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The political economy linkage between trade liberalization and domestic environmental regulations

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Abstract This paper considers the political economy linkage between trade liberalization and domestic environmental regulations in a duopolistic product market. We investigate the environmental consequences and welfare implications of a home country's unilateral tariff reduction on a polluting good. In a framework where the domestic environmental tax is subject to the influence of the home firm, we find that a tariff reduction on a good producing a consumption-type externality will improve the home country's environmental quality. Moreover, we find that the home country's tariff reduction will unambiguously enhance the home country's welfare; and it will damage the foreign firm's profits and thus the foreign country's welfare, provided that the weight that the home government attaches to its social welfare is sufficiently small. This result also suggests the possibility that a unilateral tariff reduction will achieve a Pareto improvement.

Keywords Environmental regulation · Lobbying · Pollution taxes · Strategic trade · Trade liberalization

JEL Classification D72 · Q38 · H77

1 Introduction

The linkage between trade liberalization and environmental policy has become the focus of much attention and debate. The debate was fueled by the Uruguay round of the Generalized Agreement on Tariffs and Trade (GATT) negotiations, and then it has been intensified by the establishment of the World Trade Organization (WTO).[1] Under the rules of the GATT/WTO,

[1] For example, a number of events have triggered the debate over the decisions made by the GATT/WTO dispute settlement panel, including the tuna–dolphin case and the beef hormone dispute. See Esty (1994, 2001) for more detail.

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the linkage between trade and environmental policy-making is restricted, and sometimes is prohibited (Esty 2001). This practice is consistent with the argument put forward by several scholars that environmental issues are best kept out of the trade policy-making (Cooper 1994; Bhagwati 2000), because trade policies are not the first-best instruments to deal with the environmental problem.

However, other scholars believe that the linkages between trade and the environment are inescapable (e.g., Rodrik 1997; Esty 2001). For example, when an economy is open, the importing country tends to manipulate the domestic environmental policies to substitute the tariff, thereby affecting trade flows and environmental quality. If so, then failing to consider the endogenous response of the environmental policy to trade liberalization may result in misunderstanding (Brunnermeier and Levinson 2004). The purpose of this paper is thus to highlight the different environmental consequences and welfare effects of trade liberalization between the case where the environmental policy is endogenously determined and the case where the environmental policy is exogenously given. We find that endogenizing the environmental policy as a response to trade liberalization may reverse some of the conventional wisdom.

For example, the conventional wisdom suggests that in the case where the environmental policy is exogenously given, a unilateral reduction in the importing country's tariff is beneficial to the exporting country. Additionally, previous studies such as Anderson (1992) have shown that liberalizing trade in a good whose consumption gives rise to pollution will cause a country's environment to deteriorate if the good is imported. We will demonstrate that these results may be reversed, provided that the linkage between the environmental policy and the trade policy is considered.

We construct a trade model with an imperfectly competitive product market. A home firm and a foreign firm produce a homogeneous good and compete in the home market. All of the home firm's output is sold in the domestic market, and none is exported. Consumption of the good in question gives rise to pollution. An environmental tax is imposed on the dirty good, and a tariff is imposed on the imported items. Due to the significant role of interest groups in the policy-making,[2] we consider the influence of interest groups. Before trade liberalization, both the environmental tax and the tariff are subject to the influence of the home firm, and we find that the environmental tax will be set suboptimally low and that the tariff will be set suboptimally high. Then we investigate how a unilateral reduction in the tariff will affect the home country's environment and the two countries' welfare.

A number of studies have examined the environmental impacts of trade liberalization under the assumption that the environmental policy is exogenously given (e.g., Pethig 1976; Siebert 1977; Kalt 1988; Tobey 1990; Anderson 1992; Low and Yeats 1992; Grossman and Krueger 1993). As some authors (e.g., Ederington and Minier 2003; Brunnermeier and Levinson 2004) have pointed out, ignoring the endogenous response of the environmental policy to trade may result in misunderstanding. Copeland (1990, 2000) addresses the endogenous response of the domestic environmental regulations to trade liberalization. Copeland (1990) examines negotiations over a trade barrier (e.g., tariffs) in the first stage, leaving a non-negotiable trade barrier (e.g., production subsidies) to be set non-cooperatively in the second stage. By applying a similar approach, Copeland (2000) extends the previous paper to consider the link between tariffs and domestic environmental regulations. He shows that trade liberalization will induce substitution toward the less efficient instrument of protection such as domestic environmental regulations. The two papers

[2] See, e.g., Ackerman and Hassler (1981) and Cropper et al. (1992).

of Copeland assume that the commodity markets are competitive and do not concentrate on the influence of interest groups. However, this present paper considers that the commodity markets are imperfectly competitive and that the policy formation is subject to the influence of interest groups, which distinguish this paper from those of Copeland (1990, 2000).

Due to the significant influence of interest groups in the making of environmental policy, several researchers consider the link between trade policies and environmental policies in the framework of political economy, including, e.g., Fredriksson (1997, 1999), Bommer and Schulze (1999), Damania et al. (2003), Lai (2006), Rauscher (1997), Schleich (1999), and Schleich and Orden (2000). These papers find that the effects of trade liberalization on the stringency of the environmental regulation are ambiguous, and depend on the political influence of the interest groups, and whether the polluting sector is exporting or import-competing. However, all these papers do not consider producers' strategic behavior in the product market, which is the focus of this present paper. In an oligopolistic product market, as shown by Barrett (1994) and Ulph (1996), the strategic interaction between firms will lead the government to manipulate the environmental policies in order to shift rents from foreign to domestic firms. Thus, it seems necessary to take the firms' strategic interaction into consideration, when we investigate the linkage between trade liberalization and the environmental policy. By specifying a duopolistic product market, our model allows for the firms' strategic behavior, and thus represents an extension of the papers mentioned above.

This present paper is related to Damania et al. (2004). By taking the influence of interest groups into consideration, Damania et al. (2004) also examine the effects of trade liberalization on the environmental policy in an oligopolistic product market. They find that the effects of trade liberalization on the environmental policy are ambiguous, and depend on the level of corruption. When the corruption is sufficiently high, they find that trade liberalization will increase the pollution tax. This present paper departs from Damania et al. (2004) in two ways. First, we investigate the impacts of trade liberalization on the social welfare of the home and foreign countries, whereas Damania et al. (2004) do not discuss the welfare issue. Secondly, they deal with pollution arising from production activities, and we consider pollution related to consumption activities.[3] This distinction between the consumption and production externalities is important, because under different types of externalities, the same policy may lead to different results. As demonstrated by Anderson (1992), a lowering of the tariff on a good whose production gives rise to pollution will improve the importing country's environment, whereas a lowering of the tariff on a good whose consumption generates pollution will deteriorate the importing country's environment.

Within the context mentioned previously, we find that the home country's environmental tax rate will increase as the tariff on imports is reduced. We also find that the smaller the weight that the home government attaches to the social welfare, the greater will be the extent of the increase in the environmental tax associated with a decline in the tariff. Based on these findings, we obtain the following results that may be contrary to the conventional wisdom. First, a unilateral reduction in the tariff on a good whose consumption gives rise to pollution will improve the importing country's environmental quality. Although the direct effect of the tariff reduction will increase the total consumption of the dirty good, a tariff reduction will raise the environmental tax, thereby reducing the consumption of the dirty good. We demonstrate that the indirect effect will outweigh the direct effect, so a unilateral tariff reduction will give rise to a cleaner environment in the importing country. As a result,

[3] We also note that several related papers, including Fredriksson (1997, 1999), Bommer and Schulze (1999), and Damania et al. (2003), confine their attention to the production externalities.

trade liberalization is compatible with environmental protection in this case. This finding is consistent with the empirical results provided by Damania et al. (2003). By using grams of lead content per gallon of gasoline as a proxy for environmental stringency, they find that, as an economy becomes more open, it tends to have a lower lead content per gallon of gasoline, thereby reducing the externalities arising from the consumption of gasoline. Second, the foreign firm's exports, and thus its profits, will decline as the home country's tariff is unilaterally reduced, provided that the weight that the home government attaches to the social welfare is small. As already indicated, when the home government does not care very much about social welfare, the tariff reduction will induce a substantial increase in the environmental tax, which in turn will dampen the exports of the foreign firm.

We also find that in our setting a unilateral tariff reduction will unambiguously enhance the home country's welfare. The smaller the weight that the home government attaches to the social welfare, the greater that the improvement in the social welfare will be. As mentioned earlier, before trade liberalization the tariff is set suboptimally high, and the environmental tax is suboptimally low. A tariff reduction will move both policies in the right direction, and will enhance the social welfare. If the weight the home government attaches to the social welfare is large, then combining this result with the second finding implies the possibility that a unilateral tariff reduction will achieve a Pareto improvement.

The remainder of this paper proceeds as follows. In Sect. 2, we introduce the model underlying our analysis. In Sect. 3, we discuss the determination of the equilibrium policies. The environmental consequences and welfare implications are investigated in Sects. 4 and 5, respectively. In Sect. 6, we present our concluding remarks.

2 The model

We consider a domestic country with two sectors; one produces a non-polluting numeraire good, and the other produces a polluting good. There are N identical consumers in this country. Following Brander and Spencer (1992), we denote the utility function of the representative consumer as:

$$u = v(x) + z - d,$$

where z is the consumption of the numeraire good with the world and domestic prices equal to one, x is the consumption of the polluting good with a domestic price equal to p, and $v(x)$ is a strictly concave function. The consumption of the polluting good will deteriorate the country's environment. The environmental disutility function of an individual consumer is given by d, which is a function of the aggregate consumption of the polluting good (Nx), with the properties $d' > 0$ and $d'' \geq 0$.

The representative consumer's budget constraint is given by: $px + z = w + s$, where w is the consumer's exogenous income, and s is a transfer from the government, which is financed from tax revenues. When making the consumption decisions, an individual consumer is assumed to ignore the negative externality. Utility maximization on the part of the consumer requires that

$$v'(x) = p. \tag{1}$$

Equation (1) determines the individual demand for the polluting good.

The numeraire market in the country is competitive and under free trade. The domestic polluting good market is duopolistic, consisting of two firms; one is a domestic firm and the other is a foreign firm. The two firms produce a homogeneous good. Foreign variables are

denoted by an asterisk (*). The sales of the home firm and the foreign firm are denoted by q and q^*, respectively.

The consumption of the polluting good under consideration is harmful to the environment, which imposes a disutility on the consumers. An individual consumer will ignore the adverse effect arising from his consumption on other consumers' welfare, thereby giving rise to negative externalities. SO_2 emissions associated with home heat consumption are an example of consumption-type externalities. Other examples of consumption-type negative externalities include the greenhouse gases generated by the consumption of gasoline, and the littering problem caused by the consumption of mercury oxide batteries. We assume that the consumption pollution does not affect firms' production and does not spill over to other countries. In order to protect the environment, the home country levies an environmental tax on the polluting good. This environmental tax is non-discriminatory, so that both the imported and domestically-made goods are subject to the same environmental tax rate.[4] In addition to the environmental tax, the home country levies a tariff on imported items. Tax revenues are distributed in the form of a lump sum to the consumers.

For simplicity, we assume that the output of the home firm is not exported overseas.[5] The home firm's profit is thus given by:

$$\pi = (p - c - t)q, \tag{2}$$

where t denotes the environmental tax, and c is the marginal production cost. The foreign firm's total profit is given by:

$$\pi^* = (p - c^* - t - \tau)q^*, \tag{3}$$

where τ is the tariff rate.

The two firms compete in terms of quantity. Under the Nash assumption, we can solve their first-order conditions:

$$\pi_q = p + qp' - c - t = 0, \tag{4}$$

$$\pi^*_{q^*} = p + q^* p' - c^* - t - \tau = 0, \tag{5}$$

where the subscripts denote the partial derivatives. Equations (4) and (5) are the reaction functions of the two firms in the implicit form. The Cournot equilibrium occurs when the two equations are satisfied.

The second-order conditions are $\pi_{qq} = 2p' + qp'' < 0$ and $\pi^*_{q^*q^*} = 2p' + q^* p'' < 0$. In addition, we assume that the stability condition $H = \pi_{qq}\pi^*_{q^*q^*} - \pi_{qq^*}\pi^*_{q^*q} > 0$ holds.

The effects of changes in t and τ on q and q^* can be obtained by totally differentiating the first-order conditions, which yields:

$$q_t = \left[p' + (q^* - q)p''\right]/H, \qquad q_\tau = -(p' + qp'')/H, \tag{6}$$

$$q^*_t = \left[p' + (q - q^*)p''\right]/H, \qquad q^*_\tau = (2p' + qp'')/H. \tag{7}$$

[4] In this situation, the environmental tax is equivalent to a consumption tax. The case of a discriminatory emission tax will be discussed in Sect. 6.

[5] If the home market and the foreign market are segmented, then allowing the home firm's output to be exported will not change the results that follow.

The signs of q_t and q_t^* are generally ambiguous, and depend on the signs of p'' and $q^* - q$. In the following we will assume that p'' is small, so that the regular results can be obtained. When p'' is sufficiently small, both q_t and q_t^* will be less than zero, indicating that an increase in the environmental tax rate will lower q and q^*. A small p'' also results in $q_\tau > 0$ and $q_\tau^* < 0$, indicating that an increase in the tariff will increase q but will reduce q^*, other things being equal.

3 The equilibrium policies

As shown previously, the home firm's profit is closely related to the consumption tax and the tariff. Thus the home firm has an incentive to influence the two policies. We assume that the home firm will offer political contributions to the government in exchange for more favorable policies. We also assume that consumers constitute a large part of the total population and are thus too numerous to overcome the free-rider problem and organize themselves into a lobbying group. We will first consider the situation in which the foreign firm is not allowed to lobby in the home country.[6] The foreign lobbying will be introduced in Sect. 6.

A two-stage political game is constructed in order to examine how political contributions provided by the lobbying group affect the equilibrium policy. In the first stage, the home firm offers the government a contribution schedule, which is contingent upon the policy chosen by the government. In the second stage, the government determines the policy and collects the political contributions.

We will first discuss the situation in which the home firm can influence both the environmental tax and the tariff. The resultant policies will be regarded as the benchmark. We will then turn to the situation where the home country's tariff is exogenously reduced. We will explore how trade liberalization causes the environmental tax to deviate away from the benchmark level.

Let us begin with the benchmark case. It will prove convenient in what follows to define the welfare of the home firm. The gross-of-contributions welfare of the home firm is equal to its profit function, (2). The aim of the home firm in this stage is to maximize its net welfare, which is equal to the gross welfare minus the political contributions.

Following Grossman and Helpman (1994), the home government is assumed to maximize a weighted sum of the political contributions received and aggregate gross-of-contributions social welfare, which is equal to:

$$m(t, \tau) + \theta W(t, \tau), \tag{8}$$

where m represents the political contributions provided by the home firm, $W(t, \tau)$ is the aggregate social welfare, and $\theta \geq 0$ is the weight given by the government to social welfare relative to the political contributions. The social welfare function is defined as the summation of the consumer's surplus, the home firm's profits, tax and tariff revenues, and aggregate environmental disutility, which is given by:

$$W = Nv(Q/N) - pQ + \pi + tQ + \tau q^* - D(Q), \tag{9}$$

where $Q = q + q^*$. Since in equilibrium the total domestic demand for the polluting good (Nx) equals the total supply (Q), the individual consumer's demand for the polluting good

[6] Most existing papers assume that the home firm dominates the political market; see, e.g., Damania et al. (2003, 2004).

is equal to Q/N, and $Nv - pQ$ measures the consumer's surplus. The aggregate environmental disutility is denoted by D, which is equal to Nd. Because in equilibrium $Q = Nx$, D can be expressed as a function of Q, with the properties $D' > 0$ and $D'' \geq 0$.

For ease of exposition, we assume that the home firm's political contribution function is globally truthful;[7] that is, the political contribution function of the home firm everywhere reflects its true welfare.[8] Grossman and Helpman (1994) have demonstrated that in truthful Nash equilibria a lobby that faces no opposition from competing interests captures all of the surplus from its political relationship with the government (see p. 845, example 1). Thus, we believe that the global-truthfulness assumption is reasonable in the case where there is only one politically active lobbying group. According to Bernheim and Whinston (1986) and Grossman and Helpman (1994), under the global-truthfulness assumption, the equilibrium policies can be obtained by solving the following equation:

$$\max_{t,\tau} G(t, \tau) = \pi + \theta W. \tag{10}$$

Differentiating (10) with respect to t and τ, respectively, yields:

$$G_t = \pi_t + \theta W_t, \tag{11}$$

$$G_\tau = \pi_\tau + \theta W_\tau. \tag{12}$$

The first-order conditions of the home government's maximizing G require $G_t = 0$ and $G_\tau = 0$, which imply the equilibrium policies. The second-order conditions require $G_{tt} < 0$ and $G_{\tau\tau} < 0$.

We note that in equilibrium the political contribution function of the home firm rewards the government for every change in the action by exactly the amount of the change in the home firm's profit.[9] More specifically, a marginal increase in t will induce the home firm to change its contribution by π_t. In what follows, we define π_t as the home firm's marginal willingness to contribute (MWTC) for changing the environmental tax. Likewise, the home firm is willing to provide an additional π_τ in exchange for an increase in the tariff, so that π_τ will be defined as the home firm's MWTC for changing the tariff.

Because the home firm's lobbying attitude is closely related to its MWTCs, we need to examine the home firm's MWTCs in more detail. Differentiating π with respect to t and τ yields:

$$\pi_t = (p' q_t^* - 1)q = -\frac{2qp'\pi_{q^*q}^*}{H}, \tag{13}$$

$$\pi_\tau = qp' q_\tau^* > 0. \tag{14}$$

The sign of π_τ is greater than zero, indicating that the home firm's contribution will increase with the tariff. Because an increase in the tariff will lower the imports of the polluting good and enhance the home firm's profits, the home firm will lobby for a higher tariff.

[7] The global-truthfulness assumption is not essential to the following analysis. The main results remain the same without this assumption.

[8] Bernheim and Whinston (1986) show that a truthful function is always a best response to any strategy of the opponent. Thus, they argue that truthful Nash equilibria may be focal among the set of Nash equilibria. This can justify the assumption of global-truthfulness.

[9] This property comes from the global-truthfulness assumption. Also see Grossman and Helpman (1994) for the detail.

The sign of π_t depends on the sign of $\pi^*_{q^*q}$, which equals $p' + q^* p''$. If q and q^* are strategic substitutes (see Bulow et al. 1985), which implies that $\pi^*_{q^*q} < 0$, then π_t will be less than zero, indicating that the home firm will provide fewer contributions when the government raises the environmental tax. If q and q^* are strategic complements, then π_t will be greater than zero. Because the assumption that p'' is small will ensure that $\pi^*_{q^*q} < 0$, we consider only the case of strategic substitutes throughout this paper.

We are interested in knowing the relationship between the equilibrium policies, which maximize the government's objective function, and the socially optimal policies, which maximize the social welfare. To this end, we substitute the socially optimal policies, which are denoted by $\tilde{t}$ and $\tilde{\tau}$, into (11) and (12) and obtain:

$$G_t(\tilde{t}, \tilde{\tau}) = \pi_t(\tilde{t}, \tilde{\tau}) + \theta W_t(\tilde{t}, \tilde{\tau}), \tag{15}$$

$$G_\tau(\tilde{t}, \tilde{\tau}) = \pi_\tau(\tilde{t}, \tilde{\tau}) + \theta W_\tau(\tilde{t}, \tilde{\tau}). \tag{16}$$

According to the definitions of $\tilde{t}$ and $\tilde{\tau}$, both $W_t(\tilde{t}, \tilde{\tau})$ and $W_\tau(\tilde{t}, \tilde{\tau})$ are equal to zero. As demonstrated previously, π_t is less than zero and π_τ is greater than zero, so $G_t(\tilde{t}, \tilde{\tau})$ is negative and $G_\tau(\tilde{t}, \tilde{\tau})$ is positive. Let the equilibrium environmental tax and the equilibrium tariff rate be denoted by t° and τ°, respectively. Then according to the definition of the equilibrium policies, both $G_t(t^\circ, \tau^\circ)$ and $G_\tau(t^\circ, \tau^\circ)$ will equal zero. Therefore, given the second-order conditions $G_{tt} < 0$ and $G_{\tau\tau} < 0$, $G_t(\tilde{t}, \tilde{\tau}) < 0$ implies that the equilibrium environmental tax will be lower than the socially optimal environmental tax, and $G_\tau(\tilde{t}, \tilde{\tau}) > 0$ implies that the equilibrium tariff will be higher than the socially optimal tariff.

Proposition 1 *When both the tariff and the environmental tax are subject to the influence of the home firm, the equilibrium tariff will be higher than the socially optimal tariff, and the equilibrium environmental tax will be lower than the socially optimal tax.*

This result is quite intuitive. Although an increase in the environmental tax rate will damage the foreign firm, it will hurt the home firm as well. Thus the environmental tax is not a good instrument for protection; the tariff will be a more efficient instrument for the purpose of protection. As a result, the home firm will attempt to raise the tariff and to lower the environmental tax.

The results in Proposition 1 serve as the benchmark. In what follows, we will consider how a unilateral tariff reduction affects the home country's environmental quality and the two countries' welfare.

4 The environmental impacts of trade liberalization

In Sect. 3, we discussed the situation where the home firm can affect both the tariff and the environmental tax. Now suppose that the home country is subject to an international trade agreement, and is forced to decrease its tariff. The home firm cannot affect the tariff any more, but it can still influence the environmental tax. The main goal of this paper is to investigate the effects of trade liberalization on the home country's environmental quality and on both countries' welfare. To this end, we first need to know how the environmental tax changes as the tariff is reduced.

4.1 The effect of trade liberalization on the environmental tax

In order to address this issue in a tractable manner, we follow Singh and Vives (1984) to assume that the aggregate welfare of the consumers is given by

$$U = Nu = \alpha \cdot (q + q^*) - (q^2 + 2qq^* + q^{*2})/2 + Nz - D(q + q^*), \quad \alpha > 0, \tag{17}$$

where z is the consumption of the numeraire good. The aggregate welfare function gives rise to the demand function for the polluting good:

$$p = \alpha - (q + q^*).$$

With the utility function in (17), the first-order condition of the home government's maximizing G, (11), becomes:[10]

$$G_t = (1/9)\big[-2\alpha + (4 + 3\theta)c - (2 + 3\theta)c^* + 2(1 - 3\theta)t - 2(1 + 3\theta)\tau + 6\theta D'\big] = 0. \tag{18}$$

The effect of a decline in the tariff on the environmental tax can be obtained from the following comparative-statics exercise: $\mathrm{d}t^\circ/\mathrm{d}\tau = -G_{t\tau}/G_{tt}$. The denominator is equal to:

$$G_{tt} = (2/9)\big[1 - (3 + 2D'')\theta\big]. \tag{19}$$

The second-order condition of the home government's maximizing G requires that $G_{tt} < 0$. This condition will be satisfied, provided that D'' is sufficiently large. When the marginal pollution damage is constant, which implies that $D'' = 0$, the satisfaction of the second-order condition requires that θ should be greater than one third.

By differentiating G_t with respect to τ, we obtain the numerator as follows:

$$G_{t\tau} = -(2/9)[1 + (3 + D'')\theta] < 0.$$

Therefore, we have

$$\frac{\mathrm{d}t^\circ}{\mathrm{d}\tau} = \frac{1 + (3 + D'')\theta}{1 - (3 + 2D'')\theta} < 0. \tag{20}$$

In words, the environmental tax will rise as the tariff decreases. This finding is consistent with the empirical results provided by Damania et al. (2003). They find that, as an economy reduces its tariffs, it tends to have a lower lead content per gallon of gasoline, which serves as a proxy for environmental stringency.

The inverse relationship between trade liberalization and the environmental tax can be explained by the changes in the home firm's MWTC for lobbying the environmental tax resulting from a unilateral tariff reduction. A decline in the tariff will induce more imports of the polluting good, thereby alleviating the adverse impact of the environmental tax on the home firm's profits, which are measured by π_t.[11] In other words, the tariff reduction will raise π_t, or lower $|\pi_t|$. As indicated above, when the government marginally raises (reduces) the environmental tax, the home firm will reduce (increase) its contributions by $|\pi_t|$, so $|\pi_t|$ can be regarded as the opportunity cost of the government's raising the environmental tax.

[10] The derivation of (18) is provided in the Appendix

[11] This can be seen by differentiating (32) in the Appendix with respect to τ, and obtaining $\pi_{t\tau} = -2/9 < 0$. Since $\pi_t < 0$ as shown by (13), $\pi_{t\tau} < 0$ implies that a decline in τ will reduce $|\pi_t|$.

Since the tariff reduction reduces $|\pi_t|$, it also lowers the opportunity cost of the government's raising the environmental tax. Thus the home government will increase the environmental tax rate as a response to trade liberalization.

According to (20), we also note that the degree of the impact of trade liberalization on the environmental tax depends on θ, the weight that the home government attaches to the social welfare. Differentiating $dt^\circ/d\tau$ with respect to θ yields:

$$\frac{d(dt^\circ/d\tau)}{d\theta} = \frac{7 + 3D'' + (6 + D'')\theta}{[1 - (3 + 2D'')\theta]^2} > 0. \tag{21}$$

Equation (21) indicates that a decrease in θ will lower $dt^\circ/d\tau$, or increase $|dt^\circ/d\tau|$; that is, when the home government attaches less weight to the social welfare, a tariff reduction will give rise to a greater increase in the environmental tax.

The intuition behind this result is as follows. A large θ means that the home government cares about the social welfare very much, so that the home firm's political influence on the environmental tax is limited. Even though trade liberalization will lower the home firm's MWTC ($|\pi_t|$), with the small political influence of the home firm, the decrease in $|\pi_t|$ will cause a small increase in the environmental tax. By contrast, when θ is small, meaning that the home firm has a significant influence on the formation of the environmental tax, the decrease in $|\pi_t|$ will cause a significant increase in the environmental tax. Thus trade liberalization will induce the environmental tax to rise substantially in this situation.

The following proposition summarizes what we have found:

Proposition 2 *The home country's unilateral tariff reduction will raise its environmental tax. Moreover, the lower that θ is, the greater the extent of the increase in the environmental tax associated with a tariff reduction will be.*

4.2 Environmental quality

Now we turn to the effect of trade liberalization on the sales of the two firms, which in turn determines the environmental damage in the home country. The impact of a tariff reduction on the home firm's sales is given by:

$$\frac{dq}{d\tau} = q_\tau + q_t \frac{dt^\circ}{d\tau} = \frac{-(2 + D'')\theta}{1 - (3 + 2D'')\theta} > 0. \tag{22}$$

The direct effect of a tariff reduction, which is reflected by q_τ, reduces the home firm's sales, as shown by (6). The indirect effect of a tariff reduction, which is reflected by $q_t \cdot dt^\circ/d\tau$, also reduces the home firm's sales. This is because a reduction in the tariff raises the environmental tax, which in turn lowers the home firm's sales. Therefore, the home firm's sales will be lower as the tariff is reduced.

The effect of a tariff reduction on the foreign firm's sales is more complicated, and is given by:

$$\frac{dq^*}{d\tau} = q^*_\tau + q^*_t \frac{dt^\circ}{d\tau} = \frac{-1 + (1 + D'')\theta}{1 - (3 + 2D'')\theta}. \tag{23}$$

In this case, the direct effect and the indirect effect of a decrease in the tariff work in opposite directions. Equation (7) reveals that a decrease in the tariff will increase q^*, when the environmental tax is held constant. On the other hand, an increase in the environmental tax

induced by a tariff reduction will reduce q^*. Thus the net effect of trade liberalization on the imports of the polluting good is ambiguous.

Here a somewhat surprising result emerges: a unilateral reduction in the polluting good's tariff may lower the imports of the polluting good. More specifically, because the second-order condition $G_{tt} < 0$ requires that the denominator be negative, (23) indicates that a tariff reduction will decrease the imports of the dirty good, provided that $\theta < 1/(1 + D'')$. For example, supposing that the marginal damage is constant, which implies $D'' = 0$, a decrease in the tariff will lower the imports of the dirty good, if $\theta < 1$.[12] Although the increase in q^* due to a decrease in the tariff ($|q^*_\tau| = 2/3$) is greater than the reduction in q^* associated with an increase in the environmental tax ($|q^*_t| = 1/3$), the increase in the environmental tax induced by a decrease in the tariff ($|\mathrm{d}t^\circ/\mathrm{d}\tau|$) will be sufficiently large when θ is less than one. As a result, in the case where the marginal pollution damage is constant, a unilateral tariff reduction gives rise to fewer imports of the dirty good, provided that the weight that the home government attaches to the social welfare is less than that attached to the political contributions received.

Previous studies (e.g., Anderson 1992) have shown that liberalizing trade in an imported good whose consumption gives rise to pollution will lead to a deterioration in the importing country's environment. However, by incorporating the linkage between the trade liberalization and domestic environmental regulations, we find that a tariff reduction in a country importing a good whose consumption gives rise to pollution will improve that country's environmental quality.

This can be seen by adding up (22) and (23), which yields the effect of a tariff reduction on the total consumption of the dirty good in the home country:

$$\frac{\mathrm{d}Q}{\mathrm{d}\tau} = Q_\tau + Q_t \frac{\mathrm{d}t^\circ}{\mathrm{d}\tau} = -\frac{1+\theta}{1-(3+2D'')\theta} > 0. \tag{24}$$

The direct effect of trade liberalization, which is reflected by $Q_\tau = -1/3$, will increase the total sales in the home country, thereby worsening the home country's environment. This result explains the conventional wisdom claiming that a tariff cut in a good whose consumption gives rise to pollution will damage the importing country's environment.

However, because a decrease in the tariff will raise the environmental tax, which in turn will lower the total consumption of the polluting good in the home country ($Q_t = -2/3 < 0$), the indirect effect of trade liberalization is positive. The direct effect and the indirect effect work in opposite directions, and the net effect is presented by the right-hand side of (24). The numerator is greater than zero, and the denominator is less than zero as required by the second-order condition of the government optimization, so $\mathrm{d}Q/\mathrm{d}\tau$ is unambiguously less than zero. The result $\mathrm{d}Q/\mathrm{d}\tau < 0$, implying that the indirect effect will outweigh the direct effect, is consistent with the empirical evidence provided by Wilson et al. (2003). They find that the trade-restrictive effects of environmental regulations are stronger than those in relation to tariff barriers. Because a tariff reduction will lower the total consumption of the dirty good in the home country, it will also reduce the damage to the environment in the home country.

By inspecting (24), we also note that $\mathrm{d}Q/\mathrm{d}\tau$ increases when θ decreases.[13] This means that when θ becomes smaller, a tariff reduction will give rise to a greater decrease in the

[12] Note that the second-order condition of the home government's maximizing G requires that θ should be greater than one third.

[13] This can be seen by differentiating $\mathrm{d}Q/\mathrm{d}\tau$ with respect to θ, and obtaining: $\mathrm{d}(\mathrm{d}Q/\mathrm{d}\tau)/\mathrm{d}\theta = -[1 + (3 + 2D'')]/[1 - (3 + 2D'')\theta]^2 < 0$.

total consumption of the dirty good, and thus a greater improvement in the home country's environmental quality. This result is not hard to understand. When θ is small, as shown by (21), the increase in the environmental tax due to trade liberalization will be significant, and thus the improvement in the environmental quality will also be significant.

The above analysis is summarized in the following proposition:

Proposition 3 *A unilateral tariff reduction in the home country will reduce the output of the home firm and the total consumption of the dirty good, and thus the pollution damage from consumption will be reduced. The effect of a tariff reduction on the imports of the dirty good is ambiguous*; *the imports of the dirty good will decline as the tariff decreases, provided that* $\theta < 1/(1 + D'')$.

5 The welfare effects of trade liberalization

We now turn to the effect of trade liberalization on the home country's welfare. In the situation where the government seeks to maximize the social welfare, an importing country's unilateral tariff reduction will not be welfare enhancing. When both the tariff and the environmental tax are optimally set before trade liberalization, a unilateral tariff reduction will cause the two taxes to deviate from their optimal levels.

However, in the situation where the policies are plagued by political pressures, a unilateral reduction in the home country's tariff will unambiguously enhance the home country's welfare. As indicated in Proposition 1, before trade liberalization the tariff is higher than the optimal level, and the environmental tax is lower than the optimal level. A decline in the tariff will enhance the home country's welfare in two ways. First, because the tariff is suboptimally high, a reduction in the tariff will enhance the home country's welfare. Second, a tariff reduction will increase the environmental tax rate, and thus narrow the gap between the equilibrium environmental tax and the optimal level, thereby enhancing the home country's welfare.

The above argument can be demonstrated in a more formal way. Totally differentiating the home country's social welfare function with respect to τ yields:

$$\frac{\mathrm{d}W(t^\circ, \tau^\circ)}{\mathrm{d}\tau} = W_\tau(t^\circ, \tau^\circ) + W_t(t^\circ, \tau^\circ)\frac{\mathrm{d}t^\circ}{\mathrm{d}\tau}. \tag{25}$$

The first-order condition $G_t(t^\circ, \tau^\circ) = \pi_t(t^\circ, \tau^\circ) + \theta W_t(t^\circ, \tau^\circ) = 0$ together with the fact that π_t is less than zero imply that $W_t(t^\circ, \tau^\circ)$ is greater than zero. Similarly, the first-order condition $G_\tau(t^\circ, \tau^\circ) = 0$ implies that $W_\tau(t^\circ, \tau^\circ)$ is less than zero. Together $W_\tau(t^\circ, \tau^\circ) < 0$, $W_t(t^\circ, \tau^\circ) > 0$, and $\mathrm{d}t^\circ/\mathrm{d}\tau < 0$ ensure that $\mathrm{d}W(t^\circ, \tau^\circ)/\mathrm{d}\tau < 0$; that is, trade liberalization will enhance the home country's welfare.

Moreover, we note that the smaller the weight that the home government attaches to the social welfare, the greater the improvement in its social welfare resulting from a tariff reduction will be. From the first-order conditions of the home government's maximizing G, we can derive $W_t(t^\circ, \tau^\circ) = -\pi_t(t^\circ, \tau^\circ)/\theta$ and $W_\tau(t^\circ, \tau^\circ) = -\pi_\tau(t^\circ, \tau^\circ)/\theta$. The smaller that θ is, the greater that $W_t(t^\circ, \tau^\circ)$ and $|W_\tau(t^\circ, \tau^\circ)|$ will be, other things being equal. Intuitively, when the home government does not care much about social welfare, the distortion in the policies before trade liberalization will be severe. Therefore, the welfare gain from a tariff reduction will be significant.

Proposition 4 *A unilateral tariff reduction will enhance the home country's welfare. Moreover, the smaller the weight that the home government attaches to the social welfare, the more that the home country's welfare will be enhanced due to a tariff reduction.*

We are also interested in knowing the effect of trade liberalization on the foreign country's welfare. Unilateral tariff reductions on the part of importing countries are generally expected to be beneficial to those of exporting countries, whereas the following result demonstrates that this is not necessarily the case. Totally differentiating the foreign firm's profit yields:

$$\frac{\mathrm{d}\pi^*}{\mathrm{d}\tau} = \pi^*_\tau + \pi^*_t \frac{\mathrm{d}t^\circ}{\mathrm{d}\tau} = \frac{2q^*[-1 + (1 + D'')\theta]}{1 - (3 + 2D'')\theta}. \tag{26}$$

A decrease in τ will be beneficial to the foreign country, as the environmental tax is given. Equation (30), which shows $\pi^*_\tau = -(4/9)q^* < 0$, can demonstrate this point. The term π^*_t is equal to $-(2/3)q^*$, which is also less than zero. Because the environmental tax will rise when the tariff is reduced, the indirect effect of trade liberalization will be harmful to the foreign firm. The direct effect and the indirect effect work in opposite directions, so the net effect is ambiguous.

As indicated above, the second-order condition, $G_{tt} < 0$, requires that the denominator of (26) be negative. Thus the sign of (26) is opposite to that of the numerator. There arises an interesting result: if $\theta < 1/(1 + D'')$, then a unilateral tariff reduction in the home country will reduce the foreign firm's profits, and thus the foreign country's welfare.

This result follows from Propositions 2 and 3. When the social welfare is not the home government's major concern, a tariff reduction will raise the environmental tax significantly. The net effect of a trade liberalization will lower the sales of the foreign firm, thereby reducing the foreign country's welfare.

Proposition 5 *The home country's tariff reduction will lower the foreign country's welfare, if $\theta < 1/(1 + D'')$. On the other hand, the home country's tariff reduction will enhance the foreign country's welfare, if $\theta > 1/(1 + D'')$.*

When the home government seeks to maximize the social welfare, a unilateral tariff reduction in the home country will not achieve a Pareto improvement. However, in the situation where interest groups can influence the policies, the result in Proposition 5 gives rise to the possibility that a unilateral tariff reduction may make the two countries better off. Thus trade liberalization is desirable in terms of efficiency, when the policy maker in the importing country attaches a large weight to the social welfare.

6 Concluding remarks

This paper considers the linkage between trade liberalization and domestic environmental regulations. We construct a trade model with a duopolistic market, in which there is a home firm and a foreign firm producing an identical good. We begin with a benchmark case, where the home firm can affect both the tariff and the environmental tax. Then we investigate the effects of the home country's unilateral tariff reduction on the home country's environmental quality and the home and foreign countries' welfare. We find that, once the linkage between trade liberalization and the domestic environmental regulations has been taken into consideration, some of the conventional wisdom may be reversed. For example, importing countries'

unilateral tariff reductions are generally believed to be beneficial to exporting countries, but this paper finds that this is not necessarily the case.

We should note that these results are based on several specific assumptions. Changes in assumptions will lead to different results. In the following, we attempt to relax some of the assumptions and see what will change. First of all, we can extend the model to involve the lobby from the foreign firm. Introducing the foreign lobbying may give rise to an ambiguous welfare effect of trade liberalization. In the case where both the environmental tax and the tariff are subject to the influence of interest groups, the foreign firm will intend to lower the two taxes. Since both the home firm and the foreign firm intend to reduce the environmental tax, the initial environmental tax will be lower than the socially optimal level. By contrast, the influence of the two firms on the tariff works in opposite directions, and thus the initial equilibrium tariff may be lower than the socially optimal level. As in the case where only the home firm has the political influence, a reduction in the tariff will raise the environmental tax. The increase in the environmental tax due to trade liberalization will enhance the home country's welfare, because the initial environmental tax is lower than the socially optimal level. However, if the initial tariff has been set suboptimally low, then the direct effect of trade liberalization will exacerbate the distortion in the tariff and reduce the home country's welfare. As a result, the net effect of the tariff reduction on the home country's welfare is ambiguous.

We should notice that the above argument is based on the assumption that both the home firm and the foreign firm have the same accessibility to the government. However, in practice, foreign firms are usually less efficient in lobbying than their domestic counterparts (see Bardhen 1997: 1328). If the lobbying efficiency of the foreign firm is sufficiently low, then introducing the foreign lobby will not qualitatively change the results. Thus, a unilateral tariff reduction is still beneficial to the home country's welfare, and it may give rise to a Pareto improvement.

We have assumed a non-discriminatory environmental tax, because it satisfies the rules of the GATT/WTO. In the case where a discriminatory environmental tax is adopted and only the home firm can influence the policies, the home firm will intend to lower its own environmental tax, and to raise the tariff and the foreign firm's environmental tax. Thus, the home firm's environmental tax will be suboptimally low, and both the tariff and the foreign firm's environmental tax will be suboptimally high. If the tariff is exogenously reduced, then the home firm will seek to exploit the non-tariff trade barrier. A unilateral tariff reduction is expected to lower the home firm's environmental tax and to raise the foreign firm's environmental tax further, both of which reduce the home country's welfare. As a result, the welfare effect of trade liberalization is ambiguous, because the direct effect of a tariff reduction is welfare-enhancing, whereas the indirect effect is welfare-decreasing. Additionally, since a preferential tax treatment on the domestic-produced output is equivalent to a subsidy on the home firm's output, the above analysis can also be applied to the case where the home firm is subsidized.

So far we have assumed a duopolistic market in the home country. If we extend this to consider the home industry containing more than one firm, then some results may be different. For example, in the situation where the home industry contains several identical firms and those firms can cooperate in their lobbying activity, the domestic polluting industry may intend to raise the environmental tax in order to increase the price and lower the aggregate output, so as to enhance the aggregate profit. Such an extension may yield important and interesting insights. This issue, we believe, merits further research.

Appendix

The derivation of (18):
By substituting the linear demand function into (4) and (5), we can solve for the equilibrium amount of sales:

$$q = (\alpha - 2c + c^* - t + \tau)/3, \tag{27}$$

$$q^* = (\alpha + c - 2c^* - t - 2\tau)/3. \tag{28}$$

Then we can obtain both the home and the foreign firms' profit functions as:

$$\pi = (1/9)(\alpha - 2c + c^* - t + \tau)^2, \tag{29}$$

$$\pi^* = (1/9)(\alpha + c - 2c^* - t - 2\tau)^2. \tag{30}$$

The linear demand function also results in the social welfare function as follows:

$$W = \alpha(q + q^*) - (q^2 + 2qq^* + q^{*2})/2 - pq^* - cq + (t + \tau)q^* - D(Q), \tag{31}$$

where $Q = q + q^*$.

Differentiating (29) and (31) with respect to t yields:

$$\pi_t = -(2/9)(\alpha - 2c + c^* - t + \tau), \tag{32}$$

$$W_t = (1/3)\big[c - c^* - 2(t + \tau) + 2D'\big]. \tag{33}$$

From (32) and (33), we obtain (18):

$$G_t = (1/9)\big[-2\alpha + (4 + 3\theta)c - (2 + 3\theta)c^* + 2(1 - 3\theta)t - 2(1 + 3\theta)\tau + 6\theta D'\big] = 0.$$

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