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Free trade and the greening of domestic industry

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ABSTRACT. In this paper we present an example where a domestic import-competing industry can benefit from a pollution tax borne by its consumers. We show that this pollution tax can be similar to a traditional trade barrier (such as a tariff) and can raise the price received by the domestic industry. Given an open economy, we highlight conditions under which domestic producers prefer a higher consumption-based pollution tax than is socially optimal. In contrast, when the economy is closed, we find that producers prefer a pollution tax that is lower than socially optimal. Domestic producers turn 'green' only when faced with import competition.

1. Introduction

As countries lower trade barriers, many believe that governments will weaken environmental regulation, and sacrifice environmental quality to remain globally competitive.[1] However, there are examples that contradict this view. In the 1980s, as the European Union (EU) reduced trade barriers

[1] Note that the economic, literature on trade and the environment cannot be characterized easily. Both theoretical and empirical papers argue that international trade can be either good or bad for the environmental regulation and/or the environment depending on the context analyzed (Copeland and Taylor, 2004; Copeland and Gulati, 2006, provide surveys).

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among member nations, Germany adopted stricter automobile emission controls than its partners. California consistently adopts emission standards stricter than those in the rest of the United States. Similarly, in an increasingly open world, South Korea raised regulatory standards on cars to match the US, the EU and Japan (see Vogel, 1995, 2000, for other examples).

There are also examples where import-competing industries lobby for stricter environmental regulation. Despite being among the world's largest producers of chlorofluorocarbons (CFCs), DuPont famously supported the Montreal Protocol and argued for a complete ban on their use. In 1990, US tuna fishermen supported dolphin-safe labelling. European farmers have successfully lobbied to ban genetically modified food consumption, production and imports,[2] and European car-makers, such as Fiat, have supported high gasoline taxes in Italy.

Oye and Maxwell (1994) argue that, as DuPont could provide a CFC substitute at a lower cost than its competitors, the worldwide ban on CFC use shifted demand to DuPont. Hammar *et al.* (2004) argue that, as Fiat historically produces a relatively high proportion of fuel-efficient diesel cars, high gasoline taxes make consumer prefer their cars over gasoline-based imports. Finally, DeSombre (2000) argues that, as the US tuna fishing industry could provide dolphin-safe tuna at a lower cost than its competitors, the labelling initiative helped them capture a premium for their output.[3] The common theme underlying these cases is that an increase in the stringency of environmental regulation imposed on consumers made the domestic industry better off. In this paper we provide an analytical example illustrating such a mechanism.

The question we ask is: when does an import-competing industry benefit from an increase in the pollution tax borne by the consumers of its product?

We assume that producers can influence the *pollution intensity of consumption*: that is, the amount of pollution generated on the consumption of their product.[4] Most goods that generate pollution on being consumed share this property. For example, the choice of vehicle fuel efficiency determines the amount of carbon dioxide generated per mile, the choice of material used during production determines the toxicity of household waste, and the choice of which coal seam to mine determines the sulphur content of coal. We also assume that consumers pay a pollution tax on pollution

[2] For a discussion, see a BBC news report on GMO protests at http://news.bbc.co.uk/2/hi/uk_news/england/london/3186154.stm.

[3] The tuna example involves process rather than product standards. While the paper explicitly considers product standards, the intuition presented carries over to cases involving process standards as well.

[4] Identically, we could just assume that goods produced by different producers have a different pollution intensity on consumption.

generated,[5] for example, a gas or carbon tax paid by drivers, or a tax (or the price of a permit) on sulphur dioxide emissions from a power plant.

The pollution tax creates a price premium for goods with lower pollution intensities of consumption. Domestic producers influence this price premium based on whether or not they face international competition and if they can provide a good with a lower pollution intensity than their competitors. When shielded from foreign competition, domestic producers prefer a pollution tax that is strictly lower than socially optimal. In a closed economy an increase in the pollution tax reduces consumer demand and subsequently lowers the producer price. On being exposed to international competition this changes. If the domestic industry is more efficient than importers at reducing the pollution intensity of consumption, it prefers a higher pollution tax than socially optimal. In this case the pollution tax works just like a traditional trade barrier (such as a tariff) and any increase raises the price received by the domestic industry. If the domestic industry is less efficient than importers at reducing the pollution intensity of consumption, it is indifferent to the level of the pollution tax and just sells the good in international markets where consumption is not taxed. Overall, irrespective of who is more efficient at lowering the pollution intensity of consumption, we find that the domestic industry turns 'green' as the economy opens up to trade.

1.1. Literature review

The mechanism highlighted in this paper is an extension of the well-known 'raising rivals' costs' hypothesis (see Salop and Scheffman, 1983). Previous applications of the raising rivals' costs hypothesis focus on policies that directly alter the costs of production (see Salop and Scheffman, 1983; Fischer and Serra, 2000; Copeland, 2001; McAusland, 2004) to provide advantage in an oligopolistic market. We abstract away from monopoly rents and policies designed to directly raise the costs of production.

We illustrate that environmental policies imposed on consumers create demand for certain characteristics in a product and, if chosen appropriately, can be used to create demand for characteristics that the domestic industry is more efficient at providing than its competition. Earlier models illustrating the influence of the raising rivals' costs hypothesis in environmental policy were unable to explain why producers might be interested in strategically altering policies borne by their consumers. In contrast, we demonstrate the political economy incentives underlying such policies. With a simple model we show how the raising rivals' costs hypothesis explains the incentives underlying a much broader range of policies than those originally modelled.

While these political economy incentives might have been neglected in economics, they have been long recognized in the political science and public policy literature. De Sombre (1995); DeSombre (2000) argues that most US attempts at internationalizing domestic consumption-based

[5] In this paper we use a pollution tax for illustration. However, the standard equivalence between price and quantity instruments holds and a pollution quota would have the same impact as the pollution tax.

environmental policy are also measures to protect domestic industry. In their aptly titled article 'Self interest and environmental management', Oye and Maxwell (1994) discuss the benefits to domestic industry from consumption- and production-based environmental policy. Finally, Vogel (1995, 2000) highlights the link between environmental and industrial interests in the making of environmental policy. Complementary to Vogel (1995, 2000), we provide a simple economic model illustrating how political economy interactions can align the interests of industrialists and environmentalists in setting consumption-based pollution policies.

This paper also contributes to a specialized economics literature exploring the political economy interactions between international trade and environmental policy (see, for example, Fredriksson, 1997; Aidt, 1998; McAusland, 2003; Gulati, 2008). Most directly this paper relates to McAusland (2005, 2008), discussing consumption-based pollution in a political economy context. McAusland (2005) shows that harmonizing pollution regulation across symmetric countries can worsen pollution and lower welfare. While exploring the effect of openness on environmental regulation, McAusland (2008) shows that domestic producers are indifferent to increases in the consumption-based pollution taxes in an open economy. We go further than indifference. We argue that in an open economy, producers of the polluting good can prefer an increase in the consumption pollution tax.[6]

1.2. Trade restricting environmental policies – developing country impacts
Consider some examples of the mechanism proposed in this paper impacting developing country exports. The (Illegal) Timber Regulation restricts timber and its products (including pulp and paper products) sold in the EU to being from 'legally harvested timber'. The Lacey Act in the US requires a 'free of illegal species' status in products imported into the US. This law was amended in 2008 to include a wider variety of prohibited plants and plant products, including products made of illegally harvested wood. Importers bear the risk of losing their imports to confiscation for small record-keeping errors by foreign suppliers – providing wood-product companies with a significant incentive to find domestic suppliers. Indeed, the Lacey Act amendments were strongly supported by the American lumber industry. An example of US government seizure of goods is in 2011 at the Gibson Guitar factory in Tennessee. The wood used here came from India.

Li and Beghin (2012) present evidence of protectionism related to maximum residue limits (MRLs) of chemicals that have been a big trade deterrent for developing countries given the primacy of agricultural exports. Foletti (2012) shows a robust and significant correlation between MRLs of different chemicals and import penetration. These MRLs are often designed to be easier to achieve for domestic producers than importers.

[6] In a more general sense, by focusing on consumer-level environmental policies, our paper also contributes to the growing literature on consumption-based pollution. Krutilla (1991), Copeland and Taylor (1995) and Rauscher (1997) all analyze the effects of trade on the environment given consumption-generated pollution and a welfare-maximizing government.

Agricultural businesses in developed countries are increasingly using certification systems, and have established commodity roundtables for a number of key export products, such as biofuels, cocoa, palm oil, rice and sugar (UNEP, 2013). Some coffee and chocolate companies have incorporated environmentally friendly certified products into their supply chains (Swinnen *et al.*, 2012). Similarly, in case of another very important export item for the developing countries, i.e., fisheries, increased trade links have been associated with greening reflected in the increase in the number of certification programs for wild-capture fish products. The requirements from certification often involve employing either costly technologies or costly record keeping. These costs are usually higher for the exporting country than domestic producers – who often influence the development of the certification. As most of these examples involve primary products, they adversely impact developing country exports. Similarly, as manufacturing production increasingly shifts to developing countries, the concurrent growth in energy efficiency standards and mandatory labelling for household appliances, equipment and lighting (EC 2009) can adversely impact developing country exports.

2. Assumptions and analytical setup

2.1. Broad assumptions

We consider a small economy producing one *numéraire* (price normalized to one) good, and one non-numéraire good. Both goods are produced under the assumption of constant returns to scale and perfect competition. Production of neither good generates pollution. However, consumption of the non-numéraire good produces pollution.[7] The per-unit pollution intensity from consumption of the non-numéraire good is determined during production. We assume that the polluting non-numéraire good is always imported. Consumption of the non-numéraire good is subject to a domestic pollution tax.[8]

2.2. More detail

Production of the numéraire good (y^0) is linear in labor (l^0) (the production function is $y^0 = l^0$). The world and domestic price for the numéraire good is normalized to one, and we assume that the stock of labor is large enough to ensure positive production throughout (this ensures that the wage rate, w, equals one). Consumption of the numéraire good does not produce any pollution and is denoted x^0.

[7] Pollution generated during consumption is an important source of ozone depletion, solid waste accumulation, climate change, and many broad measures of air and water pollution (please see McAusland, 2008, for a more detailed discussion).

[8] Assumptions that the non-numéraire good is always imported, and its consumption involves paying a domestic pollution tax, are important to highlight import-competing industry political incentives to influence domestic policy.

Domestic production of the non-numéraire good is denoted y and uses two inputs, sector-specific capital k and labor l. Consumption of the non-numéraire good (denoted x) generates pollution (z). For simplicity we separate production into two stages. The first is the production of the *raw* good – that has not been altered to influence its per-unit pollution intensity. If one unit of the raw good is consumed, T units of pollution (z) are emitted. The raw good is produced using a standard production function $f(k, l)$ that is twice differentiable, homogenous of degree one, increasing, and concave in its inputs. The second stage determines the per unit pollution intensity of this good in consumption. Let $a \in (0, T)$ represent the level of abatement per unit. If $c(a)$ amounts of labor ($c(.)$ is strictly increasing and convex with $c(0) = 0$) are combined with each unit of the 'raw' product, the final product has a per-unit pollution intensity of $(T - a)$ on consumption. Thus a higher level of abatement implies a lower pollution intensity of consumption. Total labor required (l^a) for abatement is thus $c(a)f(k, l)$. Let $p = \bar{p} - wc(a)$ denote the producer price net of abatement costs $c(a)$, where $\bar{p}$ denote the price producers receive per unit of the 'raw' good. Restricted profits are given by $\pi(p) = \widetilde{\pi}(p, w; k)$[9] where $\widetilde{\pi}(p, w; k) = \max_l\{pf(k, l) - wl\}$ (recall that $w = 1$).

A process similar to that for domestic production is required to determine the pollution intensity of imports. Let $a^* \in (0, T)$ denote the level of abatement associated with imports and let $c^*(a^*)$ denote the per-unit abatement cost function for imports ($c^*(.)$ is strictly increasing and convex with $c^*(0) = 0$ and need not be the same as that for domestic production). Let one unit of the raw import of the non-numéraire good m_I be priced at p^* in the world market; thus the price for one unit of the imported non-numéraire good with abatement level a^* is $p^* + c^*(a^*)$ (given that $w = 1$). Note that we assume that abatement technologies are specific to the particular good (domestic or import). Given this specificity the raw product cannot be treated like an intermediate good. If the good is imported, a per-unit labor cost of $c^*(.)$ is required for abatement while if it is produced at home a per-unit labor cost of $c(.)$ is required.[10]

Formally a cost advantage at abatement is defined below.

Definition 1. *(i) The domestic industry has a cost advantage at abatement if* $c_a(a') < c^*_a(a'), \forall a' \in (0, T]$. *(ii) The domestic industry has a cost disadvantage at*

[9] Note that the restricted profit function derives from $\widetilde{\pi}(p, w; k) = \max_l\{\bar{p}f(k, l) - wl - wl^a\}$ and that restricted profit functions are positively linearly homogeneous, and convex in prices (p, w) Diewert (1974). They also satisfy Hotelling's lemma. Output equals the partial derivative of the restricted profit function with respect to output price ($y = \pi_p(.)$, where subscripts on functions denote partial derivatives).

[10] One could assume that differences in the cost of abatement derive from differences in appropriate technologies across competitors. For example, 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).

abatement if $c_a(a') > c_a^*(a'), \forall a' \in (0, T]$. *(iii) Domestic producers and importers are equally efficient at abatement if* $c_a(a') = c_a^*(a'), \forall a' \in [0, T]$.

The domestic industry has a cost advantage at abatement if its marginal cost for any feasible level of abatement is lower than that for the importers. The opposite holds true when importers have a cost advantage. An equal marginal cost implies that domestic producers and importers are equally efficient.[11]

Pollution is given by

$$z = (T - a)y + (T - a^*)(x - y),$$

where $(x - y) = m$ (imports). Overall pollution is a weighted sum of domestic production and imports, where the weights are the respective pollution intensities. Pollution adversely affects the utility of all consumers in the economy. The representative consumer's utility is

$$U(x^0, x) = x^0 + u(x) - v(z),$$

where the sub-utility function $u(.)$ is assumed to be strictly increasing and concave, and the damage from pollution $v(z)$ is assumed to be strictly increasing and convex. Maximization of this utility function implies that the demand for the non-numéraire good $(x(q))$ is solely a function of the consumer price (q). Consumer surplus is denoted $\gamma(q) = [u(x(q)) - qx(q)]$.

2.3. Analytical framework: the influence of pollution policy on domestic prices

The government regulates pollution by a per-unit pollution tax (t). Consumers pay tax for pollution generated during consumption. Consuming one unit of the imported good implies a tax payment of $t(T - a^*)$. Similarly, consuming one unit of the domestically produced good implies a tax payment of $t(T - a)$. Given that importers are perfectly competitive and that the non-numéraire good is always imported, the effective consumer price for one unit of the imported good (q) is

$$q = p^* + c^*(a^*) + t(T - a^*). \tag{1}$$

The effective consumer price includes the world price for the raw good (p^*), the abatement cost for importers $(c^*(a^*))$, and the associated pollution tax outlay $(t(T - a^*))$.

The consumer buys the domestically produced good only if it has an effective price no greater than that of the imported good. This implies that the maximum price the domestic producer can charge the consumers for the raw good $(\bar{p})$ is given by the following equation:

$$\bar{p} + t(T - a) = p^* + c^*(a^*) + t(T - a^*),$$

where the left-hand side is the effective consumer price for the domestic good. This implies that the net price (p) received by domestic producers

[11] For simplicity we only consider those cost functions that do not cross in the relevant range.

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for producing the raw good is

$$p = p^* + c^*(a^*) - c(a) + t(a - a^*). \qquad (2)$$

The net domestic producer price equals the world price (p^*) for the raw good, plus the difference in per-unit costs of abatement ($c^*(a^*) - c(a)$), and the difference in pollution tax outlays from consuming the two goods ($t(a - a^*)$). Further, as the economy is open, domestic producers sell their good at home if and only if

$$p \geq p^*.$$

If the domestic price for the raw good is lower than the world price, domestic producers are better off selling in the world market.[12] Equation (2) indicates that if the domestic good has a lower pollution intensity ($(a - a^*) > 0$), domestic producers can charge a higher price for the domestic raw good. Moreover, as the pollution tax amplifies the premium on the domestic good ($t(a - a^*)$) and given a relative cost advantage at abatement, it may be beneficial to produce a cleaner good and lobby for a higher pollution tax. In what follows we explore these political economy incentives.

3. Pollution tax: socially optimal and political equilibrium

Assume that the government regulates the pollution tax alone. Once the pollution tax is set, competitive interactions determine the pollution intensities of the imported and domestic good.[13]

3.1. Abatement activity

The consumer prefers the good with abatement levels that minimize her effective price (from equation (1)); thus the preferred level of import abatement ($\hat{a}^*$) is given by

$$c^*_{a^*}(\hat{a}^*) = t. \qquad (3)$$

We assume that the preferred level of abatement is feasible, that is, $\hat{a}^* \in (0, T)$. Given feasibility, in a perfectly competitive market importers abate to the preferred level. This is because any importer who sells a good with abatement different from $\hat{a}^*$ loses her market to the producer who sells the good with the preferred level of abatement. The effective price paid for the imported good is thus given by

$$q = p^* + c^*(\hat{a}^*) + t(T - \hat{a}^*).$$

Import-competing producers of the non-numéraire good abate at the level that maximizes their net price (p from equation (2)). This level of

[12] The implicit assumption here is that there is an untaxed world market for the raw good. If instead world consumption was also subject to a similar pollution tax, domestic producers would sell at home irrespective of their cost advantage.

[13] In an online Technical Appendix (available at http://journals.cambridge.org/EDE) we verify that the results derived in this section hold even when the government can choose both the pollution tax and a cap on the pollution intensity for all goods sold at home.

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abatement is denoted $\hat{a}$ and is defined by

$$c_a(\hat{a}) = t. \tag{4}$$

The net price is thus given by

$$p = p^* + c^*(\hat{a}^*) - c(\hat{a}) + t(\hat{a} - \hat{a}^*). \tag{5}$$

The domestic producer price equals the world price (p^*), plus the difference in per-unit costs of abatement ($c^*(\hat{a}^*) - c(\hat{a})$), and the difference in pollution tax outlays from consuming the two goods ($t(\hat{a} - \hat{a}^*)$). Next consider two results on pollution intensities.

Lemma 1. *If* $c_a(\hat{a}') \lesseqqgtr c_a^*(\hat{a}')\ \forall \hat{a}' \in [0, T]$ *then domestic and import pollution intensities satisfy* $(T - \hat{a}) \lesseqqgtr (T - \hat{a}^*)$.

Proof : The proof follows from equations (3) and (4) and from our assumptions on the two cost functions that $c(0) = 0$, $c_a > 0$ and $c_{aa} > 0$ and similarly $c^*(0) = 0$, $c^*_{a^*} > 0$ and $c^*_{a^*a^*} > 0$. □

This lemma compares pollution intensities under three possibilities listed in Definition 1. If the domestic industry has a cost advantage, domestic producers undertake greater abatement and correspondingly the pollution intensity of the domestic good is lower than that of the imported good. Similarly, if importers have a cost advantage, the imported good has a lower pollution intensity. Finally, when the domestic producers and importers have equal marginal costs, pollution intensities are equal.

Recall that domestic producers sell their product at home if and only if $p \geq p^*$. This implies that

$$c^*(\hat{a}^*) - c(\hat{a}) \geq t(\hat{a}^* - \hat{a}). \tag{6}$$

This allows us to rule out one of the possibilities discussed above.

Lemma 2. *If the non-numéraire good is imported, domestic firms sell the non-numéraire good in the domestic market if and only if they are equally efficient or have a cost advantage at abatement.*

Proof : Please see Appendix A.1. □

Domestic firms operate in the domestic market if and only if they are at least as good as importers at abatement. If domestic firms have a cost disadvantage at abatement they are better off selling their raw product in the world market, as the maximum price they can get at home for the raw good is lower than the world price.

Lemma 2 implies that domestic producers do not sell in the domestic market when they have a cost disadvantage. Thus they do not incur any

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costs for abatement and receive the world price for their raw output,

$$p = p^*. \tag{7}$$

This also implies that given a cost disadvantage at abatement, domestic producers are indifferent to the level of the pollution tax.[14]

3.2. The social planner's benchmark

The social planner's objective is to choose the pollution tax to maximize aggregate welfare, given the utility and profit-maximizing behaviour of its agents. Assume that the mass of labor in the economy equals 1. Aggregate welfare is a sum of wage income (given that wage equals 1), producer profits, consumer surplus, tax revenue and social damage from pollution. Formally the problem is

$$\max_t W = \{1 + \pi(p) + \gamma(q) + tz - v(z)\}. \tag{8}$$

Lemma 3. *The welfare-maximizing pollution tax is given by*

$$t^w = v_z, \tag{9}$$

where the superscript w denotes the welfare-maximizing policy.

Proof : Please see Appendix A.1. □

In other words, the welfare-maximizing pollution tax equals marginal social damage from pollution.

Using equation (3) the importers choose the following level of abatement:

$$c_a(\hat{a}^{*w}) = v_z. \tag{10}$$

And if domestic producers operate in the home market, using equation (4), their abatement level is given by

$$c_a(\hat{a}^w) = v_z. \tag{11}$$

Equations (9)–(11) define the optimal welfare-maximizing policy for regulating pollution. At the optimum, the marginal cost of reducing pollution is set equal to the marginal social damage from pollution across all sectors. When domestic producers operate in the domestic market these conditions also imply that $(T - \hat{a}^w) \leq (T - \hat{a}^{*w})$. However, when domestic firms do not operate in the domestic market (under a cost disadvantage), the two equations (9) and (10) define welfare-maximizing policy and equation (11) ceases to be relevant.

These results also demonstrate that, given perfect competition in the product market, just regulating the pollution tax can lead to a maximization

[14] In case world consumption of the non-numéraire good is subject to a similar pollution tax, Lemma 2 does not hold.

of aggregate welfare. The planner sets the pollution tax equal to marginal social damage from pollution. Given perfect competition the marginal cost of abatement equals the pollution tax (which equals the marginal social damage from pollution). This combination of pollution tax and abatement levels maximizes aggregate welfare.

3.3. The political equilibrium

We now consider pollution policy in a model where domestic producers influence policy making. We choose the simplest model possible in order to capture producer influence. Assume that the government maximizes a weighted welfare function where the profits of domestic producers of the non-numéraire good get a higher weight than the rest of society. Formally,

$$\max_t G = \{1 + (1 + \psi)\pi(p) + \gamma(q) + tz - v(z)\}, \tag{12}$$

where $\psi > 0$ is the additional weight attached to domestic producer profits.[15]

There are two possibilities to consider. In the first possibility domestic producers have a cost disadvantage at abatement.

Corollary to Lemma 2. *Given a domestic firm cost disadvantage at abatement, the optimal pollution tax maximizes aggregate welfare in the economy.*

As explained earlier, given a cost disadvantage, domestic producers disengage from the domestic market and the level of pollution tax makes no difference to their profits (as $p = p^*$). The government essentially functions like an aggregate welfare maximizer and the pollution tax chosen equals marginal social damage (from equation (9)). The corresponding level of abatement chosen by importers also equals that observed under a welfare-maximizing government (see equation (10)).

Next we consider the case where domestic producers are at least as good as the importers at abatement. On maximizing the weighted welfare function in equation (12) we get the following expression for the political equilibrium pollution tax:

$$t^o = v_z + \frac{\psi(\hat{a}^o - \hat{a}^{*o})\pi_p}{-\frac{dz}{dt}}, \tag{13}$$

where the superscript o implies the political equilibrium tax and abatement level. The above equation illustrates the government's tradeoff

[15] Please see Grossman and Helpman (1994) for the micro-foundations for this weighted welfare function. The authors show that government policy obtained from maximizing the above weighted welfare function is equivalent to government policy chosen under the following conditions: (a) the government collects political contributions; (b) the producers of the non-numéraire good are organized as a political lobby; and (c) the contribution function offered by the producers is differentiable. Note that this weighted welfare function is also analogous to the political-support function popularized in the international trade literature by Hillman (1982).

between special interest profits and aggregate welfare. The first term on the right-hand side is marginal social damage. The second term reflects the government's policy compromise. The numerator of the second term is the weighted gain to domestic producers from an increase in the pollution tax ($\psi(\hat{a}^o - \hat{a}^{*o})\pi_p$) (recall that $\hat{a}^o - \hat{a}^{*o} \geq 0$). The denominator is the responsiveness of pollution to pollution tax.

By substituting $\frac{d\hat{a}^{*o}}{dt}$ and $\frac{d\hat{a}^o}{dt}$ (gained by differentiating equations (3) and (4)), equation (13) can be re-expressed as

$$t^o = v_z + \frac{\psi(\hat{a}^o - \hat{a}^{*o})\pi_p}{(\hat{a}^{*o} - \hat{a}^o)^2\pi_{pp} - (T - \hat{a}^{*o})^2 x_q + \pi_p \frac{1}{c_{aa}} + [x(q) - \pi_p]\frac{1}{c^*_{aa}}}. \quad (14)$$

This re-expression allows us to verify that, given a strict cost advantage at abatement, and domestic producer influence on policy making, the pollution tax emerging in political equilibrium is higher than socially optimal. In other words, the second term on the right-hand side of equation (14) is positive.[16] The intuition is fairly simple. Due to the cost advantage, domestic producers produce a good that has a lower pollution intensity than the imported good (Lemma 1). This in turn implies that the consumer is willing to pay a higher price for the domestic good than the imported good and, to amplify this willingness to pay, domestic producers prefer a higher pollution tax than socially optimal.[17]

The level of abatement (a^o) adopted by domestic firms is given by equation (4) and the abatement level chosen by importers (a^{*o}) is given by equation (3). As explained earlier, the abatement levels chosen equate the marginal cost of abatement to the pollution tax. As the optimal pollution tax exceeds marginal social damage, the marginal cost of abatement also exceeds marginal social damage.

Proposition 1. *Given (i) the non-numéraire good is imported, (ii) policy is influenced by domestic producers, and (iii) an untaxed world market for the raw non-numéraire exists, the pollution tax is at least as strict as that under a welfare-maximizing government. Further, if domestic producers have a strict cost advantage at abatement, the pollution tax is stricter than socially optimal.*

This proposition summarizes the results discussed above. When domestic producers have a cost disadvantage at abatement, environmental policy mimics that under a welfare-maximizing government. The pollution tax

[16] To sign the second term on the right-hand side of equation (14), consider its components. The numerator is positive, as $\psi > 0$, the domestic level of abatement is higher than that chosen by the importer, $(\hat{a}^o - \hat{a}^{*o}) > 0$ and finally, domestic production $\pi_p > 0$. The denominator is also positive, as $(\hat{a}^{*o} - \hat{a}^o) > 0$ as explained above, $x_q < 0$ the own responsiveness of demand, $c_{aa} > 0$ as we assume the convexity of both cost functions, and $[x(q) - \pi_p] > 0$ as we assume the presence of imports.

[17] Note how a pollution tax higher than socially optimal works just like a positive import tariff in a small open economy. Domestic industry prefers a positive tariff as it raises the price of its product; however, the socially optimal tax equals zero.

is set equal to marginal social damage ($t_o = v_z$) and importers abate the same amount as under a welfare-maximizing government ($c_a^*(\hat{a}^{*o}) = v_z$). Even when marginal costs of abatement are equal across the domestic producer and importer, environmental policy equals that under a welfare-maximizing government (this can be seen by substituting $\hat{a} - \hat{a}^* = 0$ in equation (14)). Only when the domestic industry has a cost advantage at abatement do we observe environmental policy different from the welfare-maximizing norm. The pollution tax chosen by the government is strictly higher than marginal social damage ($t^o > v_z$). In addition, abatement levels chosen by the importers and domestic producers are also higher than those under a welfare-maximizing pollution tax ($c_a(\hat{a}^o) > v_z$, and $c_a^*(\hat{a}^{*o}) > v_z$).

These results have an interesting implication; if we assume an exogenous world price, all else being equal, a small open economy governed by a politically motivated government favouring domestic producers cannot have higher pollution (or equivalently lower pollution taxes) than a similar economy governed by a welfare-maximizing government.[18] This is in contrast to a few earlier analyses where political influence in the hands of import-competing industries implies weaker environmental policy and higher pollution in free trade (see subsection 1.1 for further discussion).

3.3.1. Political equilibrium in a closed economy

Consider the same economy, but without international trade. As earlier, the non-numéraire good is produced under perfect competition, and consumers pay a per-unit pollution tax (denoted t). The effective consumer price (denoted q) equals

$$q = p + c(a) + t(T - a),$$

where p is the producer price for the raw good. Consumers prefer to buy the good with an abatement level that minimizes this effective price. The consumer's preferred abatement level ($\hat{a}$) is given by the condition

$$c_a(\hat{a}) = t. \tag{15}$$

As earlier, we assume that the preferred abatement level is feasible, that is, $\hat{a} \in (0, T)$ and the only good supplied competitively is the one that meets the preferred abatement level. As there are no imports, pollution produced

[18] Note that this result depends on the assumption that domestic producers can sell in markets where consumers do not pay a tax for pollution. If we consider conditions where the world market also taxed non-numéraire consumption, a richer proposition would result. In that case, a pollution tax that is either higher or lower than the welfare-maximizing pollution tax would emerge depending on the conditions considered. A cost-disadvantaged domestic industry would be forced to sell at home – as Lemma 2 would no longer hold – and would minimize its losses by influencing the pollution tax to be lower than socially optimal. A cost-advantaged domestic industry would behave as discussed above.

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in this economy is

$$z = (T - \hat{a})x(q).$$

The producer price in the economy is determined by equating domestic demand and supply. Formally,

$$\pi_p(p) = x(p + c(\hat{a}) + t(T - \hat{a})). \quad (16)$$

In other words, the supply of the good at price p is equal to the demand of the good at its effective price q.

In a closed economy, any change in the pollution tax alters the domestic demand and thus alters the price of the non-numéraire good. From equation (16) we can derive the relationship between the domestic producer price and the pollution tax. This relationship is given by

$$\frac{dp}{dt} = -[T - \hat{a}]\frac{[-x_q]}{[\pi_{pp} - x_q]} < 0. \quad (17)$$

As the pollution tax rises, the demand for the polluting good falls. In order to restore equilibrium, the price for the non-numéraire good falls.[19]

The first-order condition (for the problem in equation (12)) with respect to the pollution tax t can be expressed as

$$t^{oc} = v_z - \frac{\psi \pi_p}{[T - \hat{a}]\pi_{pp}}, \quad (18)$$

where the superscript oc distinguishes the policy chosen by the politically motivated government in a closed economy. As the government weighs producer profits higher than the rest of the economy's welfare, it sets the optimal pollution tax lower than marginal social damage. Equations (15) and (18) imply that the abatement level chosen under a politically motivated government is given by

$$c_a(\hat{a}^{oc}) = v_z - \psi \frac{\pi_p}{[T - \hat{a}]\pi_{pp}}.$$

Thus the abatement level chosen is lower than that adopted by domestic industry in a welfare-maximizing economy.[20]

Lemma 4. *Given (i) a closed economy and (ii) policy is influenced by domestic producers, the pollution tax is less stringent than that under a welfare-maximizing government.*

[19] Due to the concavity of the sub-utility function, $x_q < 0$; due to the convexity of the profit function $\pi_{pp} > 0$. Finally, by the assumption of an interior solution, $[T - \hat{a}] > 0$.

[20] The first-order condition for the problem in equation (8) with respect to the pollution tax t is $t^{wc} = v_z$, where the superscript wc denotes the welfare-maximizing policy in a closed economy. In other words, the welfare-maximizing pollution tax equals marginal social damage from pollution. Using equation (15) we find that the abatement level chosen is given by $c_a(\hat{a}^{wc}) = v_z$. In other words, the abatement level chosen by domestic producers is such that the marginal cost of abatement equals the marginal social damage from pollution.

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Lemma 4 and Proposition 1 together imply that the domestic industry turns 'green' only as the economy opens up to international trade.[21] When the economy is closed, the pollution tax chosen under the influence of domestic producers is lower than the marginal social damage from pollution ($t^{oc} < v_z$). This is because in a closed economy the pollution tax lowers consumer demand and subsequently lowers producer price. A lower pollution tax implies that the level of abatement chosen by domestic producers is also lower than socially optimal ($c_a(\hat{a}^{oc}) < v_z$).

However, on being exposed to foreign competition the domestic industry is either indifferent to environmental policy and allows the resumption of welfare-maximizing policy (given a cost disadvantage and equal efficiency), or prefers higher pollution taxes and chooses abatement levels that are higher than socially optimal (the case of a cost advantage).[22] This change in heart occurs as the domestic industry recognizes the ability of a pollution tax to shift demand towards its own product even in free trade. In other words, even in a setting where the government favours domestic producers, freer trade can raise the pollution tax.[23]

4. Conclusion

In this paper we show how free trade can alter the incentives for domestic producers to influence policy. In a closed economy, domestic producers desire pollution taxes that are lower than those chosen by a social planner. However, on facing import competition, and given a cost advantage at abatement, even though the firm has no regard for the environment, it is likely to influence the government to raise pollution tax over what is socially optimal.

[21] We provide an example of a perfectly competitive small economy if instead we assumed our economy; to be large, or allowed monopolistic behaviour, our results would change. This would create opposition (instead of indifference) to an increase in the pollution tax if the domestic firms had a cost-disadvantage, and would lower their preference for a higher pollution tax if domestic firms had a cost-advantage. However, the opposition from domestic firms would still be smaller than in autarky.

[22] In addition to a comparison between autarky and free trade, a similar argument can be made for declining trade barriers. While an analytical exposition of this case is beyond the scope of this paper, consider the underlying intuition. Assume that θ is the tariff imposed on imports of the raw good. This implies that the producer price for a unit of raw good produced at home (previously equation (2)) now becomes

$$p = p^* + \theta + t(a - a^*) + c^*(a^*) - c(a).$$

In the presence of a cost advantage at abatement, the tariff and the emissions tax are linear substitutes for raising the producer price. Thus, if the tariff (θ) is lowered, the government can compensate domestic producers for the lower tariff by raising the emissions tax (t).

[23] This statement ignores the fact that under these conditions, free trade also worsens aggregate welfare.

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Consider another example. In 1987, Puerto Rican dairy producers supported the adoption of US regulatory standards and procedures for its dairy industry. Lyon and Maxwell (2004) argue that, while the adoption of stricter standards created minor health and safety benefits, the main motive was to restrict imports from nations not complying with these standards. The domestic industry could now oust the Canadian firm Lactel from their market and win back a significant share of the ultra high temperature milk market. While this adoption was not directly a result of the adoption of free trade (as modelled in this paper), it was motivated by the presence of international competition.

In this paper we present an example where pollution taxes and pollution intensities are used to influence consumer preferences for domestically produced goods. However the underlying intuition applies beyond these specific instruments. Consumer preferences can be influenced by instruments other than consumption-based taxes. One possibility is the use of information campaigns on the environmental attributes of different products. The British government rating for cars based on their CO_2 pollution (see http://news.bbc.co.uk/2/hi/uk_news/4252359.stm) and dolphin-safe tuna labelling campaigns are good examples of such instruments.

We believe that this model has potential for some interesting extensions exploring why firms might have different costs of abatement. Some authors argue that a comparative advantage at abatement derives from pre-existing domestic regulation (Schreurs and Economy, 1997; DeSombre, 2000). Pre-existing domestic regulation allows domestic industry to develop cost-effective means for abatement (similar to a learning by doing argument). Subsequently, once this domestic regulation is internationalized through a multilateral (or similar bilateral) agreement, domestic producers do better in a world with international trade. Another useful extension would investigate the optimal design of pollution intensities. Given national treatment, a government is likely to design its requirements on industry in such a way that the domestic industry has a natural advantage. This argument is often used by the critics of the CAFE standard in the United States (Vogel, 1998). A model that allows the government to design its requirements in a broader manner than allowed in this paper is likely to explain the proliferation of different product standards across the world. It might also be a good starting point to study whether harmonizing existing product standards is a good idea.

Supplementary materials and methods

The Supplementary material referred to in this article can be found online at journals.cambridge.org/EDE/.

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Appendix A: Definition

A.1. Proofs

Proof: **for Lemma 2**. For the if statement. Assume $c_a(\bar{a}) \leq c_a^*(\bar{a})\ \forall \bar{a} \in [0, T]$. Given that firms choose their abatement levels $c_a(\hat{a}) = c_a^*(\hat{a}^*) = t$. This implies $(\hat{a} - \hat{a}^*) \geq 0$. From our definition of the cost function we know that

$$c(\hat{a}) - c^*(\hat{a}^*) = \int_0^{\hat{a}} c_a(z)dz - \int_0^{\hat{a}^*} c_a^*(z)dz = \int_0^{\hat{a}} c_a(z)dz - \left[\int_0^{\hat{a}^*} c_a(z)dz + \int_0^{\hat{a}^*} [c_a^*(z) - c_a(z)]dz\right].$$

Thus

$$c(\hat{a}) - c^*(\hat{a}^*) \leq \int_0^{\hat{a}} c_a(z)dz - \int_0^{\hat{a}^*} c_a(z)dz = \int_{\hat{a}^*}^{\hat{a}} c_a(z)dz \leq (\hat{a} - \hat{a}^*)c_a(\hat{a}) = t(\hat{a} - \hat{a}^*).$$

Rearranging

$$c^*(\hat{a}^*) - c(\hat{a}) \geq t(\hat{a}^* - \hat{a}),$$

and condition (6) is met.

For the only if statement. Assume that the domestic industry has a cost disadvantage at meeting abatement, thus $c_a(\bar{a}) > c_a^*(\bar{a})\ \forall \bar{a} \in [0, T]$. Given that firms choose their abatement levels $c_a(\hat{a}) = c_a^*(\hat{a}^*) = t$ and thus

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$(\hat{a} - \hat{a}^*) < 0$. We know that

$$t(\hat{a}^* - \hat{a}) = (\hat{a}^* - \hat{a})c_a^*(\hat{a}^*) > \int_{\hat{a}}^{\hat{a}^*} c_a^*(z)dz = \int_0^{\hat{a}^*} c_a^*(z)dz - \int_0^{\hat{a}} c_a^*(z)dz$$

$$> \int_0^{\hat{a}^*} c_a^*(z)dz - \left[\int_0^{\hat{a}} c_a^*(z)dz + \int_0^{\hat{a}} [c_a(z) - c_a^*(z)]dz\right]$$

$$= \int_0^{\hat{a}^*} c_a^*(z)dz - \int_0^{\hat{a}} c_a(z)dz = c^*(\hat{a}^*) - c_a(\hat{a}).$$

Thus we get

$$t(\hat{a}^* - \hat{a}) > c^*(\hat{a}^*) - c(\hat{a}),$$

and condition (6) is violated. □

Proof: **for Lemma 3**. The first-order condition or derivative of equation (8) yields

$$\pi(p)_p \frac{\partial p}{\partial t} - x(q)\frac{\partial q}{\partial t} + z(q) + t\frac{\partial z}{\partial t} - v(z)_z \frac{\partial z}{\partial t} = 0$$

The definitions of domestic producer price (p) and domestic consumer price (q) allow us to simplify the above equation to

$$-[\pi(p)_p(T - a) + [x(q) - \pi(p)_p](T - a^*)] + z(q) + t\frac{\partial z}{\partial t} - v(z)_z \frac{\partial z}{\partial t} = 0.$$

Using the definition of z this simplifies further to

$$t\frac{\partial z}{\partial t} - v(z)_z \frac{\partial z}{\partial t} = 0$$

□

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