Administered Protection as a Public Good

Yasukazu Ichino[1] and Kar-yiu Wong[2]

July 7, 2002
(First Draft. Comments Most Welcome.)

[1]Faculty of Economics, Konan University, 8-9-1 Okamoto, Higashinada-ku, Kobe 658-8501 Japan.
[2]Department of Economics, Box 353330, University of Washington, Seattle, WA 98195-3330, U. S. A.

Abstract

We consider a public-good problem among import-competing firms to seek protection. First, we point out that under an administered protection policy, the quantity produced by the firms is a protection-seeking effort. We show that, in spite of the public-good property of the policy, the quantity produced by the import-competing firms can be higher when the firms are noncooperative than the firms are cooperative. We also show that the tariff is not necessarily decreasing as the number of the firms increases.

1 Introduction

Policies that apply to a group of economic agents are similar to a public good in the sense that each of the economic agents cannot exclude others from being affected by the policies. When each of the agents believes that it can contribute to influencing the magnitude of a policy, externality usually arises because each agent may not take into consideration how its contribution may affect other agents. Such an externality is said to be positive (negative) if each agent's contribution will affect other agents in a favorable (unfavorable) way. In the presence of positive externality, free rides are common as each agent tends to contribute less and hopes to benefit from other agents' contribution.

Trade policies, for open economies, also have public-good nature. If firms and consumers can affect the magnitude of a trade policy, free riding usually exists. This is well known in the literature. Olson (1965), in his influential book, concludes that an industry with a smaller number of firms, or an industry with higher concentration, is more successful in collectively providing protection-seeking effort such as lobbying and receiving high level of protection. For example, consider the lobbying effort to influence protection policy. As the number of the firms increases, due to a free-rider problem, the sum of the lobbying effort may decrease, thus the level of protection may fall. Rodrik (1986) examines this line of argument, and showed that there is a negative relationship between the number of the firms and the level of protection. Mitra (1999) takes one step further, arguing that industries of low concentration tend to be less politically active because they have more difficulty in organizing lobbying groups, which are necessary for getting access to politicians.[1]

Although this presumption about industry concentration and successfulness in receiving protection is intuitively appealing, in empirical studies, there has not been found clear-cut evidence. For example, Baldwin (1985) and Trefler (1993) do not find statistically significant positive relationship between the industry concentration and the level of protection, nor the significant negative relationship between the number of firms and the level of protec-

[1] The analysis of the response of firms facing the prospect of protection is first examined by Bhagwati and Srinivasan (1976), in which a probability of quota enforcement in future depends on the current level of imports. Fischer (1992) studied endogenous probability of protection in an oligopolistic model. Reitzes (1993) presented a model where the antidumping duty depends on the price difference between the foreign market and the home market. See also Anderson (1992, 1993), and Blonigen and Ohno (1998).

tion. Thus, so far it is empirically ambiguous whether the industry with low concentration has a disadvantage in obtaining protection (see also the survey by Potters and Sloof (1996)). In response to this empirical ambiguity, recently several theoretical explanations have been developed. Pecorino (1998, 2001) models a repeated game of lobbying, and showed that the free-rider problem is not necessarily important in lobbying for protection. Hillman, Long, and Soubeyran (2001) study an oligopolistic industry where each firm allocates its resources between lobbying and internal cost-reducing activities, and showed that highly concentrated industry does not necessarily obtain more protection.

The above studies focus on economic agents' efforts in affecting the magnitude of a trade policy in a political process. When a policy is chosen by legislative branch of a government, the policy is said to be an *legislated policy*. There is, however, another type of policy called *administered policies*: The legislative branch will choose the rules for the magnitude of a policy. This means that the legislative branch will not set a particular magnitude of a tariff. Instead, it will set a formula for a policy so that the magnitude of the policy will depend on the conditions of an environment. Usually it is the administrative or executive branch of the government that is responsible for measuring the condition of the environment and will set the magnitude of the policy. Examples of administered policies are antidumping duties, countervailing duties, and escape clauses. The executive branch of the government, for example, is responsible for investigating the degree of dumping by foreign firms, and the result of the investigation will be used to set the magnitude of an antidumping duty based on the rules set by the legislative branch of the government.

In the presence of administered policies, economic agents that want to affect the magnitude of the policy will have to do that not through the legislative body but through changes in the environment that the government is going to investigate. For example, for antidumping duties, firms may want to affect variables such as outputs or market prices, which the government will measure to determine the extent of dumping. As a result, the results in the literature related to lobbying efforts may not hold.

Administered policies also have public-good nature, and when firms know that they can affect the magnitude of the policy through changing their outputs, externality and free riding arise. So, in this sense, administered policies and legislated policies are similar. However, as argued in this paper, the public-good nature of an administered policy can be quite different from what we would expect from a legislated policy. The paper also argues that different features of externality and free riding may be found as firms are facing administered instead of legislative policies. It is thus interesting to examine whether the results of Olson, Rodrik and Mitra can be carried over to administered policies.

To carry out the analysis in this paper, we extend the two-period model in Reizes (1993), in which a number of home firms compete with a foreign firm. Dumping is measured in period 1, and tariff is chosen and implemented in period 2. Thus all firms will choose their outputs carefully in period 1, taking into account how their outputs may affect the rate of protection in period 2. We examine the following three questions: (i) Is the protection-seeking effort "under-provided" when the home firms behave noncooperatively? (ii) Is the resulting tariff lower when the home firms are noncooperative than when they are cooperative? (iii) Does the tariff decrease as the number of the home firms increases?

For the first and second questions, because of the free-rider problem, one may expect that the protection-seeking effort should be under-provided; that is, the quantity produced by the home firms would be less, and thus the size of the tariff would be lower, when the home firms are noncooperative, than when the home firms are cooperative. However, in this paper, we show that this is not necessarily the case. We demonstrate that the protection-seeking effort can be larger, and thus the resulting tariff can be higher, when the home firms are noncooperative than when they are cooperative. This result may be well contrasted with the results of Rodrik (1986), and of Pecorino (1998, 2001), where the tariff is always lower in the noncooperative situation than in the cooperative situation.

For the third question, we show that the equilibrium tariff can increase as the number of the home firms increases. This finding is quite contrary to the presumption that an industry with low concentration is less successful in receiving protection, but as we mentioned above, empirical evidence for this presumption has not found so far. Thus, we consider that, in addition to the works of Pecorino (1998, 2001) and of Hillman, Long, and Soubeyran (2001), our result suggests another piece of theoretical evidence that an industry with low concentration does not necessarily have a disadvantage in receiving high protection.

Our result that the noncooperative home firms may provide more protection-seeking effort than the cooperative home firms do is seemingly counter-intuitive. However, this result is easily understood by noticing that the protection-seeking effort in our model is the quantity produced by the oligopoly firms. As we know, the noncooperative oligopoly firms tend to produce more than the cooperative firms do. Thus, there are two opposing factors in the provision of the protection-seeking effort here. The public-good property of the effort makes the home firms tend to under-provide the effort, while the oligopolistic competition makes the home firms tend to over-provide the effort. On this point, our result is closely related to the model of oligopolistic entry deterrence by Waldman (1987). He studied noncooperative entry deterrence by the oligopolistic incumbent firms, where the entry-deterring investment is the quantity produced by the incumbent firms. A main result of his paper is that the public-good factor dominates the oligopolistic-competition factor, thus the noncooperative incumbent firms always over-invest. The difference of our result from his is that, in our model, the oligopolistic-competition factor does not always outweigh the public-good factor.

The rest of this paper is organized as follows. In Section 2, we present our model, and solve the equilibrium of the game. The public-good nature of an antidumping policy is given in Section 3. Section 4 gives concluding remarks.

2 The Model

We consider an international oligopoly-Cournot model with two countries, which are labeled "home" and "foreign". There are $n > 1$ identical firms in home and a single firm in foreign, producing a homogeneous product. The home and foreign inverse demands for the product are given by $p = p(q)$ and $P = P(Q)$, respectively, where p and P are the market prices and q and Q the market demand of the corresponding countries. Each home firm faces a constant marginal cost of c_h while the foreign firm has a constant marginal cost of c_f. While the foreign market is closed to external competition, output of the foreign firm is allowed to enter the home market under a possible antidumping duty policy administered by the home government.

Following Reitzes (1993), we consider a two-period game. In period 1, the home country permits free trade, and in period 2 an antidumping duty, or tariff, may be imposed. In each period, the firms compete in a Cournot way after the policy is announced. Using subscripts "I" and "II" to denote the variables in period 1 and period 2, respectively, the rate of the antidumping duty t^{II} is chosen under the following rules: $t^{II} = \tau(P(Q^I) - p(q^I))$ if $P(Q^I) - p(q^I) \geq 0$, and $t^{II} = 0$ otherwise, where τ is a positive parameter. Alternatively, we can write $t^{II} = \max\left\{\tau(P(Q^I) - p(q^I)), 0\right\}$. The rules of the antidumping duty is known to all firms in the beginning of the game.

2.1 The period-2 solution

We solve our model from period 2. Let q_i^{II} denote the quantity produced by home firm i, $i = 1, 2, ..., n$, and q_f^{II} denote the quantity exported by the foreign firm. The profit maximization of home firm i is

$$\max_{q_i^{II}} \left[p(q_i^{II} + q_{h,-i}^{II} + q_f^{II}) - c_h\right] q_i^{II},$$

where $q_{h,-i}^{II}$ is the quantity produced by the home firms other than firm i. The first-order condition is

$$p'(q_i^{II} + q_{h,-i}^{II} + q_f^{II})q_i^{II} + p(q_i^{II} + q_{h,-i}^{II} + q_f^{II}) - c_h \leq 0,\ q_i^{II} \geq 0.$$

Summing this first-order condition over i, we have

$$p'(q_h^{II} + q_f^{II})q_h^{II} + np(q_h^{II} + q_f^{II}) - nc_h \leq 0,\ q_h^{II} \geq 0. \tag{1}$$

where $q_h^{II} = nq_i^{II}$ is the total quantity produced by all home firms.

As we mentioned above, the export of the foreign firm is subject to the tariff. The profit maximization problem of the foreign firm is[2]

$$\max_{q_f^{II}} \left[p(q_h^{II} + q_f^{II}) - (c_f + t^{II})\right] q_f^{II}.$$

Since the tariff is imposed only in period 2, hereafter we drop the period superscript on t. The first-order condition is given by

$$p'(q_h^{II} + q_f^{II})q_f^{II} + p(q_h^{II} + q_f^{II}) - c_f - t \leq 0,\ q_f^{II} \geq 0. \tag{2}$$

The equilibrium quantities are found by solving equation (1) and equation (2). We use $q_{h,n}^{II}(t)$ and $q_{f,n}^{II}(t)$ to denote the equilibrium quantity when there are n firms in the home country. Because the home firms are identical, the

[2]Since period 2 is the end of the game, the quantity sold to the foreign market has no strategic role. Thus, the foreign firm simply sells the monopoly quantity to the foreign market. This is why we consider only the export decision of the foreign firm in period 2.

equilibrium quantity produced by home firm i, $q^{II}_{i,n}(t)$, is given by $q^{II}_{h,n}(t)/n$. To guarantee a unique solution, we assume that the profit of every firm is concave in its own quantity, and that the marginal revenue of every firm is decreasing in the quantity of other firms. Also, we assume that the equilibrium quantities are positive when $t = 0$. That is, $q^{II}_{h,n}(0) > 0$ and $q^{II}_{f,n}(0) > 0$.

The comparative statics with respect to t is derived from the equations (1) and (2):

$$\begin{aligned}\frac{\mathrm{d}q^{II}_{h,n}}{\mathrm{d}t} &= \frac{-\left(p'' q^{II}_{h,n}(t) + np'\right)}{p'\left[p'' q^{II}_{n}(t) + (n+2)p'\right]} > 0 \text{ and} \\ \frac{\mathrm{d}q^{II}_{f,n}}{\mathrm{d}t} &= \frac{p'' q^{II}_{h,n}(t) + (n+1)\,p'}{p'\left[p'' q^{II}_{n}(t) + (n+2)p'\right]} < 0,\end{aligned}$$

where $q^{II}_{n}(t) = q^{II}_{h,n}(t) + q^{II}_{f,n}(t)$ is the total equilibrium quantity supplied to the home market.

We use $\pi_{i,n}(t)$ and $\pi_{f,n}(t)$ to denote the period-2 equilibrium profits of home firm i and that of the foreign firm, respectively. The sum of the equilibrium profits of all home firms, denoted by $\pi_{h,n}(t)$, is equal to $n\pi_{i,n}(t)$. The comparative statics for the equilibrium profits are as follows.

$$\begin{aligned}\frac{\mathrm{d}\pi_{h,n}}{\mathrm{d}t} &= \begin{cases} \dfrac{1}{n}\dfrac{\left[p'' q^{II}_{h,n}(t) + 2np'\right] q^{II}_{h,n}(t)}{p'' q^{II}_{n}(t) + (n+2)p'} > 0 & \text{if } t < \bar{t}_n \\ 0 & \text{if } t \geq \bar{t}_n \end{cases} \\ \frac{\mathrm{d}\pi_{f,n}}{\mathrm{d}t} &= \begin{cases} \dfrac{-\left[p''\left(q^{II}_{h,n}(t) + q^{II}_{n}(t)\right) + 2\,(n+1)\,p'\right] q^{II}_{f,n}(t)}{p'' q^{II}_{n}(t) + (n+2)p'} < 0 & \text{if } t < \bar{t}_n \\ 0 & \text{if } t \geq \bar{t}_n \end{cases}\end{aligned}$$

where $\bar{t}_n$ is the prohibitive level of the tariff, implicitly defined by the minimum rate that satisfies $q^{II}_{f,n}(\bar{t}_n) = 0$.

Qualitatively, the interpretation of these comparative statics results are straightforward. As the tariff increases, the foreign firm will export less and the home firms will produce more. Thus, the profit of the foreign firm is decreasing in t and the profits of the home firms are increasing in t, as long as t is below the prohibitive level.

To illustrate the result derived above, we can consider the special case in which the demand curves are linear: $p(q) = a - q$ and $P(Q) = A - Q$, where

a and A are sufficiently large constants. Then,

$$\begin{aligned}
q^{II}_{h,n}(t) &= \frac{n(a-2c_h+c_f+t)}{n+2} \\
q^{II}_{f,n}(t) &= \frac{a-(n+1)(c_f+t)+nc_h}{n+2} \\
\pi_{h,n}(t) &= \frac{n(a-2c_h+c_f+t)^2}{(n+2)^2} \\
\pi_{f,n}(t) &= \frac{(a-(n+1)(c_f+t)+nc_h)^2}{(n+2)^2}
\end{aligned}$$

$$\frac{\mathrm{d}\pi_{h,n}}{\mathrm{d}t} = \begin{cases} \dfrac{2n(a-2c_h+c_f+t)}{(n+2)^2} > 0 & \text{if } t < \bar{t}_n \\ 0 & \text{if } t \geq \bar{t}_n \end{cases} \tag{3}$$

$$\frac{\mathrm{d}\pi_{f,n}}{\mathrm{d}t} = \begin{cases} -\dfrac{2(n+1)\left(a-(n+1)(c_f+t)+nc_h\right)}{(n+2)^2} < 0 & \text{if } t < \bar{t}_n \\ 0 & \text{if } t \geq \bar{t}_n \end{cases}, \tag{4}$$

where $\bar{t}_n = \dfrac{a+nc_h}{n+1} - c_f$.

Now, let us consider period 1. Knowing the rules of administered protection policy, home firm i chooses its quantity to maximize the present value of the profits in two periods:

$$\max_{q^I_i} \left[p(q^I_i + q^I_{h,-i} + q^I_f) - c_h\right] q^I_i + \delta\pi_{i,n}(t), \tag{5}$$

where $t = \max\left\{\tau\left[P(Q^I) - p(q^I_i + q^I_{h,-i} + q^I_f)\right], 0\right\}$, and $\delta \in (0,1]$ is a discount factor. From now on, we drop the period superscripts, remembering that quantity variables we deal with hereafter are those of period 1 (also, keep in mind that $\pi_{i,n}(t)$ represents the profit of *period 2*). To avoid corner solutions, we assume that in equilibrium the period-1 quantities are nonzero. Then, the first-order condition of the profit maximization problem (5) is given by

$$p'(q_i+q_{h,-i}+q_f)q_i+p(q_i+q_{h,-i}+q_f)-c_h+\delta\pi'_{i,n}(t)\frac{\partial t}{\partial p}p'(q_i+q_{h,-i}+q_f) = 0 \tag{6}$$

where $\pi'_{i,n}(t) = \mathrm{d}\pi_{i,n}(t)/\mathrm{d}t$. As in period 1, we assume that the intertemporal profit function (5) is concave in q_i, and the marginal profit is decreasing in the quantity of other firms (we assume the same for the profit function of the foreign firm). Summing equation (6) over i, we have

$$[p'(q_h + q_f)q_h + np(q_h + q_f) - nc_h] + \left[\delta\pi'_{h,n}(t)\frac{\partial t}{\partial p}p'(q_h + q_f)\right] = 0. \qquad (7)$$

By solving equation (7) for q_h, we can find the total quantity produced by n home firms as a function of the quantities of the foreign firm. We call it the "reaction function" of n home firms, and denote it by $r_{h,n}(q_f, Q)$.

Notice that the second bracket term in equation (7) is nonnegative, since $\pi'_{h,n}(t) \geq 0$ and $\partial t/\partial p \leq 0$ (in particular, when t is positive and below the prohibitive level, the second bracket term in equation (7) is positive). Thus, equation (7) implies that

$$p'(r_{h,n}(q_f, Q) + q_f)r_{h,n}(q_f, Q) + np(r_{h,n}(q_f, Q) + q_f) - nc_h \leq 0. \qquad (8)$$

2.2 Strategic Outputs in Period 1

The knowledge of the administered policy rules in the next period allows all firms to make strategic moves in period 1. Let us compare the above equilibrium with that in a case in which all firms believe that no administered policy will be imposed in period 2. In the latter case, the reaction function of the home firms is simply the standard Cournot reaction function, which we denote by $r^0_{h,n}(q_f)$. That is, $r^0_{h,n}(q_f)$ is defined by

$$p'(r^0_{h,n}(q_f) + q_f)r^0_{h,n}(q_f) + np(r^0_{h,n}(q_f) + q_f) - nc_h = 0. \qquad (9)$$

Comparing equation (8) and (9), by the concavity of the profit function we can conclude that $r_{h,n}(q_f, Q) \geq r^0_{h,n}(q_f)$. The intuition is very straightforward: facing the prospect of antidumping duty, the home firms have an incentive to increase their period-1 quantity above the standard Cournot best reply level, in order to increase the tariff of period 2.

The foreign firm chooses the quantity it sells to the foreign market, Q, and the quantity it exports to the home market, q_f, to maximize the present value of the profits in two periods:

$$\max_{q_f, Q} [P(Q) - c_f]\, Q + [p(q_h + q_f) - c_f]\, q_f + \delta\pi_{f,n}(t).$$

The first-order conditions are

$$[p'(q_h+q_f)q_f+p(q_h+q_f)-c_f]+\left[\delta{\pi'}_{f,n}(t)\frac{\partial t}{\partial p}p'(q_h+q_f)\right] \quad = \quad 0 \quad (10)$$

$$[P'(Q)Q+p(Q)-c_f]+\left[\delta{\pi'}_{f,n}(t)\frac{\partial t}{\partial P}P'(Q)\right] \quad = \quad 0. \quad (11)$$

The reaction functions $q_f = r_{f,n}(q_h)$ and $Q = R_n(q_h)$ are derived from these first-order conditions. Since ${\pi'}_{f,n}(t) \leq 0$, $\partial t/\partial p < 0$, and $\partial t/\partial P \geq 0$, the second bracket term in equation (10) is non-positive (it is negative if the tariff is positive and below the prohibitive level), and the second bracket term in equation (11) is nonnegative (it is positive if the tariff is positive and below the prohibitive level). Thus, from equation (10) and (11), it is easily seen that

$$p'(q_h+r_{f,n}(q_h))r_{f,n}(q_h)+p(q_h+r_{f,n}(q_h))-c_f \quad \geq \quad 0 \qquad (12)$$

$$P'(R_n(q_h))R_n(q_h)+p(R_n(q_h))-c_f \quad \leq \quad 0. \qquad (13)$$

Without any antidumping policy, the reaction function for the export of the foreign firm is the standard Cournot reaction function, which we denote by $r_f^0(q_h)$. That is, $r_f^0(q_h)$ is defined by

$$p'(q_h+r_f^0(q_h))r_f^0(q_h)+p(q_h+r_f^0(q_h))-c_f=0; \qquad (14)$$

and the quantity sold to the foreign market is simply the monopoly level, which we denote by Q^0. That is, Q^0 is defined by

$$P'(Q^0)Q^0+p(Q^0)-c_f=0. \qquad (15)$$

Again, using the concavity of the profit function, comparing equation (12) and (14) gives us $r_{f,n}(q_h) \leq r_f^0(q_h)$, and comparing equation (13) and (15) gives us $R_n(q_h) \geq Q^0$. In words, the foreign firm exports less to the home country, and sells more to the foreign market, when the period-2 tariff depends on the period-1 price difference. These strategic responses of the foreign firm to the protection policy are due to the foreign firm's incentive to lower the period-2 tariff.

Having examined the reaction function, we now look at the equilibrium. Let $q_{h,n}^*$, $q_{f,n}^*$, and Q_n^* denote the equilibrium quantities in period 1 when there are n firms in the home country (in Appendix A.1, we present the explicit solutions in the case of linear demand). Let $q^0_{h,n}$, $q^0_{f,n}$, and Q^0 denote the equilibrium that would occur if there were no antidumping policy. That is, $q^0_{h,n}$ and $q^0_{f,n}$ are the standard Cournot equilibrium, and Q^0 is the monopoly quantity in the foreign market. The proposition below shows how the antidumping policy may affect the equilibrium outputs.

Proposition 1 *If all firms are aware of the period-2 antidumping policy rule, $t^{II} = \max\left\{\tau(P(Q^I) - p(q^I)), 0\right\}$, the equilibrium output of each home firm in period 1 is no less than, and the equilibrium export of the foreign firm in period 1 is no more than, the corresponding equilibrium quantities that would occur in the standard Cournot game: i.e., $q^*_{h,n} \geq q^0_{h,n}$ and $q^*_{f,n} \leq q^0_{f,n}$. The equilibrium quantity supplied by the foreign to its own market is no less than the monopoly level: i.e., $Q^*_n \geq Q^0$.*

Proof. First we show $Q^*_n \geq Q^0$. Suppose $Q^*_n < Q^0$. Then,

$$\begin{aligned}
0 &= P'(Q^0)Q^0 + p(Q^0) - c_f \\
&< P'(Q^*_n)Q^*_n + p(Q^*_n) - c_f \\
&\leq P'(Q^*_n)Q^*_n + p(Q^*_n) - c_f + \delta\pi'_{f,n}(t)\frac{\partial t}{\partial P}P'(Q^*_n)
\end{aligned}$$

where the first equality is by the definition of Q^0, the second inequality is from the concavity of the profit function and the hypothesis $Q^*_n < Q^0$, and the third inequality is from $\pi'_{f,n}(t) \leq 0$ and $\partial t^{II}/\partial P \geq 0$. However, the last line is equal to zero by the definition of Q^*_n, leading to a contradiction.

Second, we show $q^*_{f,n} \leq q^0_{f,n}$. Suppose $q^*_{f,n} > q^0_{f,n}$. Then,

$$\begin{aligned}
0 &= p'(r^0_{h,n}(q^0_{f,n}) + q^0_{f,n})q^0_{f,n} + p(r^0_{h,n}(q^0_{f,n}) + q^0_{f,n}) - c_f \\
&> p'(r^0_{h,n}(q^*_{f,n}) + q^*_{f,n})q^*_{f,n} + p(r^0_{h,n}(q^*_{f,n}) + q^*_{f,n}) - c_f \\
&\geq p'(r_{h,n}(q^*_{f,n}, Q^*_n) + q^*_{f,n})q^*_{f,n} + p(r_{h,n}(q^*_{f,n}, Q^*_n) + q^*_{f,n}) - c_f \\
&\geq p'(r_{h,n}(q^*_{f,n}, Q^*_n) + q^*_{f,n})q^*_{f,n} + p(r_{h,n}(q^*_{f,n}, Q^*_n) + q^*_{f,n}) - c_f \\
&\quad +\delta\pi'_{f,n}(t)\frac{\partial t}{\partial p}p'(r_{h,n}(q^*_{f,n}, Q^*_n) + q^*_{f,n}).
\end{aligned}$$

The first equality is by the definition of $q^0_{f,n}$. The second inequality is from the facts that the profit function is concave in q_f, $r^0_h(\cdot)$ is negatively sloped and the slope is less than one in absolute value, and the hypothesis $q^*_{f,n} > q^0_{f,n}$. The third inequality is from $r^0_{h,n}(q^*_{f,n}) \leq r_{h,n}(q^*_{f,n}, Q^*_n)$ and the marginal profit is decreasing in q_h. The fourth inequality is from $\pi'_{f,n}(t) \leq 0$ and $\partial t/\partial p \leq 0$. By the definition of $q^*_{f,n}$, the last two lines are equal to zero, leading to a contradiction.

The proof for $q^*_{h,n} \geq q^0_{h,n}$ is done in a similar way. ■

Proposition 1 is a natural consequence of the characteristics of the reaction functions. The home firms have an incentive to increase the tariff, and the foreign firm has an incentive to decrease the tariff. Thus, in equilibrium, the home firms' quantity is larger, the foreign firm's export is smaller, and the foreign firm's quantity supplied to the foreign market is larger. This proposition is a generalization of the one in Reitzes (1993), with n home firms instead of one home firm, but the present paper is not just a generalization of Reitzes' result because with more than one home firms there are new issues, to which we now turn.

3 Public-good Nature of the Antidumping Policy

We now examine the public-good nature of the policy. As explained, such a nature comes from the fact that all home firms contribute to the setting of the tariff rate in period 2, and the tariff benefits all firms. Since each home firm cares only about its own profit, an externality exists. The externality can be measured in two ways: either in terms of the period-1 quantity chosen by each home firm or in terms of the resulting tariff.

These two ways of measuring externality are analyzed in the following two subsections.

3.1 Equilibrium quantity of each home firm

To show the existence of externality, we analyze the equilibrium period-1 outputs of all home firms when there are $n > 1$ home firms with the equilibrium period-1 output of a single home firm in the hypothetical case in which $n = 1$. Alternatively, we consider a hypothetical case in which all n home firms cooperate and choose an aggregate output that maximize the joint profit. In particular, we want to investigate whether in the presence of multiple home firms they over-produce or under-produce in period 1.

In the present case, the aggregate home output in period 1 is $q^*_{h,n}$ while the export and domestic supply of the foreign firm in the same period are $q^*_{f,n}$ and Q^*_n, respectively. Let us consider a hypothetical case in which there is only one home firm. Let us denote its equilibrium period-1 output by $q^*_{h,1}$. By comparing between the present case with the hypothetical one-firm case, we can identify two types of externalities that exist when there are more than one home firms:

1. Oligopoly externality. This externality is well known in microeconomic theory, as firms compete in a non-cooperative, Cournot way, the sum of the firms is more than what the market will have should there be only one firm. The oligopoly externality is a negative externality because an increase in a firm's output will have a negative effect on other firms' profits.

2. Public-good externality. This externality exists because the home firms want to drive up the tariff rate to get a bigger protection, but to drive up the tariff in period 2, they need to sacrifice by produce more in period 1. However, when firms choose outputs non-cooperatively, each of them will avoid a big sacrifice, making the total output less than what one single firm will produce. Thus the public-good externality is a positive externality and will cause the firms to under-produce.

To analyze these two externalities, we begin with the two home reaction functions, $r_{h,n}(q^*_{f,n}, Q^*_n)$ and $r_{h,1}(q^*_{f,n}, Q^*_n)$, where the former is the aggregate reaction function of all home firm in the present case while the latter is that of a home monopolist in the hypothetical case with one home firm. Both reaction functions are based on the same assumed outputs of the foreign firm, meaning that they give the possible aggregate home output for n home firms or for only one home firm. For example, if $r_{h,n}(q^*_{f,n}, Q^*_n) < r_{h,1}(q^*_{f,n}, Q^*_n)$, it means that home reacts with a smaller output when there are n firms than when there is only one firm, and under normal comparative static conditions that the n home firms tend to under-produce.

Recall that $r_{h,n}(q^*_{f,n}, Q^*_n)$ is defined by equation (7):

$$\begin{aligned} 0 \;=\; & p'(r_{h,n} + q^*_{f,n})r_{h,n} + n\left[p(r_{h,n} + q^*_{f,n}) - c_h\right] \\ & - p'(r_{h,n} + q^*_{f,n})\tau\delta\pi'_{h,n}(t(r_{h,n} + q^*_{f,n}, Q^*_n)), \end{aligned} \tag{16}$$

where the arguments of $r_{h,n}$ are suppressed to simplify the expression. Similarly, $r_{h,1}(q^*_{f,n}, Q^*_n)$ is defined as follows:

$$\begin{aligned} 0 &= p'(r_{h,1} + q^*_{f,n}) r_{h,1} + \big[p(r_{h,1} + q^*_{f,n}) - c_h\big] \\ &\quad - p'(r_{h,1} + q^*_{f,n}) \tau \delta \pi'_{h,1}(t(r_{h,1} + q^*_{f,n}, Q^*_n)). \end{aligned} \tag{17}$$

Let us define the right-hand side of equation (17) as $\Psi(r_{h,1}(q^*_{f,n}, Q^*_n), q^*_{f,n}, Q^*_n)$. Since we have assumed the concavity of intertemporal profit functions, the function Ψ, which is simply the marginal profit, is decreasing in the first argument. Thus, we can see that $r_{h,n}(q^*_{f,n}, Q^*_n) < r_{h,1}(q^*_{f,n}, Q^*_n)$ if and only if $\Psi(r_{h,n}(q^*_{f,n}, Q^*_n), q^*_{f,n}, Q^*_n) > 0$, because $\Psi(r_{h,1}(q^*_{f,n}, Q^*_n), q^*_{f,n}, Q^*_n) = 0$ by definition. Now we rewrite equation (16) to obtain

$$\begin{aligned} 0 &= \Psi(r_{h,n}, q^*_{f,n}, Q^*_n) \\ &\quad + (n-1)\big[p(r_{h,n} + q^*_{f,n}) - c_h\big] - p'(r_{h,n} + q^*_{f,n}) \tau \delta \left[\pi'_{h,n}(t^*_n) - \pi'_{h,1}(t^*_n)\right]. \end{aligned} \tag{18}$$

Therefore, we can conclude that $r_{h,n}(q^*_{f,n}, Q^*_n) < r_{h,1}(q^*_{f,n}, Q^*_n)$ if and only if the following condition holds:

$$(n-1)\big[p(r_{h,n} + q^*_{f,n}) - c_h\big] - p'(r_{h,n} + q^*_{f,n}) \tau \delta \left[\pi'_{h,n}(t^*_n) - \pi'_{h,1}(t^*_n)\right] < 0. \tag{19}$$

Using the first-order condition of home firm i (equation (7)) and rearranging terms, condition (19) can be decomposed into two parts:

$$p' \tau \delta \left[\pi'_{h,1} - \frac{1}{n} \pi'_{h,n}\right] - \left(1 - \frac{1}{n}\right) p' r_{h,n} < 0. \tag{20}$$

Let us examine these two terms. First, $p'\tau\delta\pi'_{h,1}$ is the change (negative) in the discounted profit of a home firm, when it is a monopolist, due to a change in the tariff rate as a result of a marginal change in the home output. On the other hand, $p'\tau\delta\pi'_{h,n}/n$ is the corresponding change in the discounted profit of one of the home firms when there are $n > 1$ of them, with both $\pi'_{h,1}$ and $\pi'_{h.n}$ are measured at $t = t^*_n$. This term thus is a measure of the impacts of the output on the tariff rate and then on the profit that each of the home firms have ignored when it focuses on its own profit than on the aggregate and cooperative profit. We thus say that this is a measure of the *public-good externality* for this policy. In general, this sign of this externality is ambiguous, and its effect on the outputs of home firms may be positive or negative. (See the lemma below.)

To interpret the second term, which includes the minus sign, note that $p' r_{h,n}$ is the effect on the total profits of home firms due to a marginal increase in output, while $p' r_{h,n}/n$ is that on the profit of each firm. Thus the second term is equal to the difference between what the home firms should consider (the effects on the total profit) and what each of them will consider (its own profit) when choosing its own output. We call this term the *oligopoly externality.* It is clear that this term is positive, meaning that it tends to induce the home firm to produce too much, i.e., $r_{h,n}(q^*_{f,n}, Q^*_n)$ tends to be greater than $r_{h,1}(q^*_{f,n}, Q^*_n)$.

Based on the above analysis, we have the following proposition:

Proposition 2 *The home firms will under produce if and only if condition (19) or (20) holds.*

Lemma 1 *If $c_h \leq c_f$, then $p(r_{h,n} + q^*_{f,n}) - c_h > 0$.*

Proof. From the first-order condition of the foreign firm (equation (10)), we have

$$p(r_{h,n} + q^*_{f,n}) - c_f = -p'(r_{h,n} + q^*_{f,n})[q^*_{f,n} - \tau\delta\pi'_{f,n}(t^*_n)] > 0,$$

since $p' < 0$ and $\pi'_{f,n}(t^*_n) < 0$. Thus, $c_h \leq c_f$ implies $p(r_{h,n} + q^*_{f,n}) - c_h > 0$. ■

On the other hand, for the public-good externality to outweigh the oligopoly externality, the marginal cost of the home firms must be larger than the equilibrium price of period 1. Casually speaking, this is not very likely to happen, since $p(r_{h,n} + q^*_{f,n}) < c_h$ implies that, in order to increase the tariff, the home firms are selling a big output in period 1 that they are making *negative* profits in period 1.

We mentioned earlier that the sign of $\pi'_{h,1}(t^*_n) - \pi'_{h,n}(t^*_n)$ is in general ambiguous. In the cases examined below, we can determine its sign.

Lemma 2 *Suppose that the demand curve of the home market is linear such that $p(q) = a - q$. For $n = 2$ and $n = 3$, $\pi'_{h,n}(t^*_n) > \pi'_{h,1}(t^*_n)$. For $n \geq 4$, $\pi'_{h,n}(t^*_n) \leq \pi'_{h,1}(t^*_n)$.*

Proof. From equation (3),

$$\pi'_{h,n}(t^*_n) - \pi'_{h,1}(t^*_n) = 2\left(a - 2c_h + c_f + t^*_n\right)\frac{5n - n^2 - 4}{9\left(n+2\right)^2}.$$

Thus $\pi'_{h,n}(t_n^*) > \pi'_{h,1}(t_n^*)$ if and only if $5n - n^2 - 4 > 0$. The result immediately follows. ■

Proposition 3 *Suppose that the demand curves are linear and that* $c_h \leq c_f$. *If either (a)* $n = 2$, *or* 3; *or (b)* $\tau \leq 1/\sqrt{2}$, *then* $q_{h,n}^* > q_{h,1}^*$.

Proof. Part (a) follows immediately the analysis above. For (b), see Appendix A.3. ■

The additional condition $\tau \leq 1/\sqrt{2}$ makes the home firms less concerned about the profit of period 2, since this condition places an upper bound on the responsiveness of the protection policy to the period-1 quantity. The effect of the public-good externality and the effect of the difference in the marginal benefit become weaker by this condition. Hence, given $c_h \leq c_f$ and $\tau \leq 1/\sqrt{2}$, the oligopoly externality becomes dominant enough.

As a summary, in this subsection we identified the four factors that determine whether $q_{h,n}^*$ is larger or smaller than $q_{h,1}^*$. The first factor is the influence of the foreign firm. This factor has an ambiguous effect on whether $q_{h,n}^*$ is larger or smaller than $q_{h,1}^*$. The second factor is the positive externality due to the public-good property of the administered policy, and the third factor is the negative externality due to the oligopolistic competition. The public-good property of protection seeking makes the noncooperative home firms tend to produce *less*, while the oligopolistic competition makes the noncooperative firms tend to produce *more*, than the cooperative level. The fourth factor is the difference in the marginal benefit from an increase in the tariff. As Lemma 1 shows, this factor usually makes the noncooperative home firms tend to produce *less* than the cooperative home firms would produce. Because of these competing factors, whether the noncooperative home firms produce more or less than the cooperative level is not certain in general. However, in Proposition 2 and 3, we demonstrated that the negative externality due to the oligopolistic competition can be dominant enough, so that the noncooperative home firms may produce more than the cooperative level. Therefore, even though the quantity decision of the home firms has a public-good property, it does not necessarily result in under-production by the noncooperative home firms.

3.2 Equilibrium tariff

We now compare the equilibrium tariffs when the home firms are noncooperative and when the home firms are cooperative. To do that, let us first examine the equilibrium quantities of the foreign firm, since it helps the analysis of the equilibrium tariff. To keep our analysis tractable, in this subsection we focus on the case of linear demand, assuming that $p(q) = a - q$ and $P(Q) = A - Q$.

Similar to equation (**??**), we can write $q^*_{f,n} - q^*_{f,1}$ and $Q^*_n - Q^*_1$ as follows:

$$\begin{aligned} q^*_{f,n} - q^*_{f,1} &= \left[r_{f,n}(q^*_{h,n}) - r_{f,1}(q^*_{h,n})\right] + \left[r_{f,1}(q^*_{h,n}) - r_{f,1}(q^*_{h,1})\right] \\ Q^*_n - Q^*_1 &= \left[R_n(q^*_{h,n}) - R_1(q^*_{h,n})\right] + \left[R_1(q^*_{h,n}) - R_1(q^*_{h,1})\right] \end{aligned}$$

In lemma 2 below, we show that the differences in the reaction functions of the foreign firm depend on its period-2 profit.

Lemma 3 *Suppose that the demand curves are linear.* $r_{f,n}(q^*_{h,n}) > r_{f,1}(q^*_{h,n})$ *and* $R_n(q^*_{h,n}) < R_1(q^*_{h,n})$ *if and only if* $\left|\pi'_{f,n}(t^*_n)\right| < \left|\pi'_{f,1}(t^*_n)\right|$

Proof. See Appendix A.4. ■

Lemma 2 can be understood as follows. Let us consider the reaction function of the foreign firm in period 1 when the home firms do not cooperate and that when the home firms cooperate, or when there is only one home firm. If the protection policy were independent of the price difference in period 1, then these two reaction functions are the same. Thus, the difference between the foreign reaction functions comes solely from the difference in its period-2 profits in these two cases. When the home firms are noncooperative, the foreign firm is competing with n home firms, so its period-2 profit is $\pi_{f,n}$. On the other hand, when the home firms are cooperative, the foreign firm is virtually competing with one home firm, so its perod-2 profit is $\pi_{f,1}$. In period 1, facing the prospect of a protective policy, the incentive of the foreign firm to influence the size of the tariff is measured by the marginal change of its period-2 profit with respect to the tariff. If $\left|\pi'_{f,n}(t^*_n)\right| < \left|\pi'_{f,1}(t^*_n)\right|$, we can say that the foreign firm has a stronger incentive to influence the tariff when it faces the cooperative home firms than it faces the noncooperative home firms. Thus, when $\left|\pi'_{f,n}(t^*_n)\right| < \left|\pi'_{f,1}(t^*_n)\right|$, the export of the foreign firm is smaller, and the quantity supplied to the foreign market is larger, in the case of the cooperative home firms than in the case of the noncooperative home firms.

In general, $\left|\pi'_{f,1}(t_n^*)\right| - \left|\pi'_{f,n}(t_n^*)\right|$ can be positive or negative, so it is ambiguous whether $r_{f,n} > r_{f,1}$, and whether $R_n < R_1$. However, the following lemma gives a sufficient condition for $r_{f,n} > r_{f,1}$ and $R_n < R_1$.

Lemma 4 *Suppose that the demand curves are linear. If $c_h \leq c_f$, then $r_{f,n}(q_{h,n}^*) > r_{f,1}(q_{h,n}^*)$ and $R_n(q_{h,n}^*) < R_1(q_{h,n}^*)$.*

Proof. From Lemma 2, we know that $r_{f,n}(q_{h,n}^*) > r_{f,1}(q_{h,n}^*)$ and $R_n(q_{h,n}^*) < R_1(q_{h,n}^*)$ if and only if $\left|\pi'_{f,n}(t_n^*)\right| < \left|\pi'_{f,1}(t_n^*)\right|$. From equation (4), we see that

$$\begin{aligned}
\left|\pi'_{f,1}(t_n^*)\right| - \left|\pi'_{f,n}(t_n^*)\right| &= \frac{2}{9}\frac{(2n^2-n-1)\,a-(7n^2+n-8)\,c_h+(5n^2+2n-7)\,(c_f+t_n^*)}{(n+2)^2} \\
&\geq \frac{2}{9}\frac{(2n^2-n-1)\,a-(7n^2+n-8)\,c_f+(5n^2+2n-7)\,(c_f+t_n^*)}{(n+2)^2} \\
&= \frac{2}{9}\frac{(2n^2-n-1)\,(a-c_f)+(5n^2+2n-7)\,t_n^*}{(n+2)^2} > 0, \qquad (21)
\end{aligned}$$

where the second inequality comes from $c_h \leq c_f$, and the last inequality comes from $a > c_f$ (see Lemma A in Appendix A.2).[3] ∎

Now, we are ready to look at the equilibrium tariff. When the demand curves are linear, the equilibrium tariff is given by

$$t_n^* = \tau(A - Q_n^* - a + q_{h,n}^* + q_{f,n}^*).$$

The difference between the equilibrium tariffs in the case of noncooperative home firms and in the case of cooperative home firms is written as

$$t_n^* - t_1^* = \tau\left[\left(q_{h,n}^* - q_{h,1}^*\right) + \left(q_{f,n}^* - q_{f,1}^*\right) - \left(Q_n^* - Q_1^*\right)\right]. \qquad (22)$$

[3]Furthermore, using equation (21), we can demonstrate that in order to satisfy $\left|\pi'_{f,n}(t_n^*)\right| > \left|\pi'_{f,1}(t_n^*)\right|$, c_h must be quite large relative to c_f. For example, let $a = 100$ and $c_f + t = 10$. Then, $c_h > 30.46$ is required when $n = 2$, and $c_h > 34.23$ is required when $n = 10$, in order to satisfy $\left|\pi'_{f,n}(t_n^*)\right| > \left|\pi'_{f,1}(t_n^*)\right|$. So, casually speaking, $\left|\pi'_{f,n}(t_n^*)\right| > \left|\pi'_{f,1}(t_n^*)\right|$ is not very likely to happen, thus $r_{f,n} < r_{f,1}$ and $R_n > R_1$ is not very likely to happen.

When the demand curves are linear, the reaction functions are also linear. Thus, rewriting equation (**??**), $q^*_{h,n} - q^*_{h,1}$ is expressed as

$$\begin{aligned} q^*_{h,n} - q^*_{h,1} &= \left[r_{h,n}(q^*_{f,n}, Q^*_n) - r_{h,1}(q^*_{f,n}, Q^*_n)\right] \\ &\quad + \frac{\partial r_{h,1}}{\partial q_f}\left(q^*_{f,n} - q^*_{f,1}\right) + \frac{\partial r_{h,1}}{\partial Q}\left(Q^*_n - Q^*_1\right). \end{aligned} \tag{23}$$

Similarly, $q^*_{f,n} - q^*_{f,1}$ and $Q^*_n - Q^*_1$ are expressed as

$$q^*_{f,n} - q^*_{f,1} = \left[r_{f,n}(q^*_{h,n}) - r_{f,1}(q^*_{h,n})\right] + \frac{\mathrm{d}r_{f,1}}{\mathrm{d}q_h}\left(q^*_{h,n} - q^*_{h,1}\right) \tag{24}$$

$$Q^*_n - Q^*_1 = \left[R_n(q^*_{h,n}) - R_1(q^*_{h,n})\right] + \frac{\mathrm{d}R_1}{\mathrm{d}q_h}\left(q^*_{h,n} - q^*_{h,1}\right). \tag{25}$$

Substituting (24) and (25) into (23), and arranging, we get

$$\begin{aligned} q^*_{h,n} - q^*_{h,1} &= \theta\left[r_{h,n}(q^*_{f,n}, Q^*_n) - r_{h,1}(q^*_{f,n}, Q^*_n)\right] \\ &\quad + \theta\frac{\partial r_{h,1}}{\partial q_f}\left[r_{f,n}(q^*_{h,n}) - r_{f,1}(q^*_{h,n})\right] + \theta\frac{\partial r_{h,1}}{\partial Q}\left[R_n(q^*_{h,n}) - R_1(q^*_{h,n})\right] \end{aligned} \tag{26}$$

where[4]

$$\theta = \left(1 - \frac{\partial r_{h,1}}{\partial q_f}\frac{dr_{f,1}}{dq_h} - \frac{\partial r_{h,1}}{\partial Q}\frac{dR_1}{dq_h}\right)^{-1} > 0.$$

Substituting (24) and (25) into (22), and arranging, we have

$$\begin{aligned} t^*_n - t^*_1 &= \tau\left(1 + \frac{dr_{f,1}}{dq_h} - \frac{dR_1}{dq_h}\right)\left(q^*_{h,n} - q^*_{h,1}\right) \\ &\quad + \tau\left[r_{f,n}(q^*_{h,n}) - r_{f,1}(q^*_{h,n})\right] - \tau\left[R_n(q^*_{h,n}) - R_1(q^*_{h,n})\right]. \end{aligned} \tag{27}$$

Finally, substituting (26) into (27), we obtain

$$\begin{aligned} t^*_n - t^*_1 &= \left(1 + \frac{dr_{f,1}}{dq_h} - \frac{dR_1}{dq_h}\right)\theta\tau\left[r_{h,n}(q^*_{f,n}, Q^*_n) - r_{h,1}(q^*_{f,n}, Q^*_n)\right] \\ &\quad + \left[1 + \left(1 + \frac{dr_{f,1}}{dq_h} - \frac{dR_1}{dq_h}\right)\theta\frac{\partial r_{h,1}}{\partial q_f}\right]\tau\left[r_{f,n}(q^*_{h,n}) - r_{f,1}(q^*_{h,n})\right] \\ &\quad - \left[1 - \left(1 + \frac{dr_{f,1}}{dq_h} - \frac{dR_1}{dq_h}\right)\theta\frac{\partial r_{h,1}}{\partial Q}\right]\tau\left[R_n(q^*_{h,n}) - R_1(q^*_{h,n})\right] \end{aligned} \tag{28}$$

[4] In Appendix A.5, we show that θ is positive.

In equation (28), the difference between t_n^* and t_1^* is reduced to the difference in the reaction functions (in Appendix A.5, we show that the coefficients on the differences in the reaction functions are all positive). Since we already know what determine the differences in the reaction functions, we can now give the factors that determine the difference between t_n^* and t_1^*: (i) the positive externality due to the public-good property of protection-seeking among the noncooperative home firms; (ii) the negative externality due to the oligopolistic competition among the noncooperative home firms; (iii) the difference in the marginal benefits of the home firms from an increase in the tariff, i.e., $\pi'_{h,n}(t_n^*) - \pi'_{h,1}(t_n^*)$; and (iv) the difference in the marginal benefit of the foreign firm from a decrease in the tariff, i.e., $\left|\pi'_{f,1}(t_n^*)\right| - \left|\pi'_{f,n}(t_n^*)\right|$. Due to factor (i) and (iii), t_n^* tends to be lower than t_1^*, while due to factor (ii), t_n^* tends to be higher than t_1^*. Factor (iv) has an ambiguous effect. Therefore, in general, it is not certain whether the equilibrium tariff in the case of noncooperative home firms is higher or lower than the equilibrium tariff in the case of cooperative home firms. Proposition 4, however, shows that we can have a clear result with the condition of $c_h \leq c_f$.

Proposition 4 *Suppose that the demand curves are linear. If $c_h \leq c_f$, then $t_n^* > t_1^*$.*

Proof. See Appendix A.6. ■

Proposition 4 is easily understood from proposition 2 and lemma 3. If $c_h \leq c_f$, among the noncooperative home firms, the oligopoly externality outweighs the public-good externality, thus the noncooperative home firms tend to produce more than the cooperative home firms, making t_n^* higher than t_1^*. Also, if $c_h \leq c_f$, the incentive of the foreign firm to decrease the tariff is weaker when it is competing with the noncooperative home firms than when it is competing with the cooperative home firms. This, too, makes t_n^* higher than t_1^*.

Note that $c_h \leq c_f$ is just a sufficient condition. As we show in the examples below, even if $c_h > c_f$, t_n^* can be higher than t_1^*.

Example 1 $A = 72$, $a = 48$, $c_h = 29.8$, $c_f = 10$, $\delta = 0.75$, *and* $\tau = 0.5$.

	$n=1$	$n=2$	$n=3$	$n=5$
$q_{h,n}^*$	2.47	4.25	5.49	7.05
$q_{f,n}^*$	13.31	11.85	10.89	9.74
Q_n^*	35.46	36.03	36.36	36.73
t_n^*	2.161	2.034	2.011	2.032

Example 2 *$A = 100$, $a = 100$, $c_h = 18$, $c_f = 10$, $\delta = 0.75$, and $\tau = 0.5$.*

	$n=1$	$n=2$	$n=3$	$n=5$
$q_{h,n}^*$	34.20	47.03	53.14	58.56
$q_{f,n}^*$	19.81	15.18	13.63	13.10
Q_n^*	53.09	51.30	49.81	47.67
t_n^*	0.46	5.45	8.48	11.97

In Example 1, provided that $c_h > c_f$, the equilibrium tariff in the case of the noncooperative home firms ($n > 1$) is lower than the equilibrium tariff in the case of the cooperative home firms ($n = 1$). However, in Example 2, although $c_h > c_f$, the equilibrium tariff in the case of the noncooperative home firms is higher than the equilibrium tariff in the case of the cooperative home firms. These examples suggest that for $t_n^* < t_1^*$ to happen, c_h has to be sufficiently larger than c_f.

Our result that the noncooperative home firms often receive higher tariff than the cooperative home firms is well contrasted with the results of Rodrik (1986), and of Pecorino (1998, 2001), where the noncooperative firms always receive lower tariff than the cooperative firms. The difference between their result and ours is due to the different characteristic of the "effort" to influence the size of the tariff. In their models, the level of protection depends on the lobbying activities of the firms, which serves only to increase the level of protection. On the other hand, in our model of administered protection, the level of protection depends on the quantity produced by the firms, which not only serves to increase the level of protection but also affects the profit of the firms in period 1. Given the special feature of administered protection policy that the level of protection is determined by the rules rather than politics, and given that the rules of administered protection are applied to the market outcome, it results in that the noncooperative home firms may receive higher level of protection than the cooperative firms.

So far, we have compared the case of n home firms (where $n > 1$) with the case of one home firm, referring these are respectively the cases of the noncooperative home firms and of the cooperative home firms. We showed that t_n^* can be larger than t_1^*, and interpreted that the equilibrium tariff may be higher when the home firms are noncooperative than when they are cooperative. We can interpret this result more straightforwardly: the equilibrium tariff may increase as the number of the home firm increases. To strengthen this line of argument, we now present the following proposition about a comparison of the equilibrium tariffs in the case of n home firms and in the case of $n-1$ home firms. In fact, $t_n^* > t_{n-1}^*$ is shown under the same condition of Proposition 4.

Proposition 5 *Suppose that the demand curves are linear. If $c_h \leq c_f$, then $t_n^* > t_{n-1}^*$.*

Proof. See Appendix A.7. ■

To understand Proposition 5, we can use the procedures and the interpretations developed so far. Similar to the comparison of t_n^* and t_1^*, whether the equilibrium tariff rises or falls as the number of the home firms increases (i.e., whether t_n^* is higher or lower than t_{n-1}^*) depends on the differences in reaction functions, $r_{h,n} - r_{h,n-1}$, $r_{f,n} - r_{f,n-1}$, and $R_n - R_{n-1}$. In turn, the differences in the reaction functions depend on (i) the *additional* positive externality among the home firms due to an increase in n; (ii) the *additional* negative externality among the home firms due to an increase in n; (iii) the difference in the marginal benefit of the home firms from an increase in the tariff, i.e., $\pi'_{h,n}(t_n^*) - \pi'_{h,n-1}(t_n^*)$; and (iv) the difference in the marginal benefit of the foreign firm from a decrease in the tariff, i.e., $\left|\pi'_{f,n-1}(t_n^*)\right| - \left|\pi'_{f,n}(t_n^*)\right|$. When $c_h \leq c_f$, the negative externality outweighs the positive externality, thus the home firms as a whole tend to produce more as the number of the home firms increases. Also, when $c_h \leq c_f$, the incentive of the foreign firm to lower the tariff becomes weaker as the number of the home firms increases. As a result, the equilibrium tariff increases as the number of the home firms increases.

Proposition 5 implies that an increase in the number of the firms does not necessarily lower the equilibrium tariff. We consider that, in addition to the works of Pecorino (1998, 2001) and of Hillman, Long, and Soubeyran (2001), our result suggests another piece of theoretical evidence that an industry with low concentration does not necessarily has a disadvantage in receiving high protection.

4 Concluding remarks

In the existing literature, the public-good problem in seeking protection has been analyzed in the context of political economy, where the firms in an import-competing industry try to influence the level of protection via some political activities, such as lobbying or campaign contributions. In this paper, we pointed out that for administered protection policies, the economic activities of the firms, such as production decision or pricing decision, can influence the level of protection in ways quite different from what the existing literature shows. In particular, we argue that the public-good nature of administered policies can be quite different from that of legislated policies.

We showed that, in spite of the public-good property, the quantity produced by the firms, and the equilibrium tariff, can be higher when the firms are noncooperative than the firms are cooperative. We also demonstrated that the equilibrium tariff can increase as the number of the firms increases.

A direction to extend this paper is as follows. In this paper, we have implicitly assumed that the government always implements administered protection policy; that is, the tariff is always imposed in period 2. However, in reality, protection is implemented only when a petition for administered protection is filed by the import-competing firms. This means that, among the home firms, filing a petition is also an important decision to receive protection, and the decision to file a petition also has a public-good property. Thus, there are actually two public-good problems among the home firms under administered protection policy: the quantity decision of the firms to influence the level of protection, and the decision to file a petition. It will be interesting to analyze this two-fold public-good problem.

Appendix A.1: Solutions to the model with linear demands

When the demand curves of the home market and the foreign market are linear, we have explicit solutions. Let $p(q) = a - q$ and $P(Q) = A - Q$. For the profit maximization problem of home firm i in period 1, the first-order condition (equation (6)) is given by

$$-q_i + a - (q_i + q_{h,-i} + q_f) - c_h + \tau\delta\pi'_{i,n}(t(q_{h,i} + q_{h,-i} + q_f, Q)) = 0.$$

Noting that $\pi''_{i,n} = 2/(n+2)^2$, the second-order condition is satisfied if

$$-2 + \frac{2\tau^2\delta}{(n+2)^2} < 0.$$

The reaction function of the home firms, $q_{h,n} = r_{h,n}(q_f, Q)$, is the solution to the sum of the first-order condition of the home firms (equation (7)):

$$-r_{h,n} + n\left[a - (r_{h,n} + q_f) - c_h\right] + \tau\delta\pi'_{h,n}(t(r_{h,n} + q_f, Q)) = 0. \tag{A1}$$

On the other hand, the reaction functions of the foreign firm in period 1, $q_{f,n} = r_{f,n}(q_h)$ and $Q_n = R_n(q_h)$, are defined by the following first-order conditions (see equation (10) and (11)):

$$\begin{aligned} -r_{f,n} + a - (q_h + r_{f,n}) - c_f + \tau\delta\pi'_{f,n}(t(q_h + r_{f,n}, R_n)) &= 0 \quad \text{(A2)} \\ -R_n + A - R_n - c_f - \tau\delta\pi'_{f,n}(t(q_h + r_{f,n}, R_n)) &= 0 \quad \text{(A3)} \end{aligned}$$

Noting that $\pi''_{f,n} = 2(n+1)^2/(n+2)^2$, the second-order conditions are satisfied if

$$-2 + \frac{2(n+1)^2\tau^2\delta}{(n+2)^2} < 0 \text{ and } 4 - \frac{8(n+1)^2\tau^2\delta}{(n+2)^2} > 0,$$

To guarantee that these second-order conditions are satisfied, we assume $\tau^2\delta < \frac{(n+2)^2}{2(n+1)^2}$. This also guarantees that the second-order condition for the maximization problem of home firm i is satisfied.

The equilibrium quantities are solved from equations (A1), (A2), and (A3). They are

$$\begin{aligned} q^*_{h,n} &= \eta_{A,n}A + \eta_{a,n}a + \eta_{h,n}c_h + \eta_{f,n}c_f \\ q^*_{f,n} &= \phi_{A,n}A + \phi_{a,n}a + \phi_{h,n}c_h + \phi_{f,n}c_f \\ Q^*_n &= \Phi_{A,n}A + \Phi_{a,n}a + \Phi_{h,n}c_h + \Phi_{f,n}c_f \end{aligned}$$

where

$$\begin{aligned}
\eta_{A,n} &= \frac{-\tau^2\delta\left(n^2+2n-1\right)}{(n+2)^3-\left[(n+2)^3-(n+4)\right]\tau^2\delta}n \\
\eta_{a,n} &= \frac{2\left[(n+3)(n+2)-4(n+1)\tau^2\delta\right]\tau\delta+(n+2)\left((n+2)^2-\left[(n+2)^2-(2n+1)\right]\tau^2\delta\right)}{(n+2)\left((n+2)^3-\left[(n+2)^3-(n+4)\right]\tau^2\delta\right)}n \\
\eta_{h,n} &= \frac{\left[8(n+1)\tau^2\delta+2(n+2)\left(n^2+n-4\right)\right]\tau\delta-2(n+2)\left[(n+2)^2-2(n+1)^2\tau^2\delta\right]}{(n+2)\left((n+2)^3-\left[(n+2)^3-(n+4)\right]\tau^2\delta\right)}n \\
\eta_{f,n} &= \frac{(n+2)^2-2(n+1)^2\tau^2\delta-2\left(n^2+2n-1\right)\tau\delta}{(n+2)^3-\left[(n+2)^3-(n+4)\right]\tau^2\delta}n
\end{aligned}$$

$$\begin{aligned}
\phi_{A,n} &= \frac{\tau^2\delta\left((n+1)^3-n\right)}{(n+2)^3-\left[(n+2)^3-(n+4)\right]\tau^2\delta} \\
\phi_{a,n} &= \frac{(n+2)\left[(n+2)^2-3(n+1)^2\tau^2\delta\right]-2\left[(n+2)\left(n^2+3n+1\right)-3n(n+1)\tau^2\delta\right]\tau\delta}{(n+2)\left((n+2)^3-\left[(n+2)^3-(n+4)\right]\tau^2\delta\right)} \\
\phi_{h,n} &= \frac{n(n+2)\left[(n+2)^2-3(n+1)^2\tau^2\delta\right]-2\left[3n(n+1)\tau^2\delta+n(n+2)\left(n^2+2n-1\right)\right]\tau\delta}{(n+2)\left((n+2)^3-\left[(n+2)^3-(n+4)\right]\tau^2\delta\right)} \\
\phi_{f,n} &= \frac{2\left[(n+1)^3-n\right]\tau\delta-\left[(n+1)(n+2)^2-\left(2n^3+6n^2+7n+2\right)\tau^2\delta\right]}{(n+2)^3-\left[(n+2)^3-(n+4)\right]\tau^2\delta}
\end{aligned}$$

$$\begin{aligned}
\Phi_{A,n} &= \frac{(n+2)^3-2\left[(n+2)^2(n+1)-1\right]\tau^2\delta}{2\left((n+2)^3-\left[(n+2)^3-(n+4)\right]\tau^2\delta\right)} \\
\Phi_{a,n} &= \frac{(n+1)\left((n+2)(n+1)\tau^2\delta+\left[(n+2)^2-2n\tau^2\delta\right]\tau\delta\right)}{(n+2)\left((n+2)^3-\left[(n+2)^3-(n+4)\right]\tau^2\delta\right)} \\
\Phi_{h,n} &= \frac{n(n+1)\left((n+2)(n+1)\tau^2\delta+\left[(n+2)^2+2\tau^2\delta\right]\tau\delta\right)}{(n+2)\left((n+2)^3-\left[(n+2)^3-(n+4)\right]\tau^2\delta\right)} \\
\Phi_{f,n} &= \frac{(n+2)\left(2\left[(2n+1)\tau^2\delta-(n+1)^2\tau\delta\right]-(n+2)^2\right)}{2\left((n+2)^3-\left[(n+2)^3-(n+4)\right]\tau^2\delta\right)}
\end{aligned}$$

The equilibrium tariff is given by

$$\begin{aligned}
t_n^* &= \tau(A - Q_n^* - a + q_{h,n}^* + q_{f,n}^*) \\
&= \sigma_{A,n}A + \sigma_{a,n}a + \sigma_{h,n}c_h + \sigma_{f,n}c_f
\end{aligned}$$

where

$$\sigma_{A,n} = \frac{(n+2)^3}{2\left((n+2)^3 - \left[(n+2)^3-(n+4)\right]\tau^2\delta\right)}\tau$$
$$\sigma_{a,n} = -\frac{\left[(n+2)^2-n\right]\tau\delta+(n+2)^2}{(n+2)^3 - \left[(n+2)^3-(n+4)\right]\tau^2\delta}\tau$$
$$\sigma_{h,n} = -\frac{\left[(n+3)^2-(n+1)\right]\tau\delta+(n+2)^2}{(n+2)^3 - \left[(n+2)^3-(n+4)\right]\tau^2\delta}n\tau$$
$$\sigma_{f,n} = \frac{2\left[(n+2)^3-(n+4)\right]\tau\delta+n(n+2)^2}{2\left((n+2)^3 - \left[(n+2)^3-(n+4)\right]\tau^2\delta\right)}\tau$$

Appendix A.2: Lemma A

In section 2.1, we have assumed that the equilibrium quantities in the second period is positive if $t = 0$. In the case of a linear demand, this assumption implies $a > c_h$ and $a > c_f$.

Proof. $q^{II}_{h,n}(0) > 0$ implies that $c_f > 2c_h - a$, and $q^{II}_{f,n}(0) > 0$ implies that $c_f < (a + nc_h)/(n+1)$. Thus, combining these inequalities, we have $(a + nc_h)/(n+1) > 2c_h - a$. Simplifying, we get $(n+2)(a - c_h) > 0$.

Similarly, from $q^{II}_{h,n}(0) > 0$, we have $c_h < (a + c_f)/2$. From $q^{II}_{f,n}(0) > 0$, we have $c_h > [(n+1)c_f - a]/n$. Combining these two inequalities, we get $(n+2)(a - c_f) > 0$.■

Appendix A.3: Proof of Proposition 3

Suppose that $q^*_{h,n} - q^*_{h,1} \leq 0$. Then,

$$q^*_{h,n} - q^*_{h,1} = \left(\eta_{A,n} - \eta_{A,1}\right)A + \left(\eta_{a,n} - \eta_{a,1}\right)a + \left(\eta_{h,n} - \eta_{h,1}\right)c_h + \left(\eta_{f,n} - \eta_{f,1}\right)c_f \leq 0. \quad \text{(A8)}$$

It can be shown that the coefficient on A is negative:

$$\eta_{A,n} - \eta_{A,1} = -\frac{(n-1)(n+2)\tau^2\delta\left[\left(25n^2+67n+16\right)-\left(20n^2+52n+8\right)\tau^2\delta\right]}{\left((n+2)^4-\left[(n+2)^4-(n^2+6n+8)\right]\tau^2\delta\right)(27-22\tau^2\delta)} < 0.$$

On the other hand, from the assumption that t^*_n is less than prohibitive level,

$$\sigma_{A,n}A + \left(\sigma_{a,n} - \frac{1}{n+1}\right)a + \left(\sigma_{h,n} - \frac{n}{n+1}\right)c_h + \left(\sigma_{f,n} + 1\right)c_f < 0, \quad \text{(A9)}$$

where the coefficient on A is positive. Combining equation (A8) and (A9), we have

$$\begin{aligned} 0 \; < \; & \left(\frac{\eta_{a,1} - \eta_{a,n}}{\eta_{A,1} - \eta_{A,n}} - \frac{\sigma_{a,n} - \frac{1}{n+1}}{\sigma_{A,n}} \right) a \\ & + \left(\frac{\eta_{h,1} - \eta_{h,n}}{\eta_{A,1} - \eta_{A,n}} - \frac{\sigma_{h,n} - \frac{n}{n+1}}{\sigma_{A,n}} \right) c_h \\ & + \left(\frac{\eta_{f,1} - \eta_{f,n}}{\eta_{A,1} - \eta_{A,n}} - \frac{\sigma_{f,n} + 1}{\sigma_{A,n}} \right) c_f. \end{aligned} \tag{A10}$$

The coefficient on c_f is equal to

$$\frac{\eta_{f,1} - \eta_{f,n}}{\eta_{A,1} - \eta_{A,n}} - \frac{\sigma_{f,n} + 1}{\sigma_{A,n}} = -2 \frac{\left(8n^3+6n^2+11n+4\right)\delta^2\tau^4 - \left(17n^3+102n^2+195n+100\right)\tau^2\delta + 9(n+2)^3}{[(25n^2+67n+16)-(20n^2+52n+8)\tau^2\delta](n+2)\tau^2\delta}.$$

This is negative provided $\tau \leq 1/\sqrt{2}$. Now, using $c_h \leq c_f$, and arranging the inequality (A10), we get to

$$0 < \left(\frac{\eta_{a,1} - \eta_{a,n}}{\eta_{A,1} - \eta_{A,n}} - \frac{\sigma_{a,n} - \frac{1}{n+1}}{\sigma_{A,n}} \right) (a - c_h). \tag{A11}$$

However,

$$\begin{aligned} & \frac{\eta_{a,1} - \eta_{a,n}}{\eta_{A,1} - \eta_{A,n}} - \frac{\sigma_{a,n} - \frac{1}{n+1}}{\sigma_{A,n}} \\ = \; & - \frac{\left[(n+2)^3 - \left[(n+2)^3-(n+4)\right]\tau^2\delta\right]\left[\left(8\left(n^2+6n-4\right)\tau^2\delta - 6\left(2n^2+11n-4\right)\right)\tau\delta + 3(n+2)(n+1)\left(9-8\tau^2\delta\right)\right]}{[(25n^2+67n+16)-(20n^2+52n+8)\tau^2\delta](n+2)^2(n+1)\tau^2\delta} \\ < \; & 0 \end{aligned}$$

when $\tau \leq 1/\sqrt{2}$. Since $a > c_h$, equation (A11) is a contradiction.■

Appendix A.4: Proof of Lemma 2

The reaction functions $r_{f,1}(q^*_{h,n})$ and $R_1(q^*_{h,n})$ are defined by the first-order conditions of the foreign firm when $n = 1$:

$$\begin{aligned} -r_{f,1} + a - (q^*_{h,n} + r_{f,1}) - c_f + \tau\delta\pi'_{f,1}(t(q^*_{h,n} + r_{f,1}, R_1) &= 0 \quad \text{(A12)} \\ -R_1 + A - R_1 - c_f - \tau\delta\pi'_{f,1}(t(q^*_{h,n} + r_{f,1}, R_1) &= 0. \quad \text{(A13)} \end{aligned}$$

Similarly, $r_{f,n}(q^*_{h,n})$ and $R_n(q^*_{h,n})$ are defined by

$$\begin{aligned} -r_{f,n} + a - (q^*_{h,n} + r_{f,n}) - c_f + \tau\delta\pi'_{f,n}(t(q^*_{h,n} + r_{f,n}, R_n) &= 0 \quad \text{(A14)} \\ -R_n + A - R_n - c_f - \tau\delta\pi'_{f,n}(t(q^*_{h,n} + r_{f,n}, R_n) &= 0. \quad \text{(A15)} \end{aligned}$$

Let $\Gamma_q(r_{f,1}, R_1, q^*_{h,n})$ and $\Gamma_Q(r_{f,1}, R_1, q^*_{h,n})$ denote the left hand side of equation (A12) and (A13) respectively. Then, subtracting equation (A12) from equation (A14), and equation (A13) from equation (A15), we have

$$\begin{aligned} \Gamma_q(r_{f,n}, R_n, q^*_{h,n}) - \Gamma_q(r_{f,1}, R_1, q^*_{h,n}) &= -\tau\delta\left(\left|\pi'_{f,1}(t^*_n)\right| - \left|\pi'_{f,n}(t^*_n)\right|\right) \\ \Gamma_Q(r_{f,n}, R_n, q^*_{h,n}) - \Gamma_Q(r_{f,1}, R_1, q^*_{h,n}) &= \tau\delta\left(\left|\pi'_{f,1}(t^*_n)\right| - \left|\pi'_{f,n}(t^*_n)\right|\right) \end{aligned}$$

where note that $\left|\pi'_{f,1}(t^*_n)\right| - \left|\pi'_{f,n}(t^*_n)\right| = \pi'_{f,n}(t^*_n) - \pi'_{f,1}(t^*_n)$ because $\pi'_{f,n}(t^*_n) < 0$ and $\pi'_{f,1}(t^*_n) < 0$. Since we have assumed the linear demand, the functions Γ_q and Γ_Q are linear in the first and the second argument. Thus, equations above are rewritten as

$$\begin{bmatrix} \dfrac{\partial\Gamma_q}{\partial q_f} & \dfrac{\partial\Gamma_q}{\partial Q} \\ \dfrac{\partial\Gamma_Q}{\partial q_f} & \dfrac{\partial\Gamma_Q}{\partial Q} \end{bmatrix} \begin{bmatrix} r_{f,n} - r_{f,1} \\ R_n - R_1 \end{bmatrix} = \begin{bmatrix} -\tau\delta\left(\left|\pi'_{f,1}(t^*_n)\right| - \left|\pi'_{f,n}(t^*_n)\right|\right) \\ \tau\delta\left(\left|\pi'_{f,1}(t^*_n)\right| - \left|\pi'_{f,n}(t^*_n)\right|\right) \end{bmatrix} \quad \text{(A16)}$$

Noticing that

$$\begin{bmatrix} \dfrac{\partial\Gamma_q}{\partial q_f} & \dfrac{\partial\Gamma_q}{\partial Q} \\ \dfrac{\partial\Gamma_Q}{\partial q_f} & \dfrac{\partial\Gamma_Q}{\partial Q} \end{bmatrix} = \begin{bmatrix} -2 + \frac{8}{9}\tau^2\delta & -\frac{8}{9}\tau^2\delta \\ -\frac{8}{9}\tau^2\delta & -2 + \frac{8}{9}\tau^2\delta \end{bmatrix},$$

we solve equation (A16) for $r_{f,n} - r_{f,1}$ and $R_n - R_1$ to obtain

$$\begin{aligned} r_{f,n} - r_{f,1} &= \frac{9\tau\delta}{2\left(9 - 8\tau^2\delta\right)}\left(\left|\pi'_{f,1}(t^*_n)\right| - \left|\pi'_{f,n}(t^*_n)\right|\right) \\ R_n - R_1 &= -\frac{9\tau\delta}{2\left(9 - 8\tau^2\delta\right)}\left(\left|\pi'_{f,1}(t^*_n)\right| - \left|\pi'_{f,n}(t^*_n)\right|\right) \end{aligned}$$

where $9 - 8\tau^2\delta > 0$ by the second-order condition. This proves Lemma 2.■

Appendix A.5: Slopes of the reaction functions

Consider the reaction functions when $n = 1$. Differentiating equation (A1) with respect to q_f and arranging, the slope of the reaction function of the home firms, with respect to q_f, is given by

$$\frac{\partial r_{h,1}}{\partial q_f} = -\frac{9 - 2\tau^2\delta}{18 - 2\tau^2\delta}$$

Similarly, differentiating equation (A1) with respect to Q and arranging, the slope of the reaction function of the home firms, with respect to Q, is given by

$$\frac{\partial r_{h,1}}{\partial Q} = -\frac{2\tau^2\delta}{18 - 2\tau^2\delta}$$

For the foreign firm, differentiating equation (A2) and (A3) with respect to q_h, and arranging, the slopes of the reaction functions of the foreign firm are given by

$$\begin{aligned} \frac{dr_{f,1}}{dq_h} &= -\frac{9 - 12\tau^2\delta}{18 - 16\tau^2\delta} \\ \frac{dR_1}{dq_h} &= -\frac{2\tau^2\delta}{9 - 8\tau^2\delta} \end{aligned}$$

First, we show that $\frac{\partial r_{h,1}}{\partial q_f}\frac{dr_{f,1}}{dq_h} + \frac{\partial r_{h,1}}{\partial Q}\frac{dR_1}{dq_h}$ is less than one so that $\theta > 0$. When $\tau^2\delta = 0$,

$$\frac{\partial r_{h,1}}{\partial q_f}\frac{dr_{f,1}}{dq_h} + \frac{\partial r_{h,1}}{\partial Q}\frac{dR_1}{dq_h} = \frac{1}{4} < 1.$$

Differentiating this with respect to $\tau^2\delta$,

$$\begin{aligned} & \frac{\partial}{\partial\left(\tau^2\delta\right)}\left(\frac{\partial r_{h,1}}{\partial q_f}\frac{dr_{f,1}}{dq_h} + \frac{\partial r_{h,1}}{\partial Q}\frac{dR_1}{dq_h}\right) \\ = & -\frac{9}{4}\frac{405 - 432\tau^2\delta + 176\left(\tau^2\delta\right)^2}{\left(9 - \tau^2\delta\right)^2\left(9 - 8\tau^2\delta\right)^2}. \end{aligned}$$

In section 3.1, we are comparing the case of $n \geq 2$ and the case of $n = 1$. For the case of $n \geq 2$, the second-order conditions are satisfied only if $\tau^2\delta < 8/9$ (see Appendix A.1). Provided $0 \leq \tau^2\delta < 8/9$, the derivative above is negative. Therefore, $\frac{\partial r_{h,1}}{\partial q_f}\frac{dr_{f,1}}{dq_h} + \frac{\partial r_{h,1}}{\partial Q}\frac{dR_1}{dq_h} < 1$ for $0 \leq \tau^2\delta < 8/9$.

Second, we show that the coefficient on $r_{h,n} - r_{h,1}$ in equation (28) is positive:

$$1 + \frac{dr_{f,1}}{dq_h} - \frac{dR_1}{dq_h} = \frac{9}{2\left(9 - 8\tau^2\delta\right)} > 0$$

Third, we show that the coefficient on $r_{f,n} - r_{f,1}$ in equation (28) is positive:

$$1 + \theta\left(1 + \frac{dr_{f,1}}{dq_h} - \frac{dR_1}{dq_h}\right)\frac{\partial r_{h,1}}{\partial q_f} = 2\frac{-9 + 10\tau^2\delta}{-27 + 22\tau^2\delta} > 0,$$

since $\tau^2\delta < 8/9$.

Finally, we show that the coefficient on $R_n - R_1$ in equation (28) is positive:

$$1 - \theta\left(1 + \frac{dr_{f,1}}{dq_h} - \frac{dR_1}{dq_h}\right)\frac{\partial r_{h,1}}{\partial Q} = \frac{-27 + 20\delta}{-27 + 22\delta} > 0.$$

Appendix A.6: Proof of Proposition 4

Suppose that $t_n^* \leq t_1^*$. Then,

$$t_n^* - t_1^* = \left(\sigma_{A,n} - \sigma_{A,1}\right)A + \left(\sigma_{a,n} - \sigma_{a,1}\right)a + \left(\sigma_{h,n} - \sigma_{h,1}\right)c_h + \left(\sigma_{f,n} - \sigma_{f,1}\right)c_f \leq 0, \quad \text{(A17)}$$

where the coefficient on A is positive since

$$\sigma_{A,n} - \sigma_{A,1} = \frac{\tau^2\delta(n-1)\left(5n^2+35n+68\right)}{2(27-22\tau^2\delta)\left((n+2)^3-\left[(n+2)^3-(n+4)\right]\tau^2\delta\right)} > 0.$$

On the other hand, from the assumption that $t_n^* > 0$, we have

$$t_n^* = \sigma_{A,n}A + \sigma_{a,n}a + \sigma_{h,n}c_h + \sigma_{f,n}c_f > 0 \quad \text{(A18)}$$

where the coefficient on A is positive. Combining equation (A17) and (A18),

$$0 < \frac{\sigma_{A,n}\sigma_{a,1} - \sigma_{a,n}\sigma_{A,1}}{\left(\sigma_{A,n} - \sigma_{A,1}\right)\sigma_{A,n}}a + \frac{\sigma_{A,n}\sigma_{h,1} - \sigma_{h,n}\sigma_{A,1}}{\left(\sigma_{A,n} - \sigma_{A,1}\right)\sigma_{A,n}}c_h + \frac{\sigma_{A,n}\sigma_{f,1} - \sigma_{f,n}\sigma_{A,1}}{\left(\sigma_{A,n} - \sigma_{A,1}\right)\sigma_{A,n}}c_f. \quad \text{(A19)}$$

The coefficient on c_f is negative since

$$\frac{\sigma_{A,n}\sigma_{f,1} - \sigma_{f,n}\sigma_{A,1}}{\left(\sigma_{A,n} - \sigma_{A,1}\right)\sigma_{A,n}} = -2\frac{\left[\left(5n^2+35n+68\right)\tau\delta+9(n+2)^2\right]\left((n+2)^3-\left[(n+2)^3-(n+4)\right]\tau^2\delta\right)}{(n+2)^3(5n^2+35n+68)\tau^2\delta} < 0.$$

Using $c_h \leq c_f$,

$$\begin{aligned}
0 &< \frac{\sigma_{A,n}\sigma_{a,1}-\sigma_{a,n}\sigma_{A,1}}{\left(\sigma_{A,n}-\sigma_{A,1}\right)\sigma_{A,n}}a+\frac{\sigma_{A,n}\sigma_{h,1}-\sigma_{h,n}\sigma_{A,1}}{\left(\sigma_{A,n}-\sigma_{A,1}\right)\sigma_{A,n}}c_h+\frac{\sigma_{A,n}\sigma_{f,1}-\sigma_{f,n}\sigma_{A,1}}{\left(\sigma_{A,n}-\sigma_{A,1}\right)\sigma_{A,n}}c_f \\
&\leq \frac{\sigma_{A,n}\sigma_{a,1}-\sigma_{a,n}\sigma_{A,1}}{\left(\sigma_{A,n}-\sigma_{A,1}\right)\sigma_{A,n}}a+\left(\frac{\sigma_{A,n}\sigma_{h,1}-\sigma_{h,n}\sigma_{A,1}}{\left(\sigma_{A,n}-\sigma_{A,1}\right)\sigma_{A,n}}+\frac{\sigma_{A,n}\sigma_{f,1}-\sigma_{f,n}\sigma_{A,1}}{\left(\sigma_{A,n}-\sigma_{A,1}\right)\sigma_{A,n}}\right)c_h \\
&= \frac{\sigma_{A,n}\sigma_{a,1}-\sigma_{a,n}\sigma_{A,1}}{\left(\sigma_{A,n}-\sigma_{A,1}\right)\sigma_{A,n}}(a-c_h). \qquad \text{(A20)}
\end{aligned}$$

However,

$$\frac{\sigma_{A,n}\sigma_{a,1}-\sigma_{a,n}\sigma_{A,1}}{\left(\sigma_{A,n}-\sigma_{A,1}\right)\sigma_{A,n}}=-\frac{2\left(\left(8n^2+29n+44\right)\tau\delta+9(n+2)^2\right)\left((n+2)^3-\left((n+2)^3-(n+4)\right)\tau^2\delta\right)}{(n+2)^3(5n^2+35n+68)\tau^2\delta}<0.$$

Since $a > c_h$, the last line of (A20) is negative. This is a contradiction.■

Appendix A.7: Proof of Proposition 5

Suppose that $t_n^* \leq t_{n-1}^*$. Then,

$$\begin{aligned}
t_n^*-t_{n-1}^* = {} & \left(\sigma_{A,n}-\sigma_{A,n-1}\right)A+\left(\sigma_{a,n}-\sigma_{a,n-1}\right)a \\
& +\left(\sigma_{h,n}-\sigma_{h,n-1}\right)c_h+\left(\sigma_{f,n}-\sigma_{f,n-1}\right)c_f \leq 0, \qquad \text{(A21)}
\end{aligned}$$

where the coefficient on A is positive:

$$\sigma_{A,n}-\sigma_{A,n-1}=\frac{\tau^3\delta\left(20+31n+15n^2+2n^3\right)}{2\left(\left[(n+1)^3-(n+3)\right]\tau^2\delta-(n+1)^3\right)\left(\left[(n+2)^3-(n+4)\right]\tau^2\delta-(n+2)^3\right)}>0.$$

On the other hand, from the assumption that $t_n^* > 0$, we have

$$t_n^*=\sigma_{A,n}A+\sigma_{a,n}a+\sigma_{h,n}c_h+\sigma_{f,n}c_f>0 \qquad \text{(A22)}$$

where the coefficient on A is positive. Combining equation (A21) and (A22),

$$\begin{aligned}
0 < {} & \frac{\sigma_{A,n}\sigma_{a,n-1}-\sigma_{a,n}\sigma_{A,n-1}}{\left(\sigma_{A,n}-\sigma_{A,n-1}\right)\sigma_{A,n}}a+\frac{\sigma_{A,n}\sigma_{h,n-1}-\sigma_{h,n}\sigma_{A,n-1}}{\left(\sigma_{A,n}-\sigma_{A,n-1}\right)\sigma_{A,n}}c_h \qquad \text{(A23)} \\
& +\frac{\sigma_{A,n}\sigma_{f,n-1}-\sigma_{f,n}\sigma_{A,n-1}}{\left(\sigma_{A,n}-\sigma_{A,n-1}\right)\sigma_{A,n}}c_f.
\end{aligned}$$

The coefficient on c_f is negative since

$$\begin{aligned}
&\frac{\sigma_{A,n}\sigma_{f,n-1}-\sigma_{f,n}\sigma_{A,n-1}}{\left(\sigma_{A,n}-\sigma_{A,n-1}\right)\sigma_{A,n}} \\
&\quad =-2\frac{\left((n+2)^3-\left[(n+2)^3-(n+4)\right]\tau^2\delta\right)\left(\left(20+31n+15n^2+2n^3\right)\tau\delta+(n+2)^2(n+1)^2\right)}{\tau^2\delta(20+31n+15n^2+2n^3)(n+2)^3}<0.
\end{aligned}$$

Applying $c_h \leq c_f$ to (A23) and arranging, we reach to

$$0 < \frac{\sigma_{A,n}\sigma_{a,n-1} - \sigma_{a,n}\sigma_{A,n-1}}{\left(\sigma_{A,n} - \sigma_{A,n-1}\right)\sigma_{A,n}}(a - c_h) \tag{A24}$$

However,

$$\begin{aligned} & \frac{\sigma_{A,n}\sigma_{a,n-1} - \sigma_{a,n}\sigma_{A,n-1}}{\left(\sigma_{A,n} - \sigma_{A,n-1}\right)\sigma_{A,n}} \\ = \quad & -\frac{2\Big((n+2)^3 - \big[(n+2)^3 - (n+4)\big]\tau^2\delta\Big)\Big(\big(n^4+4n^3+10n^2+17n+12\big)\tau\delta + (n+2)^2(n+1)^2\Big)}{\tau^2\delta(20+31n+15n^2+2n^3)(n+2)^3} < 0. \end{aligned}$$

Since $a > c_h$, equation (A24) is a contradiction.■

References

[1] Anderson, James E. (1992), "Domino Dumping I: Competitive Exporters", *American Economic Review 82, 65-83.*

[2] Anderson, James E. (1993), "Domino Dumping II: Anti-dumping", *Journal of International Economics* 35, 133-150.

[3] Bhagwati, Jagdish N. and Srinivasan, T. N. (1976), "Optimal Trade Policy and Compensation Under Endogenous Uncertainty: The Phenomenon of Market Disruption", *Journal of International Economics* 6, 317-336.

[4] Blonigen, Bruce A. and Ohno, Yuka (1998), "Endogenous Protection, Foreign Direct Investment and Protection-Building Trade", *Journal of International Economics* 46, 205-227.

[5] Baldwin, Robert E. (1985), *The Political Economy of U.S. Import Policy.* Cambridge, Mass.: The MIT Press.

[6] Fischer, Ronald D. (1992), "Endogenous Probability of Protection and Firm Behavior", *Journal of International Economics* 32, 149-163.

[7] Hillman Arye L; Long, Ngo Van; and Soubeyran, Antoine (2001), "Protection, Lobbying, and Market Structure", Politics, and Market Structure", *Journal of International Economics* 54, 383-409.

[8] Olson, Mancur (1965), *The Logic of Collective Action*, Cambridge, MA: Harvard University Press.

[9] Pecorino, Paul (1998), "Is There a Free-Rider Problem in Lobbying? Endogenous Tariffs, Trigger Strategies, and the Number of Firms", American Economic Review 88, 652-660.

[10] Pecorino, Paul (2001), "Market Structure, Tariff Lobbying and the Free-Rider Problem", *Public Choice* 106, 203-220.

[11] Potters, Jan and Sloof, Randolph (1996), "Interest Groups: A Survey of Empirical Models That Try to Assess Their Influence", *European Journal of Political Economy* 12, 403-442.

[12] Reitzes, James D. (1993), "Antidumping Policy", *International Economic Review* 34, 745-763.

[13] Trefler, Daniel (1993), "Trade Liberalization and the Theory of Endogenous Protection: An Econometric Study of U.S. Import Policy", *Journal of Political Economy* 101, 138-160.

[14] Waldman, Michael (1987), "Noncooperative Entry Deterrence, Uncertainty, and the Free Rider Problem", *Review of Economic Studies* (1987), 301-310.

[15] Wong, Kar-yiu (1995), *International Trade in Goods and Factor Mobility.* Cambridge, Mass.: MIT Press.