National Treatment and the Optimal Regulation of Environmental Externalities

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Abstract

New forms of protection like product standards have emerged as a contentious issue in the WTO. Unlike conventional barriers, there are legitimate reasons for countries to adopt environmental product standards such as auto emission standards. In this paper we formally analyze the role of National Treatment in the regulation of environmental product standards for an open economy. Using a general equilibrium model where a welfare maximizing government uses product standards to control emissions from the consumption of a traded good, we show that in general optimal standards on foreign and domestic firms are not likely to be equal. In particular, whether National Treatment of standards interferes with welfare maximizing policy depends on the set of instruments available with the policy maker. If an emissions tax is available, National Treatment need not alter the optimal outcome. However if the emissions tax is unavailable and the government is restricted to using a consumption tax, differences in the cost of complying with the standard can result in policy that violates National Treatment. Through our analysis we also highlight the asymmetric incidence of the domestic and import product standards. We find that if either the emissions or consumption tax is suboptimal then only the import standard can be used as a second-best instrument to correct consumption. In this case we find that irrespective of the cost of compliance, it is possible that welfare maximizing policy violates National Treatment.

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1. Introduction

Much of the opposition to multilateral bodies like the World Trade Organization (WTO) comes from a fear of losing sovereignty over internal matters such as environmental regulation and labor standards. While some of this fear is related to the 'race to the bottom' hypothesis,[1] there is also a concern that multilateral organizations explicitly constrain domestic policy.

The main WTO provision influencing domestic policy is the non-discrimination principle of 'National Treatment.' Broadly speaking, *National Treatment* requires imported and domestically produced goods, services, trademarks, copyrights and patents to be treated equally after they have entered the market. This principle is one of the main defining features of the WTO and is found in all the three main WTO agreements (Article 3 of GATT, Article 17 of GATS and Article 3 of TRIPS). National Treatment is also a central and rigid principle in most other trade agreements (for example, chapter 3 in NAFTA and chapter 3 in the US Australia Free Trade agreement).

Does National Treatment affect a government's ability to optimally regulate externalities affecting the environment?

In this paper we take a systematic look at the welfare implications of observing National Treatment for a small open economy governed by a welfare maximizing social planner. Pollution is created as a by product of consuming a traded good and the per-unit emissions intensity of consumption is determined during the production of this good. We define an *environmental product standard* as an attribute chosen during production that

[1] The *race to the bottom hypothesis*: a belief that as countries lower trade barriers governments will be forced to weaken environmental and labor regulation to remain globally competitive.

determines the per-unit emissions intensity of the good.[2] Examples are: fuel efficiency standards, Genetically Modified Organism (GMO) standards, and others in the Sanitary and Phytosanitary measures agreement of the WTO. The government maximizes aggregate welfare using the following: an emissions tax borne by consumers, a consumption tax, and product standards on imported and domestically produced goods. National Treatment requires that the government mandated import standard be no higher than the domestic standard.

The first best way to regulate pollution is to use an emissions tax borne by consumers. The optimal welfare maximizing emissions tax does not depend on the origin of the good and the government does not mandate product standards. In this case we find that National Treatment does not prevent implementation of the first best.

However, while regulating consumption generated externalities often emission taxes are not feasible.[3] In this case, a combination of policy instruments including a tax on consumption and government mandated import and domestic product standards can achieve first best. Optimal policy equalizes the cost of reducing pollution reduction across all sectors and optimal product standards depend on relative compliance costs. If importers (or foreign producers) have a lower cost of complying with the standard, their optimal standard is more stringent than the domestic standard. While this policy maximizes social welfare and does not provide an unfair advantage to domestic producers, it violates National Treatment.[4] In other words, observing National Treatment can create welfare losses.

[2] We consider standards which correct an externality in the country where products are consumed and those that the market does not provide efficiently. Thus we do not discuss process standards (restrictions on inputs or the methods of production). In most cases a process standard does not correct an externality in the country that the good is consumed. Secondly, the World Trade Organization does not admit process standards.

[3] We discuss the reasons for this later in the paper.

[4] On the other hand, if the cost of compliance for the domestic producer is lower or equal to that of the importer, the domestic standard is at least as high as the import standard. This does not violate National treatment. This

More generally we consider the case where either the emissions or consumption tax is sub-optimal. This is fairly common while regulating consumption related pollution. Numerous and widely dispersed consumers generating pollution are costly to regulate. In addition, technical or political reasons can prevent governments from taxing consumption optimally. For this more general second best situation, we find that any policy which relies on environmental product standards without first best emissions/consumption taxes in place requires that the stringency of the environmental product standard vary with the compliance cost of the firm. A National Treatment rule limits the extent to which the stringency of the standard can vary across firms, and hence impedes the implementation of efficient policies.

While analyzing this general second-best case we also highlight the asymmetric incidence of import and domestic standards. In a small open economy, consumer prices are only affected by import standards. Thus in the presence of a sub-optimal emission or consumption tax only the import standard is an effective policy substitute. This implies that even if the cost of compliance for the domestic producer is equal to that of the importer, the second-best efficient policy requires a higher standard on imports. Thus, in this more general second-best case, it is even more likely that National Treatment imposes welfare losses.

The main contribution of this paper is to analyze the welfare costs of National Treatment in the context of regulating consumption generated environmental externalities. It shows that in the presence of international trade, even if we have all the necessary cost information,[5] the existence of a National Treatment rule can prevent the implementation of least cost policy. We believe that such an analysis is important on its own. It allows policy

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rationale for setting unequal standards due to differences in costs of compliance has been recognized earlier in the environmental economics literature (see for example Cropper and Oates, 1992).

[5] It is well know that if the cost of compliance is unknown to the regulator, environmental standards are not set at cost minimizing levels. In our paper the regulator knows the cost of compliance for all regulated agents.

makers to fully understand the costs and benefits of National Treatment and explore future modifications to such an important rule.

The other contribution is to highlight the asymmetric incidence of environmental product standards in a small open economy.[6] If the consumer based tax is suboptimal, welfare maximizing policy (solely due to this asymmetry and no protectionist motives) is likely to violate National Treatment. As there are several plausible technological reasons why consumer based taxes might be sub-optimal, it is likely that in the case of consumer generated pollution externalities the imposition of National Treatment creates welfare losses.

Much of the existing literature on National Treatment looks at the role of the non-discrimination principle in reducing the use of domestic policy for protectionism and increasing efficiency in trade agreements (Horn, 2006 and Battigalli and Maggi, 2003).[7] In this paper we abstract away from the use of domestic instruments for protectionism. However, despite this abstraction we believe our analysis is relevant in the context of trade agreements. Bagwell and Staiger (2001) argue that if countries negotiate market access rather than trade policies, the incentive to use domestic policies for protectionist motives disappears. Thus in the context of trade agreements where countries negotiate market access, our analysis shows that a rule like National Treatment is likely to reduce and not increase their efficiency.[8]

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[6] Even in a large open economy, the two standards have an asymmetric incidence. The import standard directly affects consumer prices and the terms of trade, while the domestic standard affects domestic producer prices and indirectly affects consumer prices through the terms of trade effect. Such an analysis is outside this papers scope.

[7] In that context, it is possible that despite the costs of observing National Treatment, the rule can reduce the use of domestic policy for protectionism and increase the efficiency of a trade agreement.

[8] Bagwell and Staiger (2001) also argue that in principle the ability of WTO members to bring 'non-violation,' complaints makes the WTO function like an agreement where members negotiate market access through tariff negotiations. They conclude that if this ability is strengthened and expanded, countries should be granted more rather than less sovereignty over their domestic policies to increase the benefits of the WTO. Our analysis supports such a conclusion.

This analysis is also related to the literature studying environmental product standards in international trade. Most of this theoretical literature does not focus on the use of a standard to correct market failures, and instead focuses on imperfectly competitive models where the standard is mandated for purely protectionist reasons (see for example, Fischer and Serra, 2000, Copeland, 2001, Ganslandt and Markusen, 2001, and McAusland, 2004).[9] In these papers the government employs standards to transfer rents from the foreign to the domestic firm. This is similar to the raising rival's costs hypothesis presented by Maloney and McCormick (1982), and Salop and Scheffman (1983). In this paper, we restrict the analysis to perfect competition and as mentioned earlier, abstract away from protectionist motives for employing environmental product standards. Our aim is solely to highlight the cases where National Treatment is not welfare maximizing.

In Section 2 we outline the model of a small open economy with environmental product standards. In Section 3 we derive the optimal pollution policy for a small open economy including emissions or consumptions taxes and environmental product standards. In the same section we also discuss the implications of National Treatment. We conclude in Section 4.

2. Modeling Standards

We consider a two good (good 1 and 2) small open economy with perfectly competitive markets where good 2 is the numeraire. Production of the 'raw' good 1 (y_r) uses labor (l) and capital (k).[10] The domestic price for the raw product is denoted by *p*. Consumption of

[9] While Copeland (2001) Fischer and Serra (2000) include environmental externalities in their papers; their focus is mainly on the protectionist use of product standards.
[10] By *raw* we imply a good that has not been altered to influence its per-unit emissions intensity from consumption.

good 1 creates emissions which adversely affect utility. Domestic producers and importers can alter the per-unit emissions intensity of consumption by adopting a costly technology.[11] We index this technology by a *product standard* $\tau \in [0, T]$ where 0 is the minimum and T is the maximum standard possible. Similar to Battigalli and Maggi (2003), we posit the overall domestic production function (including the standardization process) to be $A(\tau) f(l,k)$ with $A = 1/(1+\phi(\tau))$, where $\phi(\tau)$ can be interpreted as the cost of meeting standard τ.[12] Domestic output of finished good 1 (y_1) is given as:

$$y_1 = \frac{f(l,k)}{1+\phi(\tau)}, \qquad (1)$$

where $f(.)$ is twice differentiable, homogenous of degree one and concave in its inputs and $\phi(.)$ is increasing and convex with $\phi(0) = 0$.[13]

Let m_r denote raw imports of the good 1. The world price for the 'raw' product is denoted p^*. Correspondingly, finished imports that are sold in the domestic market (m_1) are:

$$m_1 = \frac{m_r}{1+\phi^*(\tau^*)}, \qquad (2)$$

[11] Most goods that generate pollution on consumption share this property. Some examples are: the fuel efficiency of a vehicle determines carbon dioxide and other emissions per mile driven. The choice of material used during production determines the toxicity of household waste. Sulphur content in coal is directly related to sulphur dioxide emissions from coal fired power plants (Carlson et. al., 2000) and the sulphur content of diesel determines vehicular particulate matter, and sulphur dioxide emissions (Wahlin et. al., 2001).

[12] In Battigalli and Maggi (2003) the production function for the standardized output is given as $y = A(e)F(l,k)$ where e is the emissions intensity of the product. In their model a higher emissions intensity implies that the good is dirtier and thus cheaper to make (i.e. $A' > 0$). In our specification, we use the standard (the inverse of the emissions intensity) as an argument in the production function. Thus in our specification $A' < 0$.

[13] This final assumption disallows any economies of scale from fixed costs consistent with our assumption that the market for good 1 is perfectly competitive.

where the cost for meeting the standard on the imported good is $\phi^*\left(\tau^*\right)$ (also increasing and convex in the import standard $\tau^* \in \left[0,T\right]$ with $\phi^*(0)=0$). Note that this cost function ($\phi^*\left(.\right)$) need not be the same as that on domestically produced goods.

Given our modeling framework any difference in the cost of meeting standards derives from differences in technology across competitors (here domestic producers and importers).[14] Consider some examples of such differences. Due to its development of a new kind of gasoline (EC-X), ARCO, a leading gasoline refiner in California, provided cleaner gasoline (with low levels of carbon monoxide and ozone precursor emissions) at a lower cost than its competitors (Innes and Bial, 2002). Due to its development of hydroflurocarbons (HFCs), DuPont provided a substitute for ozone depleting chloroflurocarbons (CFCs) at a lower cost than its competitors (Oye and Maxwell, 1994).[15]

We now formally define a 'cost advantage' in meeting the standard.

Definition 1. *(i) The domestic industry has a cost advantage at meeting the standard if* $\phi_\tau\left(\tau^{'}\right) < \phi^*_{\tau^*}\left(\tau^{'}\right),\ \forall\, \tau^{'} \in (0,T]$. *(ii) The domestic industry has a cost disadvantage at meeting the standard if* $\phi_\tau\left(\tau^{'}\right) > \phi^*_{\tau^*}\left(\tau^{'}\right),\ \forall\, \tau^{'} \in (0,T]$. *(iii) Domestic producers and importers are equally efficient at meeting the standard if* $\phi_\tau\left(\tau^{'}\right) = \phi^*_{\tau^*}\left(\tau^{'}\right),\ \forall\, \tau^{'} \in [0,T]$.

[14] The cost of meeting the import standard can derive from a single country employing a different technology in meeting the standard. Or alternatively, the cost of meeting the import standard could represent an average of the cost of meeting this standard across a set of countries exporting to the domestic market. Given our assumption of a small open economy, the origin of the imported good is not crucial.

[15] It is important to note that a difference in the cost of compliance can also derive from a difference in endowment. For example, coal producers in the western United States have an endowment of coal that has a lower sulphur content than the endowment of their counterparts in the mid-western region. This difference in endowment allows western coal producers to provide coal that produces lower sulhpur dioxide emissions at a lower price than their competitors (Carlson et. al, 2000). We do not explicitly model the difference in endowments in this paper, however the main intuition presented here carries over even in that case.

The domestic industry has a cost advantage at meeting the standard if its marginal cost of meeting any feasible standard is lower than that for the importers. The opposite holds true when importers have a cost advantage. An equal marginal cost for any feasible standard implies that domestic producers and importers are equally efficient.[16]

Total emissions (Z) from consumption of good 1 are given by,

$$Z = (T - \tau^{*})m_1 + (T - \tau)y_1, \tag{3}$$

where m_1 and y_1 denote the imports and domestic production of the finished good 1 respectively. Equation (3) implies that at zero standards, the emissions from imports and the home produced good are equal (to T). Further, the equation also implies that a standard identically and linearly reduces the emission intensity for both imports and domestic production.

2.1. Policy Instruments

In order to control emissions from the consumption of good 1 the government has the following instruments available: an emissions tax (t), a consumption tax (α), a domestic (τ) and an import standard (τ^{*}).

2.2. General Equilibrium

The revenue function in the economy is given by:

$$R(p,1) = \tilde{R}(p,1,\bar{K},\bar{L}), \tag{4}$$

where p is the relative price for the raw non-numeraire good. $\bar{K}$ and $\bar{L}$ represent the economy wide endowments of capital and labor respectively. The revenue function is convex and homogeneous of degree 1 in output prices. Assuming the economy wide endowments of

[16] Since both cost functions start at the origin and are strictly increasing and convex this definition is complete. That is, all cost functions in our feasible set can be classified using this definition.

labor and capital to be fixed, the revenue function can be expressed only as a function of the effective producer prices of the two goods. By Hotelling's lemma, the domestic output supply function for the finished good 1 is:

$$y_1 = \frac{R_p}{1+\phi(\tau)}, \tag{5}$$

where R_p represents the derivative of the revenue functions with respect to the price of good 1.

The demand side of the economy is represented by the expenditure function.

$$E(q,1,u,Z), \tag{6}$$

where q is the domestic consumer price for the finished non-numeraire good (to be defined later). The arguments of the expenditure function are the consumer prices (of good 1 and 2), utility and because of the externality, the aggregate level of emissions.[17] The expenditure function satisfies the standard properties; $E_q > 0$, $E_u > 0$ and $E_z > 0$. The derivative of the expenditure function with respect to the i$^{\text{th}}$ price gives the demand for the i$^{\text{th}}$ good. Furthermore $E_{ii} < 0$ assuming demand curve to be downward sloping.

General equilibrium of this small open economy is given by the equality of expenditure and revenue in the economy (Dixit and Norman 1980).

$$R(p,1) + g = E(q,1,u,Z) \tag{7}$$

Where g is government revenue from the tax employed (either emissions, or consumption tax).

[17] Since the social welfare depends on aggregate emissions, Z enters the expenditure function as an argument. Higher emissions imply that a higher expenditure is required to attain the same level of utility.

3. Optimal Policy

In this section we present the optimal policy required to regulate the consumption externality. This policy consists of a consumption based tax (either on emissions, or on consumption), and environmental product standards on domestic production and imports. Optimal standards depend on the type of tax paid by consumers (either an emissions or a consumption tax), and whether this tax is set optimally. In what follows we first derive optimal standards (import and domestic) for three plausible scenarios and evaluate whether these standards violate National Treatment.

3.1. In the Presence of an Emissions Tax

Without loss of generality let the world price of the raw product be normalized to 1 ($p^* = 1$). Since the importing country is small, and markets are perfectly competitive, the consumer price given positive imports and an import standard τ^* is $q = 1 + \phi^*(\tau^*)$.[18] Once the government imposes a per unit emissions tax (t), consuming one unit of the imported good implies a tax burden of $t(T - \tau^*)$. Now the effective consumer price for one unit of the imported good (q^t) is:

$$q^t = 1 + \phi^*(\tau^*) + t(T - \tau^*) . \tag{8}$$

The effective consumer price includes the world price of the raw product, the cost of meeting the standard for the importers and the associated emissions tax burden: $t(T - \tau^*)$. Importers

[18] Exporters sell in the domestic country with standards only if the price they could receive for one unit of the raw good equals the revenue from selling the good after meeting the standard for the domestic market, thus, $1 = q \dfrac{1}{1 + \phi\left(\tau^*\right)}$, which implies that $q = 1 + \phi^*(\tau^*)$.

realize that consumers prefer to purchase a good with the standard that minimizes this effective price. A consumer's preferred import standard ($\hat{\tau}^*$) is given by

$$\phi_{\tau^*}^*(\hat{\tau}^*) = t\,, \tag{9}$$

where the subscript denotes a partial derivative with the argument in the subscript. We assume that the preferred standard is feasible, that is: $\hat{\tau}^* \in [0, T]$. Given feasibility, in a perfectly competitive market importers only provide the preferred standard.[19]

Consumers only buy the domestically produced good if the effective price of the domestically produced good is no greater than the imported good. Consuming one unit of the domestically produced good implies a tax payment of $t(T-\tau)$. Thus the maximum price that the domestic producer can charge the consumers ($\overline{p}$) for the finished product is given by,

$$\overline{p} + t(T-\tau) = 1 + \phi^*(\hat{\tau}^*) + t(T-\hat{\tau}^*)\,. \tag{10}$$

This yields the net price (p^t) received by domestic producers for producing the raw good

$$p^t = \frac{1+\phi^*(\hat{\tau}^*) + t(\tau - \hat{\tau}^*)}{1+\phi(\tau)}\,. \tag{11}$$

The net domestic producer price equals the world price for the raw good, plus the cost of meeting the import standards ($\phi^*(\hat{\tau}^*)$) plus the difference in emissions tax outlays from consuming the two goods ($t(\tau-\hat{\tau}^*)$), divided by the cost of meeting the standard for the domestic good.[20] Note that given a small open economy, the two standards have an

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[19] This is because; any importer who sells a good with a standard different from $\hat{\tau}^*$ loses her market to the producer who sells the good with the preferred standard.

[20] The effective domestic producer price for the raw good (the world price for the raw product) can be less than 1 if the domestic producers incur greater costs of meeting the standard than imports. We assume that domestic producers always compete with imports and do not sell outside the home country. This could be justified by assuming that the disadvantage in cost of compliance is global for domestic producers, or that there is no real

asymmetric effect on domestic prices. The import standard affects consumer prices, while the domestic standard affects only domestic producer prices.

Import competing producers of the good 1 adopt the standard that maximizes their net price. This standard is denoted $\hat{\tau}$ and is defined by,

$$p^t \phi_\tau \left(\hat{\tau}\right) = t \,. \tag{12}$$

Equations (9) and (12) show that given an emissions tax, and perfectly competitive markets, domestic producers and importers are induced to provide standards. The following result establishes the relationship between the market induced provided import and domestic standards.

Result 1. *If* $\phi_\tau\left(\tau^{'}\right) \overset{<}{\underset{>}{-}} \phi^*{}_\tau\left(\tau^{'}\right), \forall \tau^{'} \in (0, T]$ *then the market induced domestic and foreign standards satisfy* $\tau \overset{>}{\underset{<}{-}} \tau^*$.

Proof: Please see Appendix A.

If the domestic industry has a cost advantage at meeting standards, the domestic standard adopted is higher than the import standard. Similarly, if importers have a cost advantage, the import standard is higher than the domestic standard. Finally, when the domestic producers and importers have equal marginal costs for feasible standards, both standards are equal.

3.1.1. The Optimal Emissions Tax and Market Induced Standards

In the presence of an emissions tax equation (7) becomes

market for raw products and the price we operate under is just what can be backed out given world prices for the finished good.

$$R(p^t,1)+tZ=E(q^t,1,u,Z)\,, \tag{13}$$

where expanding the expression of Z from equation (3) we can substitute in the following

$$Z=(T-\hat{\tau}^*)E_q+(\hat{\tau}-\hat{\tau}^*)\frac{R_p}{1+\phi}\,. \tag{14}$$

The optimal policy can be found by taking a total derivative of equation (13) and solving for the optimal emissions tax by setting $\frac{du}{dt}=0$. The welfare maximizing emissions tax ($\hat{t}$) is

$$\hat{t}=E_Z \tag{15}$$

In other words, the optimal emissions tax is set equal to marginal social damage from emissions. Using equation (9) the standard provided by the importing firm is defined by

$$\phi_{\tau^*}^{\ *}=E_Z\,. \tag{16}$$

In other words, the marginal cost of meeting the import standard equals marginal damage from emissions. Similarly, from equation (12), the domestic standard provided is

$$p^t\phi_\tau=E_Z. \tag{17}$$

The marginal cost of meeting the domestic standard also equals marginal damage from emissions. Note that this is also the standard Pigouvian prescription for controlling pollution.

Equations (15) – (17) imply that given perfect competition in the product market, regulating the emissions tax is sufficient to lead to maximization of social welfare. Once the planner sets emissions tax equal to the marginal social damage, perfect competition amongst domestic producers and importers ensures that the marginal cost of adopting standards equal marginal social damage. This equalizes the marginal cost of reducing pollution across consumers, importers, and domestic producers and aggregate welfare is maximized.[21]

3.1.2. The Effect of National Treatment on the Regulation of the Consumption Externality

In the presence of an emissions tax, National Treatment of environmental product standards has no obvious effect on the government's ability to optimally regulate the consumption externality. The emissions tax is non-discriminatory, and producers and importers provide the standard due to market interactions. Even though these standards might be different they are not mandated by the government and thus do not violate National Treatment.[22]

3.2. In the Presence of a Non-Discriminating Consumption Tax

In case of consumption externalities it is often difficult to employ an emissions tax. For example: according to Fullerton and West (2002), the technology to apply a tax per unit of automobile emissions is currently unfeasible. It is not possible to measure each car's emissions in a reliable and cost effective manner. The inability to measure, and regulate emissions effectively is generally true for most consumption generated pollutants mainly because the technology to do so does not justify the costs. In the absence of an emissions tax, the government's next best alternative is to tax consumption instead. However, unlike an emissions tax the consumption tax does not encourage consumers to value goods with a higher

[21] Note that for the market induced standards to be optimal, the emissions tax must be optimal, that is, it must equal the marginal social damage from emissions. If the chosen emissions tax is not optimal, the marginal social damage from emissions would not equal marginal cost of providing the standards.

[22] In this context, Horn (2006) distinguishes a good from the characteristics of a good. He argues that National Treatment is imposed on all forms of taxation paid for 'like' goods. According to this interpretation even though the tax might be non-discriminatory by applying equally to good characteristics, if it implies a higher tax outlay on the imported good it can be a violation of National Treatment. Emissions from consumption are a product characteristic. In our context, an equal tax on emissions generated by the consumption of the good could be considered a violation of National Treatment if the market induced import standard is lower than the domestic standard (implying a higher emissions tax outlay on the imported good). Thus in a strict interpretation of National Treatment even a non-discriminatory tax on emissions that has no protectionist motives could be interpreted as a violation of National Treatment.

environmental standard.[23] Under a consumption tax, the market fails to deliver the optimal environmental standard, and the government has to regulate both the standard and the consumption tax to achieve its first best.[24]

In this section we allow the government control over the following set of instruments: a per unit consumption tax that does not discriminate between domestic and imported goods (α),[25] a domestic standard (τ), an import standard (τ^*) and finally a per unit domestic production tax/subsidy on finished output (*s*) (the role of the production tax/subsidy in achieving the first best will become clear as we characterize the equilibrium).

When the government imposes a per unit consumption tax (α), the effective consumer price (q^α) is:

$$q^\alpha = 1 + \phi^*(\tau^*) + \alpha \,. \tag{18}$$

The effective consumer price includes the world price of the raw product, the cost of meeting the standard for the importers and the associated emissions tax burden, α.

Note that similar to the case of the emissions tax, the wedge in consumer prices from the world price occurs because of the import standard and *not* due to the domestic standard.

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[23] In the absence of an emissions tax, consumers do not have pay for consuming dirtier goods. In other words, consumers do not value a cleaner good any more than the dirty good and are not willing to pay for a higher standard. Correspondingly, the consumers' preferred standard is zero. Thus, in the absence of an emissions tax, neither importers nor domestic producers provide standards. To illustrate this further, consider the automobile emissions example. Instead of taxing carbon monoxide emissions from driving, often a tax on gasoline is applied. In the absence of a premium on low emissions intensity, consumers have no incentive to buy cars that have lower carbon monoxide intensity, and correspondingly producers have no incentive to supply such vehicles.

[24] The joint use of standards and consumption taxes is widespread. In the US, the federal Corporate Average Fuel Efficiency (CAFÉ) standard, and more decentralized state level emission standards are used in combination with gasoline taxes to control a variety of pollutants. Similarly, in Europe, there are emissions standards (like Euro I, Euro II norms) that are used alongside gasoline taxes.

[25] We do not allow the government to set a different consumption tax on domestic production and imports as we wish to focus on the effect of National Treatment on product standards separate from the effect of National Treatment on domestic taxes. Note however that changing this assumption has no effect on the product standards mandated by the government. Even when the government sets different consumption taxes based on origin, the standards mandated are the same as those presented in this equilibrium.

Given a small open economy, the two standards have an asymmetric effect on domestic prices. The import standard effects consumer prices, while the domestic standard affects only domestic producer prices. This difference in incidence is instrumental in determining the relative levels of the two standards in equilibrium and hence the optimality of National Treatment.

In the absence of an emission tax, and given a production subsidy/tax for producing the finished product, the price received by the domestic producers for the raw product is

$$p^{\alpha s} = \frac{1+\phi^*(\tau^*)+s}{1+\phi(\tau)}. \tag{19}$$

The net domestic producer price equals the world price for the raw good, plus the cost of meeting the import standards ($\phi^*(\tau^*)$) plus the subsidy (s), divided by the cost of meeting the standard for the domestic good.[26]

Emissions are

$$Z = (T-\tau^*)E_q(q^a,1,u,Z) + (\tau^*-\tau)\frac{R_p\left(p^{\alpha s}\right)}{1+\phi(\tau)}. \tag{20}$$

General equilibrium is represented by the income expenditure equality, from equation (7) with net government revenue being equal to the revenue from the consumption tax and the expenditure/revenue from the production subsidy/tax ($g = \alpha E_q - s\frac{R_p}{1+\phi(\tau)}$).

By totally differentiating the general equilibrium equation and the emissions equation we can solve for optimal policy (please see Appendix B for a complete derivation). The

[26] Note that as described earlier (see footnote 20) the effective domestic producer price can either be greater than or less than 1 (the world price for the raw product). We maintain the earlier assumption that irrespective of the price received, domestic producers always sell at home.

optimal consumption tax can be obtained by solving for the condition $\frac{\partial u}{\partial \alpha} = 0$ from the expenditure income inequality. The optimal consumption tax is given by

$$\hat{\alpha} = E_Z(T - \hat{\tau}^*) . \tag{21}$$

Equation (21) is the Pigouvian consumption tax for the level of emissions in the economy ($\hat{\tau}^*$ is determined by the first order conditions below). E_Z (the shadow price of pollution) measures the amount by which the expenditure must go up in order to keep the utility constant, this is multiplied by per unit emissions to equal the optimal consumption tax.

By setting $\frac{\partial u}{\partial s}$ to zero we get the optimal production tax/subsidy

$$\hat{s} = E_Z(\hat{\tau} - \hat{\tau}^*) \tag{22}$$

If the optimal domestic standard is higher than the optimal import standard ($(\hat{\tau} - \hat{\tau}^*) > 0$) then $\hat{s} > 0$ and the government sets a subsidy for domestic production. However, if the domestic standard is lower than the import standard ($(\hat{\tau} - \hat{\tau}^*) < 0$) then $\hat{s} < 0$ and the government sets a tax on domestic production. This subsidy or tax is meant to equate the marginal cost of meeting the standard across domestic producers and importers, and ensures that marginal costs of production are equalized across the two producers. In other words, if the optimum involves unequal standards, it also includes a tax or subsidy.

By setting $\frac{\partial u}{\partial \tau^*}$ to zero we get the condition for the optimal import standard ($\hat{\tau}^*$).

$$E_Z = \phi_{\tau^*}^{\ *}(\hat{\tau}^*) . \tag{23}$$

At the optimum, the marginal cost of meeting the import standard equals the marginal social benefit of a higher standard. Similarly, the standard on home produced good is given by,

$$E_Z = p^{as}\phi_\tau\left(\hat{\tau}\right) \tag{24}$$

The marginal cost of meeting the domestic standard equals marginal damage from pollution.

Result 2. *Assume that the government regulates the consumption tax, and production subsidy/tax to maximize aggregate welfare. (i) If* $\phi_\tau\left(\tau^{'}\right) > \phi^{*}_{\tau^*}\left(\tau^{'}\right),\ \forall\tau^{'} \in (0,T]$ *then the government mandated welfare maximizing standards satisfy* $\tau < \tau^{*}$. *(ii) National Treatment of product standards (*$\tau \geq \tau^{*}$*) is welfare maximizing if and only if* $\phi_\tau\left(\tau^{'}\right) \leq \phi^{*}_{\tau^*}\left(\tau^{'}\right),\ \forall\tau^{'} \in (0,T]$.

Proof: Please see Appendix B.

The optimal policy for a small open economy is to set $\phi_\tau^{*} = p^{\alpha s}\phi_\tau = E_Z$ (equal marginal costs across consumers, imports and domestic production). If cost functions are identical, this condition reduces to $\phi_{\tau^*}^{*} = \phi_\tau = E_Z$, and both standards are equal. When cost functions are not identical, marginal costs are equal when standards are not equal. In this case, we have a higher domestic standard when domestic producers have an advantage at complying with the product standard. However, if domestic producers have a cost disadvantage at complying with the standard ($\phi_\tau\left(\tau^{'}\right) > \phi^{*}_{\tau^*}\left(\tau^{'}\right),\ \forall\tau^{'} \in (0,T]$) the import standard is higher than the domestic standard and violates National Treatment.

3.2.1. The Effect of National Treatment

For our context National Treatment requires that the import standard be no higher than the domestic standard. Also in the spirit of non-discrimination the WTO bans subsidies to all import competing firms in non-agricultural sectors (with certain exceptions such as subsidies in special export promoting zones in developing countries). An imposition of a tax on domestic producers however, is compatible with WTO rules.

Based on the result discussed above there are three possible cases. The first is when the cost of meeting standards is equal across domestic producers and importers. In this case, the optimal domestic and import standard are equal, and there is no subsidy or tax required. National Treatment is optimal.

Next is the case where domestic producers have a cost advantage over importers at meeting the standard. Optimal policy requires that domestic producers meet a higher standard (which is not a violation of National Treatment), and that they receive a production subsidy (which is a violation of WTO rules). To evaluate this case more carefully we derive the optimal consumption tax and product standards in the absence of a production subsidy in Appendix B. When the optimal production subsidy is not available the marginal costs of meeting the standards cannot be equalized. While this prevents a maximization of welfare, we find that National Treatment of product standards need not be violated. We find that the relative levels for the two standards depend only on the costs of meeting the standard and not on the availability of the subsidy.[27] Hence, if domestic firms have a cost advantage in meeting the standards (as in definition 1), National Treatment is not a constraint on optimal policy.

Finally we consider the case where the domestic producer has a cost disadvantage at meeting the environmental product standard. Optimal policy requires an import standard that is higher than the domestic standard (which is a violation of National Treatment) and a

[27] This can be seen from equation (A20) in Appendix B (the equation that determines the two standards in the absence of a subsidy). Equation (A20) implies that the sign of $\tau^* - \tau$ (the import standard relative to the domestic standard) derives from an ordering of cost structures (as determined by the following expression $\frac{\phi_{\tau^*}^*(\tau^*)}{[1+\phi^*(\tau^*)]} - \frac{\phi_\tau(\tau)}{[1+\phi(\tau)]}$). In other words, if $\phi_{\tau^*}^*(\tau^*) \overset{<}{\underset{>}{-}} \phi_\tau(\tau)$ then $\tau^* \overset{>}{\underset{<}{-}} \tau$.

production tax (not a violation). We find that in this case, National Treatment prevents the government from applying optimal policy and results in a welfare loss. National treatment is not optimal when domestic producers have a cost disadvantage at meeting the standard.

The main message from this sub-section is similar to the standard efficiency argument for setting optimal environmental policy. Optimal policy requires an equalization of marginal costs for compliance across home and foreign producers. A lower cost of compliance for the importers implies that it is efficient to set higher standard on them. However, National Treatment prevents a non-protectionist government from setting optimal policy and thus creates welfare losses.

3.3. When the Emissions and Consumption Tax is Suboptimal

In this sub-section we derive optimal domestic and import standards when the emission and consumption tax is suboptimal. A consumer based emissions tax can be suboptimal if the technology to measure emissions is costly. Further, if consumers are numerous and dispersed, the cost of implementing the optimal emissions tax can be unfeasible. A consumption tax can be suboptimal due to similar technical reasons. Both emissions and consumption taxes can also be suboptimal due to political economy reasons. Take fuel taxes as an example, fuel tax hikes are often met with stiff opposition from transporters and consumer groups. Such organized opposition from consumer groups can lead to a suboptimal consumption or emissions taxes.[28] Parry (2002) provides evidence of the existence of a sub-optimal

[28] Lobbying from producer interest groups could also cause non-optimal consumer based emission taxes. This is illustrated in Gulati and Roy (2006) who show that a consumer emissions tax can in some cases be used to discriminate against imports.

consumption tax. He finds gasoline taxes in the US to be lower than optimal by approximately \$1 a gallon.[29]

To evaluate optimal standards when the emissions or consumption tax is suboptimal we analyze the models from Subsections 3.1, and 3.2 in appendix C with an additional constraint that the emissions tax or consumption tax is less than the socially optimal level. Given this constraint, the optimal domestic and import standards are derived. The results from this exercise are summarized in Lemma 3 below.

Result 3: *Assume that the emissions or consumption tax is below the socially efficient level (marginal social damage). (i) If* $\phi_{\tau}\left(\tau^{'}\right) \geq \phi^{*}{}_{\tau}\left(\tau^{'}\right), \forall \tau^{'} \in (0,T]$ *then the welfare maximizing government mandated domestic and foreign standards satisfy* $\tau < \tau^{*}$*. (ii) There exists a range where* $\phi_{\tau}\left(\tau^{'}\right) < \phi^{*}{}_{\tau}\left(\tau^{'}\right), \tau^{'} \in (0,T)$ *and the welfare maximizing government mandated domestic and foreign standards satisfy* $\tau < \tau^{*}$*. (iii) National Treatment of product standards (*$\tau \geq \tau^{*}$*) is welfare maximizing only if domestic firms have a sufficiently large cost advantage at complying with the standard.*

Proof: Please see Appendix C.

When either the emissions or consumption tax is suboptimal we find the following. Firstly, even if the marginal cost of compliance is identical across importers and domestic producers the welfare maximizing import standard is higher than the domestic standard. This occurs because in a small open economy, consumer price can only be affected by the import standard. Thus when the emissions or consumption standard is suboptimal, the import

[29] The average gasoline tax is more than \$2/gallon in many European countries, while in the US, federal taxes are only 18cents/gallon and average state taxes 22cents/gallon (Becker, 2002).

standard is used as a substitute for the consumption tax and is higher than the domestic standard even when costs of compliance are identical. The second result is that National Treatment of standards (where the domestic standard is at least as high as the import standard) maximizes aggregate welfare only if domestic producers have a large enough strict advantage at complying with the product standard, there exists a range where domestic producers have a cost advantage at meeting the standard and even then the import standard is higher than the domestic standard.

3.3.1. The Effect of National Treatment

To evaluate the effect of National Treatment when emissions or consumption taxes are suboptimal we shall consider the three potential cost advantage situations separately.

For the first case we assume that domestic producers have a cost advantage over importers at meeting the standard. When either the emissions tax or the consumption tax is suboptimal we find the following result. If domestic producers have a significantly 'large' cost advantage over importers (where the exact definition of large will depend on specific parameters of our model), we find that they have to comply with a higher standard than importers. This is not a violation of National Treatment. However, if the cost advantage for domestic producers is not significantly large we find that they have to comply with a lower standard than importers. This is a violation of National Treatment. The level of the import standard depends on the cost of compliance and its second-best adjustment to substitute for the suboptimal emissions or consumption tax. If this second best adjustment is large enough the optimal import standard can be higher than the domestic standard.

Next assume that the cost of meeting standards is equal across domestic producers and importers. When the emissions or consumption tax is suboptimal we find that the domestic standard is always lower than the import standard. This occurs as the import standard is raised to substitute for the suboptimal emissions/consumption tax. Thus, even with equal costs, optimal policy violates National Treatment. This is in contrast to the case with optimal taxes, where equal costs imply equal standards and National Treatment does not impose losses.

Finally consider the case where the domestic producer has a cost disadvantage at meeting the environmental product standard. Similar to the results from the previous two subsections we find that optimal policy requires the import standard to be higher than the domestic standard. As discussed earlier this policy violates National Treatment. In this case, the import standard is higher due to a cost advantage and also due to the fact that it is raised to substitute for the suboptimal emissions/consumption tax.

When the emissions/consumption tax is suboptimal National Treatment is likely to prevent a government from applying optimal policy in most cases. We find that National treatment is not optimal when domestic producers have a cost disadvantage or are equally efficient as importers at meeting the standard. In addition, National Treatment might be not optimal even when domestic producers have a cost advantage at complying with the standard.

7. Conclusions and further research

In this paper we investigate the welfare effects of observing National Treatment of environmental product standards for a small open economy. We find that the impact of National Treatment depends on the set of instruments available. In the presence of an optimal emissions tax National Treatment need not impose constraints on a government regulating the externality. In the presence of an optimal consumption (rather than emissions) tax, National Treatment need not constraint the policymaker as long as the costs of compliance for foreign producers are at least as high as those for domestic producers.

However, when the emissions/consumption tax is suboptimal National Treatment is likely to prevent a government from applying optimal policy in most cases. We find that National treatment is not optimal even when domestic producers have the same cost of compliance as importers. This follows from differential incidence of the two standards. As only the standard on imports can substitute for the suboptimal emissions/consumption tax the policymaker is likely to raise the import standard over the domestic standard to correct for the suboptimal tax. This violates National Treatment.

As there are several plausible technological reasons why consumer based taxes might be suboptimal, we feel that it is likely that in the case of consumer generated pollution externalities the imposition of National Treatment is likely to create welfare losses. Our analysis suggests that there may be reasons to consider a modification to this rule that allows exceptions for cases where consumer based taxes cannot be applied.

In the future we intend to explore two extensions. In the first extension we shall explore how National Treatment can serve as a commitment mechanism to curb the influence of domestic special interests. This line of reasoning follows Maggi and Rodriguez Claire (1998) where a small country government ensures that lobbies cannot gain high levels of protection by committing to free trade. In the second extension we shall consider the case where the cost of compliance includes fixed costs. The welfare implications under the fixed costs of meeting the standard are likely to be quite different (similar to Romer (1994) who discusses the welfare costs of trade restrictions in the presence of fixed costs). We expect that with fixed costs even small changes in the standards could make products operating at near zero profits to disappear altogether from the market. In such a case inefficiencies in regulation can lead to higher social costs than obvious from our current analysis.

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Appendices

Appendix A: Proof of Lemma 1

Competitively provided standards are given by equations (16) and (17). We know that the cost of compliance functions satisfy the following: $\phi(0)=0$, $\phi_\tau > 0$ and $\phi_{\tau\tau} > 0$, and $\phi^*(0)=0$, $\phi^*_{\tau^*} > 0$ and $\phi^*_{\tau^*\tau^*} > 0$. On substituting for p^t from equation (11) into equation (17) we get

$$\frac{1+\phi^*(\hat{\tau}^*)+t(\hat{\tau}-\hat{\tau}^*)}{1+\phi(\tau)}\phi_\tau = E_Z\,. \tag{A1}$$

Equating equations (16) and (A1) we get $\frac{1+\phi^*(\hat{\tau}^*)+t(\tau-\hat{\tau}^*)}{1+\phi(\tau)}\phi_\tau = \phi^*_{\tau^*}$ on rearranging we have

$$\frac{\phi_\tau}{\left(1+\phi(\hat{\tau})\right)} - \frac{\phi^*_{\tau^*}}{\left(1+\phi^*(\hat{\tau}^*)\right)} = \frac{-t(\hat{\tau}-\hat{\tau}^*)\phi_\tau}{\left(1+\phi(\hat{\tau})\right)\left(1+\phi^*(\hat{\tau}^*)\right)} \tag{A2}$$

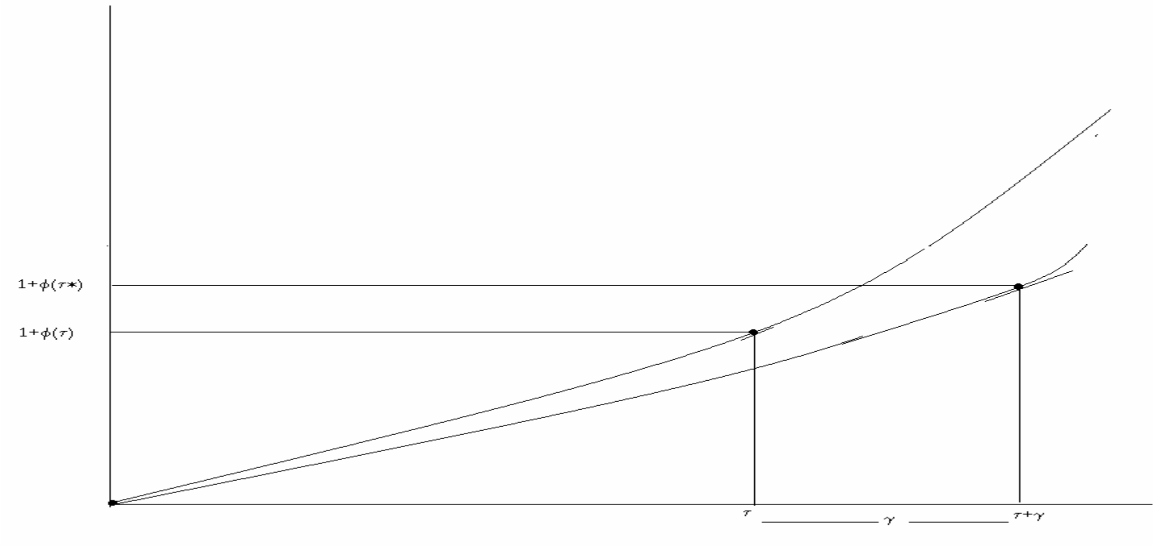
The sign of the right hand side of equation (A2) depends on the sign of $\left(\hat{\tau}^*-\hat{\tau}\right)$.

Suppose that at any given common standard $\tilde{\tau}$, $\phi_{\tilde{\tau}} > \phi^*_{\tilde{\tau}}$. Given that $\phi^*(0)=\phi(0)=0$ and $\phi_{\tau\tau} > 0$ and $\phi^*_{\tau^*\tau^*} > 0$, at $\tau=\tau^*=\overline{\tau}$ the right hand side equals of (A2) is zero while the left hand side is positive. Optimally chosen standards cannot be equal with a difference in costs.

To see that with $\phi_{\tilde{\tau}} > \phi^*_{\tilde{\tau}}$, $\tau > \tau^*$ cannot be optimal, a higher standard on home produced good implies that the right hand side of the equation (A2) is negative. Given the assumptions on the cost functions, if $\tau > \tau^*$, the left hand side is positive. Thus, $\tau > \tau^*$ cannot hold true.

Now, with $\tau < \tau^*$ the right hand side of (A2) is positive. Now consider a standard $\tilde{\tau}$ on home and a standard $\tilde{\tau}+\gamma$ on the imports. A sufficient condition for the equilibrium to exist is that $\exists\ \gamma$ such that $\phi_{\tilde{\tau}} > \phi^*_{\tilde{\tau}+\gamma}$ and $1+\phi^*(\tilde{\tau}+\gamma) > \phi(\tau)$ as shown in Figure A below.

Figure A: Sufficient conditions for an inverse relationship between costs and standards



Similar reasoning can be used to prove that when $\phi_{\tilde{\tau}} < \phi^*_{\tilde{\tau}}$ for all feasible τ then the optimal standard on domestic production is higher than the import standard. Similarly one can also show that equal standards are optimal when the two cost functions are identical.

Appendix B: Optimal policy in the presence of a non-discriminating consumption tax

The government uses the following instruments. (i) A per unit consumption tax (α), (ii) An emission standard on the home produced good (τ). (iii) An emission standard on the imports (τ^*) and (iv) a per unit production tax/subsidy ($s > 0$). The instruments that are not a part of the optimum will equal zero in equilibrium.
Emissions are given by

$$Z = (T-\tau^*)E_q(q^a,1,u,Z) + (\tau^*-\tau)\frac{R_p\left(p^{\alpha s}\right)}{1+\phi(\tau)}, \tag{A3}$$

where imports of good 1 equal the residual domestic demand over domestic supply. General equilibrium is represented by the following income expenditure equality,

$$E(q^a,1,u,Z) = R(\frac{p^{\alpha s}}{1+\phi(\tau)}) + \alpha E_q(q^a,1,u,Z) - s\frac{R_p\left(p^{\alpha s}\right)}{1+\phi(\tau)} \tag{A4}$$

Totally differentiating (A3) we have

$$dZ = \eta_{\tau^*}d\tau^* + \eta_\alpha d\alpha + \eta_s ds + \eta_\tau d\tau + \eta_u du\,, \tag{A5}$$

where $\eta_{\tau^*}, \eta_\alpha, \eta_s, \eta_\tau$ and η_u represent the partial derivative of Z with respect to τ^*, α, s, τ and u respectively. More specifically,

$$\eta_{\tau^*} = \frac{1}{1-(T-\tau^*)E_{qZ}}\left[-m_1 + (T-\tau^*)E_{qq}\phi^*_{\tau^*} + (\tau^*-\tau)\frac{R_{p_{\alpha s}p_{\alpha s}}\phi^*_{\tau^*}}{(1+\phi)^2}\right], \tag{A6}$$

$$\eta_\alpha = \frac{1}{1-(T-\tau^*)E_{qZ}}[(T-\tau^*)E_{qq}], \tag{A7}$$

$$\eta_s = \frac{1}{1-(T-\tau^*)E_{qZ}}[(\tau^* - \tau)\frac{R_{p_{\alpha s}p_{\alpha s}}\phi^*_{\tau^*}}{(1+\phi)^2}], \tag{A8}$$

$$\eta_\tau = -\frac{1}{1-(T-\tau^*)E_{qZ}}[\frac{R_{p_{\alpha s}}}{1+\phi} + (\tau^* - \tau)\frac{R_{p_{\alpha s}}\phi_\tau}{(1+\phi)^2} + (\tau^* - \tau)\frac{R_{p_{\alpha s}}\phi_\tau}{(1+\phi)^3}(1+\phi^* + s)\phi_\tau], \tag{A9}$$

$$\eta_u = \frac{1}{1-(T-\tau^*)E_{qZ}}[(T-\tau^*)E_{qu}]. \tag{A10}$$

The consumption tax reduces the level of pollution in the economy by reducing the demand. The more elastic the demand, the more pronounced the effect as seen in equation (A7). The effect on pollution owing to changes in the import standard is presented in equation (A6). A rise in standard on imports reduces emissions on the existing level of imports, captured by the first term in equation. Moreover, since an import standard taxes consumption at a rate equal to the per unit cost of meeting the standard of the importers/foreign producers there is a reduction in pollution owing to this consumption tax. This is captured by the second term. Moreover, a higher import standard results in shifting the source of some consumption from imports to domestic producers. This switch can result in higher (lower) pollution depending upon whether the switched portion is consumed at a lower (higher) standard (the last term in the equation (A6)). A similar interpretation applies to the equation (A9). The first term is, as before, the direct effect of a higher standard on existing domestic supply while the other terms relate to the effects caused by the switch in source of consumption. In a small economy, the effect of a production subsidy on pollution comes only from the impact on domestic supply as in equation (A8).

Next we totally differentiate equation (A4) to get

$$\begin{aligned}&[E_u - \alpha E_{qu}]du + [E_Z - \alpha E_{qZ}]dZ + [m_1\phi^*_{\tau^*} - \alpha E_{qq}\phi^*_{\tau^*} + s\frac{R_{p_{\alpha s}p_{\alpha s}}}{(1+\phi)^2}\phi^*_{\tau^*}]d\tau^* - \alpha E_{qq}d\alpha + s\frac{R_{p_{\alpha s}p_{\alpha s}}}{(1+\phi)^2}ds \\ &+[-\frac{R_{p_{\alpha s}}}{(1+\phi)^2}(1+\phi^*+s)\phi_\tau - s\frac{R_1}{(1+\phi)^2}\phi_\tau - s\frac{R_{p_{\alpha s}p_{\alpha s}}}{(1+\phi)^3}(1+\phi^*+s)\phi_\tau] = 0.\end{aligned} \tag{A11}$$

To find optimal policy substitute in dZ from equation (A5) into equation (A11), and then find the policy levels that maximize utility (*u*). Thus the optimal consumption tax is given by the first order condition $\frac{du}{d\alpha} = 0$. This implies

$$\hat{\alpha} = E_Z(T-\tau^*). \tag{A12}$$

The optimal production tax/subsidy is given by the first order condition $\frac{du}{ds} = 0$, and thus

$$\hat{s} = E_Z(\tau - \tau^*). \tag{A13}$$

A higher (lower) standard on the domestic firm in an optimum implies an optimal subsidy (tax). Production efficiency requires equating marginal costs of production. Thus, if the optimum involves unequal standards, it also includes a tax/subsidy.

The optimal standard on the imported product satisfies the first order condition $\frac{du}{d\tau^*} = 0$.

$$E_Z = \phi^*_{\tau^*}(\tau^*) \tag{A14}$$

And the optimal standard on the home produced good satisfies $\frac{\partial u}{\partial \tau} = 0$, thus,

$$E_Z\frac{R_{p_{\alpha s}}}{1+\phi} = \frac{R_{p_{\alpha s}}}{(1+\phi)^2}(1+\phi^*+s)\phi_\tau, \tag{A15}$$

which can be simplified to

$$E_Z = p_{\alpha s}\phi_\tau . \qquad \text{(A16)}$$

Equations (A14) and (A16) are the same as equations (16) and (17) in the text. According to lemma 1 we thus know that if $\phi_\tau\left(\tau'\right) \substack{<\\=\\>} \phi^*_\tau\left(\tau'\right),\ \forall \tau' \in (0,T]$ then optimal domestic and foreign standards satisfy $\tau \substack{>\\=\\<} \tau^*$.

In the absence of a production subsidy

The optimal consumption tax is given as

$$\hat{\alpha} = E_Z(T-\tau^*) . \qquad \text{(A17)}$$

The import standard is given by the following equation,

$$-\phi^*_{\tau^*}m_1 + E_Z m_1 - E_Z(\tau^*-\tau)\phi^*_{\tau^*}\frac{R_{pp}}{(1+\phi(\tau))^2} = 0 . \qquad \text{(A18)}$$

And finally the domestic standard is given by,

$$E_Z\frac{R_p}{1+\phi(\tau)} + E_Z(\tau^*-\tau)R_{pp}\frac{(1+\phi^*(\tau^*))}{[1+\phi(\tau)]^3}\phi_\tau + E_Z(\tau^*-\tau)\frac{R_p\phi_\tau}{[1+\phi(\tau)]^2} - \frac{(1+\phi^*(\tau^*))}{[1+\phi(\tau)]^2}R_p = 0 . \qquad \text{(A19)}$$

Combining (A18) and (A19) the the relative ordering of standards is given by,

$$\begin{aligned}&[\phi^*_{\tau^*}(1+\phi(\tau)) - \phi_\tau(1+\phi^*)]\frac{R_p}{(1+\phi(\tau))^2}m_1 = [\tau^*-\tau]\{[m_1\frac{R_{pp}}{(1+\phi(\tau))^3}(1+\phi^*)\phi_\tau + m_1\frac{R_p}{(1+\phi(\tau))^2}\phi_\tau + \\ &\phi_\tau\phi^*_{\tau^*}\frac{R_{pp}(1+\phi^*(\tau^*)R_p}{(1+\phi(\tau))^4}]\} = 0\end{aligned} \qquad \text{(A20)}$$

Since the terms multiplying the expressions $(\tau^*-\tau)$ and $[\phi^*_{\tau^*}(1+\phi(\tau)) - \phi_\tau(1+\phi^*)]$ are both positive, it implies that the sign of the two expressions are the same. Hence, when $\tau^* > \tau$ it must be true that $\frac{\phi^*_{\tau^*}}{[1+\phi^*(\tau^*)]} > \frac{\phi_\tau}{[1+\phi(\tau)]}$ and vice versa. Thus, equation (A20) implies that if domestic producers are at a cost disadvantage in meeting the standards, after setting the consumption tax optimally, the government would like to set a lower standard on home products and thereby violate National Treatment.

Appendix C: Optimal Standards when the Consumption Tax is Suboptimal

Note that for optimality the consumption tax must be set equal to the value of marginal social damage from consumption. Sometimes the consumption tax is not set equal to its optimal level. Let us consider the case where $\hat{\alpha} \le E_Z(T-\tau^*)$, that is for some reason the consumption tax is less than the optimal tax. To derive optimal standards in this case we take the consumption tax as exogenously given and optimize over τ, τ^* and s.

The emissions function is given as:

$$Z = (T-\tau^*)E_q + (\tau^*-\tau)\frac{R_p}{1+\phi(\tau)} \qquad \text{(A21)}$$

The consumption price and producer price are given by equations (18) - (19)from the main text. The only difference is that now the consumption tax is given exogenously, and is less than $\hat{\alpha} \le E_Z(T-\tau^*)$.

The general equilibrium condition is the expenditure revenue equality given below,

$$E(q,1,uZ) = R(p) - s\frac{R_p}{1+\phi(\tau)} + \alpha E_q\,. \tag{A22}$$

The optimal production subsidy is determined by the condition $\frac{\partial u}{\partial s} = 0$ which implies that,

$$(E_Z - \alpha E_{qZ})\frac{\partial Z}{\partial s} = -s\frac{\partial y_1}{\partial s}, \tag{A23}$$

where the partial effect of the subsidy on pollution is given as, $\frac{\partial Z}{\partial s} = \frac{(\tau^* - \tau)\frac{R_{pp}}{(1+\phi)^2}}{1-(T-\tau^*)E_{qZ}}$. On substituting for $\frac{\partial Z}{\partial s}$ and $\frac{\partial y_1}{\partial s}$ the optimal production subsidy $\hat{s}$ is,

$$\hat{s} = \frac{E_Z - \alpha E_{qZ}}{[1-(T-\tau^*)E_{qZ}]}(\tau - \tau^*)\,. \tag{A24}$$

The optimal import standard is given by the condition $\frac{\partial u}{\partial \tau^*} = 0$ which implies

$$(E_Z - \alpha E_{qZ})\frac{\partial Z}{\partial \tau^*} = R_p\frac{\partial p}{\partial \tau^*} - E_q\frac{\partial q}{\partial \tau^*} + \alpha E_{qq}\frac{\partial q}{\partial \tau^*} - s\frac{\partial y_1}{\partial \tau^*}\,. \tag{A25}$$

In the above equation we substitute: $\frac{\partial Z}{\partial \tau^*} = \frac{1}{1-(T-\tau^*)E_{qZ}}[-m_1 + (T-\tau^*)E_{qq}\phi^*_{\tau^*} + (\tau^* - \tau)\frac{R_{pp}}{(1+\phi)^2}\phi^*_{\tau^*}]$, $\frac{\partial p}{\partial \tau^*} = \frac{\phi^*_{\tau^*}}{1+\phi}$, $\frac{\partial q}{\partial \tau^*} = \phi^*_{\tau^*}$ and $\frac{\partial y_1}{\partial \tau^*} = \frac{R_{pp}}{(1+\phi)^2}\phi^*_{\tau^*}$, to get

$$\frac{E_Z - \alpha E_{qZ}}{[1-(T-\tau^*)E_{qZ}]}[(T-\tau^*)E_{qq}\phi^*_{\tau^*} - m_1] = [\alpha E_{qq} - m_1]\phi^*_{\tau^*}\,. \tag{A26}$$

Similarly the optimal domestic standard is determined by the condition $\frac{\partial u}{\partial \tau} = 0$ which implies that,

$$(E_Z - \alpha E_{qZ})\frac{\partial Z}{\partial \tau} = R_p\frac{\partial p}{\partial \tau} - s\frac{\partial y_1}{\partial \tau}\,. \tag{A27}$$

In this equation we substitute:

$$\frac{\partial Z}{\partial \tau} = \frac{1}{1-(T-\tau^*)E_{qZ}}[-\frac{R_p}{1+\phi(\tau)} - (\tau^* - \tau)\frac{R_{pp}}{(1+\phi)^3}(1+\phi^*(\tau^*)+s)\phi_\tau - (\tau^* - \tau)\frac{R_p}{(1+\phi)^2}\phi_\tau],$$

$$\frac{\partial p}{\partial \tau} = -\frac{1+\phi^*(\tau^*)+s}{[1+\phi(\tau)]^2} \text{ and } \frac{\partial y_1}{\partial \tau} = -[\frac{R_p}{(1+\phi)^2}\phi_\tau + \frac{R_{pp}(1+\phi^*+s)}{(1+\phi)^3}\phi_\tau] \text{, to get}$$

$$\frac{E_Z - \alpha E_{qZ}}{[1-(T-\tau^*)E_{qZ}]}\frac{R_p}{1+\phi} = \frac{R_p}{(1+\phi)^2}(1+\phi^*+s)\phi_\tau \text{ which can be written as}$$

$$\frac{E_Z - \alpha E_{qZ}}{[1-(T-\tau^*)E_{qZ}]}[1+\frac{(\tau^*-\tau)\phi_\tau}{1+\phi}] = \frac{(1+\phi^*)\phi_\tau}{1+\phi}. \quad \text{(A28)}$$

Equations (A26) and (A28) together imply

$$(E_Z - \alpha E_{qZ})m_1[\phi^*_{\tau^*} - \phi_\tau \frac{(1+\phi^*)}{1+\phi}] + [E_Z(T-\tau^*)-\alpha]E_{qq}\phi^*_{\tau^*}\phi_\tau \frac{(1+\phi^*)}{1+\phi} = -(E_Z - \alpha E_{qZ})(\tau^*-\tau)m_1\frac{\phi^*_{\tau^*}\phi_\tau}{1+\phi} \quad \text{(A29)}$$

From homogeneity of degree 1 in prices of the expenditure function we can know that, $E = qE_q + q_2 E_{q_2}$ where q_2 is the price of the numeraire good 2. Take a derivative of this condition with z to get $E_Z \geq qE_{qZ} \Rightarrow E_Z > \alpha E_{qZ}$.

Given the concavity of the expenditure function in prices, Equation (A29) implies that when the consumption tax is set suboptimally ($\alpha < E_Z(T-\tau^*)$) we find that if the costs of compliance are equal, that is, $\phi_\tau = \phi^*_\tau$, $\forall \tau$ equal domestic and import standards are not optimal. To see this consider the case where costs of compliance are equal and the two standards are set equal. This implies that the right hand sides of equation (A29) equals zero, but the left hand sides does not equal zero.

We find that equal domestic and import standards ($\tau = \tau^*$) are optimal if and only if the costs of compliance are higher for the foreign firm ($\phi^*_{\tau^*} > \phi_\tau$). Equation (A29) also implies that a higher domestic standard is optimal only when the costs of compliance is lower for the home firm ($\phi^*_{\tau^*} < \phi_\tau$). Thus, there must exist a range of relatively higher costs of compliance for the foreign firm where in spite of higher costs of compliance it is optimal to set a relatively higher standard on imports.

Optimal Standards when the Emissions Tax is Suboptimal

When the emissions tax is not set optimally the market induced standards are also not optimal (the proof for this follows from equations (16) and (17) in the text). The government is functioning in a second best world and needs to re-optimize environmental product standards to maximize welfare. In other words, there is a rationale for the government to regulate the level of standards and make them mandatory. In what follows below we shall show that if the emissions tax is set sub-optimally the import standard has to bear the role of the missing instrument and having equal costs of compliance with the standard does not translate into National Treatment being optimal.

The producer price when an emissions tax (t) is employed is given by equation (11), the consumer price is given by equation (8), and emissions are given by equation (14). General equilibrium in the economy is given by equation (13). When the emissions tax is set suboptimally (thus $\hat{t} \leq E_Z$) we treat t as exogenously given and maximize welfare using standards.

The first order condition for the domestic standard is given by ($\frac{\partial u}{\partial \tau} = 0$) which implies

$$(t - E_Z)\frac{\partial Z}{\partial \tau} + R_p \frac{\partial p}{\partial \tau} - E_q \frac{\partial q}{\partial \tau} = 0. \quad \text{(A30)}$$

The output of the standardized final product is given by $y_1 = \dfrac{R_p}{1+\phi(\tau)}$, and thus equation (A30) can be rewritten as,

$$y[t-\phi_\tau p] = -\frac{\partial Z}{\partial \tau}(t-E_Z). \tag{A31}$$

If we expand for $\dfrac{\partial Z}{\partial \tau}$ we get,

$$\left[\phi_\tau p - t\right] = \frac{\left[E_Z - t\right]\left[1+\dfrac{(\tau^*-\tau)}{1+\phi(\tau)}\phi_\tau\right]y_1}{\left[y_1\left(1-(T-\tau^*)E_{qZ}\right)\right]-\left[\dfrac{(\tau^*-\tau)}{(1+\phi)^2}\left(E_Z-t\right)R_{pp}\right]}. \tag{A32}$$

Note the difference between equation (A31) and equation (12). When the emissions tax is set optimally $\left[\phi_\tau p - t\right] = 0$. In the case it is not set optimally, the import standard has to adjust for the suboptimal emissions tax (the terms on the right hand side of equation (A31)).

The first order condition for the import standard is given by $\dfrac{\partial u}{\partial \tau^*} = 0$, which implies,

$$R_p \frac{\partial p}{\partial \tau^*} - E_q \frac{\partial q}{\partial \tau^*} + (t-E_Z)\frac{\partial Z}{\partial \tau^*} = 0, \tag{A33}$$

and after substituting $\dfrac{\partial p}{\partial \tau^*}, \dfrac{\partial q}{\partial \tau^*}, \dfrac{\partial Z}{\partial \tau^*}$ we get

$$\phi^*_{\tau^*} - t = \frac{\left[E_Z - t\right]}{\left[1-(T-\tau^*)E_{qZ}\right]+\left[\dfrac{(\tau^*-\tau)}{(1+\phi)^2}R_{pp} + (T-\tau^*)E_{qq}\dfrac{(E_Z-t)}{\left[E_q - y_1\right]}\right]}. \tag{A34}$$

Note that the domestic standard is also adjusted for the suboptimal tax. However, the adjustment of the domestic standard is different than the adjustment of the import standard. This derives from the difference in incidence of the two standards.

We find that if the costs of compliance are equal, that is, $\phi_\tau = \phi^*_\tau, \forall \tau$ equal domestic and import standards are not optimal. To see this consider the case where costs of compliance are equal, and the two standards are set equal. This implies that the left hand sides of equations (A32)and (A34) are equal but the right hand sides are unequal.

Now consider when the two standards are equal i.e. $\tau^* = \tau = \bar{\tau}$. (A32) and (A34) imply that $\dfrac{\phi^*_{\bar{\tau}}}{1+\phi^*(\bar{\tau})} > \dfrac{\phi_{\bar{\tau}}}{1+\phi(\bar{\tau})}$ since the denominator in (A34) is smaller at equal standards (as $E_{qq} < 0$). Hence, equal standards are optimally chosen not at equal costs of compliance but at a higher cost of meeting the standards for the foreign producer. The sub-optimal pollution tax $(t < E_Z)$ implies that the foreign standard substitutes for the missing element of the tax. Equations (A32)and (A34) also imply that a higher domestic standard is optimal only when the costs of compliance is lower for the home firm ($\phi^*_{\tau^*} < \phi_\tau$). Thus, there must exist a range of relatively higher costs of compliance for the foreign firm where in spite of higher costs of compliance it is optimal to set a relatively higher standard on imports.