Optimal Tariff Discrimination in International Oligopoly
– Alternative Approach to Specific vs. Ad Valorem Taxation –

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Abstract

In this paper, we reconsider the welfare comparison between specific and ad valorem tariffs as well as shaping the general formulas for optimal specific and ad valorem import tariffs in imperfect competition. It will be demonstrated that the standard approach of international monopsony enables us to capture the feature underlying the optimal tariffs both in perfect and imperfect competition.

Keywords: optimal tariff, oligopoly, specific tariff, ad valorem tariff
JEL classification: F13, H21

1 Introduction

Specific and ad valorem tariffs are alternatives for the importing country's government to restrict its trade. Although the two policies are equivalent in perfect competition, this equivalence does not hold in general under imperfect competition, as motivated by their non-equivalence proven for a closed economy.

The non-equivalence in imperfect competition without international trade has been discussed by many, such as Bishop (1968) and Suits and R.A.Musgrave (1953) for a monopoly, Skeath and G.A.Trandel (1994) for a symmetric Cournot oligopoly, and others. The point of the proof lies in the fact that the tax revenue is greater under the ad valorem tax than under the specific tax, which also implies that given the ad valorem tax equivalent to the specific tax in terms of the tax rate per unit of output the firms have incentive to produce more and reduce the tax burden. [1]

The result is extended to the comparison between specific and ad valorem tariffs. Brander and Spencer (1984) and Jones (1987) discuss the case of a foreign monopoly, Shea and Shea

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[1]Product quality or variety has also been taken into account by Schröder (2004) and Jørgensen and Schröder (2005) for instance.

(2006) the case of quasi-Cournot duopoly with a domestic firm and a foreign rival having non-Cournot conjectural variations, and Collie (2006) the case of asymmetric Cournot oligopoly with n domestic firms and m foreign firms.

Most of the discussions emphasize the qualitative difference of the equivalence issue as well as the optimal tariff problem between perfect and imperfect competition. However this is due to their too much reliance on the reaction function or game-theoretic approach. Once we formalize the issues from the viewpoint of the standard international monopsony and price discrimination, we can find theoretical continuity in the theory of tariffs between perfect and imperfect competition as will be demonstrated by this paper.

In section 2, we build a model of tariff discrimination by the importing country facing N exporting countries, each of which has several identical firms having non-Cournot conjectural variations. By defining the export supply price function, we characterize the marginal import cost from each exporting country and a relatively simple formula of the optimal discriminatory specific tariff formula generalized in the sense of covering both perfect and imperfect competition. In section 3, we reformulate the problem for the ad valorem tariff policy, and obtain another general formula for the optimal discriminatory ad valorem tariff. In each of the two optimal tariff formulas we will see how the monopoly rent earned by the firms affect the optimal tariff rates, which constitutes the effect peculiar to imperfect competition. In section 4, we compare the export supply prices between the two tariff policies, and reconfirm that the familiar non-equivalence holds between specific and ad valorem tariffs.

2 Specific Tariff Policies

Consider a country depending for the domestic consumption totally on the imports from N exporting countries. Exporting country $i \in \boldsymbol{N} := \{1, \ldots, N\}$ has n_i firms with the same total cost function $C_i(x_i)$ where x_i denotes the individual export. Let X_T denote the total consumption (=import) of the importing country, $U(X_T)$ its utility function expressing the total benefits from consumption, p its domestic price and $p = P(X_T) := U'(X_T)$ its inverse market demand function. We also let t_i denote the specific tariff on the imports from country i. Then the welfare of the importing country is expressed by

$$W := U(X_T) - P(X_T)X_T + \sum_{k \in \boldsymbol{N}} t_k X_k, \tag{1}$$

where X_i denotes the total imports from country i or its total output.

The individual profit in country i is given by

$$\pi := P(X_T)x_i - C_i(x_i) - t_i x_i.$$

We consider the conjectural variations equilibrium for expressing the international oligopoly competition here. We assume [2]

Assumption 1 *The conjectural variation, λ_i, expressing how much the individual firm in country i expects to increase with its output expansion, is a non-negative constant.*

We also assume

Assumption 2 *The marginal cost of each firm is non-decreasing in the output, i.e., $C_i''(x_i) \geq 0$.*

Assumption 3 *The inverse market demand function $P(X_T)$ is concave in the total output, i.e., $P''(X_T) \leq 0$.*

Given this assumption, we can express the industry equilibrium of country i with the following first-order condition for profit maximization. [3]

$$0 = P(x_T) + \frac{\lambda_i}{n_i} X_i P'(X_T) - C_i'\left(\frac{X_i}{n_i}\right) - t_i. \tag{2}$$

Solving the above equation for X_i, we obtain the so-called "quasi-reaction function" $R^i(X_T, t_i)$. [4] We further note that the export price, which is equal to the net-tariff sales price, facing country i, denoted by V_i, is given by

$$V_i = V^i(X_i, X_T) := P(X_T) - t_i = C_i'\left(\frac{X_i}{n_i}\right) + IMR^i(X_i, X_T) - \frac{\lambda_i}{n_i} X_i P'(X_T), \tag{3}$$

where

$$IMR^i(X_i, X_T) := -\frac{\lambda_i}{n_i} X_i P'(X_T) \tag{4}$$

represents the monopoly rent earned per unit over the marginal cost.

Then the welfare function of the importing country, (1), can be rewritten as follows.

$$W^S(\boldsymbol{X}) := U\left(\sum_k X_k\right) - \sum_k V^k\left(X_k, \sum_\ell X_\ell\right) X_k$$

For the importing country's welfare maximization to make sense, the above welfare function $W^S(\boldsymbol{X})$ must be concave in the import vector. Since the utility function $U(X_T)$ is strictly

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[2] Assumption 3 ensures stability and uniqueness of equilibrium.

[3] The first-order condition for the individual firm's profit maximization is

$$0 = P(X_T) + \lambda_i x_i P'(X_T) - C_i'(x_i) - t_i.$$

In view of Assumptions 2 and 3, the implicit function theorem assures the individual firm to produce the same output, so that there holds $X_i = n_i x_i$.

[4] That is, $X_i = R^i(X_T, t_i)$ satisfies the above condition for the industry equilibrium in country i.

concave, it is sufficient to assume that the total import cost $TIC(\boldsymbol{X}) := \sum_k V^k\left(X_k, \sum_\ell X_\ell\right) X_k$ is convex in the import vector. This also implies that the marginal import cost from exporting country i, defined by,

$$MIC^i(\boldsymbol{X}) := \frac{\partial TIC(\boldsymbol{X})}{\partial X_i} = V^i(X_i^S, X_T^S) + X_i^S \frac{\partial V^i(X_i^S, X_T^S)}{\partial X_i} + \sum_k X_k^S \frac{\partial V^k(X_k^S, X_T^S)}{\partial X_T}$$

is increasing in its own export, X_i. By using (3) and (4), we may rewrite this marginal import cost as follows.

$$MIC^i(\boldsymbol{X}) = x_i C_i''(x_i) - 2\frac{\lambda_i}{n_i} X_i P'(X_T) - P''(X_T) \sum_k \frac{\lambda_k}{n_k} X_k^2. \tag{5}$$

Note that the marginal import cost in perfect competition is given only by the first term on the right-hand side of (5). Thus in view of Assumption 3, the marginal import cost is higher in imperfect competition than in perfect competition.

(5) also implies that the marginal import cost from each exporting country is increasing in its own export when there additionally holds

Assumption 4 *The inverse market demand function $P(X_T)$ satisfies $P'''(X_T) \leq 0$.*

Given the above set of conditions, the optimal import vector $\boldsymbol{X}^S$ should satisfy $0 = \frac{\partial W^S(\boldsymbol{X}^S)}{\partial X_i} = P(X_T^S) - MIC^i(X_i^S, X_T^S)$, i.e.,

$$P(X_T^S) = V^i(X_i^S, X_T^S) + X_i^S \frac{\partial V^i(X_i^S, X_T^S)}{\partial X_i} + \sum_k X_k^S \frac{\partial V^k(X_k^S, X_T^S)}{\partial X_T}$$

Since there holds $t_i = P(X_T) - V^i(X_i, X_T)$, the optimal discriminatory specific tariff on the imports from country i, denoted by t_i^S, is given by

$$t_i^S = X_i^S \frac{\partial V^i(X_i^S, X_T^S)}{\partial X_i} + \sum_k X_k^S \frac{\partial V^k(X_k^S, X_T^S)}{\partial X_T},$$

which can be further rewritten as follows by virtue of (3).

$$t_i^S = x_i^S C_i''(x_i^S) + X_i^S \frac{\partial IMR^i(X_i^S, X_T^S)}{\partial X_i} + \sum_k X_k^S \frac{\partial IMR^k(X_k^S, X_T^S)}{\partial X_T},$$

which gives a general optimal specific tariff formula covering both perfect and imperfect competition. [5]

[5] Tariff discrimination has already been discussed by Hwan and Mai (1991) for example. However, because they rely on the comparative statics approach, they fail to characterize the optimal tariff rate from the viewpoint of the changes in the individual monopoly rents.

Proposition 1 *In the quasi-Cournot international oligopoly market, the optimal discriminatory specific tariff rate on the imports from exporting country i, denoted by t_i^S, is given by*

$$t_i^S = x_i^S C_i''(x_i^S) + X_i^S \frac{\partial IMR^i(X_i^S, X_T^S)}{\partial X_i} + \sum_k X_k^S \frac{\partial IMR^k(X_k^S, X_T^S)}{\partial X_T}.$$

Note that the second and third terms are specific to imperfect competition. Evaluate these terms on the right-hand side by using (4).

$$\begin{aligned}\frac{\partial IMR^i(X_i, X_T)}{\partial X_i} &= -\frac{\lambda_i}{n_i} P'(X_T) > 0 \\ \frac{\partial IMR^i(X_i, X_T)}{\partial X_T} &= -\frac{\lambda_i}{n_i} X_i P''(X_T) > 0,\end{aligned}$$

where use was made of Assumption 3. Thus the optimal discriminatory tariff is likely to be higher in imperfect competition than in perfect competition. Since imperfect competition decreases the output of the firms, it depends also on the eventual output level whether the tariff rate is actually higher in imperfect competition.

3 Ad Valorem Tariff Policy

We now discuss the ad valorem tariff policy. Let τ_i represent the ad valorem tariff on the imports from country i. Then the profit of the individual firm in country i is given by

$$\pi^i = \frac{P(X_T)x_i}{1+\tau_i} - C_i(x_i),$$

so that the first-order condition for profit maximization is expressed by

$$0 = P(X_T) + \frac{\lambda_i}{n_i} X_i P'(X_T) - (1+\tau_i) C_i'\left(\frac{X_i}{n_i}\right). \tag{6}$$

The export price facing the individual firm in country i, denoted by v_i, is then given by $v_i = \frac{P(X_T)}{1+\tau_i}$. And this export price is rewritten as

$$v_i = v^i(X_i, X_T) := \rho^i(X_i, X_T) C_i'\left(\frac{X_i}{n_i}\right) \tag{7}$$

where

$$\rho^i(X_i, X_T) := \frac{P(X_T)}{P(X_T) + \frac{\lambda_i}{n_i} X_i P'(X_T)} (> 1) \tag{8}$$

measures the monopoly rent per output over the price, which we call the rent ratio for simplicity of exposition. Then as in the case of specific tariff policies, we may express the welfare of the importing country as follows.

$$W^A(\boldsymbol{X}) := U\left(\sum_k X_k\right) - \sum_k v^k\left(X_k, \sum_\ell X_\ell\right) X_k.$$

As discussed concerning the specific tariff policies, we may define the total import cost $tic(\boldsymbol{X}) := \sum_k v^k\,(X_k, \sum_\ell X_\ell)\,X_k$ and the associated marginal import cost from exporting country i, defined by

$$\begin{aligned} mic^i(\boldsymbol{X}) := {} & \rho^i(X_i, X_T)C_i'(x_i) + x_i C_i''(x_i)\rho^i(X_i, X_T) \\ & + X_i C_i'(x_i)\frac{\partial \rho^i(X_i, X_T)}{\partial X_i} + \sum_k X_k C_k'(x_k)\frac{\partial \rho^k(X_k, X_T)}{\partial X_T}, \end{aligned} \tag{9}$$

where (8) implies

$$\begin{aligned} \frac{\partial \rho^i}{\partial X_i} &= -\frac{\frac{\lambda_i}{n_i}P(X_T)P'(X_T)}{\left(P(x_T) + \frac{\lambda_i}{n_i}X_i P'(X_T)\right)^2} > 0 \\ \frac{\partial \rho^i(X_i, X_T)}{\partial X_T} &= \frac{\frac{\lambda_i}{n_i}X_i\left\{(P'(X_T))^2 - P(X_T)P''(X_T)\right\}}{\left(P(X_T) + \frac{\lambda_i}{n_i}X_i P'(X_T)\right)^2} > 0 \end{aligned}$$

Note that the marginal import cost in perfect competition given by (9) is expressed by only the first term on the right-hand side. Thus the above two equations show that the marginal import cost is higher in imperfect competition. Unlike the case of specific tariff policies, it is hard to obtain simple set of conditions ensuring the total import cost function to be convex in the import vector. Thus we just assume

Assumption 5 *The importing country's welfare function under the ad valorem tariff policies,* $W^A(\boldsymbol{X})$*, is strictly concave in the import vector.*

Let $\boldsymbol{X}^A$ denote the optimal import vector under the ad valorem tariff policy. Then since there holds $P(X_T) - v^i(X_i, X_T) = \tau_i v^i(X_i, X_T)$, the first-order condition for welfare maximization, i.e., $P(X_T^A) = mic^i(X_i^A, X_T^A)$, yields

$$\tau_i^A = \frac{\partial C_i'(x_i^A)}{\partial \ln x_i} + \frac{\partial \ln \rho^i(X_i^A, X_T^A)}{\partial X_i} + \frac{\bar{v}(\boldsymbol{X}^A)}{v^i(X_i^A, X_T^A)}\sum_k \theta^k(X_k^A, X_T^A)\frac{\partial \ln \rho^k(X_k^A, X_T^A)}{\partial \ln X_T}$$

where $\bar{v}(\boldsymbol{X}) := \sum_k v^k(X_k, X_T)X_k/X_T$ measures the average import price facing the importing country and $\theta^k(X_k, X_T) := \frac{X_k v^k(X_k, X_T)}{X_T \bar{v}(\boldsymbol{X})}$ the share of the import cost from country k in the total import costs.

Therefore we have established a general formula for optimal discriminatory ad valorem tariffs covering both perfect and imperfect competition as follows.

Proposition 2 *In the quasi-Cournot international oligopoly market, the optimal discriminatory ad valorem tariff rate on the imports from exporting country i, denoted by τ_i^A, is given by*

$$\tau_i^A = \frac{\partial C_i'(x_i^A)}{\partial \ln x_i} + \frac{\partial \ln \rho^i(X_i^A, X_T^A)}{\partial X_i} + \frac{\bar{v}(\boldsymbol{X}^A)}{v^i(X_i^A, X_T^A)} \sum_k \theta^k(X_k^A, X_T^A) \frac{\partial \ln \rho^k(X_k^A, X_T^A)}{\partial \ln X_T}.$$

4 Specific vs. Ad Valorem Tariff Policies

Let us first compare the export prices between the two policies. By (3) and (7), there holds

$$\begin{aligned}
&V^i(X_i, X_T) - v^i(X_i, X_T) \\
=&C_i'(x_i) - \frac{\lambda_i}{n_i} X_i P'(X_T) - \frac{P(X_T)}{P(X_T) + \frac{\lambda_i}{n_i} X_i P'(X_T)} C_i'(x_i).
\end{aligned}$$

Consider the outputs leading to strictly positive marginal revenue, i.e., $P(X_T) + \frac{\lambda_i}{n_i} X_i P'(X_T) > 0$. Then we may rewrite the above equation as follows.

$$\begin{aligned}
&V^i(X_i, X_T) - v^i(X_i, X_T) \\
\propto&\frac{\lambda_i}{n_i} X_i P'(X_T) \left\{ C_i'(x_i) - \left(P(X_T) + \frac{\lambda_i}{n_i} X_i P'(X_T) \right) \right\} \\
=& - t_i \frac{\lambda_i}{n_i} X_i P'(X_T),
\end{aligned}$$

so that we have established

Proposition 3 *The export price of each exporting country is the same between the specific and ad valorem tariff policies when there holds at least one of the following three conditions.*

(i) The firms are all competitive,

(ii) $X_i = 0$,

(iii) The importing country employs free trade policy, i.e., $t_i = 0 = \tau_i$.

Otherwise, with strictly binding tariff policies, the export price is larger under the specific tariff policy than under the ad valorem tariff policy, i.e., $V^i(X_i, X_T) > v^i(X_i, X_T)$.

The importing country faces the lower export price under the ad valorem tariff policy, for it can earn the greater tariff revenue. This can be demonstrated as follows.

Consider any binding specific tariff policy $\boldsymbol{t}$ with $t_i^S > 0$ for all i. We let $TR^S := \sum_k t_k X_k$ denote the associated tariff revenue.

And consider the equivalent ad valorem tariff policy $\boldsymbol{\tau}$. In view of (2) and (6), this ad valorem tariff policy should satisfy

$$t_i = \tau_i C_i'(x_i). \tag{10}$$

Then the associated tariff revenue, denoted by TR^A, is given by

$$TR^A = \sum_k \frac{\tau_k}{1+\tau_k} P(X_T) X_k$$

Then there holds

$$\begin{aligned} TR^S &= \sum_k t_k X_k \\ &= \sum_k \tau_k C_k'(x_k) X_k \quad (\because (10)) \\ &= \sum_k \tau_k \frac{P(X_T) + \frac{\lambda_k}{n_k} P'(X_T)}{1+\tau_k} X_k \quad (\because (6)) \\ &< \sum_k \frac{\tau_k}{1+\tau_k} P(X_T) X_k \quad (\because P'(X_T) < 0) \\ &= TR^A. \end{aligned}$$

Proposition 4 *For any binding equivalent tariff policies,* $\boldsymbol{t}$ *and* $\boldsymbol{\tau}$*, in the sense of giving rise to the same import vector, the tariff revenue is greater under the ad valorem tariff policy than under the equivalent specific tariff policy.*

This proposition holds because the equivalent ad valorem tariff, in fact, gives rise to the higher tariff rate in terms of specific tariffs.

Then it is straightforward to establish

Proposition 5 *The importing country is better off under the optimal discriminatory ad valorem tariff policy than under the optimal discriminatory specific tariff policy.*

The last problem is whether the importing country employs more protective trade policies by employing the ad valorem tariff policies instead of the specific tariff policies. This depends on whether the marginal import cost becomes greater when we replace the specific tariff with the ad valorem tariff.

Take an example in which all the exporting firms are symmetric in the sense of holding the same cost functions and conjectural variations. [6] Then the optimal discriminatory tariffs

[6] Otherwise, the marginal import cost curve for each exporting country is interdependent, and we cannot compare the export volumes between the two policies without taking account of such interdependence, which makes the analysis too complicated here.

are also the same for all the firms. In view of Proposition 3, the marginal import costs under the two tariff policies cross at least once below the free-trade import level as shown by Figure 1.

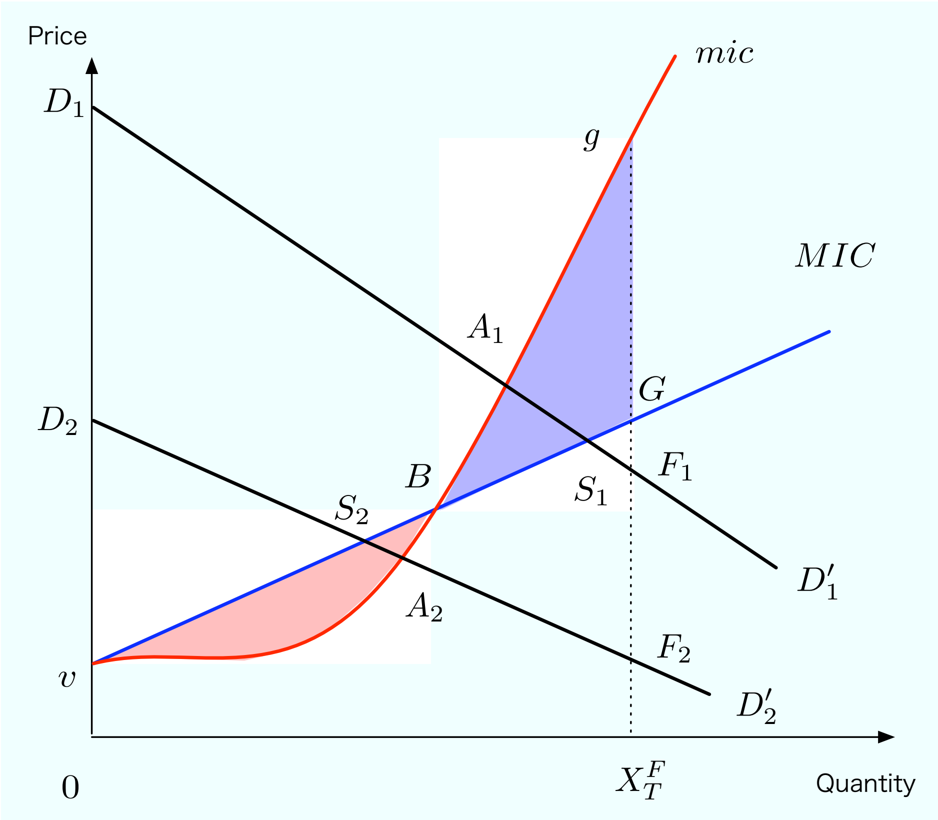

Figure 1: Specific vs. Ad Valorem Tariff Policies

In the figure, there are two demand curves named D_1D_1' and D_2D_2'. The curve mic represents the marginal import cost curve under the ad valorem tariff policy and the curve MIC the counterpart under the specific tariff policy. For simplicity of exposition, the free trade import volume is assumed to be the same between the two demand curves, which is shown by X_T^F. Proposition 3 implies that the area vA_2BS_2 is the same as the area gA_1BS_1G, because the total import cost at free trade with the import X_T^F are the same between the two tariff policies.

Given the demand curve D_1D_1', the optimal import volume under the specific tariff policy is given by point S_1, while the optimal level under the ad valorem tariff policy is given by point A_1. In this case, the import volume is smaller under the ad valorem tariff policy.

However, when the demand curve is given by D_2D_2', the import volume given by S_2 under the specific tariff policy is smaller than the one given by A_2 under the ad valorem tariff policy. Therefore it is ambiguous in general whether the trade volume is smaller under the ad valorem tariff policy than under the specific tariff policy.

5 Concluding Remarks

As is demonstrated in this paper, there is a close theoretical link in optimal tariffs between perfect and imperfect competition. Although we have compared between specific and ad valorem tariffs, we may consider their mix for further welfare improvement for the importing country as have been discussed by Myles (1996). Another approach is to take account of product variety, but we should be very careful in formulating the product substitution and gains from product variety.

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