Uniform versus Discriminatory Tariffs: When Will Export Taxes Be Used?

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May 24, 2003

Abstract

This paper examines the non-cooperative interactions between two exporting countries and one importing country when all of them are seeking the optimal policies to improve their welfare. For the importing country, a uniform tariff regime is preferable, but the exporting countries may prefer a discriminatory tariff regime instead. In either tariff regime, the importing country chooses to impose import tariffs, but the choice of export policies of the exporting countries depends on the tariff regime. In some cases, the optimal export subsidies for the exporting countries are negative under a discriminatory tariff regime.

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1 Introduction

This paper attempts to combine two branches of strategic trade policy literature together, and to analyze the choice of export subsidies and import taxes in a unified framework in order to provide a better insight into the interactions among the governments of two exporting countries and an importing country.

In a seminal paper, Brander and Spencer (1985) show that under Cournot competition a domestic export subsidy allows a domestic firm to gain at the expense of a rivalry firm in another exporting country. Their paper initiates a great deal of interest on the proper use of export subsidies.[1] It is noted that in the Brander-Spencer and related models, the government of the third country, which imports the goods from the two countries, is assumed to be inactive. On the other hand, there is a separate literature which analyzes the optimal policies for an importing country, which buys a homogeneous product from two countries with rivalry firms. For example, Gatsios (1990) and Hwang and Mai (1991) show that the optimal policy for the importing country is to impose a higher tariff on the product from the more cost-efficient exporter. Choi (1995) and Horiba and Tsutsui (2000) extend the literature by comparing the impacts of discriminatory and uniform tariffs. Both of these two papers examine the choice of the two tariff regimes by the importing country, and investigate how a regime may affect the level of technologies chosen by the exporting firms. All these papers focus on the policies of the importing country, while assuming that the exporting governments are inactive.

In this paper, we consider a model similar to those examined by all these papers:

[1] It has been shown that Brander and Spencer's result is sensitive to some of the assumptions in the model. For example, Eaton and Grossman (1986) argue that if the firms compete in a Bertrand way, the optimal domestic policy is an export tax. Horstmann and Markusen (1986) consider the case of integrated markets with free entry and find that an export subsidy is welfare-deteriorating. See, for example, Wong (1995) and Brander (1995) for recent discussion of the use of some of these strategic policies.

two exporting countries and one importing country, with one firm in each of the exporting country competing in a Cournot way. What makes the present paper different from others is that we allow all three governments to be active in choosing the optimal values of their policies: an export subsidy/tax for each exporting country and a tariff/subsidy for the importing country. We also analyze the impacts of two different tariff regimes: a uniform tariff regime, as required by the "Most-Favored-Nations" (MFN) clause of the GATT/WTO, and a discriminatory tariff regime. Choosing between these two types of tariff regimes is an interesting issue in the present framework, because it not only determines the welfare of the importing country, but also affects the export subsidies chosen by the exporting countries. The present more extensive model and analysis as compared with what is existing in the literature can be used to answer several questions: If each exporting country is aware of the tariffs to be imposed by the importing country on the products from itself and its rival, does it still have an incentive to impose an export subsidy, as Brander and Spencer proposed? Does such an export subsidy depend on whether the importing country is using discriminatory tariffs or a uniform tariff? How may the non-cooperative equilibrium in terms of export subsidies be affected by the tariff regimes chosen by the importing country? What is the optimal tariff of the importing country in response to the export subsidies chosen by the exporting countries? How would the importing country choose between the two tariff regimes? How would the welfare of these countries be affected by the policies and the policy regimes?

Some of the results obtained in the present paper can be linked to the existing results. Under a uniform tariff regime, as required by the MFN clause of the GATT/WTO, the Brander-Spencer argument kicks in, and each country has the right incentive to promote the export of its own firm with an export subsidy. If the importing country is using discriminatory tariffs, the argument in the papers by

Gatsios, Hwang and Mai, Choi, and Horiba and Tsutsui is applicable: An importing country tends to impose a higher tariff on the more cost-efficient exporter. Thus, in our model, there are two forces that affect the export subsidy chosen by an exporting country: the profit-shifting argument of Brander and Spencer and the tariff effects that tend to induce each government to raise the effective marginal cost of its own firm in order to avoid a higher tariff. As a result, the actual export subsidy can be negative.

The remainder of the paper is organized as follows: Section 2 describes the assumptions of the model and the features of a four-stage game. Sections 3 and 4 analyze the equilibrium of a game under a uniform tariff regime and a discriminatory tariff regime, respectively. Section 5 compares the two tariff regimes in terms of the welfare of all these countries. Section 6 provides a brief summary and some concluding remarks.

2 The Model

We consider a one-product, two-firm, three-country model. Two of the countries, which are labeled 1 and 2, have a firm producing a homogeneous product to be exported to the third country, M. There is no other producer of this product in country M and there is no consumption of this product in the two exporting countries. Demand in country M is given by the inverse demand function, $p = p(Q)$, where p is the market price. We assume $p(.)$ is decreasing and twice continuously differentiable with $p''(Q)Q + p'(Q) < 0$, where a prime after a variable represents a derivative.[2] The output of firm i, the one in country i, is denoted by q_i, $i = 1, 2$. So in equilibrium $Q = q_1 + q_2$. Firm i has a constant marginal cost, c_i, and a fixed cost, f_i. For simplicity,

[2] The assumption that $p''(Q)Q + p'Q < 0$, which is satisfied if the demand curve is not too convex to the origin, is made to ensure a declining marginal revenue curve.

fixed cost f_i is set to zero because it will not affect the equilibrium of the game. All technology and demand information is known to all parties.

The governments of all three countries are active in setting policy parameters to improve the welfare of its economy. The government of each exporting country considers an export subsidy (may be negative), while the importing country, M, chooses a tariff. Facing the goods from countries 1 and 2, country M can choose to impose the same tariff rates on these goods, the so-called "Most-Favored-Nations" (MFN) clause, or choose to impose different tariff rates on the goods from different countries. In order to analyze how the exporting country may respond to these two types of tariff treatments, it is assumed that country M has announced credibly whether it is going to impose a uniform tariff rate or differential tariff rates. After the governments have announced their policies, the firms compete in a Cournot way.

To analyze the interactions among the countries, we consider the following four-stage, one-shot non-cooperative game. In the first stage, country M announces whether it is using a uniform tariff regime or a discriminatory tariff regime. In the second stage, the two exporting countries choose their export subsidies, s_1 and s_2, simultaneously and non-cooperatively. In the third stage, after observing the export subsidies, country M imposes tariffs according to the tariff regime it announced in the first stage. All government announcements are credible and cannot be reversed. In the fourth stage, the two firms compete in quantities in the market of country M. To make our analysis interesting, we assume that the market in country M is big enough so that both firms are willing to produce a positive output under all policy parameters chosen by the governments.[3] Note that country M is assumed to choose the tariff regime before, but the actual tariff rates after, the exporting countries' choice

[3] As a matter of fact, country M would never want to impose a prohibitive tariff, and each exporting country would want to use an export subsidy to promote its own export, but usually would not want to drive the other firm out of the market.

of their export subsidy policies. This reflects the assumption that it is easier for the importing country to set its tariff rate, but that the tariff regime, which represents the country's international commitment or its position in an international setting, e.g., whether it has to follow the MFN clause of GATT/WTO, cannot be changed so easily.

In what follows, we analyze the two tariff regimes separately. The two regimes are then compared in terms of the welfare of the importing country and the exporting countries.

3 Optimal Export Subsidy Policy under Uniform Tariff Regime

Denote the uniform specific tariff imposed by country M by $\hat{t}$, and the exporting countries know that a uniform tariff will be imposed. The game is solved by backward induction. In the fourth stage, taking the specific export subsidies, s_1 and s_2, and the uniform tariff $\hat{t}$ as given, firm i maximizes its following profit:

$$\pi_i = [p(Q) - c_i + s_i - \hat{t}]q_i, \;\; i = 1, 2.$$

The first-order condition for each firm to choose the optimal quantity is

$$\frac{\partial \pi_i}{\partial q_i} = p' q_i + p - c_i + s_i - \hat{t} = 0. \tag{1}$$

Define $a_{ij} \equiv \partial^2 \pi_i / \partial q_i \partial q_j$, i, $j = 1$, 2. Using the assumption $p''Q + p' < 0$, the second-order condition $a_{ii} = p''q_i + 2p' < 0$ is satisfied. In addition, $a_{ij} = p''q_i + p' < 0$, implying that quantities are strategic substitutes under Cournot competition. Moreover, the "stability" condition $\Delta_1 \equiv a_{11}a_{22} - a_{12}a_{21} = p'p''Q + 3(p')^2 > 0$ is satisfied. By solving the two first-order conditions in (1) simultaneously, we can derive the Cournot equilibrium outputs $q_1^*(s_1, s_2, \hat{t})$, $q_2^*(s_1, s_2, \hat{t})$, and $Q^*(s_1, s_2, \hat{t}) = q_1^*(s_1, s_2, \hat{t}) + q_2^*(s_1, s_2, \hat{t})$. Totally differentiating (1), we can get the following comparative statics results:

$$\frac{\partial q_i^*}{\partial \hat{t}} = \frac{p''(q_j^* - q_i^*) + p'}{\Delta_1} < 0, \tag{2a}$$

$$\frac{\partial q_i^*}{\partial s_i} = -\frac{p''q_j^* + 2p'}{\Delta_1} > 0, \ i, j = 1, 2 \text{ and } i \neq j, \tag{2b}$$

$$\frac{\partial q_j^*}{\partial s_i} = \frac{p''q_j^* + p'}{\Delta_1} < 0, \tag{2c}$$

where the signs are based on the assumption that the demand function is not too concave. Equations (2) show that the uniform tariff affects negatively the output of each firm, while each export subsidy will promote its country's export but hurt the export of the other country. Furthermore, (2a) implies that $\partial Q^*/\partial \hat{t} = 2p'/\Delta_1 < 0$, and adding (2b) and (2c) up gives $\partial Q^*/\partial s_i = -p'/\Delta_1 > 0$.

In the third stage, country M chooses $\hat{t}$ to maximize its welfare. Its welfare is given by the sum of the consumer surplus and tariff revenue:

$$W_M^u(s_1, s_2, \hat{t}) = \int_0^{Q^*(s_1, s_2, \hat{t})} p(x)dx - p(Q^*(s_1, s_2, \hat{t}))Q^*(s_1, s_2, \hat{t}) + \hat{t}Q^*(s_1, s_2, \hat{t}). \tag{3}$$

The first-order condition for maximization is given by:

$$\frac{\partial W_M^u}{\partial \hat{t}} = -p'Q^*\frac{\partial Q^*}{\partial \hat{t}} + Q^* + \hat{t}\frac{\partial Q^*}{\partial \hat{t}} = 0. \tag{4}$$

The second-order condition $\partial^2 W_M^u/\partial \hat{t}^2 < 0$ is assumed. The solution to the first-order condition (4) is

$$\hat{t}^* = -\frac{1}{2}(p''Q^* + p')Q^* > 0. \tag{5}$$

In the second stage, each exporting country chooses its export subsidy, taking the other country's export subsidy as given and being fully aware of how its export subsidy may affect the tariff rate and firms' outputs later. The national welfare of each exporting country is given by the profit of the firm, less the export subsidy payment:

$$W_i^u(s_1, s_2) = [p(Q^*) - c_i + s_i - \hat{t}^*]q_i^* - s_i q_i^*, \ i = 1, 2.$$

The first-order condition for the optimal export subsidy is given by

$$\begin{aligned} \frac{\partial W_i^u}{\partial s_i} &= -q_i^* \frac{\partial \hat{t}^*}{\partial s_i} - s_i \left(\frac{\partial q_i^*}{\partial \hat{t}} \frac{\partial \hat{t}^*}{\partial s_i} + \frac{\partial q_i^*}{\partial s_i} \right) + p' q_i^* \left(\frac{\partial q_j^*}{\partial \hat{t}} \frac{\partial \hat{t}^*}{\partial s_i} + \frac{\partial q_j^*}{\partial s_i} \right) \\ &= 0, \ i, j = 1, 2 \text{ and } i \neq j. \end{aligned} \tag{6}$$

Define $b_{ij} \equiv \partial^2 W_i^u / \partial s_i \partial s_j$, $i, j = 1, 2$. The second-order conditions $b_{11} < 0$, $b_{22} < 0$ and the stability condition $\Delta_2 \equiv b_{11}b_{22} - b_{12}b_{21} > 0$ are all assumed to ensure global uniqueness of the Nash equilibrium in the export subsidy policy game. Denote the export subsidy chosen by country i under a uniform tariff regime by s_i^u. From condition (6), we can get

$$s_i^u = \frac{q_i^* \left[p' \left(\partial q_j^* / \partial s_i \right) + \left(p' \partial q_j^* / \partial \hat{t} - 1 \right) \left(\partial \hat{t}^* / \partial s_i \right) \right]}{\left(\partial q_i^* / \partial \hat{t} \right) \left(\partial \hat{t}^* / \partial s_i \right) + \left(\partial q_i^* / \partial s_i \right)}, \ i, j = 1, 2 \text{ and } i \neq j. \tag{7}$$

To examine the sign of s_i^u, denote the numerator and denominator in (7) by X_i^u and

Y_i^u, respectively.

$$\begin{aligned} Y_i^u &= \frac{\partial q_i^*}{\partial \hat{t}} \frac{\partial \hat{t}^*}{\partial s_i} + \frac{\partial q_i^*}{\partial s_i} \\ &= \frac{1}{p'(p''Q + 3p')} \left\{ \left[p''(q_j^* - q_i^*) + p' \right] \frac{\partial \hat{t}^*}{\partial s_i} - (p''q_j^* + 2p') \right\} > 0, \end{aligned}$$

because $\partial \hat{t}^* / \partial s_i < 1/2$, proved in the appendix. Variable X_i^u can be disaggregated into two components: $X_{i1}^u = q_i^* p'(\partial q_j^* / \partial s_i)$ and $X_{i2}^u = q_i^* \left(p' \partial q_j^* / \partial \hat{t} - 1 \right) (\partial \hat{t}^* / \partial s_i)$. Variable X_{i1}^u is the traditional profit-shifting effect, and by equation (2c) it is positive. Variable X_{i2}^u is interpreted as the tariff effect, which measures the impact of a change in an export subsidy on welfare through a change in country M's tariff. Its sign is ambiguous. It is proved in the appendix that the sum of the profit-shifting and tariff effects is positive. Thus we have

Proposition 1. *Under a uniform tariff regime, the optimal policy for each exporting country is an export subsidy.*

Proof. See the appendix. ■

By Proposition 1, the total effect is always positive. This is an extension of the Brander and Spencer (1985) result, which is a special case of what is presented here with the tariff effect being zero. To understand Proposition 1 intuitively, we note that under a uniform tariff regime the tariff effect, whether it may be positive or negative, applies to both exporting countries equally. To them a change in the tariff rate is just like a change in the trade opportunity they are facing. The usual profit-shifting argument can still be used to show that each exporting country has an incentive to impose an export subsidy non-cooperatively to promote the export of its own firm.

One thing should be noticed is that Proposition 1 still holds even if export subsidies and tariffs are chosen at the same time. This is because there exists only the profit-shifting effect and it is always positive. This result is what Brander and Spencer (1985) show in the Nash tariff and subsidy equilibrium between the three governments.

4 Optimal Export Subsidy Policy under Discriminatory Tariff Regime

Now we examine a discriminatory tariff regime. Denote the specific import tariff imposed by country M on the goods from country i by t_i, $i = 1,\ 2$.

The game is again solved by backward induction. In the fourth stage, taking the export subsidies $(s_1,\ s_2)$, the tariffs $(t_1,\ t_2)$, and the output of the other firm as given, each firm maximizes its profit:

$$\pi_i = [p(Q) - c_i + s_i - t_i]q_i,\ \ i = 1, 2,$$

by choosing its own output. The first-order condition is given by[4]

$$\frac{\partial \pi_i}{\partial q_i} = p'q_i + p - c_i + s_i - t_i = 0,\ \ i = 1, 2. \tag{8}$$

The two first-order conditions in (8) for the two firms can be solved for the Cournot equilibrium outputs $q_1^*(s_1, s_2, t_1, t_2)$ and $q_2^*(s_1, s_2, t_1, t_2)$. Totally differentiating (8), the following comparative statics results can be obtained:

$$\frac{\partial q_i^*}{\partial t_i} = -\frac{\partial q_i^*}{\partial s_i} = \frac{p''q_j^* + 2p'}{\Delta_1} < 0, \tag{9a}$$

$$\frac{\partial q_j^*}{\partial t_i} = -\frac{\partial q_j^*}{\partial s_i} = -\frac{p''q_j^* + p'}{\Delta_1} > 0,\ \ i, j = 1, 2 \text{ and } i \neq j. \tag{9b}$$

[4] It is easy to show that the second-order condition is satisfied.

Equations (9) show that an increase in tariff on firm i will reduce q_i^* but increase q_j^*. The equations also show that $\partial(q_1^*+q_2^*)/\partial t_i = p'/\Delta_1 < 0$, i.e., the total output decreases as t_i increases. It is easy to show further that the export subsidy s_i has the opposite effects: it increases the output of firm i and the total output, but it decreases the output of firm j.

In the third stage, country M sets tariffs t_1 and t_2 to maximize its national welfare, which is defined as the sum of consumer surplus and tariff revenue:

$$W_M^d(s_1, s_2, t_1, t_2) = \int_0^{Q^*} p(x)dx - p(Q^*)Q^* + t_1 q_1^* + t_2 q_2^*. \tag{10}$$

The first-order conditions for maximization are given by:

$$\frac{\partial W_M^d}{\partial t_i} = -p'Q^* \frac{\partial Q^*}{\partial t_i} + q_i^* + t_1 \frac{\partial q_1^*}{\partial t_i} + t_2 \frac{\partial q_2^*}{\partial t_i} = 0, \;\; i = 1, 2. \tag{11}$$

Define $g_{ij} = \partial^2 W_M^d/\partial t_i \partial t_j$, $i, j = 1, 2$. The second-order conditions, $g_{11} < 0$, $g_{22} < 0$, are assumed. Solving the two conditions in (11) for the two tariff rates simultaneously yields the optimal discriminatory tariffs:

$$t_i^* = -p'q_i^* - p''(q_1^{*2} + q_2^{*2}), \;\; i = 1, 2. \tag{12}$$

By using (8), the difference between the two tariff rates is equal to

$$t_i^* - t_j^* = p'(q_j^* - q_i^*) = \frac{1}{2}[(c_j - s_j) - (c_i - s_i)], \;\; i, j = 1, 2 \text{ and } i \neq j. \tag{13}$$

Hwang and Mai (1991) show that with constant marginal costs but no export subsidies, the difference between the optimal tariffs chosen by the importing country is half of that of the marginal costs. Equation (13) is a simple extension of their result when export subsidies are present. Differentiate both sides of (13) with respect to s_i to give

$$\frac{\partial(t_i^* - t_j^*)}{\partial s_i} = \frac{1}{2}, \ i, j = 1, 2 \text{ and } i \neq j. \tag{14}$$

Equations (13) and (14) give the following lemma.

Lemma 1 (The Fifty-Percent Rule). *Assuming constant marginal costs, (a) the difference between the tariff rates on the goods from countries 1 and 2 is half of the difference between the effective marginal costs of the firms; (b) a small rise in the subsidy rate imposed by one of the countries leads to a change in the tariff rate differential by half of the change in the subsidy rate.*

Totally differentiating (11) with respect to s_1 yields

$$\begin{bmatrix} g_{11} & g_{12} \\ g_{12} & g_{22} \end{bmatrix} \begin{bmatrix} \partial t_1^*/\partial s_1 \\ \partial t_2^*/\partial s_1 \end{bmatrix} = \begin{bmatrix} -\partial^2 W_M^d/\partial t_1 \partial s_1 \\ -\partial^2 W_M^d/\partial t_2 \partial s_1 \end{bmatrix} = \begin{bmatrix} g_{11} - \partial q_1^*/\partial t_1 \\ g_{12} - \partial q_1^*/\partial t_2 \end{bmatrix}. \tag{15}$$

For "stability", it is assumed that $\Delta_3 \equiv g_{11}g_{22} - g_{12}g_{21} > 0$. Solving (15), we get

$$\frac{\partial t_1^*}{\partial s_1} = 1 + \frac{1}{\Delta_3}\left(g_{12}\frac{\partial q_1^*}{\partial t_2} - g_{22}\frac{\partial q_1^*}{\partial t_1}\right) \tag{16a}$$

$$\frac{\partial t_2^*}{\partial s_1} = \frac{1}{\Delta_3}\left(g_{12}\frac{\partial q_1^*}{\partial t_1} - g_{11}\frac{\partial q_1^*}{\partial t_2}\right). \tag{16b}$$

The signs of $\partial t_1^*/\partial s_1$ and $\partial t_2^*/\partial s_1$ are in general ambiguous.

Lemma 2. *(a) If* $g_{12} < 0$, *then* $0 < \partial t_j^*/\partial s_i < \partial t_i^*/\partial s_i < 1$. *(b) If* $g_{12} > 0$, *because* $|g_{ii}| > |g_{ij}|$, *then* $\partial t_j^*/\partial s_i < \partial t_i^*/\partial s_i < 1$. *(c) If the demand function is linear, then* $\partial t_i^*/\partial s_i = 3/8 > 0$ *and* $\partial t_j^*/\partial s_i = -1/8 < 0$, $i, j = 1, 2$ and $i \neq j$.

The proof of this lemma is straightforward and is omitted here.

In the second stage, while fully aware of the effect of its policy on the tariffs set in the next stage, each exporting country sets its own export subsidy to maximize its national welfare, taking the other country's export subsidy as given, where the national welfare is the profit of its firm less the export subsidy payment:

$$W_i^d = [p(Q^*) - c_i + s_i - t_i^*]q_i^* - s_i q_i^*, \ i = 1, 2.$$

The first-order condition is given by

$$\begin{aligned}\frac{\partial W_i^d}{\partial s_i} &= -q_i^* \frac{\partial t_i^*}{\partial s_i} - s_i \left(\frac{\partial q_i^*}{\partial t_i} \frac{\partial t_i^*}{\partial s_i} + \frac{\partial q_i^*}{\partial t_j} \frac{\partial t_j^*}{\partial s_i} + \frac{\partial q_i^*}{\partial s_i} \right) + p' q_i^* \left(\frac{\partial q_j^*}{\partial t_i} \frac{\partial t_i^*}{\partial s_i} + \frac{\partial q_j^*}{\partial t_j} \frac{\partial t_j^*}{\partial s_i} + \frac{\partial q_j^*}{\partial s_i} \right) \\ &= 0, \ i, j = 1, 2 \text{ and } i \neq j. \end{aligned} \tag{17}$$

Assume again the second-order conditions and a globally unique Nash equilibrium in the export subsidy policy game. Define the following variables for country i: $PS_i = q_i^* p'(\partial q_j^* / \partial s_i)$, $OT_i = q_i^*[p'(\partial q_j^* / \partial t_i) - 1](\partial t_i^* / \partial s_i)$, $CT_i = q_i^* p'(\partial q_j^* / \partial t_j)(\partial t_j^* / \partial s_i)$, and

$$\gamma_i = \frac{\partial q_i^*}{\partial t_i} \frac{\partial t_i^*}{\partial s_i} + \frac{\partial q_i^*}{\partial t_j} \frac{\partial t_j^*}{\partial s_i} + \frac{\partial q_i^*}{\partial s_i}, \ i, j = 1, 2 \text{ and } i \neq j.$$

It is shown in the appendix that $\gamma_i > 0$. Variables PS_i, OT_i, and CT_i are interpreted as the profit-shifting effect, own-tariff effect, and cross-tariff effect of an increase in s_i on the welfare of country i. Condition (9b) implies that $PS_i > 0$, a result well-known in the literature. The own-tariff and cross-tariff effects generally have ambiguous signs.

Denote the export subsidy chosen by country i under a discriminatory tariff regime as s_i^d. From condition (17) we can get

$$s_i^d = \frac{PS_i + OT_i + CT_i}{\gamma_i}. \tag{18}$$

Let us define the following condition:

Condition C. One or more of the followings is satisfied: (a) $\partial t_j^* / \partial s_i \geq 0$ for $i, j = 1, 2$, and $i \neq j$; or (b) $\partial (t_i^* + t_j^*)/\partial s_i \geq 0$, $i, j = 1, 2$ and $i \neq j$; or (c) the demand function is linear.

Note that by Lemma 1 (the Fifty-Percent Rule), condition C (a) implies condition C (b), and that by Lemma 2 (c), condition C (c) implies condition C (b). The reverse, however, is not true, meaning that there are cases in which condition C (b) holds but not C (a) or C (c). We now have the following proposition:

Proposition 2. *In the sequential game under a discriminatory tariff regime in which export subsidies/taxes are chosen before the tariffs, the optimal policy for each exporting country is an export tax if condition C is satisfied.*

Proof. See the appendix. ■

Proposition 2 is an interesting result. When the government of an exporting country is choosing an export subsidy, it will take into consideration how a subsidy may affect the output of the other firm (the profit-shifting effect), the tariff imposed by the importing country on its export (the own-tariff effect), and the tariff imposed of its rival's export (the cross-tariff effect). In general, the sign of the net effect is ambiguous. Proposition 2 states the conditions under which the profit-shifting and the cross-tariff effects will encourage the government to impose an export subsidy, while the own-tariff effect will lead to an export tax, and the own-tariff effect dominates so that the government of an exporting country will choose an export tax. Under these conditions, the Brander-Spencer argument for an export subsidy is dominated by the government's desire to avoid a high tariff on its export.

It is also clear from the above analysis that if the importing country uses a uniform tariff regime, the own-tariff effect can never be dominating because the same tariff rate is always imposed on the products from both exporting countries.

If export subsidies and tariffs are chosen simultaneously, the above analysis implies that the optimal policy for each exporting country is an export subsidy because there exists only the profit-shifting effect. This result has been shown in Gatsios (1990).

5 Uniform or Discriminatory Tariffs?

In this section we examine the welfare impacts of these two tariff regimes to all these countries. To do that, we consider a special case in which the two exporting countries are identical, i.e., $c_1 = c_2$.[5] As before, the fixed costs of the firms are assumed to be zero.

Because the two firms are identical, the exporting country governments will choose the same subsidy rate under a uniform tariff regime. However, even under a discriminatory tariff regime, because by equation (13), which states that $t_1^* = t_2^*$ if and only if $s_1 = s_2$, the two exporting country governments will still choose the same subsidy rate, knowing that the importing country will respond with the same tariff rate on their exports. Of course, what the exporting country governments choose (and thus how the importing country responds) under a uniform tariff regime is not the same as what they do under a discriminatory tariff regime. Denote the maximum welfare level of the importing country under a uniform or discriminatory tariff regime

[5] In doing so, we eliminate the effects of different levels of productivity of the two exporting firms and concentrate more on the interactions among the countries.

by $W_M^u(s_1, s_2)$ or $W_M^d(s_1, s_2)$, respectively, when exporting countries choose subsidy rates of s_1 and s_2.

For the importing country, as long as the exporting countries choose the same subsidy rate, its welfare is independent of the tariff regimes, i.e.

$$W_M^u(s, s) = W_M^d(s, s). \tag{19}$$

We now examine how the welfare is dependent on the subsidy rate. Consider first the uniform tariff regime. We have

$$\begin{aligned} \left.\frac{\partial W_M^u}{\partial s_i}\right|_{s_1=s_2} &= -p'Q^*\frac{\partial Q^*}{\partial s_i} + \hat{t}\frac{\partial Q^*}{\partial s_i} \\ &= \frac{1}{2}\left(p'Q^*\frac{\partial Q^*}{\partial \hat{t}} - \hat{t}\frac{\partial Q^*}{\partial \hat{t}}\right) \\ &= \frac{Q^*}{2} > 0,\ \ i = 1, 2. \end{aligned} \tag{20}$$

Equation (20) implies that subject to the same subsidy rate, country M benefits from a higher subsidy rate imposed by both exporting countries. Since the two exporting countries prefer the same subsidy rate under each tariff regime, (19) implies the following lemma:

Lemma 3. *Under either tariff regime, a rise in the export subsidy rate simultaneously chosen by both exporting countries, with country M choosing the optimal tariff, will benefit country M.*

The intuition is simple. A simultaneous rise in the export subsidies will lower the price of the product, thus benefiting the importing country. Now let us denote the common, non-cooperative subsidy rate chosen by the exporting countries as s^d and

s^u under a discriminatory and a uniform tariff regimes, respectively. We now state another result.

Lemma 4. *The export subsidy rate chosen by both exporting countries under a discriminatory tariff regime is smaller than that under a uniform tariff regime, i.e.,* $s^d < s^u$.

Proof. See the appendix. ■

Lemma 4 holds independent of the sign of s^d. If $s^d < 0$, as in the case when condition C holds, Lemma 4 follows immediately because $s^u > 0$. The lemma holds even if $s^d > 0$.

Combining Lemmas 3 and 4 and (19), we have

$$W_M^d(s^d, s^d) = W_M^u(s^d, s^d) < W_M^u(s^u, s^u). \tag{21}$$

Equation (21) implies that the importing country prefers a uniform tariff regime.

We now turn to the welfare effects of the tariff regimes on the exporting countries. Suppose that the exporting countries can cooperate and choose the export subsidy to maximize the joint welfare, $(W_1 + W_2)$. The first-order condition for country i when choosing s_i to maximize the joint welfare of the exporting countries is given by

$$\frac{\partial(W_1 + W_2)}{\partial s_i} = 0, \ \ i = 1, 2. \tag{22}$$

Denote the common, optimal export subsidy rate for each exporting country by $\tilde{s}$. Note that this subsidy rate is independent of the tariff regime because in either regime the same subsidy rate will be chosen for both exporting country and the importing country will react with a common tariff rate.

Lemma 5. Assume a uniform tariff regime. (a) $\partial W_j/\partial s_i < 0$ evaluated at $s_1 = s_2 = \tilde{s}$ or s^u, $i \neq j$. (b) $\tilde{s} < s^u$.

Proof. See the appendix. ■

Part (a) of Lemma 5 is similar to a well-known result in the special case in which the import tariff is zero.[6] It is now argued that this result holds in the present case in which the importing country reacts to the subsidy rates chosen by the exporting countries under a uniform tariff regime.

Lemma 6. Assume a discriminatory tariff regime. (a) $s^d < 0$ if and only if $\tilde{s} < s^d < 0$. (b) If condition C holds, $\partial W_j/\partial s_i < 0$ evaluated at $s_1 = s_2 = \tilde{s}$ or s^d, $i \neq j$.

Proof. See the appendix. ■

Result (b) of Lemma 6 for a discriminatory tariff regime is analogous to result (a) of Lemma 5 for a uniform tariff regime, although the former requires condition C.

Lemma 7. If condition C is satisfied, (a) $\tilde{s} < s^d < 0 < s^u$; and (b) $W_i(\tilde{s}, \tilde{s}) > W_i(s^d, s^d) > W_i(s^u, s^u),\ i = 1, 2$.

Proof. See the appendix. ■

Lemma 7 gives the ranking of the three subsidy rates, $\tilde{s}$, s^d, and s^u in terms of their magnitudes and their welfare impacts on the two exporting countries, under condition C. Equations (21) and Lemma 7 give the following proposition:

Proposition 3. *Suppose that the two exporting countries are identical. The importing country will optimally choose a uniform tariff regime. Given condition C, the exporting countries prefer a discriminatory tariff regime.*

[6] The literature considers the case in which the importing country has zero import tariff, but the same result applies if the importing country's tariff is fixed and independent of the subsidy rates.

Note that the ranking of the two tariff regimes for the two exporting countries depends on the ranking of the exporting subsidy rates. If condition C holds, the two countries, when acting cooperatively, will choose an export *tax* higher than what they will do independently under a discriminatory tariff regime. Thus they will prefer a discriminatory tariff regime, choosing an export tax, to a uniform tariff regime, in which they choose an export subsidy. In this case, they will not like the tariff regime the importing country prefers. If, however, condition C does not hold, it is possible that all three countries prefer a uniform tariff regime.

It is interesting to compare our result with what is in the literature. By assuming that the importing and exporting countries set up their policies simultaneously, with the exporting firms equally cost efficient, Gatsios (1990) found that both the importing country and the exporting countries are indifferent to the tariff regimes.

6 Concluding Remarks

This paper examines the policy interactions among three countries: two exporting countries and one importing country. While the exporting countries choose an export subsidy policy, the importing country uses tariffs to extract rents from the two oligopolistic firms. All countries are allowed to choose appropriate policies in a four-stage game, which permits us to examine the interactions among the governments and the choice of relevant strategic trade policies.

As is well known in the literature and from the work of Brander and Spencer (1985), exporting countries have the temptation to use an exporting subsidy to shift profit from a rival firm to its own firm. In the present model, an export subsidy could have other impacts that are not so desirable for an exporting country. In particular, under a discriminatory tariff regime, an export subsidy could cause a sufficiently large tariff to be imposed on the export of a country's firm, severely hurting the competitiveness of the firm in the importing country. Under certain plausible conditions, including the use of discriminatory tariffs by the importing country, the optimal export subsidy for each exporting country is negative, suggesting an export tax should be used.

We also compare the uniform tariff and discriminatory tariff regimes in terms of the welfare of the countries. We found out that, at least in the case when the two exporting countries are identical, the importing country would choose a uniform tariff regime while the export countries prefer a discriminatory tariff regime. For the importing country, this result, which is consistent with countries's willingness to apply the "Most-Favored-Nations" (MFN) clause of the GATT/WTO, may seem to be contrary to the usual belief that a discriminatory tariff regime should dominate a uniform tariff regime because under the former the country can also choose the same tariffs. Our result suggests that this preconception does not hold in the present model because the exporting countries react with export subsidies under a uniform tariff regime but possibly export taxes under a discriminatory tariff regime.

Appendix

Proof of Proposition 1.

All we need in this proof is to show that X_i^u in equation (7) is positive, $i = 1, 2$. We already showed that the profit-shifting effect X_{i1}^u is positive. The tariff effect reduces to

$$X_{i2}^u = q_i^* \left(p' \frac{\partial q_j^*}{\partial \hat{t}} - 1 \right) \frac{\partial \hat{t}^*}{\partial s_i} = \quad -2q_i^* \left(\frac{p'' q_j^* + p'}{p'' Q^* + 3p'} \right) \frac{\partial \hat{t}^*}{\partial s_i}. \tag{A.1}$$

By the assumption about the demand function, the fraction inside the parenthesis on the RHS of (A.1) is positive. If $\partial \hat{t}^* / \partial s_i < 0$, by (A.1) $X_{i2}^u > 0$, and $X_i^u > 0$. Consider now the case in which $\partial \hat{t}^* / \partial s_i > 0$. Totally differentiating equation (4) with respect to s_i gives $\partial \hat{t}^* / \partial s_i = -\left(\partial^2 W_M^u / \partial \hat{t} \partial s_i \right) / \left(\partial^2 W_M^u / \partial \hat{t}^2 \right)$. Differentiating equation (3) with respect to s_i yields

$$\frac{\partial W_M^u}{\partial s_i} = -p' Q^* \frac{\partial Q^*}{\partial s_i} + \hat{t} \frac{\partial Q^*}{\partial s_i} = \frac{1}{2} \left(p' Q^* \frac{\partial Q^*}{\partial \hat{t}} - \hat{t} \frac{\partial Q^*}{\partial \hat{t}} \right). \tag{A.2}$$

Substituting (A.2) into (4) we get

$$\frac{\partial W_M^u}{\partial \hat{t}} = Q^* - 2 \frac{\partial W_M^u}{\partial s_i}. \tag{A.3}$$

Differentiating equation (A.3) with respect to $\hat{t}$ yields $\partial^2 W_M^u / \partial \hat{t}^2 = (\partial Q^* / \partial \hat{t}) - 2(\partial^2 W_M^u / \partial \hat{t} \partial s_i)$ and

$$\frac{\partial \hat{t}^*}{\partial s_i} = -\frac{\partial^2 W_M^u / \partial \hat{t} \partial s_i}{\partial^2 W_M^u / \partial \hat{t}^2} = \frac{(\partial^2 W_M^u / \partial \hat{t}^2) - (\partial Q^* / \partial \hat{t})}{2(\partial^2 W_M^u / \partial \hat{t}^2)} = \frac{1}{2} \left(1 - \frac{\partial Q^* / \partial \hat{t}}{\partial^2 W_M^u / \partial \hat{t}^2} \right) < \frac{1}{2}. \tag{A.4}$$

Since in the present case, $\partial \hat{t}^*/\partial s_i > 0$, equation (A.4) implies that $0 < \partial \hat{t}^*/\partial s_i < 1/2$. Thus the total effect is $X_i = [q_i^*(p''q_j^* + p')/(p''Q^* + 3p')][1 - 2(\partial \hat{t}^*/\partial s_i)] > 0$.

Proof of Proposition 2.

The profit-shifting effect is known to be positive, $PS_i > 0$. The signs of own-tariff and cross-tariff effects are ambiguous. The sum of them is equal to

$$
\begin{aligned}
OT_i + CT_i &= q_i^* \left[\left(p' \frac{\partial q_j^*}{\partial t_i} - 1 \right) \frac{\partial t_i^*}{\partial s_i} + p' \frac{\partial q_j^*}{\partial t_j} \frac{\partial t_j^*}{\partial s_i} \right] \\
&= q_i^* \left[- \left(\frac{p''q_j^* + p''Q^* + 4p'}{p''Q^* + 3p'} \right) \frac{\partial t_i^*}{\partial s_i} + \left(\frac{p''q_i^* + 2p'}{p''Q^* + 3p'} \right) \left(\frac{\partial t_i^*}{\partial s_i} - \frac{1}{2} \right) \right] \\
&= -q_i^* \left[2 \left(\frac{p''q_j^* + p'}{p''Q^* + 3p'} \right) \frac{\partial t_i^*}{\partial s_i} + \frac{1}{2} \left(\frac{p''q_i^* + 2p'}{p''Q^* + 3p'} \right) \right], \qquad \text{(A.5)}
\end{aligned}
$$

which may be positive or negative, depending on the values of $\partial t_i^*/\partial s_i$ and $\partial t_j^*/\partial s_i$. In case (a) of condition C, $\partial t_j^*/\partial s_i \geq 0$, which implies that $1/2 \leq \partial t_i^*/\partial s_i < 1$. The two tariff effects in equation (A.5) reduce to $OT_i + CT_i \leq -q_i^*[p''(\frac{1}{2}q_i^* + q_j^*) + 2p']/(p''Q^* + 3p') < 0$. Thus, the sum of all three effects $PS_i + OT_i + CT_i \leq -q_i^*(\frac{1}{2}p''q_i^* + p\,')/(p''Q^* + 3p') < 0$. Suppose now that $\partial t_j^*/\partial s_i < 0$ while condition C (b) holds, i.e., $\partial t_i^*/\partial s_i + \partial t_j^*/\partial s_i \geq 0$. Thus we have $1/4 \leq \partial t_i^*/\partial s_i < 1/2$, and the two tariff effects in equation (A.5) reduce to $OT_i + CT_i \leq -q_i^*/2$. Since the profit-shifting effect is $q_i^*(p''q_j + p')/(p''Q + 3p') < q_i^*/2$, the sum of all three effects is again negative. In case (c) of condition C, the demand function is linear. We showed earlier that it implies that $\partial t_i^*/\partial s_i + \partial t_j^*/\partial s_i > 0$. Thus again the total effect is negative. Turning to the denominator in (18), we have

$$
\begin{aligned}
\gamma_i &= \frac{\partial q_i^*}{\partial t_i}\frac{\partial t_i^*}{\partial s_i} + \frac{\partial q_i^*}{\partial t_j}\frac{\partial t_j^*}{\partial s_i} + \frac{\partial q_i^*}{\partial s_i} \\
&= \left[\frac{p'' q_j^* + 2p'}{p'(p''Q^* + 3p')}\right]\left(\frac{\partial t_i^*}{\partial s_i} - 1\right) - \left[\frac{p'' q_i^* + p'}{p'(p''Q^* + 3p')}\right]\left(\frac{\partial t_i^*}{\partial s_i} - \frac{1}{2}\right) \\
&= \left[\frac{p''(q_j^* - q_i^*) + p'}{p'(p''Q^* + 3p')}\right]\left(\frac{\partial t_i^*}{\partial s_i} - 1\right) - \frac{(p'' q_i^* + p')}{2p'(p''Q^* + 3p')} > 0,
\end{aligned}
$$

because $\partial t_i^*/\partial s_i < 1$ from Lemma 2. Thus, if condition C is satisfied, $PS_i + OT_i + CT_i < 0$ and $\gamma_i > 0$. By equation (18), the optimal subsidy $s_i^d < 0$ for $i = 1, 2$.

Proof of Lemma 4.

Define two variables $\delta_i = (\partial q_j^*/\partial t_i)(\partial t_i^*/\partial s_i) + (\partial q_j^*/\partial t_j)(\partial t_j^*/\partial s_i) + (\partial q_j^*/\partial s_i)$ and $\eta_i = (\partial q_j^*/\partial \hat{t})(\partial \hat{t}^*/\partial s_i) + (\partial q_j^*/\partial s_i)$. Evaluating under the condition $s_i = s^u$, we have

$$
\begin{aligned}
\left.\frac{\partial W_i^d}{\partial s_i}\right|_{s_i = s^u} &= -q_i^* \frac{\partial t_i^*}{\partial s_i} - s_i^u \left(\frac{\partial q_i^*}{\partial t_i}\frac{\partial t_i^*}{\partial s_i} + \frac{\partial q_i^*}{\partial t_j}\frac{\partial t_j^*}{\partial s_i} + \frac{\partial q_i^*}{\partial s_i}\right) \\
&\quad + p' q_i^* \left(\frac{\partial q_j^*}{\partial t_i}\frac{\partial t_i^*}{\partial s_i} + \frac{\partial q_j^*}{\partial t_j}\frac{\partial t_j^*}{\partial s_i} + \frac{\partial q_j^*}{\partial s_i}\right) \\
&= -q_i^* \frac{\partial t_i^*}{\partial s_i} - \left(p' q_i^* \eta_i - q_i^* \frac{\partial \hat{t}^*}{\partial s_i}\right)\frac{\gamma_i}{Y_i^u} + p' q_i^* \delta_i \\
&= q_i^* \left[\frac{\partial \hat{t}^*}{\partial s_i}\frac{\gamma_i}{Y_i^u} - \frac{\partial t_i^*}{\partial s_i} + p'\left(\delta_i - \eta_i \frac{\gamma_i}{Y_i^u}\right)\right]. \qquad \text{(A.6)}
\end{aligned}
$$

The sign of the partial derivative in (A.6) is determined in the following steps. (a) equations (16) implies that

$$
\frac{\partial t_i^*}{\partial s_i} + \frac{\partial t_j^*}{\partial s_i} = 1 + \frac{(g_{ij} - g_{ii})}{\Delta_3}\left(\frac{\partial q_i^*}{\partial t_i} + \frac{\partial q_i^*}{\partial t_j}\right) = 1 - \frac{p'}{\Delta_1(g_{ii} + g_{ij})}, \; i \neq j,
$$

where the assumption of identical firms has been used. Moreover, from equation

(A.4), we have

$$2\frac{\partial \hat{t}^*}{\partial s_i} = 1 - \frac{\partial Q^*/\partial \hat{t}}{\partial^2 W_M^u/\partial \hat{t}^2} = 1 - \frac{2p'}{\Delta_1(\partial^2 W_M^u/\partial \hat{t}^2)}.$$

Using again the assumption of identical firms, we have $\partial^2 W_M^u/\partial \hat{t}^2 = 2[(\partial^2 W_M^d/\partial t_i^2) + (\partial^2 W_M^d/\partial t_i t_j)] = 2(g_{ii} + g_{ij})$, $i \neq j$. Thus, $(\partial t_i^*/\partial s_i) + (\partial t_j^*/\partial s_i) = 2(\partial \hat{t}^*/\partial s_i)$. Combining with $(\partial t_i^*/\partial s_i) - (\partial t_j^*/\partial s_i) = 1/2$, we have $\partial \hat{t}^*/\partial s_i = (\partial t_i^*/\partial s_i) - 1/4$, implying $\partial \hat{t}^*/\partial s_i < \partial t_i^*/\partial s_i$.

(b) Second, as shown in Propositions 1 and 2, $Y_i^u > 0$ and $\gamma_i > 0$. Moreover,

$$\begin{aligned}
Y_i^u - \gamma_i &= \frac{\partial q_i^*}{\partial \hat{t}}\frac{\partial \hat{t}^*}{\partial s_i} - \frac{\partial q_i^*}{\partial t_i}\frac{\partial t_i^*}{\partial s_i} - \frac{\partial q_i^*}{\partial t_j}\frac{\partial t_j^*}{\partial s_i} \\
&= \frac{p'}{\Delta_1}\left(\frac{\partial t_i^*}{\partial s_i} - \frac{1}{4}\right) - \left(\frac{p'' q_j^* + 2p'}{\Delta_1}\right)\frac{\partial t_i^*}{\partial s_i} + \left(\frac{p'' q_i^* + p'}{\Delta_1}\right)\left(\frac{\partial t_i^*}{\partial s_i} - \frac{1}{2}\right) \\
&= -\frac{1}{4p'} > 0,
\end{aligned}$$

implying that $0 < \gamma_i/Y_i^u < 1$. (c) Finally,

$$\begin{aligned}
\delta_i - \eta_i &= \frac{\partial q_j^*}{\partial t_i}\frac{\partial t_i^*}{\partial s_i} + \frac{\partial q_j^*}{\partial t_j}\frac{\partial t_j^*}{\partial s_i} - \frac{\partial q_j^*}{\partial \hat{t}}\frac{\partial \hat{t}^*}{\partial s_i} \\
&= -\left(\frac{p'' q_j^* + p'}{\Delta_1}\right)\frac{\partial t_i^*}{\partial s_i} + \left(\frac{p'' q_i^* + 2p'}{\Delta_1}\right)\left(\frac{\partial t_i^*}{\partial s_i} - \frac{1}{2}\right) - \frac{p'}{\Delta_1}\left(\frac{\partial t_i^*}{\partial s_i} - \frac{1}{4}\right) \\
&= -\frac{1}{4p'} > 0.
\end{aligned}$$

Combining these steps, we have $(\partial W_i^d/\partial s_i)\big|_{s_i = s^u} < 0$. Based on the assumption of a concave welfare function, we have $s^d < s^u$.

Proof of Lemma 5.

Consider a uniform tariff regime. Evaluating (6) at $s_1 = s_2 = \tilde{s}$, we have

$$\left.\frac{\partial W_i^u}{\partial s_i}\right|_{s_1=s_2=\tilde{s}} = -q_i^* \frac{\partial \hat{t}^*}{\partial s_i} + p' q_i^* \eta_i - \tilde{s} Y_i^u,$$

where $Y_i^u = (\partial q_i^*/\partial \hat{t})(\partial \hat{t}^*/\partial s_i) + (\partial q_i^*/\partial s_i)$ and $\eta_i = (\partial q_j^*/\partial \hat{t})(\partial \hat{t}^*/\partial s_i) + (\partial q_j^*/\partial s_i)$. Differentiating W_j^u with respect to s_i and evaluating at $s_1 = s_2 = \tilde{s}$, we have

$$\begin{aligned}
\left.\frac{\partial W_j^u}{\partial s_i}\right|_{s_1=s_2=\tilde{s}} &= -q_j^* \frac{\partial \hat{t}^*}{\partial s_i} + p' q_j^* \left(\frac{\partial q_i^*}{\partial \hat{t}} \frac{\partial \hat{t}^*}{\partial s_i} + \frac{\partial q_i^*}{\partial s_i} \right) - \tilde{s} \left(\frac{\partial q_j^*}{\partial \hat{t}} \frac{\partial \hat{t}^*}{\partial s_i} + \frac{\partial q_j^*}{\partial s_i} \right) \\
&= -q_j^* \frac{\partial \hat{t}^*}{\partial s_i} + p' q_j^* Y_i^u - \tilde{s} \eta_i.
\end{aligned}$$

Since $q_1^* = q_2^* = Q^*/2$, and $\eta_i - Y_i^u = 1/p' < 0$, we have

$$\left.\frac{\partial W_i^u}{\partial s_i} - \frac{\partial W_j^u}{\partial s_i}\right|_{s_1=s_2=\tilde{s}} = (p' q_i^* + \tilde{s})(\eta_i - Y_i^u) > 0, \tag{A.7}$$

where $p' q_i^* + \tilde{s} = -(p - c_i - \hat{t}) < 0$ from the first-order condition (1). Since we know that

$$\left.\frac{\partial W_i^u}{\partial s_i} + \frac{\partial W_j^u}{\partial s_i}\right|_{s_1=s_2=\tilde{s}} = 0,$$

Condition (A.7) implies that $\partial W_i^u/\partial s_i > 0$ and $\partial W_j^u/\partial s_i < 0$ when evaluating at $s_1 = s_2 = \tilde{s}$. Note that condition (A.7) holds also at $s_1 = s_2 = s^u$. When exporting country i chooses its optimal subsidy rate s^u in a non-cooperative way, $\partial W_i^u/\partial s_i = 0$. Thus condition (A.7) implies that $\partial W_j^u/\partial s_i < 0$ at $s_1 = s_2 = s^u$. This is part (a) of the lemma.

For part (b), note that at $s_1 = s_2 = s^u$, condition (A.7) implies that

$$\left.\frac{\partial(W_1^u + W_2^u)}{\partial s_i}\right|_{s_1=s_2=s^u} < 0.$$

As a result, when both exporting countries cooperate to maximize $W_1^u + W_2^u$, they want to lower the common subsidy rate. This proves part (b).

Proof of Lemma 6.

Consider a discriminatory tariff regime. (a) Evaluating (17) at $s_1 = s_2 = s$, for a given s, we have

$$\left.\frac{\partial W_i^d}{\partial s_i}\right|_{s_1=s_2=s} = -q_i^* \frac{\partial t_i^*}{\partial s_i} + p' q_i^* \delta_i - s\gamma_i,$$

where $\gamma_i = (\partial q_i^*/\partial t_i)(\partial t_i^*/\partial s_i) + (\partial q_i^*/\partial t_j)(\partial t_j^*/\partial s_i) + (\partial q_i^*/\partial s_i)$ and $\delta_i = (\partial q_j^*/\partial t_i)(\partial t_i^*/\partial s_i) + (\partial q_j^*/\partial t_j)(\partial t_j^*/\partial s_i) + (\partial q_j^*/\partial s_i)$. Differentiating W_j^d with respect to s_i and evaluating at $s_1 = s_2 = s$, we have

$$\left.\frac{\partial W_j^d}{\partial s_i}\right|_{s_1=s_2=s} = -q_j^* \frac{\partial t_j^*}{\partial s_i} + p' q_j^* \gamma_i - s\delta_i.$$

Since $q_1^* = q_2^* = Q^*/2$, and $\delta_i - \gamma_i = 1/(2p') < 0$, we have

$$\begin{aligned}
\left.\frac{\partial W_i^d}{\partial s_i} - \frac{\partial W_j^d}{\partial s_i}\right|_{s_1=s_2=s} &= -q_i^* \left(\frac{\partial t_i^*}{\partial s_i} - \frac{\partial t_j^*}{\partial s_i}\right) + (p' q_i^* + s)(\delta_i - \gamma_i) \\
&= -\frac{q_i^*}{2} + (p' q_i^* + s)\left(\frac{1}{2p'}\right) \\
&= \frac{s}{2p'}. \qquad \text{(A.8)}
\end{aligned}$$

At $s_1 = s_2 = s^d$, $\partial W_i^d/\partial s_i = 0$, and (A.8) reduces to

$$\left.\frac{\partial W_j^d}{\partial s_i}\right|_{s_1=s_2=s^d} = \left.\frac{\partial(W_i^d + W_j^d)}{\partial s_i}\right|_{s_1=s_2=s^d} = -\frac{s^d}{2p'}. \qquad \text{(A.9)}$$

Thus $s^d < 0$ if and only if $\partial W_j^d/\partial s_i < 0$ or $\partial(W_i^d + W_j^d)/\partial s_i < 0$. Since the welfare function is assumed to be concave, $s^d < 0$ if and only if the exporting countries cooperatively want to lower their subsidy rate from s^d, i.e., $\tilde{s} < s^d$.

(b) Given condition C, by Proposition 2, $s^d < 0$. Evaluating at $s_1 = s_2 = s^d < 0$, (A.9) implies that $\partial W_j^d/\partial s_i < 0$, $i \neq j$. Consider instead $s_1 = s_2 = \tilde{s} < 0$. Since (A.8) is applicable, $\partial(W_i^d - W_j^d)/\partial s_i > 0$. Since $\tilde{s}$ is the optimal subsidy rate when the exporting countries act cooperatively, $\partial(W_i^d + W_j^d)/\partial s_i = 0$. Combining the previous two conditions gives $\partial W_j^d/\partial s_i < 0$, $i \neq j$.

Proof of Lemma 7.

Part (a) follows immediately Proposition 2 and Lemma 6. Part (b) follows the fact the W_i is at a maximum when $s = \tilde{s}$, concavity of the welfare function, and the ranking $\tilde{s} < s^d < s^u$.

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