The Effect of Free Trade on Pollution Policy and Welfare*

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The Effect of Choosing Free Trade on Pollution Policy and Welfare*

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Abstract

In this paper I consider a small economy facing accession to a trade agreement. Before accession the government has control over trade and environmental policy. After accession it retains control over environmental policy but has to allow free trade. Through the analysis I highlight an effect of free trade neglected in the literature so far. Adoption of free trade shifts the economic incidence of pollution tax from consumers onto producers of the polluting good. Under fairly plausible conditions, this change in incidence can reduce the distortion in pollution tax. Even though the choice of accession is influenced by special interest groups, I find that accession can be accompanied by an improvement in pollution policy and an increase in aggregate welfare.

1 Introduction

The relationship between trade and the environment is of immense concern today. Environmentalists fear that without international coordination, governments will sacrifice environmental quality and the welfare of their citizens to become globally competitive.

Economic theory often supports these fears. Bhagwati (1971) shows that if free trade is adopted in the presence of a domestic policy distortion, welfare can fall.[1]

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[1]Also see Pethig (1976), and Siebert (1977) for similar analysis of the effects of free trade on aggregate welfare.

Beghin et al. (1997), and Ederington (2001) show that in the presence of an international trade policy distortion, exogenous trade liberalization brings about a reduction in pollution tax. Assuming open access in the harvest of a natural resource (similar to a distortion in environmental policy) Brander and Taylor (1997 and 1998), and Chichilnisky (1994) demonstrate a reduction in welfare when free trade is adopted.[2]

In this paper I reconsider the effects of choosing free trade on an economy with distorted domestic policy.

A small economy faces accession to a trade agreement. The government of this economy is influenced by special interest groups and consequently, trade and pollution policy are subject to special interest induced distortions. Accession provides greater market access to other members, but takes away control over trade policy. Before accession, the government has full control over both trade and pollution policy. After accession, it retains control over pollution policy, but must allow free trade in all goods.

I find that accession to the agreement (adoption of free trade) need not reduce aggregate welfare. I provide plausible conditions under which the choice of free trade is accompanied by an improvement in pollution policy and a gain in aggregate welfare. This gain in welfare occurs even if the economy exports the polluting good. Through the analysis I highlight an effect of free trade neglected in the literature so far. Adoption of free trade shifts the economic incidence of pollution tax from consumers onto producers of the polluting good. This change in incidence can reduce the distortion in pollution tax.

Before accession, both trade and pollution policy are used to redistribute income to special interest groups. With any increase in the pollution tax the government also increases the 'nominal rate of protection' on the polluting good. This increase in protection partially offsets the loss in profits from the increase in pollution tax. It also transfers some of the incidence of pollution tax onto consumers of the polluting good. Once free trade is adopted, the rate of protection cannot be altered and domestic prices are exogenously given. As trade policy can no longer be used to redistribute income, the marginal burden of pollution tax on producers rises. This causes pollution to be more responsive to increases in tax. Under fairly plausible assumptions, higher responsiveness of pollution to pollution tax raises overall lobbying for an increase in pollution tax, and induces the government to raise the pollution tax. In addition, if the price for the polluting good under free trade is higher than the domestic price before free trade, free trade also brings about a gain in aggregate welfare.

There is some empirical support for the above result. In the formerly Centrally Planned Economies, Vukina et al. (1999) found that liberalization in trade and foreign

[2] It is not possible to present a clear consensus on the welfare effects of free trade in the presence of environmental distortions. This effect depends on the pattern of trade and the stringency of environmental regulation. However, it is often demonstrated that if environmental policy does not internalize the pollution externality completely, and the country exports the polluting good on adopting free trade, aggregate welfare can fall.

exchange steered manufacturing output towards less-polluting sectors. The authors link this improvement in composition to environmental policy reforms that accompanied trade reforms. Antweiler et al. (2001) estimate the scale, composition and technique effect from trade and find that freer trade appears to reduce pollution. The authors demonstrate that freer trade brings about an adjustment of environmental policy, and can improve the environment.

Under different settings, earlier studies have shown an improvement in endogenous environmental policy when free trade is adopted. Alpay (2000), and Rauscher (1994) highlight the incentive to tighten environmental policy on exported goods to favorably influence world prices. In contrast, the economy considered in this paper is small. Domestic policy cannot influence world prices or the terms of trade. Improvements in pollution policy stem solely from a change in its incidence.

Bagwell and Staiger (2000) show that a country adjusts labor standards when international trade is permitted. The authors show how free trade reduces the economic incidence of the labor standard on consumers, but increases it on the producers of the good. Thus if the gain from trade is extra consumer surplus, the labor standard is tightened (an importing country). If instead the gain from trade is extra producer surplus, the labor standard is relaxed (an exporting country). In Bagwell and Staiger (2000) the labor standard maximizes aggregate welfare, and the country always gains from trade. In this paper, the pollution tax is distorted to favor the producers of the polluting good and international trade need not always raise welfare. Due to this difference, unlike Bagwell and Staiger (2000) I do not focus on the variation in pollution tax. Instead, I present conditions under which free trade is accompanied by a reduction in the policy distortion, and a gain in aggregate welfare. I also find that this gain occurs irrespective of whether the good is imported or exported.

McAusland (2002) and Yu (1999) also incorporate a change in the incidence of pollution policy from free trade. Comparing the two polar cases of free trade and autarky the authors find that free trade worsens the inefficiency in pollution policy. Pollution policy in free trade is further from the welfare maximizing ideal than it was under autarky. In this paper I differentiate the change in incidence of pollution policy from free trade into two components. The first is the effect on consumer and producer surplus (from consumption and production of the polluting good), and the other is the effect on responsiveness of pollution to pollution tax. I show that depending on the relative magnitude of these two effects pollution policy may improve or deteriorate as free trade is adopted. In McAusland (2002) and Yu (1999) the effect on consumer and producer surplus always outweighs the effect from increased responsiveness. This implies that pollution policy always deteriorates once free trade is adopted.

Copeland (1990) presents a comprehensive analysis of how domestic policies can substitute for trade barriers, once trade barriers are prohibited by a trade agreement. Considering two large economies that cooperatively negotiate the terms of their agreement he argues that governments negotiate trade agreements mindful of the domestic policy distortions created in their response. The author shows that despite the substitution of environmental policy for trade policy, and the presence of domestic policy distortions, a bilaterally negotiated trade liberalization can raise aggregate welfare. In this paper, I consider a small economy which can choose to join or reject a multilateral trade agreement, but cannot influence the terms offered. Similar to Copeland (1990) I find that despite the substitution of pollution policy for trade policy to redistribute income to special interests, and the presence of policy distortions, accession to the trade agreement can raise aggregate welfare.

This paper is structured as follows. In Section 2, I present the analytical framework for the paper. Characteristics of pollution policy when the government is restricted in its choice of trade policy are presented in Section 3. In Section 4, I present the characteristics of pollution policy when the government has complete control over its trade policy. Section 5 brings the results from previous sections together to analyze the pollution policy and welfare impacts of choosing free trade over endogenously chosen trade policy. Section 6 concludes the paper.

2 Analytical Framework

I present an extension of the common agency model of government[3] from Grossman and Helpman (1994). In a small economy producing three goods, one generates pollution as a by-product, while the other two do not. Utility of all individuals is reduced by pollution. The government regulates pollution by a pollution tax and regulates international trade by either a quantitative restriction (import or export quota), or a tariff.

There are three groups of people: the owners of labor, the owners of sector-specific polluting capital, and the owners of sector-specific non-polluting capital.[4] I maintain the (now) standard assumption in political economy models of international trade that owners of specific factors are organized as special interests, while labor owners are not.

2.1 Basics

There is one 'numeraire' good (denoted y^0) and there are two 'non-numeraire' goods (denoted y^1 and y^2). Good y^0 is produced by a constant returns to scale technology

[3]Common agency refers to the situation where several principals exert influence on a single agent to perform a costly action. The government in a common agency model serves as an agent for special interest groups and the general public. Common agency was first analyzed by Bernheim and Whinston (1986) and was subsequently popularized in models of international trade by Grossman and Helpman (1994).

[4]Polluting capital by itself does not create pollution. The two forms of capital are named so only to differentiate them as specific factors employed in two different industries, polluting and non-polluting.

using labor (l^0). The input requirement set is

$$V^0\left(y^0\right) = \left\{l^0 : l^0 \geq y^0\right\}.$$

The world and domestic price for good y^0 is normalized to one and is thus referred to as the *numeraire* good. In any equilibrium involving production of the numeraire, the wage rate (w) equals one. Positive production of the numeraire is assumed throughout.

Good y^1 the non-polluting good represents final goods and services that produce negligible amounts of pollution in their production. It is produced by a constant returns to scale and convex technology using two inputs: sector specific non-polluting capital (h), and labor (l^1). The input requirement set is

$$V^1\left(y^1\right) = \left\{(h, l^1) : (h, l^1) \text{ can produce } y^1\right\},$$

and domestic price is denoted p^1. The return to owners of non-polluting capital is represented by a restricted profit function

$$\pi^h\left(p^1\right) = \widetilde{\pi}^h\left(p^1, w; h\right).$$

Restricted profit functions are positively linearly homogeneous, and convex in prices (p^1, w). They also satisfy Hotelling's lemma. Output equals the partial derivative of the restricted profit function with respect to output price ($y^1 = \pi_p^h(.)$ where subscripts denote partial derivatives).

Production of the polluting good y^2 produces pollution (z) as a by-product. The two outputs y^2 and z are produced by a constant returns to scale and convex technology using two inputs: sector specific polluting capital (k), and labor (l^2). The input requirement set for the polluting good is

$$V^2\left(y^2\right) = \left\{(k, l^2) : (k, l^2) \text{ can produce } \left(y^2, z\right)\right\},$$

and domestic price is denoted p^2. Return to the owners of polluting capital is represented by a restricted profit function:

$$\pi^k\left(p^2, t\right) = \widetilde{\pi}^k\left(p^2, t, w; k\right)$$

where t is the tax rate on pollution. Using Hotelling's Lemma output of the polluting good is $y^2 = \pi_p^k(p^2, t)$, and pollution produced is $z = -\pi_t^k(p^2, t)$.

Utility is assumed quasi-linear in form. Sub-utility functions for non-numeraire goods are denoted $u^i(.)$, $i = 1, 2$, and are assumed strictly increasing and concave. Damage from pollution is linearly separable and is represented by a strictly increasing and convex function $v(z)$. Demands for non-numeraire goods are $x^i(p^i)$, and

$$\gamma^i(p) = \left[u^i\left(x^i\left(p^i\right)\right) - p^i x^i\left(p^i\right)\right]$$

represents consumer surplus.

Each individual is endowed with a single unit of labor and total population is normalized to 1. Income is a combination of wages, profits and government transfers. Government transfers comprise of pollution tax revenues, tariff revenues, and rents from import or export quotas. Pollution tax revenues are distributed proportionately to all individuals. Quota rents, and tariff revenues are distributed proportionately to the consumers of the regulated good. Total tax revenue is tz, total tariff revenue or quota rents are $\sum_i (p^i - p^{iw}) m^i$, where p^{iw} is the world price, and m^i is the import level for good i.

Individuals owning only labor (group l) are in proportion n^l. Group l does not organize to form a contributing lobby. Their welfare (indirect utility) is

$$W^l = n^l \left(1 + tz + \left(p^1 - p^{1w}\right) m^1 + \gamma^1 \left(p^1\right) + \lambda \left[\left(p^2 - p^{2w}\right) m^2 + \gamma^2 \left(p^2\right)\right] - v\left(z\right)\right), \tag{1}$$

where $\lambda \in [0, 1]$ is an exogenous parameter that alters group l's consumption of the polluting good (group consumption is $\lambda x^2 \left(p^2\right)$).

Owners of polluting and non polluting capital are organized into two lobby groups (h and k). Each group offers the government contributions to influence policy. Their proportion of population is n^j, $j \in \{h, k\}$, and their welfare (gross of contributions) is

$$W^j = n^j \left(1 + tz + \left(p^1 - p^{1w}\right) m^1 + \gamma^1 \left(p^1\right) + \frac{\left[\left(p^2 - p^{2w}\right) m^2 + \gamma^2 \left(p^2\right)\right]}{\left(1 - n^l \left(1 - \lambda\right)\right)} - v\left(z\right)\right) + \pi^j \tag{2}$$

where π^j is the restricted profit function. Each group's welfare net of contributions is $\Omega^j = W^j - C^j$, where C^j is contribution to the government.

2.2 Market Equilibrium

I present market equilibrium conditions only for the polluting good. Corresponding conditions for the non-polluting good can be put together analogously.

Quantitative restrictions and tariffs are available as trade policy. If domestic price in *autarky* (a condition of no international trade) is higher than the world price, either an import quota or an import tariff can be used to restrict imports. If the government's objective is to promote imports, an import subsidy can be provided. If domestic price in autarky is lower than the world price, either an export quota or export tax can be used to restrict exports. To promote exports an export subsidy can be provided. Note that quantitative restrictions can only restrict imports or exports.

Let $\bar{m}^2$ denote a quantitative restriction for the polluting good ($\bar{m}^2 \geq 0$ for an import quota and $\bar{m}^2 \leq 0$ for an export quota). Market equilibrium is given by

$$x^2 \left(p^2\right) \leq \pi_p^k \left(p^2, t\right) + \bar{m}^2. \tag{3}$$

In equilibrium, domestic demand for the polluting good is no greater than net domestic supply. Under a binding quantitative restriction, equation (3) holds with equality.[5]

Assuming a binding quantitative restriction differentiate equation (3) with respect to $\bar{m}^2$ to obtain

$$\frac{dp^2}{d\bar{m}^2} = \frac{1}{x_p^2(p^2) - \pi_{pp}^k(p^2, t)} < 0. \tag{4}$$

An exogenous marginal increase in the import quota, or a reduction in the export quota causes a reduction in the price of the polluting good.

Let τ^2 denote an *ad-valorem* tariff for the polluting good ($\tau^2 \geq 0$ for an import tariff or export subsidy, and $\tau^2 \leq 0$ for an export tax, or import subsidy – all measured in terms of the world price). With a tariff the domestic price for the polluting good is

$$p^2 = p^{2w}\left(1 + \tau^2\right).$$

2.3 Political Equilibrium

The government chooses a trade policy instrument (either a tariff or a quantitative restriction) and its level for each good. Given two non-numeraire goods, and two possible trade instruments for each good, there are four distinct trade regimes to choose from. A trade regime is denoted $R \in \{R^{\tau\tau}, R^{\tau m}, R^{mm}, R^{m\tau}\}$ where the first superscript denotes trade policy for the non-polluting good, and the second for the polluting good (for example, $R^{\tau m}$ is a regime with a tariff for the non-polluting good, and a quantitative restriction for the polluting good (τ^1, m^2)). The government also chooses the level of pollution tax.

Let $\tau = \{\tau^1, \tau^2\}$ denote the list of tariffs, and $\bar{m} = \{\bar{m}^1, \bar{m}^2\}$ denote the list of quantitative restrictions. $W(t, \tau, \bar{m}, R) = \sum_{g\in\{h,k,l\}} W^g$ denotes aggregate (gross of contributions) welfare in the economy and $C^j(t, \tau, \bar{m}, R)$ denotes lobby group j's contribution schedule.[6] Contribution schedules and group welfare functions are assumed differentiable in all continuous policy instruments (t, $\bar{m}^1, \bar{m}^2, \tau^1, \tau^2$). The government's objective function is a weighted sum of contributions and aggregate welfare (where $a > 0$ is the weight attached to aggregate welfare). Formally,

$$G = \sum_{j\in\{h,k\}} C^j(t, \tau, \bar{m}, R) + aW(t, \tau, \bar{m}, R). \tag{5}$$

Policy is determined as a sub-game perfect outcome of a two stage noncooperative game. In the first stage, lobbies simultaneously choose their political contribution

[5] For an import quota to bind it should be smaller in value than the quota where domestic price equals world price. For an export quota to bind it should be larger in value than the quota where domestic price equals world price. Formally, let $p^2\left(\bar{m}^2, t\right)$ be the implicit price function obtained from the solution of equation (3) under equality. Further, let $\tilde{m}^2$ be defined by the condition $p^2\left(\tilde{m}^2, t\right) = p^{2w}$. A import quota for the polluting good is binding if $0 \leq \bar{m}^2 < \tilde{m}^2$, and an export quota for the polluting good is binding if $0 \geq \bar{m}^2 > \tilde{m}^2$.

[6] $C^j(.) \geq 0$ to ensure that lobby groups cannot use this function to extract payments from the government.

schedules so as to maximize their net of contributions group utility (Ω^j). In the second stage, the government takes contribution schedules as given, and sets policy to maximize its own welfare.

Proposition 1 *Conditions for a political equilibrium (Bernheim and Whinston (1986) & Grossman and Helpman(1994)):* $\left(\{C^{j0}(t^0,\tau^0,\bar{m}^0,R^0)\}_{j\in J}, t^0,\tau^0,\bar{m}^0,R^0\right)$ *is a subgame perfect Nash equilibrium of the environmental policy game if and only if conditions C1-C4 hold. (C1) Contribution Schedule* $C^{j0}(t^0,\tau^0,\bar{m}^0,R^0)$ *and policy vector* $(t^0,\tau^0,\bar{m}^0,R^0)$ *are feasible* $\forall j$. *(C2) The policy vector satisfies,*

$$\left(t^0,\tau^0,\bar{m}^0,R^0\right) = \arg\max\left\{\sum_{j\in J} C^{j0}(t,\tau,\bar{m},R) + aW(t,\tau,\bar{m},R)\right\}.$$

(C3) For every $j' \in J$

$$\left(t^0,\tau^0,\bar{m}^0,R^0\right) = \arg\max\left\{\begin{array}{c} W^{j'}(t,\tau,\bar{m},R) - C^{j'0}(t,\tau,\bar{m},R) + \\ \sum_{j\in J} C^{j0}(t,\tau,\bar{m},R) + aW(t,\tau,\bar{m},R)\end{array}\right\}.$$

(C4) $\forall j' \in J, \exists\; t^{j'}, \tau^{j'}, \bar{m}^{j'} \& R^{j'}$:

$$\left(t^{j'},\tau^{j'},\bar{m}^{j'},R^{j'}\right) = \arg\max\left\{\sum_{j\in J,\; j\neq j'} C^{j0}(t,\tau,\bar{m},R) + aW(t,\tau,\bar{m},R)\right\}$$

Condition (C1) stipulates feasible contribution schedules (non-negative, and no greater than aggregate welfare of lobby members) and policy vectors. Condition (C2) states that the government sets pollution policy to maximize its own welfare. Condition (C3) stipulates efficiency in the relation between the government and each lobby involved in the political process; it requires the optimal tax to maximize their joint welfare. Finally, condition (C4) requires that there exist an alternate tax schedule, and choice of trade policy; the next best option for the government, in case it wishes to cut out any particular lobby from the political process.[7].

For the optimal pollution tax, equilibrium implies that

$$\frac{d}{dt}\left[\sum_{j\in J} W^j\left(t^0,\tau^0,\bar{m}^0,R^0\right) + aW\left(t^0,\tau^0,\bar{m}^0,R^0\right)\right] = 0. \tag{6}$$

For the quantitative restriction (if chosen for good $i : i \in \{1,2\}$) equilibrium implies that

$$\frac{d}{d\bar{m}^i}\left[\sum_{j\in J} W^j\left(t^0,\tau^0,\bar{m}^0,R^0\right) + aW\left(t^0,\tau^0,\bar{m}^0,R^0\right)\right] = 0 \tag{7}$$

[7] See Grossman and Helpman (1994) for a more detailed explanation and discussion of these conditions.

and for the optimal tariff (if chosen for good $i : i \in \{1, 2\}$) equilibrium implies that

$$\frac{d}{d\tau^i}\left[\sum_{j\in J} W^j\left(t^0, \tau^0, \bar{m}^0, R^0\right) + aW\left(t^0, \tau^0, \bar{m}^0, R^0\right)\right] = 0 \tag{8}$$

Equations ((6), (7) and (8)) illustrate the effect of lobbying activity. The optimal pollution tax/trade policy maximizes a weighted welfare function where the welfare of the lobby groups gets a higher weight ($(1 + a)$) than that of unorganized citizens (a). This maximization results in a policy that is systematically different from policy that maximizes aggregate welfare.

3 Restricted Trade Policy

I present a restricted version of the political model from Section 2. The government can choose from a quantitative restriction or tariff for each non-numeraire good. However, the level of quantitative restriction, or tariff, is determined exogenously. The results from this section link forward to Section 5, where I explicitly consider this economy's decision to join a multilateral trade agreement. As the multilateral agreement takes away control over trade policy, accession is similar to choosing a regime where trade policy levels are exogenously determined.

Before proceeding to politically determined policy I present the benchmark of aggregate welfare maximizing trade and pollution policy.

Aggregate Welfare Maximizing Policy Aggregate welfare is $W(.) = \sum_{g\in\{l,h,k\}} W^g$. As the economy is small, welfare maximizing trade policy is free trade (all tariffs equal zero). The corresponding welfare maximizing tax schedule equals marginal damage from pollution. Formally,

$$t^* = v_z(z). \tag{9}$$

3.1 The Pollution Tax under Quantitative Restrictions

Assume that an exogenously specified binding quantitative restriction is chosen to regulate trade in the polluting good ($R^0 \in \{R^{\tau m}, R^{mm}\}$). Also assume that an increase in pollution tax reduces the equilibrium output of the polluting good ($-\pi^k_{pt} > 0$). Given that the level of quantitative restriction is exogenously determined, differentiate the goods market equilibrium (equation (3)) with respect to pollution tax to obtain

$$\frac{dp^2}{dt} = \frac{-\pi^k_{pt}\left(p^2, t\right)}{\left[\pi^k_{pp}\left(p^2, t\right) - x^2_p\left(p^2\right)\right]} > 0. \tag{10}$$

When the pollution tax is raised, domestic supply of the polluting good falls. To restore parity between net domestic demand and supply, equilibrium price rises. An increase in domestic price when the pollution tax rises implies that producers can transfer some of the increase in pollution tax onto the consumers of their good. This ability to transfer an increase in pollution tax effects the optimal pollution tax chosen under quantitative restrictions. I illustrate this in the lemma below.

Lemma 1 *When the optimal trade policy for the polluting good is a binding quantitative restriction ($R^0 \in \{R^{\tau m}, R^{mm}\}$) the optimal pollution tax is*

$$t^m = v_z(z) + \frac{n^l \pi_t^k + \frac{\lambda n^l}{\left(1 - n^l + \lambda n^l\right)} \pi_p^k \frac{dp^2}{dt}}{\left(\left(1 - n^l\right) + a\right)\left[\pi_{tp}^k \frac{dp^2}{dt} + \pi_{tt}^k\right]}. \quad (11)$$

Lemma 1 illustrates how the government trades off social welfare to favor special interest groups. The first term on the right hand side of equation (11) ($v_z(z)$) is marginal social damage from pollution. The second term reflects the government's policy compromise to special interest groups. The numerator measures the loss in aggregate special interest welfare from an increase in pollution tax. This loss is the increase in pollution tax payments returned to the owners of labor ($n^l \pi_t^k$) less the amount transferred through an increase in the price of the polluting good ($\frac{\lambda n^l}{\left(1+n^l(\lambda-1)\right)} \pi_p^k \frac{dp^2}{dt}$). The denominator normalizes the loss in aggregate special interest welfare by the weighted responsiveness of pollution to pollution tax. The term $\left(\left(1 - n^l\right) + a\right)$ is the weight assigned by the government to the pollution externality, and $\left[\pi_{tp}^k \frac{dp^2}{dt} + \pi_{tt}^k\right]$ is general equilibrium responsiveness of pollution to pollution tax. If the responsiveness of pollution to pollution tax is very high any deviation of pollution tax from marginal social damage causes large fluctuations in pollution, and subsequently large losses in aggregate welfare. Thus, high responsiveness induces the government to set pollution tax closer to marginal social damage.[8] However, when responsiveness of pollution is finite and aggregate special interest losses from an increase in pollution tax are non-negligible, the government sets pollution tax to be less than marginal social damage.

Corollary 1 *If $\left[\pi_t^k + \pi_p^k \frac{dp^2}{dt}\right] \leq 0$, $t^m < v_z(z)$.*

Proof. Please see Appendix A.1. ■

Whether the optimal pollution tax is greater or less than marginal social damage depends on the sign of the second term in equation (11). The denominator of this term is positive. A sufficient condition for the numerator to be negative is that the change in polluting industry profits from an increase in pollution tax be negative ($\left[\pi_t^k + \pi_p^k \frac{dp^2}{dt}\right] < 0$). If polluting industry profits fall when the pollution tax is raised the pollution tax under quantitative restrictions is lower than marginal social damage.

[8] In the limit $\left[\pi_{tp}^k \frac{dp^2}{dt} + \pi_{tt}^k\right] \rightarrow \infty$ pollution tax equals aggregate welfare maximizing tax.

A tax lower than marginal social damage is the result of a political process. Due to lobbying activity the government assigns a higher weight to the welfare of the producers of pollution than that assigned to losses from pollution to the unorganized. Since a part of the externality from pollution is the disutility to this group the optimal tax never fully reflects their losses. Corollary 1 is an illustration of *incomplete environmental policy*, that is, a policy that does not completely account for the benefits and costs associated with an environmental resource.

3.2 The Pollution Tax under Tariffs

Now assume that the government chooses a tariff to regulate trade in the polluting good ($R^0 \in \{R^{\tau\tau}, R^{m\tau}\}$). Under an exogenous tariff (in a small economy) the pollution tax does not effect the domestic price of the polluting good. This is unlike the case of an exogenously given binding quantitative restriction. In that case the owners of polluting capital could transfer a part of the incidence of pollution tax onto consumers of the polluting good. They cannot do so under tariffs.

The optimal pollution tax under tariffs is given by the following lemma.

Lemma 2 *When the optimal trade policy for the polluting good is a tariff ($R^0 \in \{R^{\tau\tau}, R^{m\tau}\}$) the optimal pollution tax is*

$$t^{\tau} = v_z(z) + \frac{n^l}{((1-n^l)+a)} \left[\frac{\pi_t^k}{\pi_{tt}^k}\right] + \frac{\left(\frac{(1-n^l)}{(1-n^l)+\lambda n^l} + a\right)}{((1-n^l)+a)} \left(p^2 - p^{2w}\right) \left[\frac{-\pi_{pt}^k}{\pi_{tt}^k}\right] \qquad (12)$$

The first term on the right hand side is marginal social damage from pollution. The second term is the government's policy compromise to special interest groups. The numerator is the loss in aggregate special interest welfare from an increase in pollution tax, which is now, the entire net tax burden ($n^l\pi_t^k$). The denominator is the weighted responsiveness of pollution to pollution tax, which is higher under tariffs than quantitative restrictions. As an increase in tax can no longer be transferred onto consumers through an increase in price its marginal burden on the producers of the polluting good is higher. A higher marginal burden induces a greater reduction in the output of pollution when pollution tax is raised.

The third term on the right hand side of equation (12) depends directly on the degree of tariff protection granted to the polluting good. This term reflects the use of the pollution tax as a second-best tool to reduce the impact of an exogenous trade distortion (also an attempt to optimize either tariff revenues, or subsidy payouts). An increase in pollution tax reduces domestic production of the polluting good, which at a fixed price either increases imports, or reduces exports. If the polluting good is *protected* ($\tau^2 > 0 \Rightarrow (p^2 - p^{2w}) > 0$), the pollution tax is adjusted upwards. If the polluting good is *discriminated against* ($\tau^2 < 0$), the pollution tax is adjusted downwards.

This result is related to earlier papers. Ederington (2001), Krutilla (1991), and Markusen (1975) analyze welfare maximizing domestic policy in the presence of multiple environmental, and trade distortions. They all find that when tariff policy is exogenous, domestic policy is adjusted to correct for trade distortions.

It is interesting to note that in the presence of exogenously specified quantitative restrictions (see Lemma 1) the pollution tax is not used as a second-best trade instrument. Similar results are found in Copeland (1994), and Corden and Falvey (1985). In both these papers, a quota prevents the spill-over of a distortion to other sectors. In our case, the presence of a binding trade quota implies that the government cannot use pollution policy to alter the quantity imported, or exported, and thus cannot use domestic policy to correct for the trade distortion.

In equation (12) the difference between pollution tax and marginal social damage is a linear function of the difference between the domestic price and world price for the polluting good. This observation is useful for cross-good comparisons. All else being equal, if among two goods one has the same domestic price owing to greater tariff protection, that good will also have a higher pollution tax.

For the same good it is useful to look at the comparative statics of pollution tax to changes in the exogenous tariff. These comparative statics depend on third order derivatives of the profit and utility functions for the polluting good. If we assume that the third order derivatives are negligible the following proposition results.

Proposition 2 *Assume that all third order derivatives for* $\pi^k(p^2, t)$ *equal zero. Further assume that* $x^2_{pp}(p^2) = 0$*. For a strictly non-zero tariff (*$\tau^2 \neq 0$*):* $a \geq (2n^l - 1)$ *is sufficient for* $\frac{d}{dp^2}t^\tau \geq 0$*, and* $\frac{d}{dp^2}[t^\tau - v_z] \geq 0$*.*

Proof. Please see Appendix A.1. ■

A sufficient condition for signing the comparative statics is $a \geq (2n^l - 1)$. By definition the parameter $n^l \leq 1$, thus $a \geq 1$ is sufficient for all n^l in the above proposition. Goldberg and Maggi (1999) provide a 95% confidence interval for the estimate of a in the literature where $a \in [32.33, 99]$.[9] Based on this estimate the assumption that $a \geq 1$ seems plausible.

Like in Proposition 2, Bommer and Schulze (1999) find that an increase in the price of the polluting good increases the stringency of environmental regulation. However, unlike Proposition 2, Fredriksson (1997) finds that an increase in the price of the polluting good reduces the pollution tax.[10]

[9] Goldberg and Maggi (1999) empirically estimate a government welfare function $G = (1-\beta)\sum_{j\in J} C^j(.) + \beta W(.)$ based on Grossman and Helpman (1994) for US data. They find a 95% confidence interval for $\beta \in [0.97, 0.99]$. In our model $a = \frac{\beta}{(1-\beta)}$; thus based on the Golberg and Maggi estimate $a \in [32.33, 99]$.

[10] Fredriksson's result is driven by the assumption that marginal social damage from pollution is constant at all pollution levels but polluting industry benefits from pollution rise with the price of the polluting good. This assumption is at odds with the typical notion of convex disutility from pollution.

Given that $\frac{dp^2}{d\tau^2} > 0$ Proposition 2 implies that

$$\frac{d}{d\tau^2} t^{\tau} \geq 0, \; \frac{d}{d\tau^2} \left[t^{\tau} - v_z \right] \geq 0. \tag{13}$$

As the import tariff or the export subsidy for the polluting good is exogenously reduced the pollution tax falls. Further, this fall moves the pollution tax further away from marginal social damage. In other words, trade liberalization can have a deleterious impact on pollution policy.

Equation (13) illustrates the concern that environmental policy may be used as a secondary trade barrier. If a trade agreement mandates reduction in import tariffs the government may allow domestic producers a reduction in pollution policy (or some other domestic policy not governed by the agreement). Such concerns were first raised by the second-best analyses of trade and environmental distortions listed above. More recently these concerns have also been analyzed in empirical work by Levinson and Taylor (2001), and Ederington and Minier (2001). Ederington and Minier (2001) find evidence of the use of environmental regulation as a secondary means to provide protection to domestic industries. In their analysis of US environmental policy, the authors find that regulation is lower in industries with higher net imports. However, they also find it to be higher for industries with higher tariffs which contradicts the above result.

3.2.1 The Pollution Tax under Free Trade: The Post Accession Economy

Now assume that this country accedes to a multilateral trade agreement which requires free trade, but allows full control on pollution policy.

Free trade is equivalent to a trade regime where all tariff rates equal zero ($\{\tau^1, \tau^2\} = 0$). Like the case of an exogenously given tariff, a change in the pollution tax has no effect on the domestic price of the polluting good. The corresponding optimal pollution tax is characterized by the following lemma.

Lemma 3 *When the optimal trade regime is free trade the optimal pollution tax is*

$$t^F = v_z(z) + \frac{n^l}{((1-n^l)+a)} \left[\frac{\pi_t^k}{\pi_{tt}^k} \right] \tag{14}$$

The first term on the right hand side of equation (14) is marginal social damage from pollution. The second term reflects the government's policy compromise to special interest groups. The numerator measures the loss in aggregate special interest welfare from an increase in pollution tax and the denominator is the weighted responsiveness of pollution to pollution tax.

The second term in the right hand side of equation (14) is negative. This leads to the following corollary.

Corollary 2 $t^F < v_z(z)$.

The optimal pollution tax in free trade is smaller in value than marginal social damage from pollution. In other words, even under free trade, the externality from pollution is not completely internalized by pollution policy.

4 Unrestricted Trade Policy: The Pre-Accession Economy

In this section I characterize pollution and trade policy prior to accession to a multilateral trade agreement. Before joining the trade agreement the government has full control on trade and environmental policy (formally this requires me to relax the restrictions imposed on trade policy in the previous section). The results from this section constitute the starting point for the economy as it considers accession to the multilateral trade agreement. They also link forward to the next section where I explicitly consider the government's choice of accession to a multilateral trade agreement.

Trade policy is expressed as a *nominal rate of protection*, which is the proportional change in domestic price directly brought about by the trade policy instrument. The quantitative restriction can be either an import or an export quota. A binding import quota raises the domestic price over the world price while a binding export quota lowers domestic price below the world price. An import quota results in a positive nominal rate of protection, while an export quota results in a negative rate. If instead a tariff is chosen, an import tariff, or an export subsidy raises the domestic price above the world price implying positive nominal protection. An import subsidy, or export tax lowers domestic price below the world price implying negative nominal protection.

I present results for the polluting good alone. The optimal pollution tax when trade policy is unrestricted is

$$t^0 = v_z(z) + \frac{n^l \pi_t^k + \frac{\lambda n^l}{\left(1-n^l+\lambda n^l\right)} \pi_p^k \frac{\left[-\pi_{tp}^k\right]}{\left[\pi_{pp}^k - x_p^2\right]}}{\left((1-n^l)+a\right)\left[\pi_{tt}^k - \frac{\left[\pi_{tp}^k\right]^2}{\left[\pi_{pp}^k - x_p^2\right]}\right]}. \tag{15}$$

Equation (15) has the same form as equation (11) which was the optimal pollution tax when the polluting good is regulated with a binding quantitative restriction. The first term on the right hand side of equation (15) is marginal social damage from pollution. The second term reflects the government's policy compromise to special interest groups. The numerator measures the loss in aggregate special interest welfare from an increase in pollution tax. Which includes the increase in pollution tax payments returned to the owners of labor ($n^l \pi_t^k$) less the amount transferred through an increase in the price of the polluting good ($\frac{\lambda n^l}{\left(1+n^l(\lambda-1)\right)} \pi_p^k \frac{dp^2}{dt}$, recall that $\frac{dp^2}{dt} = \frac{\left[-\pi_{tp}^k\right]}{\left[\pi_{pp}^k - x_p^2\right]}$). The denominator normalizes the loss in aggregate special interest welfare by the weighted responsiveness of pollution to pollution tax.

Like the case of a binding quantitative restriction when trade policy is unrestricted a portion of the increase in pollution tax is transferred onto consumers of the polluting good. I find that all else being equal, any increase in the pollution tax also increases the nominal rate of protection (see the Appendix A.1 for an explanation). There are two instruments available to redistribute income to special interest groups: pollution and trade policy. An increase in pollution tax implies a loss in profits to the owners of polluting capital. To partially offset this loss, nominal protection on the polluting good is raised. However, this increase in nominal protection also transfers some of the incidence of pollution tax onto the consumers of the polluting good.

The rate of nominal protection on the polluting good when trade policy is unrestricted is

$$\frac{(p^2 - p^{2w})}{p^2} = \frac{1}{\kappa p^2}\left[\frac{\lambda n^l}{(1-n^l)+\lambda n^l}\pi_p^k \frac{\left[\pi_{tt}^k\right]}{\left[\pi_{pp}^k - x_p^2\right]} + n^l \pi_t^k \frac{\left[-\pi_{tp}^k\right]}{\left[\pi_{pp}^k - x_p^2\right]}\right]. \tag{16}$$

All else being equal the polluting good has higher nominal protection if a higher proportion is consumed by unorganized consumers ($\frac{\lambda n^l}{\left(1-n^l\right)+\lambda n^l}\pi_p^k$) and has lower protection if pollution produced (π_t^k) is higher.

The equality of nominal rates of protection, and pollution tax is summarized in the following proposition.

Proposition 3 *Assume both pollution tax and the level of trade policy (tariffs, or quantitative restrictions) are chosen endogenously. If the optimal tariff is not an import or an export subsidy, then i) the equilibrium pollution tax ($t^0 = t^m = t^\tau$) and ii)the nominal rate of protection ($\frac{\left(p^2 - p^{2w}\right)}{p^2}$) are constant across a tariff or quantitative restriction for good* 2*.*

Proof. Please see Appendix A.1. ■

In other words, tariffs and quotas are equivalent even when all policy is politically determined. Note that an important reason why tariffs and quantitative restrictions differ has been assumed away. In this model tariffs revenues and quota rents are distributed equally among the consumers of each regulated good. If quota rents are distributed differently than tariff revenues (for example to a group of importers, or to the producers of the polluting good (as under the US dairy quotas (Feenstra (1992)) equilibrium trade protection, and subsequently the equilibrium pollution tax would differ across tariffs and quantitative restrictions (see for an example, Maggi and Rodríguez-Claire (2000)).

5 Choosing Free Trade over Endogenously Determined Trade Policy

Now consider the choice of joining either a regional, or global multilateral trade agreement. If the country is small and has limited influence in setting the trade agreement's agenda, joining the trade agreement is similar to adopting exogenously determined trade policy.[11]

Consider such a small country facing accession to a trade agreement with the explicit goal of free trade. The benefit of accession is increased market access to other members of the trade agreement (modelled as a set of new goods prices). Before accession trade and pollution policy are endogenously chosen. After accession the government retains control over domestic pollution policy, but cannot have any barriers to international trade.

Using the results from previous sections, I evaluate the potential environmental policy, and welfare impacts of joining such a trade agreement.

Considering accession to the trade agreement requires minor adjustments to the analytical framework and notation. Accession to the agreement, or free trade is denoted as F. Trade policy under free trade is restricted. The possibility of accession adds another trade regime to the four listed in Section 2.3. Now the optimal trade regime $R \in \{R^{\tau\tau}, R^{\tau m}, R^{mm}, R^{m\tau}, F\}$, where in the first four regimes trade policy is endogenously determined. Superscript m denotes a variable in the pre-accession trade equilibrium (with endogenously chosen trade policy in the polluting good). Thus, t^m denotes pollution tax, z^m is level of pollution, W^{gm} is group welfare (where $g \in \{l, h, k\}$), W^m is aggregate welfare, G^m is government welfare, and finally p^{2m} is domestic price of the polluting good. These variables constitute the starting point from which free trade is adopted. Superscript F is also attached to all variables in free trade, t^F, z^F, W^{gF}, W^F, G^F are the corresponding levels in free trade. The world price for the polluting good available after accession is denoted p^{2F}. This price need not equal the world price (p^{2w}) available before accession. To isolate the impact of free trade from a change in the price of the polluting good, I assume that the non-polluting good has no trade barriers before accession, and also that its world price is constant before and after accession.

I first consider how the choice of free trade affects the pollution tax. To this end I compare two pollution tax schedules. The first is the tax schedule when trade

[11] Consider accession to the World Trade Organization as an example. During a period before accession, market access to current members, and rules for accession are negotiated. Further, most new policies are finalized only after negotiations with all members. Despite the World Trade Organization's democratic nature, it is well accepted that the bargaining power of small economies is considerably smaller than the larger economies. Also as there are currently 144 members of the World Trade Organization, a single small economy usually does not have considerable impact on the negotiated policy (please see http://www.wto.org for more details).

policy on the polluting good is endogenously determined (t^m). The second is the tax schedule under free trade (t^F).

Recall that both tax schedules (t^F and t^m) are determined in part by special interest contributions and are lower in value than the marginal social damage from pollution (see corollaries 1 and 2). Both special interest tax schedules diverge from marginal social damage by a ratio that reflects the government's trade off between special interest profits and aggregate welfare (see equations (11), (15) and (14)). This ratio divides the loss in aggregate special interest welfare from an increase in pollution tax by the weighted responsiveness of pollution to pollution tax. On adopting free trade both the loss in aggregate special interest welfare, and the responsiveness of pollution to pollution tax can change.

The loss in aggregate special interest welfare changes due to a change in the economic incidence of pollution tax. When trade policy is endogenously chosen, the producers of the polluting good can transfer some of the incidence of pollution tax onto their consumers (see discussion after equations (11), and (15)). When some of the polluting good is consumed by unorganized consumers the entire burden of pollution tax is not borne by special interests. Under free trade this transfer is no longer possible. The producers of pollution now bear the entire pollution tax. This change in incidence implies that the loss in special interest welfare from an increase in the pollution tax is at least as large under free trade than before.

A change in economic incidence is also responsible for an increase in the responsiveness of pollution to pollution tax. Under free trade the marginal burden from an increase in pollution tax on the producers of the polluting good is higher. A higher marginal burden causes a greater reduction in the output of pollution when pollution tax is raised. In other words the responsiveness of pollution to pollution tax increases in free trade. This increase in responsiveness when free trade is adopted is termed the *efficiency effect (of free trade)* (the pollution tax is now more efficient in reducing pollution).

When free trade is adopted the increase in special interest welfare losses exerts a downward pressure on pollution tax and increases its divergence from marginal social damage. Meanwhile, the efficiency effect, exerts an upwards pressure on pollution tax, decreasing its divergence from marginal social damage. Relative magnitudes determine whether a change in economic incidence causes pollution policy to move closer to, or further from, marginal social damage.

At a constant domestic price the pollution tax under free trade is closer to marginal social damage if

$$\frac{\left[\pi_t^k\right]}{\left[\pi_t^k + \left(\frac{\lambda}{\left(\left(1-n^l\right)+\lambda n^l\right)}\right)\pi_p^k \frac{dp^2}{dt}\right]} \leq \frac{\left[\pi_{tt}^k\right]}{\left[\pi_{tp}^k \frac{dp^2}{dt} + \pi_{tt}^k\right]}. \tag{17}$$

The left hand side of equation (17) is the ratio of special interest losses in free trade to those before accession. The right hand side is the corresponding ratio of pollution responsiveness (greater than one). If the ratio of special interest losses is smaller than the ratio of responsiveness the efficiency effect dominates.

Let $\varepsilon_{z,t} = \frac{-\pi^k_{tt} t}{\pi^k_{tt}}$ denote the partial equilibrium elasticity of pollution to pollution tax, and $\varepsilon_{y^2,t} = -\frac{\pi^k_{pt} t}{\pi^k_p}$ denote the partial equilibrium elasticity of polluting good output to pollution tax. Assume, for now, that the elasticity of pollution to pollution tax is higher than the elasticity of polluting good output to pollution tax ($\frac{\varepsilon_{z,t}}{\varepsilon_{y^2,t}} \geq 1$) and that the ratio of elasticities is constant. Under these conditions there exists a critical value for group l's consumption of the polluting good ($\tilde{\lambda} \in [0,1]$) at which the change in incidence has no impact on pollution tax when free trade is adopted. At this critical value the ratio of aggregate special interest losses equals the ratio of pollution responsiveness (equation (17) holds with equality). The critical value is

$$\tilde{\lambda} = \frac{\left(1 - n^l\right)}{\left(\frac{\varepsilon_{z,t}}{\varepsilon_{y^2,t}} - n^l\right)}. \quad (18)$$

Proposition 4 *Assume* $\frac{\varepsilon_{z,t}}{\varepsilon_{2,t}} \geq 1$ *and is constant, also assume that the domestic price of the polluting good is constant pre and post accession* ($p^{2m} = p^{2F}$)*. i) If* $\lambda > \tilde{\lambda}$, $t^* > t^m > t^F$ *. ii) If* $\lambda = \tilde{\lambda}$, $t^* > t^m = t^F$*. iii)Finally if* $\lambda < \tilde{\lambda}$, $t^* > t^F > t^m$

Proof. Please see Appendix A.1. ■

Assume a constant domestic price for the polluting good pre and post accession. If consumption of the polluting good by unorganized consumers is less than the critical value $\tilde{\lambda}$, the pollution tax under free trade is higher than the pollution tax before accession (the efficiency effect dominates). If consumption of the polluting good is greater than the critical level, the pollution tax under free trade is smaller than the pollution tax under quantitative restrictions. It is also further from marginal social damage (the change in special interest losses dominates). Finally, if consumption equals this critical level, the pollution tax under free trade equals the pollution tax before accession.

In other words, the proportion of polluting good consumed by unorganized individuals determines the overall impact of a change in economic incidence on pollution tax.

Now consider a special case where consumers in the unorganized group l do not consume the polluting good ($\lambda = 0$).[12] This case is useful to consider for a number of reasons. First, it allows us to isolate the efficiency effect of free trade on pollution policy. Second, it may also be realistic in modelling pollution generated in the modern manufacturing sector. A majority of the most pollution-intensive industries are intermediate good industries (see Hettige et al. (1992), (1995), and Stern et al. (1997) for evidence). If the intermediate input using industry is organized as a special

[12] Note that as the amount of polluting good consumed by an unorganized consumer tends to zero ($\lambda \to 0$) the condition in equation (17) necessarily holds true.

interest group the polluting good is not consumed by unorganized citizens.[13] Low, or negligible consumption of the polluting good by unorganized citizens is also realistic for some developing countries (like those in South Asia). In these countries the urban rich have significant influence in policy making. The urban rich also consume a majority of manufactured products. The unrepresented poor live a subsistence lifestyle, depend on mud and clay housing, subsistence agriculture, and have almost no demands on the modern manufacturing sector.

Corollary 3 *Assume a constant domestic price for good* 2, $p^{2F} = p^{2m}$. *If* $\lambda = 0$, *then* $t^* > t^F > t^m$.

Note that no restriction on production elasticities is required for the result in Corollary 3 to hold. If only organized interests produce and consume the polluting good ($\lambda = 0$) there is no change in aggregate special interest profits when free trade is adopted. Nevertheless, lobbying is altered due to an increase in the efficiency of pollution tax. Due to the increase in efficiency the government sets a higher pollution tax and reduces its divergence from the socially optimal rate (t^*).[14]

Next I establish conditions under which accession to the multilateral trade agreement brings about an increase in aggregate welfare.

Let $\tilde{p}^2$ denote the world price where the pollution tax under free trade equals the pollution tax prevailing before accession. Let $t^{F0}(.)$, and $t^{m0}(.)$ denote implicit functions derived from equations (14) and (15) respectively, $\tilde{p}^2$is formally defined by

$$t^{F0}\left(\tilde{p}^2\right) = t^{m0}\left(p^{2m}\right). \tag{19}$$

Assume that pollution tax under free trade rises when the price of the polluting good rises, formally $\frac{d}{dp^2} t^{F0}\left(p^2\right) \geq 0$. Under these conditions

$$p^{2w} \geq \tilde{p}^2 \Rightarrow t^F \geq t^m. \tag{20}$$

In other words, if the world price for the polluting good is higher than the price where pollution taxes are equal, the pollution tax in free trade is higher.

Lemma 4 *If* $\lambda = 0$, *then* $\tilde{p}^2 < p^{2m}$

Lemma 4 states, if unorganized consumers do not consume the polluting good, the price where pollution taxes are equal is lower than the domestic price before accession. This result derives from Corollary 3 which shows that at a constant price for the polluting good, when $\lambda = 0$, pollution tax in free trade is higher than the pollution

[13]With a pure intermediate good, $\lambda = 0$. A solution for this model with an intermediate good can be requested from the author.

[14]For other analyses also incorporate a change in the incidence of pollution policy from free trade see McAusland (2002) and Yu (1999). However, both McAusland (2002) and Yu (1999) only highlight the effect of changing special interest losses from adopting free trade.

tax before accession. This implies that a reduction in the price after accession below the price before accession lowers the pollution tax ($\frac{d}{dp^2} t_F^0 (p^2) \geq 0$) and brings it closer to that before accession.

Using the notation above, I present the following proposition.

Proposition 5 *If $\lambda = 0$, $p^{2F} \geq \tilde{p}^2$, and accession ($R = F$) satisfies equilibrium conditions C1-C4 from Proposition 1 then $W^F \geq W^m$.*

Proof. Please see Appendix A.1. ■

The conditions $\lambda = 0$ and $p^{2F} \geq \tilde{p}^2$ are sufficient to guarantee that aggregate welfare (W) increases when the government chooses free trade. When unorganized consumption of the polluting good is zero, and the post accession price ensures a higher pollution tax, a country with endogenous but incomplete environmental policy gains aggregate welfare from the adoption of free trade.

While the formal proof to Proposition 5 is somewhat tedious (see Appendix A.1) the basic intuition is quite simple. When the pollution tax after accession is higher than that before accession, pollution tax revenues rise faster than the increase in the pollution externality. This implies that if unorganized consumers do not consume the polluting good, their welfare rises as free trade is adopted. Under these conditions a decline in aggregate welfare from adopting free trade has to derive from a decline in aggregate special interest welfare. It also implies that this decline in aggregate special interest welfare is larger than the gain in unorganized group welfare. However, a decline in aggregate special interest welfare of this magnitude ensures that special interest contributions are too small to induce a move to free trade.

To relate this result to domestic prices note that when unorganized members of society do not consume the polluting good ($\lambda = 0$) the domestic price pre accession is greater than the price where pollution taxes are equal ($p^{2m} \geq \tilde{p}^2$, see lemma 4). This implies that the condition that the post accession world price is higher than pre accession domestic price also ensures a higher pollution tax post accession (as $p^{2F} \geq p^{2m} \geq \tilde{p}^2$). In other words a sufficient condition for a gain in aggregate welfare from adopting free trade is that the domestic price for the polluting good rises after adoption. This implies that even though the economy might export the polluting good, aggregate welfare can rise as free trade is adopted.

6 Conclusion

Some earlier studies predict a decline in welfare from adopting free trade in the presence of a domestic policy distortion. These studies assume distortions are exogenously given and do not allow any policy response to rising social damages from free trade. They also do not specify a mechanism for the choice of free trade. This results in a somewhat unrealistic scenario; the economy losing welfare from free trade cannot choose to stay in economic isolation.

In this paper I present a comprehensive analysis of the interaction between international trade and environmental policy. Building on the assumption of special interest politics all trade and pollution policy distortions are endogenized. A mechanism for the choice of free trade is also specified. I present plausible conditions where the choice of free trade improves pollution policy and brings about an increase in aggregate welfare.

The improvement in welfare and pollution policy comes from a change in the incidence of pollution tax. A change in incidence in pollution tax occurs when a countries ability to influence the domestic price of the polluting good falls as free trade is adopted. In this paper I consider the case of a small country. A small country has no ability to influence domestic prices once free trade is adopted. However, this assumption is not necessary for the results presented in the paper. Greater competition and larger markets in free trade reduce the ability to influence domestic prices even for large countries. [15]

However, one needs to interpret the above results with caution. The proportion of polluting good consumed by unorganized agents determines whether pollution policy improves or deteriorates once free trade is adopted. This implies that an understanding of the type of good is important before one draws any conclusions from this research.

Future research can extend this paper in both theoretical, and empirical directions. One of the reasons why quantitative restrictions are chosen over tariffs is because special interests gain a larger share of quantitative restriction rents (see Maggi and Rodríguez-Claire (2000)). An interesting extension would be to see how different distributions of rents from quantitative restriction influence environmental policy in a tariff, or quantitative restrictions equilibrium.

There are a few empirical hypotheses that derive from this paper. *Ceteris paribus*, countries trading pollution intensive goods should have more stringent environmental regulation than countries that impose barriers on the trade of such goods. Another empirical hypothesis is, *ceteris paribus*, if among two goods one has greater exogenous tariff protection, that good will also have a higher pollution tax.

[15] There is only one extreme case where these results are not valid, when the country analyzed is the sole producer and consumer of the polluting good. In this case the country has the same influence on domestic prices before and after free trade is adopted.

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A Appendix

A.1 Proofs

Proof to Corollary 1

The denominator of the second term in equation (11) is positive. Given that n^l and λ are positive and less than 1 the following holds true

$$n^l \left[\pi_t^k + \pi_p^k \frac{dp^2}{dt} \right] \geq \left[n^l \pi_t^k + \frac{\lambda n^l}{\left(1 + n^l \left(\lambda - 1\right)\right)} \pi_p^k \frac{dp^2}{dt} \right].$$

Note that $\left[\pi_t^k + \pi_p^k \frac{dp^2}{dt} \right]$ is the change in polluting industry profits from an increase in pollution tax. In other words, a decline in polluting industry profits when the pollution tax is raised is sufficient for the numerator of the second term in equation (11) to be negative.

Proof to Proposition 2

The pollution tax from equation (12) is expressed as a fixed point problem

$$t = f\left(p^2, t\right) + g\left(p^2, t; \lambda\right). \tag{21}$$

>From equation (21) I obtain

$$\frac{dt}{dp^2} = \frac{[f_p + g_p]}{[1 - f_t - g_t]} \tag{22}$$

and

$$\frac{d\left[t-f\left(.\right)\right]}{dp^{2}}=\frac{\left[g_{p}\left(1-f_{t}\right)+f_{p}g_{t}\right]}{\left[1-f_{t}-g_{t}\right]}. \tag{23}$$

The function

$$f\left(p^{2},t\right)=v_{z}\left(-\pi_{t}^{k}\left(p^{2},t\right)\right).$$

Partial derivatives are

$$\begin{aligned} f_{p} &= v_{zz}\left[-\pi_{tp}^{k}\right]>0 \\ f_{t} &= v_{zz}\left[-\pi_{tt}^{k}\right]<0. \end{aligned}$$

The function

$$g\left(p^{2},t;\lambda\right)=\frac{1}{\left[\left(1-n^{l}\right)+a\right]\left[\pi_{tt}^{k}\right]}\left[n^{l}\pi_{t}^{k}+\left(\frac{\left(1-n^{l}\right)}{\left(1-n^{l}+\lambda n^{l}\right)}+a\right)\left(p^{2}-p^{2w}\right)\left[-\pi_{pt}^{k}\right]\right].$$

Assume third order derivatives equal zero. Partial derivatives are

$$g_{p} = \frac{\left[\frac{\left(1-n^{l}\right)}{\left(1-n^{l}\right)+\lambda n^{l}}+a\right]}{\left[\left(1-n^{l}\right)+a\right]}\frac{\left[-\pi_{tp}^{k}\right]}{\left[\pi_{tt}^{k}\right]} \tag{24}$$

$$g_{t} = \frac{n^{l}}{\left(1-n^{l}\right)+a}. \tag{25}$$

A sufficient condition for $g_p \geq 0$ for all λ is $a \geq \left(2n^l - 1\right)$. Further $\forall a \geq \left(2n^l - 1\right)$, $g_t \leq 1$. This implies that $[f_p + g_p] \geq 0$ and $[1 - f_t - g_t] \geq 0$. Thus

$$\forall a\in\left\{a:a\geq\left(2n^{l}-1\right)\right\}:\frac{dt}{dp^{2}}\geq 0\,\&\,\frac{d\left[t-f\left(.\right)\right]}{dp^{2}}\geq 0.$$

Rates of nominal protection when trade policy is unrestricted and proof to Proposition 3.

First consider an endogenously determined quantitative restriction ($\bar{m}$) on the polluting good. Let $\theta^2\left(p^2\right) = \frac{\pi_p^k}{\bar{m}^2}$ denote the ratio of domestic production to imports, and $e^2\left(p^2\right) = \frac{-\left[x_p^2\left(p^2\right)-\pi_{pp}^k\right]p^2}{x^2\left(p^2\right)-\pi_p^k}$ denote the elasticity of import demand for the polluting good. The nominal rate of protection for the polluting good (derived using equation (7)) is

$$\frac{\left(p^{2}-p^{2w}\right)}{p^{2}}=\frac{1}{\kappa}\left[\frac{\lambda n^{l}}{\left(1-n^{l}\right)+\lambda n^{l}}\left[\frac{\theta^{2}}{e^{2}}\right]+\left[\left(1-n^{l}\right)+a\right]\frac{\left[-\pi_{tp}^{k}\right]}{\left[\pi_{pp}^{k}-x_{p}^{2}\right]p^{2}}\left[t-v_{z}\right]\right], \tag{26}$$

where $\kappa = \left[\frac{\left(1-n^l\right)}{\left(1-n^l\right)+\lambda n^l} + a\right]$. All else being equal the polluting good has higher nominal protection if: it has a lower elasticity of imports, a higher proportion of domestic production to imports, and a higher proportion is consumed by unorganized consumers. It also has a higher nominal rate of protection if the tax rate on pollution is higher.

Now consider the case of an endogenously determined tariff (τ^2) on the polluting good. Let $m^2(p^2) = x^2(p^2) - \pi_p^k$ denote imports of the non polluting good, let $\phi^2(p^2) = \frac{\pi_p^k}{m^2(p^2)}$ denote the ratio of domestic production to imports, and $e^2(p^2) = \frac{[-m_p^2(p^2)]p^2}{m^2(p^2)}$ denote the elasticity of import demand for the non polluting good. The nominal rate of protection for the polluting good (derived using equation (8)) is

$$\frac{(p^2 - p^{2w})}{p^2} = \frac{1}{\kappa}\left[\frac{\lambda n^l}{(1-n^l)+\lambda n^l}\left[\frac{\phi^2}{e^2}\right] + \left[(1-n^l)+a\right]\frac{-\pi_{tp}^k}{\left[\pi_{pp}^k - x_p^2\right]p^2}\left[t - v_z\right]\right]. \quad (27)$$

The nominal rate of protection of the polluting good is equal to that under an endogenously chosen quantitative restriction (compare equations (27) and (26)). All else being equal, the polluting good has higher nominal protection if: it has a lower elasticity of imports, a higher proportion of domestic production to imports, and a higher proportion is consumed by unorganized consumers. It also has a higher nominal rate of protection if the tax rate on pollution is higher. Both equations (26) and (27) also demonstrate the use of tariffs as a second-best tool. Tariffs are used to correct for the environmental externality. If the pollution tax for the polluting good is less than marginal social damage, nominal protection for the polluting good is reduced. However if pollution tax is greater than marginal social damage, nominal protection is increased.

When quantitative restrictions are chosen as the optimal trade policy the pollution tax is determined by equation (11). When a tariff is implemented for the polluting good the pollution tax is determined by equation (12). For the case of a tariff substitute equilibrium tariff protection (from equation (27)) into equation (12) to obtain

$$t^\tau = v_z(z) + \frac{n^l\pi_t^k + \frac{\lambda n^l}{(1-n^l+\lambda n^l)}\pi_p^k\frac{\left[-\pi_{tp}^k\right]}{\left[\pi_{pp}^k - x_p^2\right]}}{((1-n^l)+a)\left[\pi_{tt}^k - \frac{\left[\pi_{tp}^k\right]^2}{\left[\pi_{pp}^k - x_p^2\right]}\right]}. \quad (28)$$

The tax rate on pollution under an optimally chosen tariff is the same as that under an optimally chosen quantitative restriction (as the nominal rates of protection are also equal).

Proof to Proposition 4

Assuming a fixed price p^2 three fixed point solutions are graphed in t space (see Figure 1). These are $t^* = \xi(p^2, t^*)$, $t^F = \Theta(p^2, t^F)$, and $t^m = \zeta(p^2, t^m)$, where

$$\xi(p^2, t^*) = v_z\left(-\pi_t^k(p^2, t^*)\right),$$

$$\Theta(p^2, t^F) = v_z\left(-\pi_t^k(p^2, t^F)\right) + \frac{n^l}{((1-n^l)+a)}\left[\frac{\pi_t^k(p^2, t^F)}{\pi_{tt}^k(p^2, t^F)}\right],$$

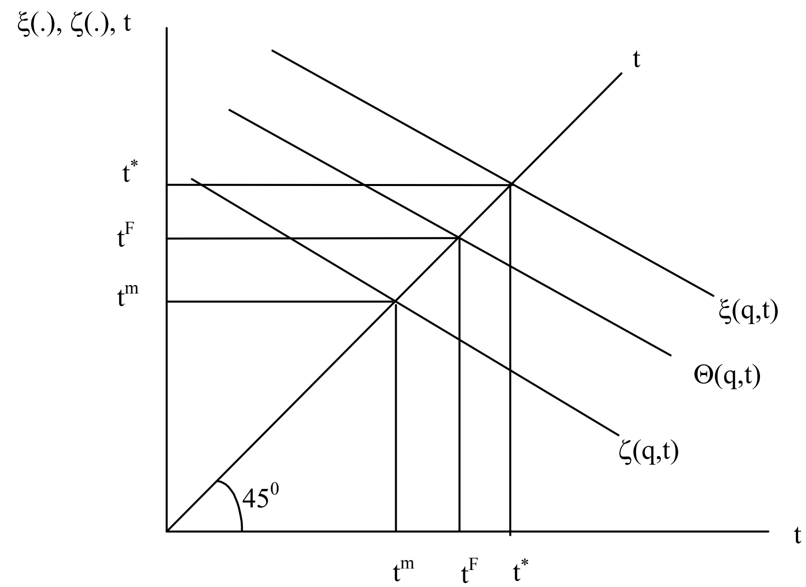

Figure 1: Comparing Tax Schedules

and

$$\zeta\left(p^2,t^m\right)=v_z\left(-\pi_t^k\left(p^2,t^m\right)\right)+\frac{n^l\pi_t^k\left(p^2,t^m\right)+\frac{\lambda n^l}{\left(1-n^l+\lambda n^l\right)}\pi_p^k\left(p^2,t^m\right)\frac{dp^2}{dt}}{\left(\left(1-n^l\right)+a\right)\left[\pi_{tp}^k\left(p^2,t^m\right)\frac{dp^2}{dt}+\pi_{tt}^k\left(p^2,t^m\right)\right]}.$$

I illustrate the logic of the proof for case iii). Cases i) and ii) can be proved similarly. If $\lambda<\tilde{\lambda}$, at constant prices (p^2,t) the following relationship holds true: $\xi\left(p^2,t\right)>\Theta\left(p^2,t\right)>\zeta\left(p^2,t\right)$, in other words, at every t $\xi\left(.\right)$ lies above $\Theta\left(.\right)$ which lies above $\zeta\left(.\right)$. Second order conditions guarantee that the curves intersect the 45^0 line t from above.[16] When $\lambda<\tilde{\lambda}$ Figure 1 illustrates the relation between the three tax rates.

Proof to Proposition 5.

This proof requires a series of lemmas before the main proof. I list them all below.

Lemma 5 *If* $p^{2F}\geq\tilde{p}^2$, $\left[t^Fz^F-v\left(z^F\right)\right]-\left[t^mz^m-v\left(z^m\right)\right]\geq0$.

Proof. Convexity of $v\left(.\right)$ implies

$$\left[v\left(z^m\right)-v\left(z^F\right)\right]\geq v_z\left(z^F\right)\left[z^m-z^F\right].$$

Corollary 2 shows that $v_z\left(z^F\right)\geq t^F$. Thus

$$\left[v\left(z^m\right)-v\left(z^F\right)\right]\geq t^F\left[z^m-z^F\right].$$

[16] In addition to the second order conditions we can verify that $\frac{d}{dt}\left[\xi\left(p_2,t\right)\right]=-\pi_{tt}^kv_{zz}<0$, thus all three curves are downward sloping as drawn in the graph.

Given that $t^F \geq t^m$

$$\left[v\left(z^m\right) - v\left(z^F\right)\right] \geq t^m z^m - t^F z^F,$$

which can be re-arranged to yield

$$\left[t^F z^F - v\left(z^F\right)\right] - \left[t^m z^m - v\left(z^m\right)\right] \geq 0.$$

■

Which implies that

Corollary 4 *If* $\lambda = 0$ & $p^{2F} \geq \tilde{p}^2; W^{lF} - W^{lm} \geq 0$

Which further implies that

Corollary 5 *If* $\lambda = 0$ *and* $p^{2F} \geq \tilde{p}^2; W^F - W^m < 0 \Longrightarrow \sum_{j \in \{h,k\}} \left[W^{jF} - W^{jm}\right] < 0.$

Another lemma used in the proof is

Lemma 6 *Without any loss in generality assume that special interest group* $\sigma \in \{h, k\}$ *prefers the quantitative restrictions equilibrium to free trade. Group* σ*'s contribution schedule must satisfy*

$$\left[W^{\sigma m} - W^{\sigma F}\right] \geq \left[C^{\sigma m} - C^{\sigma F}\right] \geq 0. \tag{29}$$

And then the final proof for Proposition 5.

Proof. This proof shows that when $\lambda = 0$ and $p^{2F} \geq \tilde{p}^2$, an improvement in aggregate welfare ($W^F - W^m \geq 0$) is a necessary condition for the governments choice of free trade.

Recall that free trade is the government's equilibrium choice if and only if it satisfies conditions C1-C4 from Proposition 1. Now assume that $W^F - W^m < 0$. From Corollary 5 this implies $\sum_{j \in J} \left[W^{jF} - W^{jm}\right] < 0$. If total special interest welfare declines in free trade at least one special interest group must prefer the quantitative restrictions equilibrium to free trade. Further, the total welfare losses for this group have to be larger than the gains from free trade. In this setup there are only two lobby groups, $J = \{h, k\}$ which provides two possibilities.

1. In the first possibility welfare in free trade is lower for both lobby groups. Thus $\left[W^{jF} - W^{jm}\right] < 0, \forall j \in J$. From equation (29) this requires that $\left[C^{jF} - C^{jm}\right] \leq 0, \forall j$. For a lobby group $\sigma \in J$, condition C3 from Proposition 1 implies

$$\left[W^{\sigma F} - W^{\sigma m}\right] \geq -a\left[W^F - W^m\right] - \left[C^{iF} - C^{im}\right], i \in J \& i \neq \sigma. \tag{30}$$

The condition in equation (30) cannot hold under the above conditions. The term on the left hand side is negative (group σ loses welfare from free trade), and both terms on the right hand side are positive.

2. In the second possibility one group (σ) loses welfare, and the other group ($i \in J \& i \neq \sigma$) gains welfare from the adoption of free trade. However for $\sum_{j \in J} \left[W^{jF} - W^{jm}\right] < 0$ to hold the losses to group σ have to be larger than the gains for group i. Thus

$$\left[W^{\sigma F} - W^{\sigma m}\right] < -\left[W^{iF} - W^{im}\right] \leq -\left[C^{iF} - C^{im}\right] \tag{31}$$

where the second inequality results from substituting the preference for free trade for group i from Lemma 5. Even in this case for group σ, condition C3 from Proposition 1 (see equation (30)) cannot hold. The left hand side of equation (30) is still negative, and the first term in the right hand side ($-a\left[W^F - W^m\right]$) is still positive by assumption. The second term on the right hand side ($-\left[C^{iF} - C^{im}\right]$) is negative but is larger than the left hand side (see equation (31)).

When $\lambda = 0$, and $p^{2F} \geq \tilde{p}^2$ a decline in aggregate welfare from choosing free trade implies that free trade cannot be an equilibrium trade regime. Thus, if free trade was chosen aggregate welfare must have improved upon choosing it. ■