal subsidy is negative) are lower for the high cost firm, therefore $\hat{\pi}_2^H > \hat{\pi}_2^{H/L}$.

Equation (10) states that if the home firm was low cost then it will prefer to produce q^L in the first period and be perceived as low cost in period 2 rather than be perceived as high cost and forced to produce q^H in period 1. However, note that $\hat{\pi}_2^L < \hat{\pi}_2^{L/H}$ since when the low cost firm

mimics a high cost one, import tariff and export tax are lower compared to the case when the low-cost firm reveals the true costs. The low cost firm, therefore, has an incentive to deviate. Let $q_1^L(q_1^*, s_1, t_1)$ be the solution of $\arg \max \pi_1^L(q_1^L, s_1, t_1)$. Given $q_1^L(q_1^*, s_1, t_1)$, there are many q_1^H that satisfy equation (10). However, only one survives as part of separating equilibrium once the dominated strategies are eliminated when forming out-of-equilibrium beliefs. Any output level less than \bar{q}_1^H in Figure 1 is a sequential separating equilibrium since the posterior belief after observing q_1^H is that $\delta(q_1^H) = 0$. However, output q_1^H is dominated for the low cost firm by the output q_1^L and if the uninformed parties believe that the home firm will never choose a dominated output, then the only possible posterior beliefs after observing output q_1^H are $\delta(q_1^H) = 1$. This overturns any equilibrium involving output less than \bar{q}_1^H in favour of q_1^H as it yields higher profits. We can argue a similar case for any output greater than \bar{q}_1^H . Therefore the only separating equilibrium that survives after dominated strategies are eliminated when forming out-of-equilibrium beliefs are $q_1^L(q_1^*, s_1, t_1)$ and $\underline{q}_1^H(q_1^*, s_1, t_1) < q_1^H$.

The output level $q_1^L(\cdot)$ is chosen only by the low cost firm and hence the low cost firm is able to obtain complete information profits. The high-cost firm, however, needs to distort its output away from the complete information level to convince the governments and the foreign firm that it is indeed high-cost. This distortion causes a cost on the high-cost firm as the output necessary to achieve this, \underline{q}_1^H , is lower than the complete information output.

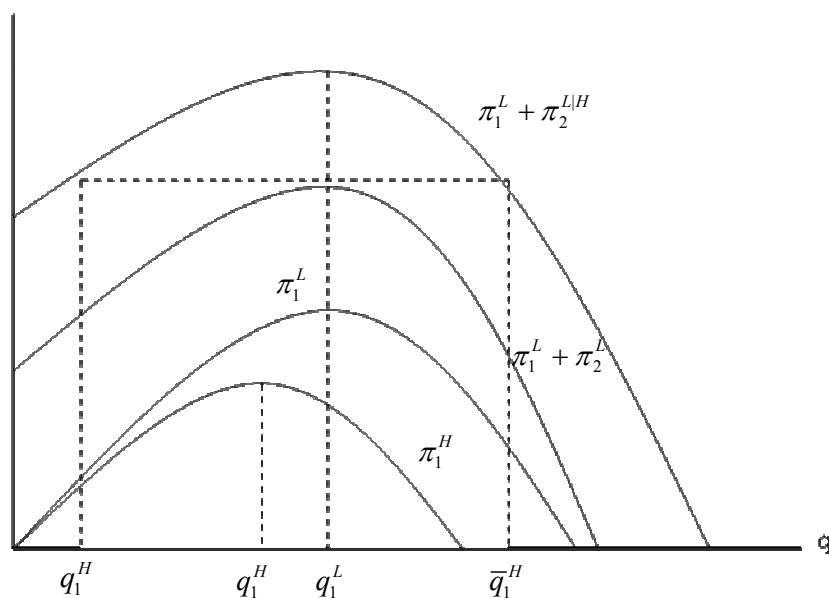


Figure 1: Separating Equilibria

The outputs q_1^H and q_1^L (.) satisfy equation (10) and therefore the incentive compatibility constraint for the low-cost firm is binding. Also, given that foreign firm maximises expected profits and that the home firm chooses the output level that creates distortion and high profits, the separating sequential equilibrium could be solved by simultaneously solving equation (10) and the following equations,

$$q_1^L(q_1^*, s_1, t_1) = \arg \max \pi_1^L(q_1^L, s_1, t_1) \quad (11)$$

$$q_1^*(q_1^H, q_1^L, s_1, t_1) = \arg \max \left\{ \delta \pi_1^{*H}(q_1^H, q_1^*, s_1, t_1) + (1-\delta) \pi_1^{*L}(q_1^L, q_1^*, s_1, t_1) \right\} \quad (12)$$

The solution of these equations yields q_1^L (.), q_1^H (.) and q_1^* (.) as the unique separating equilibrium of the signalling game. Note that equation (10) is quadratic and therefore gives two solutions, q_1^H and \bar{q}_1^H , one of which yields higher profits and hence will be chosen by the home firm.

$$q_1^H = \frac{1}{3} (a - 2c^L + c^* + 2s - 2t) - \frac{(3+\delta)}{30} \sqrt{K} \quad (13)$$

$$q_1^L = \frac{1}{3} (a - 2c^L + c^* + 2s - 2t) - \frac{\delta}{30} \sqrt{K}$$

$$q_1^* = \frac{1}{3} (a - 2c^* + c^L + c^* - s + t) + \frac{\delta}{15} \sqrt{K} \quad (14)$$

where, $K = (c^H - c^L)(2a + c^H - 9c^L + 6c^*) > 0$.⁵

Both governments take this equilibrium as given and choose the level of their respective policy instruments. Working backwards, the foreign government chooses import tariff by maximising its welfare and taking into account subsidy chosen in the first stage,

$$\max_{t_1} G_1^* = \delta \left[V(p(q_1^H, q_1^*)) + \pi_1^{*H}(q_1^H, q_1^*) + t_1 q_1^H \right] + (1-\delta) \left[V(p(q_1^L, q_1^*)) + \pi_1^{*L}(q_1^L, q_1^*) + t_1 q_1^L \right] \quad (15)$$

The home government similarly maximises its welfare to choose export subsidy knowing the reaction of the foreign government in the next stage,

$$\max_{s_1} G_1 = \delta \left[\pi_1^H(q_1^H, q_1^*) - s_1 q_1^H(s_1, t_1) \right] + (1-\delta) \left[\pi_1^L(q_1^L, q_1^*) - s_1 q_1^L(s_1, t_1) \right] \quad (16)$$

⁵ See Appendix for the proof that $K > 0$.

where π is obtained by substituting the separating equilibrium of the output game into home firm profit. Solving the first order conditions for this problem yields the optimal subsidy,

$$s_1^D = -\frac{1}{40}(a - 4c^L + 3c^*) - \frac{9\delta}{10}(c^H - c^L) + \frac{\delta}{5}\sqrt{K} \quad (17)$$

Putting the value of subsidy in the tariff obtained from solving equation (16) we get

$$t_1^D = \frac{1}{40}(13a - 12\bar{c} - c^*) \quad (18)$$

where, $\bar{c} = \delta c^H + (1 - \delta)c^L$.

Putting the subsidy and tariff values obtained above in the separating equilibrium outputs, equations (13) and (14), gives

$$\hat{q}_1^H = \frac{1}{10}(a - 4\bar{c} + 3c^*) - \frac{(1 - \delta)}{10}\sqrt{K} \quad (19)$$

$$\hat{q}_1^L = \frac{1}{10}(a - 4\bar{c} + 3c^*) + \frac{\delta}{10}\sqrt{K}$$

$$\hat{q}_1^* = \frac{1}{20}(9a + 4\bar{c} - 13c^*) \quad (20)$$

Proposition 1: *The solution defined by (17) – (20) constitute a unique separating sequential equilibrium of the signalling game when the home firm's costs are private information.*

In the presence of asymmetric information about home firm's costs, the high-cost firm is forced to lower its equilibrium quantity to \hat{q}_1^H in order to distinguish itself from the low-cost firm. The government, therefore, must distort its subsidy upwards in order for the firm to signal the true costs through its choice of quantity in the first period. A more detailed analysis of this result is conducted in section 5.

3.2 Pooling Equilibrium

In a pooling equilibrium both types of home firm produce the same level of output in the first period and hence the prior beliefs of the foreign firm and both governments are also the posterior beliefs. As before we will first solve for period 2 levels and then move back to period 1.

Period 2

Given beliefs and the subsidy and tariff, the home firm maximises profits as in period 2 in section 3 and the foreign firm maximises expected profits given by,

$$\max_{q_{2p}^i} E\pi_2^* = \delta(a - q_2^H - q_2^* - c^*)q_2^* + (1 - \delta)(a - q_2^L - q_2^* - c^*)q_2^*$$

Solving the three first order conditions simultaneously yields the Bayesian-Cournot equilibrium quantities. Putting these values in the profit functions give us the maximised profits for both firms. Using these profit values, the governments of both countries maximise their welfares as before in a sequential fashion with the home government setting the subsidy first followed by the foreign government. Maximising the expected welfares and solving for s and t , we get

$$s_{2p}^D = -\frac{1}{40}(a + 4\bar{c} - 3c^*) \quad (21)$$

$$t_{2p}^D = \frac{1}{40}(13a - 12\bar{c} - c^*) \quad (22)$$

where, p in the subscript refers to the pooling equilibrium. Putting these values in the firms' quantities we get the following:

$$\hat{q}_{2p}^H = \frac{1}{10}(a + \bar{c} - 5c^H + 3c^*) \quad (23)$$

$$\hat{q}_{2p}^L = \frac{1}{10}(a + \bar{c} - 4c^L + 3c^*)$$

$$q_{2p}^* = \frac{1}{20}(9a + 4\bar{c} - 13c^*) \quad (24)$$

Period 1

For the home firm, the output level chosen in the first period to be part of the pooling equilibrium, the same level of output must be chosen by the high- and low-cost firm. The following are the necessary and sufficient conditions for an output level q_1^p to be part of the pooling equilibrium,

$$\pi_{1p}^H(q_{1p}^H, s_1, t_1) + \hat{\pi}_{2p}^H \geq \pi_1^H(q_1^H, s_1, t_1) + \hat{\pi}_2^H$$

$$\pi_{1p}^L(q_{1p}^L, s_1, t_1) + \hat{\pi}_{2p}^L \geq \pi_1^L(q_1^L, s_1, t_1) + \hat{\pi}_2^L$$

Again we will have multiple equilibria emerging in this setup as any output level q_1^p with beliefs $\delta(q_1) = 0$ if $q_1 < q_1^p$, $\delta(q_1) = 1$ if $q_1 > q_1^p$ and $\delta(q_1) = \delta$ if $q_1 = q_1^p$, can be part of the pooling equilibrium (see Fig. 2). However, none of these output levels survive as part of the equilibrium once dominated strategies are eliminated when forming out-of-equilibrium beliefs. Take output level q_1^p . It forms the pooling equilibrium only because after observing an output level q_1^L the posterior beliefs of the foreign firm and both governments are that $\delta(q_1^L) = 1$. Nevertheless, output q_1^L is dominated by output q_1^p for the high cost firm. And hence if the foreign firm and the governments believe that the home firm will never choose a dominated output, the only posterior beliefs upon observing q_1^L is $\delta(q_1^L) = 0$. This overturns any equilibrium involving q_1^L because the posterior beliefs on which it is based are found to be implausible. A similar argument applies to any other out-of-equilibrium output level. Therefore, using the intuitive criteria due to Cho and Kreps (1987), we can state the following result.

Proposition 2: *There does not exist any pooling equilibria and the only possible outcome of such a game is a separating equilibrium.*

As mentioned, in a pooling equilibrium the quantity selected by the firm is independent of its type. In the absence of any signalling, the uninformed agents learn nothing about the home firm's costs and its posterior beliefs are equal to its prior beliefs. One could, however, consider pessimistic beliefs to sustain a pooling sequential equilibrium. The output q_1^p could possibly be sustained as a pooling equilibria with pessimistic beliefs like $\delta(c^H) = 1$ if $q = q^p$, $\delta(c^H) = 0$ if $q \neq q^p$. The existence of pooling equilibrium depends on whether the pooling quantity played by the home firm in period 1 lowers the tax and tariff in the second period. Beliefs on q_1^p are such that the home and foreign governments believe that the home firm is high cost and choose lower tax and tariff, respectively. These beliefs minimise the incentive for the low cost to deviate. If the output is different from q_1^p , the governments believe that the firm has low costs and set high levels of their respective policy instruments. q_1^p constitutes a pooling equilibrium if and only if $q_1^H \leq q_1^p \leq q_1^L$.

Nevertheless, none of these output levels can be equilibrium, as either the home firm deviates or the beliefs are found to be implausible when considering out-of-equilibrium strategies.

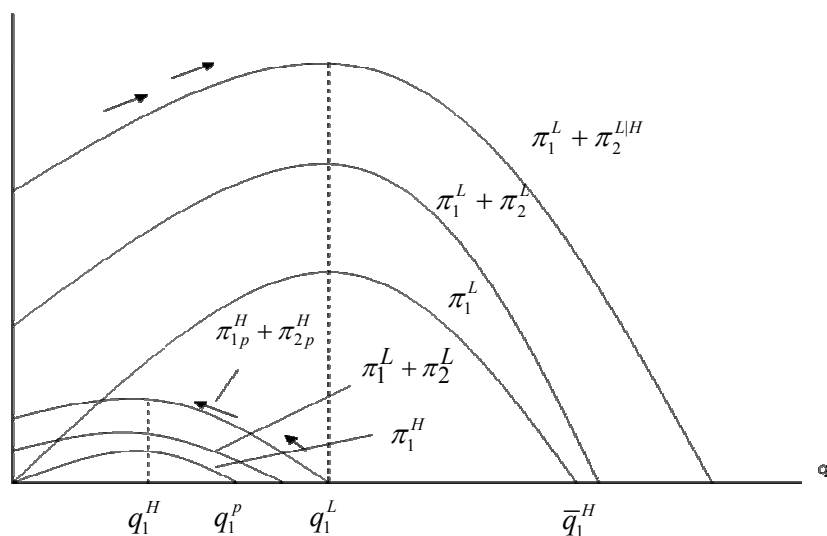


Figure 2: Pooling Equilibria

4. Incomplete Information about Foreign Firm's Costs

In the previous section we showed that foreign government's tariff decision is unchanged when there is information asymmetry about the home firm's costs. In this section we analyse the reversal of information asymmetry, i.e., the case where the home firm's costs are common knowledge but the foreign firm's costs are not known to the home and foreign governments and the home firm.⁶ However, it is common knowledge that the foreign firm's costs are low (c^L) with probability δ and high (c^H) with probability $(1-\delta)$.

The general structure of the game is the same as in Section 3. However, here the high-cost foreign firm has an incentive to misrepresent itself as low-cost in order to gain a strategic advantage in terms of its governments' trade policies, especially to manipulate its government to impose a higher tariff. After observing foreign firm's output choice made in the last stage of period 1, the uninformed parties update their beliefs about the costs of the foreign firm. Then based on the updated beliefs both governments set their respective policy instrument levels to maximise welfare in period 2.

The optimal behaviour in period 1 must satisfy the following incentive compatibility conditions

⁶ Wright (1998) has analysed the case where both firms signal their costs. However, unlike Wright, since we have an active foreign government it is useful to see the impact of the reversal of information asymmetry in our model. Furthermore, it is difficult to obtain analytical solution when both firms signal their costs to the rival.

$$\pi_1^{*H}(q_1^{*H}, s_1, t_1) + \hat{\pi}_2^{*H} \geq \pi_1^{*H}(q_1^{*L}, s_1, t_1) + \hat{\pi}_2^{*H|L} \quad (25)$$

$$\pi_1^{*L}(q_1^{*L}, s_1, t_1) + \hat{\pi}_2^{*L} \geq \pi_1^{*L}(q_1^{*H}, s_1, t_1) + \hat{\pi}_2^{*L|H} \quad (26)$$

The explanation of these equations is analogous to the one given for equations (9) and (10). Given this, and using the same approach as before, we find that the only separating equilibrium that survives after dominated strategies are eliminated when forming out-of-equilibrium beliefs are $q_1^{*H}(q_1, s_1, t_1)$ and $\underline{q}_1^{*L}(q_1, s_1, t_1) > q_1^L$. Then solving (25) along with the following system of equations,

$$q_1^{*H}(q_1, s_1, t_1) = \arg \max \pi_1^{*H}(q_1^{*H}, s_1, t_1) \quad (27)$$

$$q_1(q_1^{*H}, q_1^{*L}, s_1, t_1) = \arg \max \left\{ \delta \pi_1^L(q_1, q_1^{*L}, s_1, t_1) + (1 - \delta) \pi_1^H(q_1, q_1^{*H}, s_1, t_1) \right\} \quad (28)$$

we get the quantities for the home and foreign firms as functions of subsidy and tariff, which could then be used to derive the optimal subsidy and tariff levels.

$$s_1^F = -\frac{1}{40}(a - 4c + 3c^{*H}) + \frac{\delta}{20}(c^{*H} - c^{*L}) + \frac{\delta}{400}\sqrt{K^*} \quad (29)$$

$$t_1^F = \frac{1}{40}(13a - 12c - c^{*H}) + \frac{7\delta}{20}(c^{*H} - c^{*L}) - \frac{13\delta}{400}\sqrt{K^*} \quad (30)$$

Substituting these back in the values obtained above, we get

$$\hat{q}_1^{*L}(F) = \frac{1}{20}(9a - 4c + 3c^{*H}) + \frac{\delta}{10}(c^{*H} - c^{*L}) + \frac{(10 - 7\delta)}{600}\sqrt{K^*} \quad (31)$$

$$\hat{q}_1^{*H}(F) = \frac{1}{20}(9a - 4c + 3c^{*H}) + \frac{\delta}{10}(c^{*H} - c^{*L}) + \frac{\delta}{200}\sqrt{K^*}$$

$$\hat{q}_1(F) = \frac{1}{10}(a - 4c + 3c^{*H}) - \frac{\delta}{5}(c^{*H} - c^{*L}) - \frac{\delta}{100}\sqrt{K^*} \quad (32)$$

where $K^* = 3(c^{*H} - c^{*L})(18a + 8c - 23c^{*H} - 3c^{*L}) > 0$ (see Appendix for the proof) and F (for foreign) in the brackets is used to distinguish the values from Section 2 results.

Proposition 3: *The solution defined by (29) – (32) constitutes a unique separating sequential equilibrium of the signalling game when the foreign firm's costs are private information.*

The intuition is analogous to the one for proposition 1. Here, in the presence of asymmetric information about foreign firm's costs, the low-cost firm is forced to produce more in order to distinguish itself from the high-cost firm. This will then distort the output of the home firm as well subsidy and tariff levels. More detailed discussion of this result is provided in Section 5.

Pooling

As before there does not exist a pooling equilibria and again the only possible outcome of such a game is a separating equilibrium. Instead of repeating the analysis from before, we here report only the optimal values obtained after solving the maximisation problem of the respective agent.

$$s_{2p}^F = -\frac{1}{40}(a + 4c - 3\bar{c}^*)$$

$$t_{2p}^F = \frac{1}{40}(13a - 12c - \bar{c}^*)$$
(33)

$$\hat{q}_{2p}^{*H}(F) = \frac{9}{20}(a + 4c - 13\bar{c}^*)$$

$$\hat{q}_{2p}^L(F) = \frac{9}{20}(a + 4c - 3\bar{c}^* - 10c^{*L})$$
(34)

$$q_{2p}^*(F) = \frac{1}{10}(9a - 4c + 3\bar{c}^*)$$
(35)

5. Analysis and Discussion

In this section we analyse the policy choices of all players in this trade game, i.e., both firms and both governments. In particular, we compare the levels of output and the level of trade policy instruments of the two information structures, i.e., when there is incomplete information about the home and the foreign firm's costs. Thus comparing (5-6) with (17-28) and (7-8) with (13-14), we get our first result.

Proposition 4: *In the presence of incomplete information about the home firm's costs, (i) the subsidy is higher (i.e., export tax is lower) than complete information level whereas tariff is the same as in complete information: $s_1^D > s^C$, $t_1^D = t^C$*
(ii) Low-cost (high-cost) type home firm's demand is lower (higher) compared to the complete information levels: $q_1^H < q^C$, $q_1^L > q^C$.

Proof: See Appendix.

The intuition behind the above result is as follows. Given the strategy of the two policymakers, the low cost home firm has an incentive to present itself as high cost since that will mean a higher export subsidy (lower tax) in the second period. Therefore, the high cost firm must distort its output away from the one that maximises profits when there is no signalling. The distortion is below the profit maximising level since that will deter a low cost firm from mimicking a high cost one.

As regards the policymakers, for the home government it is optimal to impose a lower tax in the first period. This is because signalling commits a high cost firm to a lower output level $q_1^H(q_1^*, s_1, t_1) < q_1^H$ in the first period and hence a smaller tax is needed to reduce this distortion and improve domestic welfare. Furthermore, a reduced export tax increases the production of both types of firms but since signalling tends to reduce the high cost firm's output, the *expected* output of the home firm is the same in signalling and under complete information. This in turn results in the same level of expected output by the foreign firm and the same level of tariff by the foreign government whether the home firm signals its costs or not.

This result is in contrast with the one obtained in Brainard and Martimort (1997), not only because the presence of foreign retaliation results in an export tax (which is a well known result), but also because they show that the subsidy under incomplete information is lower than the one obtained under full-information.

For the second case of incomplete information, i.e., when foreign firm has private information about its costs, we can compare the incomplete information levels of trade policy instruments and quantities (equations, 29-32) with their respective levels under complete information (equations, 5-8) to obtain the following result.

Proposition 5: *In the presence of incomplete information about foreign firm's costs, (i) subsidy is higher (i.e., tax is lower) and tariff is lower than under complete information: $s_1^F > s^C$, $t_1^F < t^C$*

*(ii) output for both types of foreign firms is higher under signalling equilibrium compared to the complete information levels: $q_1^{*i}(F) > q^C$, while the home firm's output level is lower under signalling equilibrium: $q_1(F) < q^C$.*

Proof: See Appendix.

Here both types of foreign firm has an incentive to produce more under signalling than under complete information as that way they can induce the home firm to produce less in the second period. Given the foreign firm's commitment to produce more, the foreign government sets a lower tariff than the one obtained under complete information. More foreign firm production shifts rents from the home country and a lower tariff increases the consumer surplus, thus

maximising foreign country welfare. Faced with the prospect of, in essence, a commitment to lower retaliatory tariff by the foreign government, the home government provides a higher subsidy under incomplete information than under full information.

Since both governments are assumed to be active in their trade policy in this paper, analysis of the results obtained under the two different information structure is one of the key elements. Therefore, after comparing subsidies and tariffs in equations (17,18) with those in equations (29,30), we can state the final result of this paper.

Proposition 6: *Subsidy is lower and tariff is higher when home firm has private information about its costs compared to when foreign firm has the private information: $s_1^D < s_1^F$; $t_1^D > t_1^F$*

It is easier to show this result using an example. Letting $a = 50$, $\rho = 0.5$, $c^H = c^{*H} = 10$, $c^L = c^{*L} = 5$, $c = c^* = 7.5$, the subsidy and tariff under the first information structure are, respectively $s_1^D = -1.22$ and $t_1^D = 13.81$; whereas under the second information structure $s_1^F = -0.99$ and $t_1^F = 12.94$, which proves the above result.

The high-cost foreign firm distorts the output level below the profit-maximising level when its costs are private information in order to convince the home firm and the policymakers that it is indeed high-cost. Also, the expected output level for the foreign firm is higher under signalling than under complete information, resulting in expected output level for the home firm under signalling to be less than under complete information. Given this, the foreign government requires a lower tariff level as foreign firm commits to a higher output level. Anticipating this, the home government provides a higher subsidy under foreign private information case (compared to home private information case). Note here that a lower home output level is not so much because of lower home firm efficiency but because of higher distortion caused by foreign firm's private information, hence higher subsidy (or actually a lower tax) is required to shift rents.

6. Conclusion

This paper has explored the role of information in the formulation of trade policy for home and foreign country, in a setting in which the home government chooses its subsidy level first after which the foreign government retaliates by imposing tariffs on its imports. We have analysed the effect on optimal levels of policy instruments in an environment in which home firm costs are private information but it can signal these costs to both policymakers and the foreign firm by choosing the appropriate output level and a similar analysis when the foreign firm's costs are private knowledge.

The benchmark case of complete information for this Stackelberg game showed that the best policy for the home government is to impose an export tax on its firm since that results in a

lower tariff by the foreign government. Then, under asymmetric information, the low cost firm has an incentive to mimic the inefficient one by choosing the output level of a high cost firm. The high cost firm, in order to prove that it indeed has high costs distorts its output below the profit maximising level. Since signalling creates a distortion, it is optimal for the home government to use a lower export tax in the first period. However, since the expected home firm output is same in signalling vs. complete information equilibria, the optimal policy for the foreign government is to use the same level of tariff regardless of home firm's first period actions, and similarly the foreign firm produces the same level of output.

In the case when foreign firm's costs are private information we found that both countries' level of policy instrument is higher under incomplete information (signalling) than under complete information. For the foreign government, the commitment of its firm to produce more means that lower tariff is needed to maximise profits. In turn the home government can provide a higher subsidy given the foreign government's commitment to a lower tariff.

Although there are a number of other retaliating instruments to an export subsidy, in practice governments only use tariffs to respond to a subsidy. Since domestic welfare is maximised by imposing an export tax when the home government anticipates tariffs from the importing country, it seems that the actual policy of giving a subsidy is based on some other factors, as it is clearly welfare worsening. One can therefore argue that the presence of asymmetric information in favour of the subsidising country is at least one of the culprits since a significant distortion of the output level by the home firm could result in the home government giving a subsidy to reduce distortion, when it is actually not the best policy.

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Appendix

Proof that $K > 0$.

Putting the optimal values of subsidy and tariff in (3) in the text gives us

$q_2^H = \frac{1}{10}(a - 4c^H + 3c^*)$. For the interior solution of the home firm output, we need

$$a - 4c^H + 3c^* > 0 \quad (\text{A1})$$

Multiplying (A1) by 2 we get

$$2a - 8c^H + 6c^* > 0 \quad (\text{A2})$$

Finally noting that $c^H - c^L > 0$ and adding $9(c^H - c^L)$ in (A2), we get

$$2a + c^H - 9c^L + 6c^* > 0 \quad (\text{A3})$$

Hence $K > 0$.

Proof that $K^* > 0$.

Putting the optimal values of subsidy and tariff in optimal value of foreign output we get

$q_2^{*H} = \frac{1}{20}(9a + 4c - 13c^{*H})$. For the interior solution of the home firm output, we need

$$9a + 4c - 13c^{*H} > 0 \quad (\text{A4})$$

Multiplying (A4) by 2 we get

$$18a + 8c - 26c^{*H} > 0 \quad (\text{A5})$$

Again noting that $c^H - c^L > 0$ and adding $3(c^H - c^L)$ in (A2), we get

$$18a + 8c - 23c^{*H} - 3c^{*L} > 0 \quad (\text{A6})$$

Hence $K^* > 0$.

Proof of Proposition 4:

(i) Subtracting elements of equation (20) from equation (16) in the text, we get

$$s_1^D - s_1^C = -\frac{9\delta}{10}(c^H - c^L) + \frac{\delta}{40}\sqrt{K} \quad (\text{A7})$$

From (A2) and the fact that $c^H > c^L$ we get

$$2a + c^H - 9c^L + 6c^* > 9(c^H - c^L) \quad (\text{A8})$$

Therefore, $\sqrt{K} > 9(c^H - c^L)$ and hence $s_1^D > s_1^C$.

(ii) It is clear that subtracting equation (22) from (18) gives us the required result.

Proof of Proposition 5:

(i) Subtracting subsidy in equation (31) from (28) we get

$$s_1^F - s^C = \frac{\delta}{20}(c^{*H} - c^{*L}) + \frac{\delta}{40}\sqrt{K^*} > 0 \quad (\text{A9})$$

and hence $s_1^F > s^C$.

(ii) Subtracting tariff in equation (31) from (28), we get

$$t_1^F - t^C = \frac{7\delta}{20}(c^{*H} - c^{*L}) - \frac{13\delta}{40}\sqrt{K^*} \quad (\text{A10})$$

From (A4) and the fact that $c^H > c^L$ we get

$$10(c^{*H} - c^{*L}) < 18a + 8c - 23c^{*H} - 3c^{*L}$$

Therefore, for a sufficiently large a $\sqrt{K^*} > 10(c^{*H} - c^{*L})$ and hence $t_1^F < t_1^C$.