Tariffs versus Quotas in the Presence of Imperfect Competition and Cross-Border Pollution∗

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Abstract

We consider trade policies intended to affect the production of a foreign monopolist that generates pollution. We derive the optimal tariff and optimal import quota, and examine which policy measure should be used to maximize the domestic welfare. We find that if the domestic government does not know the foreign firm’s attitude to the environment and if pollution is transboundary, import quotas are in some cases preferable to tariffs. Otherwise, however, tariffs are preferable to quotas.

Keywords: Tariffs; Quotas; Imperfect competition; Cross-border pollution;

Asymmetric information

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1 Introduction

It is well known that under imperfect competition, tariffs and quotas set so as to result in the same level of imports usually lead to different consumer prices [see Bhagwati (1965); Itoh and Ono (1982, 1984); Helpman and Krugman (1989).] Then it is natural to ask which policy is preferable.\(^1\) Krishna (1987) states in the conclusions that the common feeling is that tariffs are superior to quotas.\(^2\) Itoh and Ono (1984) also claim that tariffs are more desirable than quotas on the grounds that domestic prices are lower under a tariff than under the equivalent quota in the case of international price-setting duopoly over differentiated goods.

There are two advantages of tariffs over quotas when the industry is imperfectly competitive. First, the government can collect revenue from tariffs. Whereas in the quota case, the foreign economy is likely to capture some quota rent. Second, if we allow tariff rates to take negative values, the government can select a negative tariff (or an import subsidy) so as to encourage imports.

An interesting extension of the analysis of the comparison between tariffs (or equivalently, price-based measures) and quotas (or equivalently, quantity-based measures) is to introduce cross-border externalities such as cross-border pollution.\(^3\) Environmental damages used be local problems. However, there is now worldwide concern for the environment. This is mainly because recent serious environmental damages such as global warming, acid rain, and depletion of the ozone layer are transboundary. Even though countries cannot intervene in other countries’ domestic policymaking and environmental regulation, they can affect through trade policies other countries’ economic activities that generate pollution. Indeed, imports have sometimes been restricted in the name of environmental protection [see Hudec (1996), for example].

The purpose of this paper is, thus, to compare tariffs and import quotas with imperfect competition\(^4\) and cross-border externalities. We specifically investigate the effects of tariffs

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\(^1\)In an international duopoly model, Ishikawa (1994) ranks several policies in respect of consumer prices, profits and economic welfare.

\(^2\)Krishna (1987) indeed argues that quotas tend to dominate tariffs, contrary to the “common feeling”, when a foreign monopolist endogenously determines the quality of its products.

\(^3\)In fact, there are a number of studies that deal with various issues of trade policies in a situation of perfect competition and transboundary pollution. See Markusen (1975a,b), Asako (1979), Copeland (1996), Copeland and Taylor (1995), and Ludema and Wooton (1994, 1997), among others.

\(^4\)For example, Barrett (1994), Kennedy (1993) and Ulph (1996) examine the relationship between trade policies and environment when pollution-generating industries are imperfectly competitive. However, their focuses are on strategic interactions between governments.
and import quotas on output decisions by a foreign monopolist that exports its product to the domestic market, and also on domestic social welfare in the presence of cross-border pollution. We derive the optimal tariff and optimal quota, and examine which policy measure should be used to maximize domestic social welfare. We also introduce asymmetric information into our analysis. It is unlikely that policymakers have complete information which is necessary to determine optimal policies. In particular, it is reasonable to believe that the domestic government knows less about the foreign economy relative to the domestic economy.

We find that if the domestic government knows whether or not the foreign firm has adopted pollution abatement technology, tariffs are always preferable to import quotas, regardless of the seriousness of cross-border pollution. Even if the domestic government does not know the foreign firm’s attitude to the environment, we show that the same conclusion holds if pollution is not transboundary. However, if there exists asymmetric information on the firm’s type and if pollution is transboundary, import quotas are in some cases preferable to tariffs. The point is that in contrast to tariffs, quotas can “selectively” affect a foreign firm’s output decision depending on the firm’s type. Therefore, quotas may be preferable to tariffs when some selective restriction is desirable such as in the case where the domestic government wishes to reduce firm’s output only if the firm is neglectful of the environment.

The rest of the paper is organized as follows. Section 2 provides the formal description of the foreign monopoly model with cross-border pollution. Section 3 examines the effects of trade policies on the domestic welfare under symmetric information. Section 4 extends the analysis to the case of asymmetric information. Section 5 discusses some alternative assumptions and the robustness of our results. Section 6 provides the conclusions and some final observations.

2 The Basic Model

We consider an industry in which a foreign monopolist supplies its product to the domestic market. The domestic inverse demand function $P(x)$ exhibits the constant elasticity of the slope, which is denoted by $\epsilon$ (i.e., $-P''(x)x/P'(x) \equiv \epsilon = \text{const.}$), for any supply $x$ in the

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5 To our knowledge, there are few papers that rigorously analyze trade policy and environment under asymmetric information. In their analysis on trade and environmental policies, Ludema and Wooton (1997) have considered asymmetric information on administrative costs to apply an externality tax.

6 For simplicity, we do not consider the foreign market. A segmented foreign market can be incorporated into the model without affecting any result.
support of $P$, which is denoted by $\text{supp}(P)$.$^7$ The inverse demand function is linear if $\epsilon = 0$, concave if $\epsilon \leq 0$, and convex if $\epsilon \geq 0$. We assume the constant-returns-to-scale technology that is characterized by the cost function $C(x) = cx$. Foreign production generates cross-border pollution that causes environmental damage to the home country. We assume that the environmental damage is measured by $Z(x)$, where $Z$ is a convex function of the monopolist’s output level such that $Z(0) = 0$, $Z'(x) > 0$, and $Z''(x) \geq 0$.$^8$

The domestic government imposes either a tariff or a quota so as to maximize social welfare. Under a tariff policy, which we interpret in a broad sense, the government may impose an import tariff or may subsidize the import of the foreign product. We define $t$ as a specific tariff rate on imports, which takes a negative value if the domestic government subsidizes the import. On the other hand, the government may simply impose a quota on the import of the good. We assume that the foreign firm captures the entire rents of quotas, since as a monopolist the firm can set a price at the market clearing domestic price that is raised by a (binding) quota.$^9$ Social welfare consists of the consumer surplus, tariff revenue (if it exists), and environmental damage. We represent social welfare as a function of the foreign firm’s output level and the specific tariff rate:

$$W(x, t) = [V(x) - P(x)x] + tx - \alpha Z(x),$$

where $V(x) \equiv \int_0^x P(y)dy$, and $\alpha \geq 0$ is a parameter that measures the seriousness of cross-border pollution. Alternatively, the parameter $\alpha$ can be considered as representing how much the government cares about the environment with cross-border pollution.

Since the monopolist’s profits can be written as $\pi(x, t) \equiv P(x)x - (c + t)x$, the first-order condition for the profit maximization is given by

$$P(x) + P'(x)x - (c + t) = 0.$$

$^7$We make this assumption to simplify the analysis. The essence of our results would not be affected even without this assumption. See Section 6 for more details. When $\epsilon$ is constant, the inverse demand function is given by $P = a_1X^{1-\epsilon}/(\epsilon - 1) + a_2$ for $\epsilon \neq 1$ and $P = -b_1\ln X + b_2$ for $\epsilon = 1$ (where $a_1$, $b_1$ and $b_2$ are positive parameters); and the price elasticity $\eta(X)$ is given by $\eta = a_2X^{\epsilon-1}/a_1 + 1/(\epsilon - 1)$ for $\epsilon \neq 1$ and $\eta = -\ln X + b_2/b_1$ for $\epsilon = 1$. In the case of iso-price-elastic demand, $\epsilon$ is also constant and is given by $\epsilon = 1 + 1/\eta$. The slope of the marginal revenue curve is flatter (resp. steeper) than the slope of the demand curve if $\epsilon > 1$ (resp. $\epsilon < 1$).

$^8$This type of environmental damage function is often assumed. See Kennedy (1994), for example.

$^9$In reality, the domestic government may capture a part of quota rents by selling import licenses. Our results would hold even if the government and the foreign monopolist share the quota rents, as far as the foreign monopolist captures some of those rents.
We assume that the second-order condition is satisfied:

\[ D_1^2 \pi(x, t) = P'(x)(2 - \epsilon) < 0. \]

Notice that this assumption requires \( \epsilon < 2 \). It is immediate to see from (2) that

\[ x'(t) = \frac{1}{P'(x)(2 - \epsilon)} < 0, \tag{3} \]

where we represent the firm's output level as a function of the tariff rate.

### 3 Trade Policies and Domestic Welfare

In this section, we derive the optimal tariff and quota when the domestic government knows the foreign firm’s type. Then we discuss which policy measure achieves higher welfare.

In free trade, the foreign firm sells \( x(0) \) units of the good in the domestic market. Social welfare in free trade is thus written as \( W(x(0), 0) \). In general, free trade is not an optimal policy when a foreign firm monopolizes the domestic market, and in addition when foreign production generates cross-border pollution. To derive the optimal import level, we first obtain

\[ D_1 W(x, 0) = -P'(x)x - \alpha Z'(x). \tag{4} \]

We define \( x^* \) by \( D_1 W(x^*, 0) = 0 \). If \( D_1 W(x, 0) > 0 \) for any \( x \in supp(P) \), we set \( x^* \) to be the largest number in \( supp(P) \) if \( supp(P) \) is bounded above, and infinity if it is unbounded. Then, \( x^* \) represents the optimal import level that the government wishes to achieve. Let us consider a small increase in \( x \). The first term in (4) represents a resulting increase in the consumer surplus while the second term shows an increase in the environmental damage. At the optimal import level \( x^* \), this marginal benefit to the consumers exactly matches the marginal environmental damage. Notice that the government wishes to increase the import level as much as possible if pollution is not transboundary.

Now, let us derive the optimal quota. The import quota is effective, or binding, if and only if the quota level \( q \) is less than \( x(0) \). Thus, the optimal quota equals \( x^* \) if \( x^* < x(0) \), while the optimal quota can be any level such that \( q \geq x(0) \) if \( x^* \geq x(0) \). Notice that the quota is more likely to be effective if \( \alpha \) is large. If \( \alpha = 0 \), for example, the quota is not effective since it cannot raise the import level.
Next, we derive the tariff rate that maximizes $W(x(t), t)$. By totally differentiating $W(x(t), t)$ with respect to $t$, we obtain

$$D_1W(x(t), t)x'(t) + D_2W(x(t), t) = 0$$

$$[1 - P'(x(t))x'(t)] x(t) + tx'(t) - \alpha Z'(x(t))x'(t) = 0$$

$$\frac{(1 - \epsilon)x(t)}{2 - \epsilon} + \frac{t - \alpha Z'(x(t))}{P'(x(t))(2 - \epsilon)} = 0.$$  

We find that the tariff rate,$$
\hat{\epsilon} \equiv \frac{\alpha Z'(x(\hat{\epsilon})) - P'(x(\hat{\epsilon}))(1 - \epsilon)x(\hat{\epsilon})}{(\epsilon)}  
$$
satisfies the above first-order condition and hence maximizes social welfare. The optimal tariff rate $\hat{\epsilon}$ is large if $\alpha$ is large and if $\epsilon$ is small. Indeed, if $\epsilon < 1$, then $\hat{\epsilon} > 0$. If $\alpha = 0$, the optimal tariff policy is (i) to impose a tariff if $\epsilon < 1$, (ii) free trade if $\epsilon = 1$, and (iii) to subsidize the import if $\epsilon > 1$.\footnote{This result is obtained in Brander and Spencer (1984). See also Ishikawa (2000).} Since the government is inclined more to reduce the foreign firm’s output level in the presence of cross-border pollution, it is more likely to tax the import as (5) shows.

Having derived the optimal quota and optimal tariff, we can compare these two policy measures to determine which of them is adopted by the welfare maximizing government. First, consider the case in which $x^* < x(0)$. Let $t^*$ denote the tariff rate that induces the foreign firm to supply $x^*$ units in the domestic market, i.e., $x(t^*) = x^*$. Since $t^* > 0$, it follows immediately from (1) that social welfare realized by this tariff policy outweighs social welfare under the optimal quota by the tariff revenue $t^*x^*$. Since $t^*$ is not the optimal tariff rate in general, we obtain

$$W(x^*, 0) < W(x(t^*), t^*) \leq W(x(\hat{\epsilon}), \hat{\epsilon}).$$

The optimal tariff dominates the optimal quota if $x^* < x(0)$.

If $x^* \geq x(0)$, on the other hand, the quota is not effective and hence achieves the same welfare as in free trade. Since the optimal tariff policy can generally enhance social welfare from the free trade level, social welfare under the optimal tariff $W(x(\hat{\epsilon}), \hat{\epsilon})$ is at least as large as social welfare under the optimal quota $W(x(0), 0)$. Indeed, the strict inequality $W(x(\hat{\epsilon}), \hat{\epsilon}) > W(x(0), 0)$ holds except for the case where $\alpha Z'(x(0)) = P'(x(0))(1 - \epsilon)x(0)$. That is, if the government’s wish to increase the consumer surplus through import subsidies
exactly offsets the government’s wish to reduce cross-border pollution through import tariffs, the optimal tariff rate becomes zero. In that case, tariffs and quotas are equivalent in terms of social welfare maximization. However, except for this knife-edge case, tariffs are preferred to quotas. We record this finding as Proposition 1.

**Proposition 1** If the government knows the foreign firm’s cost structure and pollution generating function, tariffs are strictly preferred to quotas except for the case where the optimal tariff rate equals zero. In this knife-edge case where the optimal tariff rate is zero, tariffs and quotas are equivalent.

### 4 Trade Policies under Asymmetric Information

The last section shows the dominance of tariffs over quotas when the government knows the foreign firm’s cost structure and pollution generating function. This conclusion is not always valid if the government does not know the foreign firm’s type. In this section, we derive the optimal tariff and the optimal quota, and rank these two measures from the viewpoint of domestic welfare. We find that in certain cases, quotas are preferable to tariffs in the presence of asymmetric information on the producer’s attitude to the environment.

There are two types of the firm differing in pollution abatement technology. A good type (Type G) emits less pollutants than a bad type (Type B) for any production level. We assume, for simplicity, that Type G does not emit any pollutants. Production by Type B pollutes the environment as described in the previous sections. It is common knowledge that the foreign firm is Type G with probability \( \mu \in (0, 1) \) and Type B with probability \( 1 - \mu \). However, the firm’s realized type is private information. We assume that the marginal cost (MC) for Type G is higher than that for Type B, reflecting a common observation that pollution abatement is costly. That is, we have \( c_G > c_B \), where \( c_i \ (i = G, B) \) denotes Type \( i \)'s MC. Letting \( x_i \) denote Type \( i \)'s output level, we consequently have \( x_G(t) < x_B(t) \) for any \( t \).

Since Type G does not emit any pollutants, social welfare function when the foreign firm is Type G can be defined as

\[
W_G(x, t) = [V(x) - P(x)x] + tx,
\]

whereas social welfare function when the foreign firm is Type B is the same function as defined in (1). Here, we call it \( W_B \). The expected social welfare that the domestic government
maximizes is given by

\[ EW(x_G, x_B, t) = \mu W_G(x_G, t) + (1 - \mu) W_B(x_B, t). \]

Now, let us derive the optimal quota. Whether the government wishes to encourage or discourage foreign production depends crucially on the firm’s type. As was shown in the last section, the government wishes to increase the import level as much as possible if the foreign firm is Type G, while it wishes to import only as much as \( x^* \) that satisfies

\[-P'(x^*)x^* = \alpha Z'(x^*) \]

if the foreign firm is Type B. There are three cases that we must consider: (i) \( x^* < x_G(0) \), (ii) \( x_G(0) \leq x^* < x_B(0) \), and (iii) \( x_B(0) \leq x^* \).

If \( \alpha \) is so large that \( x^* < x_G(0) \), the government strongly wishes to restrict foreign production if the firm is Type B. On the other hand, provided that imposing quota cannot increase the import level, the government wishes to keep the import at the free trade level if the firm is Type G. The optimal quota must satisfy \( q \leq x_G(0) \), since the quota is not effective for Type G if \( q > x_G(0) \). Thus, the quota is binding for both types of the firm. The government selects \( q \in [0, x_G(0)] \) so as to maximize \( EW(q, q, 0) \). The first-order condition for this maximization problem is

\[-P'(q)q - (1 - \mu)\alpha Z'(q) \geq 0, \tag{6}\]

where the equality must hold if \( q < x_G(0) \). Since \(-P'(x^*)x^* - \alpha Z'(x^*) = 0\) by the definition of \( x^* \), we obtain

\[-P'(x^*)x^* - (1 - \mu)\alpha Z'(x^*) = \mu \alpha Z'(x^*) > 0,\]

which means that \( q > x^* \). Therefore, we find that the optimal quota should satisfy \( x^* < q \leq x_G(0) \). If the left-hand side of (6) is negative at \( q = x_G(0) \), then the optimal quota is strictly binding for both types, i.e., \( x^* < q < x_G(0) \). If the left-hand side of (6) is nonnegative at \( q = x_G(0) \), on the other hand, the optimal quota may be set at the free trade import level for Type G, i.e., \( q = x_G(0) \).

11The expected social welfare increases as \( q \) decreases from \( x_B(0) \) until \( q \) reaches \( x_G(0) \), at which the quota starts binding also for Type G. The expected welfare \( EW(q, q, 0) \) has a kink and possibly reaches a peak at \( q = x_G(0) \). That is why the first-order condition involves inequality.

12Since \( Z \) is a convex function, the left-hand side of (6) is a concave function of \( q \) on \([x^*, x_G(0)]\) if \( P'(q)q \) is convex, i.e., if \( P'(q)(1 - \epsilon) > 0 \). Therefore, in the case where \( \epsilon \geq 1 \), we can definitely conclude that \( q = x_G(0) \) if the left-hand side of (6) is nonnegative.
the government wants to reduce the import level to $x^*$ when the firm is Type B. Obviously, the government can achieve this goal by selecting $q = x^*$. Thus, the optimal quota in this case equals $x^*$. Finally, in the case where $x_B(0) \leq x^*$, the quota is not effective for either type of the firm so that any quota that satisfies $q \geq x_B(0)$ is optimal.

Next, we consider the tariff policy. The government chooses $t$ so as to maximize $EW(x_G(t), x_B(t), t)$. The first-order condition for this maximization is

$$\mu \{(1 - P'(x_G(t))x_G'(t))(tx_G(t) + t)\} + (1 - \mu) \{(1 - P'(x_B(t))x_B'(t))(tx_B(t) - \alpha Z'(x_B(t))x_B'(t))\} = 0. \quad (7)$$

As (3) indicates, we have $x'_i(t) = 1/P'(x_i(t))(2 - \epsilon)$ for $i = G, B$. Consequently, (7) can be rewritten as

$$\mu[P'(x_G(t))(1 - \epsilon)x_G(t) + t] + (1 - \mu)[P'(x_B(t))(1 - \epsilon)x_B(t) + t - \alpha Z'(x_B(t))x_B'(t)] = 0. \quad (8)$$

The optimal tariff rate $\hat{t}$ is the rate that satisfies (8). As in the case of symmetric information, if $\alpha = 0$, then (i) $\hat{t} > 0$ when $\epsilon < 1$, (ii) $\hat{t} = 0$ when $\epsilon = 1$, and (iii) $\hat{t} < 0$ when $\epsilon > 1$. Moreover, as $\alpha$ increases, $\hat{t}$ increases as is expected. Notice that these qualitative features of the optimal tariff are the same as those in the case of symmetric information.

However, in the presence of asymmetric information, the government may encounter a conflict between two possibilities. If $\epsilon > 1$ and $\alpha$ is large, for example, the government wishes to increase the import level if it believes that the firm is Type G, whereas it has an incentive to reduce the output level if it believes that the firm is Type B. Tariff policies cannot be tailored to achieve these two conflicting goals simultaneously, since tariffs inevitably affect the firm’s output decision in one particular direction irrespective of its type. Therefore, it is possible that quotas dominate tariffs in the presence of asymmetric information.

First, let us consider the case where $\alpha = 0$. Since $x^*$ is the largest value in $supp(P)$ (or infinity if $supp(P)$ is not bounded above), any quota that satisfies $q \geq x_B(0)$ is optimal. Since the optimal quota is not binding for either type, the expected social welfare equals $EW(x_G(0), x_B(0), 0)$. Obviously, tariffs can improve on this free trade situation unless in the case where $\hat{t} = 0$, or equivalently $\epsilon = 1$. That is, we have $EW(x_G(\hat{t}), x_B(\hat{t}), \hat{t}) \geq EW(x_G(0), x_B(0), 0)$, and this relationship holds with strict inequality unless $\epsilon = 1$.

**Proposition 2** Suppose that the government does not know whether or not the firm has adopted pollution abatement technology. Then, if pollution is not transboundary, tariffs dom-
inate quotas except for the case where the optimal tariff rate equals zero. In this knife-edge case where the optimal tariff rate is zero, tariffs and quotas are equivalent.

When pollution is transboundary, i.e., $\alpha \neq 0$, there exists a case where the government prefers quotas to tariffs. Such situations are likely to emerge when the optimal tariff rate is close to zero due to the conflict between raising Type G’s output and reducing Type B’s output. Let us consider the case where $\hat{i} = 0$. It follows from (8) that $\epsilon > 1$ and the government is faced with the conflict that is just described. The optimal tariff cannot enhance social welfare from the free trade level. However, the optimal quota definitely helps attain higher social welfare than the free trade level since the quota can reduce Type B’s output without affecting Type G’s output level. Under asymmetric information, quotas are in some cases preferable to tariffs since quotas can affect the foreign firm’s output differently depending on its type.

**Proposition 3** Suppose that the government does not know whether or not the firm has adopted pollution abatement technology, and that pollution is transboundary. Quotas are preferable to tariffs in the case where the optimal tariff rate is close to zero.

It follows from Propositions 1, 2 and 3 that quotas are preferable to tariffs only if the domestic government does not know the foreign firm’s attitude to the environment and pollution is transboundary. If at least one of these two requirements is absent, tariffs are preferable to import quotas.

## 5 Discussion

Any level of import restriction with quota is achievable with a tariff. Moreover, the tariff generates revenue whereas the quota rent accrues to the foreign monopolist. It follows that if the technology were known to the government, then a tariff would always be superior to a quota. When the technology is not known, however, it is not so simple. In our model, the government has two distinct motives for restricting trade. One is to extract rent from the foreign monopolist and the other is to reduce cross-border pollution. The interesting case is when the rent extraction motive results in a negative tariff (i.e., an import subsidy). In that case, the government would want import restriction with Type B but not with Type G, thus restricting imports only when it is needed. To make our point in a transparent way, we have considered a simple model: a foreign monopolist with only two possible technologies.
Naturally, one may wonder to what extent our main result (Proposition 3) is robust. In this section, we discuss some generalization to gain insight on this issue.

We first consider alternative assumptions on technologies. We have assumed that there exit two possible technologies (or types) and that the MC of a good technology is higher than that of a bad technology (i.e., $c_G > c_B$). It is obvious that our result does not hold with $c_G < c_B$. In this case, even if the optimal tariff rate is close to zero, a quota cannot decrease the imports from Type B without affecting the imports from Type G. It is straightforward, however, that our result is robust with respect to the presence of many technologies as long as the imports generalized under the lowest MC should be reduced from the viewpoint of social welfare. In fact, even in the case where the imports under the lowest MC should be raised, our result may be valid. To see this, suppose that there is an excellent technology (Type E) in addition to Types B and G. Type E has a lower MC than Type B but is pollution free, like Type G. In this case, a quota set to be binding under Type B, but not Type G, would definitely bind under Type E. Such a quota, however, could still raise welfare if the probability of Type E is very low and the optimal tariff is close to zero.

Although we have confined ourselves to the case where a foreign monopolist exports its product to the domestic market, it is easy to extend our analysis to the case of multiple foreign producers that compete with the Cournot conjecture. For this, let us consider the case where the domestic government knows that some fraction of the foreign firms are the good type but does not know exactly which firms are. Suppose for simplicity that each foreign firm, on the other hand, knows other firms’ types as well as its own. For any given tariff rate, the bad type produces the good more than the good type. But their outputs decline as the tariff rate increases. Similarly to the monopoly case, the government may want to increase the imports from the good type but want to suppress the bad type’s production. The optimal tariff rate is close to zero in this case, giving almost no impact on the foreign firms’ production decisions. However, if the government sets a quota applied to each foreign firm at a level that is lower than the bad type’s free trade export level but is higher than the good type’s, then social welfare unambiguously improves.

Moreover, our main result could hold even with domestic firms when all firms including foreign firm(s) compete with the Cournot conjecture. In this case, the government is more likely to restrict imports since the domestic firms’ profits enter its objective function.

\footnote{Furusawa, Higashida and Ishikawa (2002) investigate some related issues.}
However, it can be verified that there are again cases where the government wants to reduce imports if and only if the foreign firm is the bad type. In such cases, quotas tend to dominate tariffs.

6 Concluding Remarks

We have examined the policy ranking between tariffs and quotas, in the context that a foreign monopolist generates cross-border pollution. Tariffs are generally conceived as a better measure to affect foreign production, since the government can collect tariff revenue when it intends to restrict trade. Moreover, if the government wishes, negative tariffs (or subsidies) on imports can increase the trade volume, which quotas can never achieve. However, tariffs inevitably affect the foreign firm’s output in one particular direction irrespective of the firm’s type, whereas quotas can reduce the output of one type of the foreign firm without affecting the output of the other. Under asymmetric information on the firm’s attitude to the environment, the government may be faced with a conflict such that it wishes to increase the imports if the firm has adopted pollution abatement technology while it wishes to reduce the imports if the firm’s production causes serious environmental damage. In such cases, quotas tend to dominate tariffs.

In concluding this paper, three final remarks are in order. First, our analysis has proceeded with an inverse demand function with the constant elasticity of the slope. If we abandon this assumption, our main result that quotas dominate tariffs only if the foreign firm’s attitude to the environment is private information and pollution is transboundary is slightly modified. In the case of general inverse demand functions, the government may be faced with a conflict such that it wishes to subsidize the imports from the high-cost firm while it wishes to tax the imports from the low-cost firm, even if pollution is not transboundary. Thus, quotas may dominate tariffs even without transboundary pollution. It should be noted, however, that even in such general cases, quotas are more likely to dominate tariffs when pollution is transboundary.

Second, imperfect competition plays a crucial role in our analysis. Under perfect competition, the goals of the government become an improvement of terms of trade and a reduction of cross-border pollution. Both goals can always be attained by import restrictions. This implies that there is no conflict between the two goals under perfect competition. Moreover, the import quota rent accrues to the domestic economy. Under perfect competition, thus,
tariffs and import quotas would be equivalent with incomplete information as well as with complete information.

Finally, it should be emphasized that our primary purpose is not to design the first best policy in the presence of foreign monopoly, cross-border pollution and asymmetric information, but to compare tariffs with quotas. In our context, one may be able to design the first best policies (or the first best policy combinations) using policies more directly related to pollution such as pollution-content tariffs. However, this is beyond the scope of our paper and left for the future research.
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