Environmental policy with green consumerism

Stefan Ambec[1] and Philippe De Donder[2]

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[1]Toulouse School of Economics, (INRA) and University of Gothenburg, email: stefan.ambec@toulouse.inra.fr.

[2]Toulouse School of Economics, CNRS, University of Toulouse Capitole, Toulouse, France. Email: philippe.dedonder@tse-fr.eu

Abstract

We analyze the interplay between public policy and consumers' concerns for the environment. Consumers can reduce their impact on the environment by buying greener goods and by voting for more stringent regulations. Supplying greener goods allows firms to enjoy some competitive advantage and to exert market power on green consumers. We show that all consumers support laxer environmental standards (or taxes) when some of them are willing to pay more for greener goods. The presence of green consumers lowers environmental protection as well as the overall welfare in the economy to the benefit of the green good supplier. It also reverses the dominance of market-based instruments over command-and-control because the green firm obtains a higher share of the welfare with environmental taxes.

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1 Introduction

Economists usually perceive the degradation of the environment by economic activities as a market failure that should be fixed, or at least mitigated, by public policy. Firms and customers motivated by their self-interest tend to ignore their negative impact on the environment, which leads to excessive pollution and overexploitation of open-access natural resources such as water and clean air. This view is contradicted by the many private initiatives to reduce the negative impacts of human activities on the environment. For instance, some consumers purchase environmentally-friendly products at a higher price. This phenomenon is sometimes referred to as 'green consumerism'. On the supply side, firms often reduce their emission of pollutants and their use of natural resources beyond what is mandated by regulations. They engage into costly eco-labelling of their products and production processes. They endorse the so-called Corporate Social Responsibility (CSR) policy and code of conduct.

CSR is now very popular among managers and policy makers. It is part of most business school curricula. There is wide evidence that consumers care about CSR as many of them are willing to pay more for greener or fair trade products. The positive view of CSR and green consumerism contrasts with Friedman's famous criticism published in 1970 in The New York Times (Friedman, 1970). In an article provocatively entitled 'The Social Responsibility of Business is to Increase its Profits', Milton Friedman criticized CSR for being undemocratic. He argued that, with CSR, the businessman 'decides whom to tax by how much and for what purpose'. In a democratic society, 'the machinery must be set up to make the assessment of taxes and to determine through a political process the objectives to be served'.

The aim of this paper is to investigate Friedman's criticism in the light of economic theory. We analyze the interplay between citizen's purchases and voting decisions regarding environmental protection. We build a model in which people take both decisions. They consume a good which generates pollution when produced or consumed. Everyone suffers from the damage due to pollution. Some conscious consumers enjoy a warm-glow benefit from purchasing and consuming a greener version of the good emitting less pollution. The standard version of the good is available on a competitive market while the one with higher environmental performance is supplied by a single firm. The so-called green firm gains a competitive advantage from supplying a greener version of the good. The motive for supplying greener goods is strategic. It is purely profit-maximization: the green firm pays the cost of higher environmental performance to move away from perfect competition by exerting some market power on green consumers.

We first examine the choice of a minimal quality standard on environmental performance. The green firm might decide to go beyond the standard if charging a price premium for higher environmental performance is profitable. It turns out that two political outcomes might emerge: (i) a first-best standard with homogenous goods (no supply of green goods), (ii) a sub-optimal standard with products differentiated on environmental quality. Due to the exercise of market power exerted by the green firm, the former outcome Pareto dominates the latter one. Interestingly, all consumers vote for the same weak standard regardless of their taste for green products but for different reasons: green consumers favor a lower standard to reduce the price of the greener product while neutral consumers free-ride on the environmental protection provided by the green firm.

Next we consider the choice of an environmental tax. We find similar political outcomes: (i) a Pigou tax with homogenous products, (ii) a suboptimal tax with products differentiated on environmental quality. In contrast with standards, a higher tax increases not only the minimal environmental performance but also the environmental performance of the green product. The way the money collected by taxing pollution is refunded matters for the choice of the tax rate and its efficiency. For instance, a feebate (taxing emissions above a threshold and subsidizing abatement below) makes the inefficient outcome with differentiation on environmental quality more likely that if the tax is refunded with lump-sum payments. It also reduces consumers' welfare as more profit is extracted by the green firm.

Our paper builds on the literature on self-regulation and corporate social responsibility (see Ambec and Lanoie, 2008, and Kitzmueller and Shimshack, 2012, for surveys). Most studies aim at assessing the profitability of voluntary environmental protection and CSR strategies. Some previous works have analyzed the interplay between environmental policies and firm's or consumer's green behavior using different approaches. For instance, Fleckinger and Glachant (2011) analyze a game between a social-welfare maximizing regulator and a profit-maximizing firm with frictions in the regulation process. They show that self-regulation can be a firm's strategy to preempt more stringent future regulations. In the same vein, the private politic approach assumes that CSR and environmental policies result from combined pressure from lobbies (firms) or NGOs (consumers/citizens). We depart from those studies by modeling explicitly the collective decision process that determines environmental policy. Other papers highlight that CSR might crowd-out donation and charity (Kotchen, 2006, Besley and Ghatak, 2007). However, they do not endogenize environmental regulations using a political economy approach. The closest paper to ours is Calveras et al. (2007) which also relies on green consumers with warm-glow preferences who vote on environmental regulations. They show that the presence of green consumers might lead to laxer regulations when a majority of voters free-ride on their contribution to the environment. We provides a more negative view on green consumerism when being green is a way for firms to enjoy a comparative advantage: *all* consumers vote for laxer regulations. Furthermore, we analyze the political outcome when an environmental tax is implemented instead of an environmental standard.

2 The setting

2.1 The model

We consider a good whose production or consumption generates environmental externalities, typically pollution. We index pollution abatement by the continuous variable x that we call the *environmental quality*. A higher value of x reflects, for instance, the use of a cleaner source of energy to produce electricity, a less polluting car, food grown with less pesticide or water, a manufactured product that can be more easily recycled, etc. Alternatively, one can see x as a 'public good' contribution to society in the corporate social responsibility (CSR) sense, e.g. better working conditions, transparency, banning child labor, investment in education, infrastructure, etc. The unit cost of supplying one unit of the good with environmental quality x is denoted $c(x)$ where $c(.)$ is an increasing, twice differentiable and convex function of x, with $c(0) = 0$.

On the demand side, we consider a continuum of mass one of consumers who are divided into two types, green and neutral, with respective shares α and $1 - \alpha$. They are denoted by subscripts g and n, respectively. All consumers derive a private value v from consuming one unit of the good, regardless of its environmental quality. Both types of consumers suffer from pollution. Each of them enjoys a benefit $b(X)$ from the average environmental quality in the economy, denoted X. The function $b(.)$ is increasing, twice differentiable and concave. Neutral consumers do not care directly about the pollution generated by their own purchase decision. In other words, they do not value the environmental quality of the good they consume, since it does not impact the average environmental quality in the economy. Their utility when they purchase the good at price p is $v - p + b(X)$. By contrast, green consumers enjoy a 'warm glow' for contributing to environmental protection above the minimal environmental quality standard, that we denote x_0. Let ω be the green consumers' willingness to pay for environmental quality when above standard. Green consumers' utility when purchasing a good of environmental quality x at price p is $v - p + \omega x + b(X)$ when $x > x_0$, and $v - p + b(X)$ otherwise.[1]

On the supply side, a competitive industry is supplying the standard version of the good with environmental quality x_0. Perfect competition drives down their profit to zero. Firms can move away from perfect competition by supplying goods of higher environmental quality (to target green consumers) but only if few firms are able to do that. Let's assume that only one firm can supply higher environmental quality than the standard $x > x_0$.[2] Let us label this firm 1. Firm 1 has a monopoly position on the green version of the good (called the green good) with a competitive fringe of producers of its brown version.

We first analyze the socially desirable amount of environmental quality, which will constitute our main benchmark.

2.2 First-best environmental quality

The first-best environmental quality maximizes social welfare defined as the sum of consumers' welfare and firms' profit. We follow the canonical approach first proposed by Harsanyi (1995) and Hammond (1988) who advocate to exclude all external preferences, even benevolent ones, when computing a social welfare function. This means that we "launder" the green consumers' preferences by assuming away the warm-glow part of their utility. Both types of consumers then enjoy the same welfare regarding environmental quality. This implies that only one environmental quality x should be supplied. Assuming perfect competition for the homogenous good of quality x, its price equals to production cost $c(x)$ and profits are nil. Furthermore, with a continuum of consumers of mass one, the total welfare is also the average welfare. Thus social welfare with environmental quality x is $v + b(x) - c(x)$. Maximizing it with respect to x, we obtain the first-best level of environmental quality x^{FB} characterized by the following

[1] The alternative formulation where the warm glow factor is modeled as $\omega(x - x_0)$ would lead to qualitatively similar results.

[2] This assumption can be justified by the ownership of a particular technology or the long-term development of a reputation of being greener. For instance, the firm is the only one that can credibly commit to issue a label of better environmental quality.

the first-order condition:

$$b'(x^{FB}) = c'(x^{FB}), \tag{1}$$

which equates the marginal benefit and marginal cost of increasing x.

We investigate successively two forms of public intervention: a minimum standard on environmental quality and a tax on pollution. In both cases, we assume the same timing for the model. First, consumers vote over the value of the instrument (level of the standard or of the tax). Second, firms set simultaneously their prices and environmental quality given the policy enacted. Third, consumers make their purchasing decisions.

3 Environmental standard

In this section, we study the setting of a minimum quality standard imposed on all firms. We solve the model by backward induction. In a first sub-section, we study the price setting firms' behavior as well as the choice by consumers of which variant of the good to consume.

3.1 Firms' and consumers' behavior

Competition among producers of the good with minimal quality x_0 drives down its price towards its costs, so that we have an equilibrium price of $p_0 = c(x_0)$.

Firm 1 has exclusive capacity to supply greener goods. It charges p_1 for a production with environmental quality x_1. Green consumers buy green goods whenever[3]

$$v - p_1 + \omega x_1 + b(X) \geq v - p_0 + b(X).$$

We first assume that $x_1 > x_0$ and compute the profit-maximizing price for firm 1. We then check that firm 1 makes a positive profit and that $x_1 > x_0$ at that price. If it is not the case, then firm 1 prefers to offer $x_1 = x_0$ for $p_1 = p_0$.

The maximum price p_1 compatible with green consumers buying quality x_1 rather than x_0 is

$$p_1 = \omega x_1 + c(x_0). \tag{2}$$

[3] We make the simplifying assumption that green consumers buy from firm 1 when they are indifferent between the offerings of firms 0 and 1.

Firm 1's profit is then

$$\begin{aligned}\pi_1 &= \alpha[p_1 - c(x_1)] \\ &= \alpha[\omega x_1 + c(x_0) - c(x_1)],\end{aligned} \tag{3}$$

where we have used the one-to-one relationship between firm 1's price and quality defined in (2). It is then equivalent for firm 1 to choose its profit-maximizing price or quality. Maximizing π_1 with respect to x_1, we obtain:

$$\frac{\partial \pi_1}{\partial x_1} = \alpha\left(\omega - c'(x_1)\right),$$

so that the profit-maximizing quality level, denoted by x_1^S (where the superscript S denotes the fact that firms are constrained by a standard) is such that

$$c'(x_1^S) = \omega, \tag{4}$$

with the profit-maximizing price given by

$$p_1^S = \omega x_1^S + c(x_0). \tag{5}$$

Firm 1 uses its monopoly power to capture all the green consumer surplus created by the warm glow effect of consuming a greener-than-x_0 product. It then chooses its quality level such that the marginal cost of providing a higher quality is equal to the marginal benefit to the firm (through a larger price), which is equal to the warm glow factor ω.

To check whether the environmental quality x_1^S is profitable for firm 1, first observe that, if $x_1^S > x_0$, firm 1 for sure makes a positive profit as long as consumers buy the green good. This is due to the fact that the cost function c is convex: since x_1^S is set so that its marginal cost to firm 1 is equal to its marginal benefit (the constant ω), the marginal cost of producing all inframarginal quality values below x_1^S is always strictly smaller than its cost ω, resulting in a positive profit.

Note from (4) that x_1^S does not depend on x_0, but increases with ω (since the cost function is convex). We then obtain the following proposition.

Proposition 1 *With a standard set at x_0, firm 1 chooses $x_1 = x_1^S$ (given by equation (4)) if $x_0 < x_1^S$, and chooses $x_1 = x_0$ (and $p_1 = p_0$) if $x_0 > x_1^S$.*

In words, a lax standard allows firm 1 to exert its market power, sell a green good and capture the extra surplus from green voters. A standard that is stringent (in the sense that its marginal cost is larger than ω) results in firm 1 producing the same good as the competitive fringe, at the same price.

The following definition will prove useful later on.

Definition 1 *We denote by ω_1^S the unique value of ω such that $x_1^S = x^{FB}$.*

3.2 The second-best standard

Before moving to the collective choice of the standard, let us investigate what would be the second-best quality standard, when a benevolent social planner chooses the standard x_0 before firms compete in the way described in the previous section. We denote by x_0^{SB} the second-best level standard. Observe first that $x_0^{SB} = x^{FB}$ if $x^{FB} > x_1^S$. This means that allowing firm 1 to choose its quality level x_1 has no impact on the second-best quality standard in that case: the first-best standard is so restrictive that firm 1 finds it too costly to provide a greener version of the good than what the standard imposes, and prefers to offer the same variant of the good as the one offered by the competitive fringe.

We then focus on the case where $x^{FB} < x_1^S$. The objective of the social planner is then to choose the value of x_0 to maximize social welfare defined as

$$W^{SB}(x_0) = v - \alpha c(x_1^S) - (1-\alpha)c(x_0) + b\left(X^S\right).$$

Recall that x_1^S is not affected by x_0, so that the first-order condition defining x_0^{SB} is given by

$$c'(x_0^{SB}) = b'\left(\alpha x_1^S + (1-\alpha)x_0^{SB}\right). \tag{6}$$

Comparing (1) and (6), we obtain that their respective solutions x^{FB} and x_0^{SB} are such that $x_0^{SB} < x^{FB}$. It is because $x_1^S > x_0$ implies that the right hand side of (6), namely $b'(\alpha x_1^S + (1-\alpha)x_0)$, is smaller than $b'(x_0)$. Recall that x_0 only affects the quality of the good purchased by the neutral consumers (since $x_0 < x_1^S$). The second-best formula compares marginal cost and benefit of increasing x_0 for those consumers. Marginal benefit is lower than in the first-best scenario because of the green consumers who purchase a good with a higher-than-minimum environmental quality ($x_1^S > x_0$).

Observe that, unlike for the first-best, the second-best level x_0^{SB} depends on ω (through the pricing and quality decisions of firm 1). Applying the implicit function theorem on equation (6), and using the fact that x_1^S increases with ω (see (4)), we obtain that x_0^{SB} decreases with ω. As green voters care more about the environment, the good they purchase is produced with more environmentally friendly processes, decreasing the marginal benefit of environmental quality and resulting in a weaker second-best standard. At the same time, equation (4) shows that $X^{SB} = \alpha x_1^S + (1-\alpha)x_0^{SB}$ increases with ω (since the LHS decreases with ω), so that the increase in x_1^S is larger than the decrease in x_0^{SB} as ω increases. Finally, since $X^{SB} = X^{FB}$ when $x_1^S = x^{FB}$, and X^{SB} increases with ω while X^{FB} is constant, we obtain that $X^{SB} > X^{FB}$ when $x_1^S > x^{FB}$.

We summarize those results in the following proposition.

Proposition 2 *The second-best standard, x_0^{SB}, equals the first-best one when ω is low enough that $x_1^S < x^{FB}$, and is lower than x^{FB} if ω is large enough that $x_1^S > x^{FB}$. In the latter case, x_0^{SB} is decreasing with ω, total second-best environmental quality X^{SB} increases with ω, and is larger than its first-best level.*

Note that, with the alternative definition of welfare as the sum of the *unlaundered* consumer's utilities and firm's profits,

$$W(x_0) = v - \alpha c(x_1^S) - (1-\alpha)c(x_0) + b(X^{SB}) + \alpha\omega x_1^S,$$

the first-order condition is also (6) since x_1^S does not depends on the standard. Hence, the second-best standard x_0^{SB} does not depend on the inclusion or not of the warm-glow effect into total welfare.

3.3 Collective choice of an environmental standard

We now examine the choice of minimal environmental performance for the product x_0 set as a standard.

We first define the utility of both types of consumers as a function of x_0, when firm 1 chooses its price p_1 and quality x_1. The utility of neutral consumers is

$$U_n^S(x_0) = \begin{cases} v - c(x_0) + b(X^S) & \text{if} \quad x_0 < x_1^S, \\ v - c(x_0) + b(x_0) & \text{if} \quad x_0 \geq x_1^S, \end{cases} \tag{7}$$

with $X^S = \alpha x_1^S + (1-\alpha)x_0$ and $x_1^S = c'^{-1}(\omega)$ following equation (4). The utility of green consumers is given by

$$U_g^S(x_0) = \begin{cases} v - p_1^S + \omega x_1^S + b(X^S) & \text{if} \quad x_0 < x_1^S, \\ v - c(x_0) + b(x_0) & \text{if} \quad x_0 \geq x_1^S. \end{cases}$$

Replacing p_1^S by its formulation (5), the utility of green consumers if $x_0 < x_1^S$ can be simplified to

$$\begin{aligned} U_g^S(x_0) &= v - \omega x_1^S - c(x_0) + \omega x_1^S + b\left(X^S\right) \\ &= v - c(x_0) + b\left(X^S\right). \end{aligned}$$

We then obtain that $U_n^S(x_0) = U_b^S(x_0)$, but for reasons which differ according to whether x_0 is smaller or larger than x_1^S. When $x_0 \geq x_1^S$, the standard is set so high that it is too costly for firm 1 to differentiate its offering, and all consumers, whether neutral or green buy the minimum standard good at a price equal to its cost $c(x_0)$. When $x_0 < x_1^S$, firm 1 does differentiate its offering. The warm-glow part of the green consumers' utility is entirely captured by firm 1 through its pricing.

The unanimity approved standard is the value of x_0 maximizing either the first or the second line in (7). The second line is maximized with first-best environmental quality: $x_0 = x^{FB}$. It is the preferred standard when a single good is supplied. The first line of (7) peaks at a standard denoted x_0^{SV} defined by the following first-order condition:

$$c'(x_0^{SV}) = (1-\alpha)b'\left(\alpha x_1^S + (1-\alpha)x_0^{SV}\right). \tag{8}$$

The marginal cost of the standard in the left-hand side should be equal to its marginal benefit in the right-hand side. Compared to the case of the first-best level x^{FB} in (1), the marginal benefit is deflated by $1-\alpha$ because, with two environmental qualities x_0^{SV} and x_1^S, increasing the standard only affects the contribution of neutral consumers to average environmental protection $X = \alpha x_1^S + (1-\alpha)x_0^{SV}$. Moreover, applying the implicit function theorem on (8), we have proved the following lemma.

Lemma 1 *The standard x_0^{SV} is lower than first-best, and is decreasing in ω.*

As ω increases, the environmental quality of the green good increases, which decreases the marginal benefit from the standard, and so decreases x_0^{SV}.

The following definition and lemma will prove useful later on.

Definition 2 *We define by ω_2^S the unique value of ω such that $x_0^{SB} = 0$ (if $x_0^{SB} > 0$ for all ω, then we set $\omega_2^S = \infty$).*

Lemma 2 *We have $\omega_1^S < \omega_2^S$ and $x_0^{SV} = x_0^{SB} = 0$ for $\omega \geq \omega_2^S$.* ***[Is this Lemme useful, here, or can we postpone/refer to Lemma 6? If not, has to be proved here.]***

The preferred standard among the two candidates x^{FB} and x_0^{SV} depends on green consumers' willingness to pay for environmental quality ω. Let $\tilde{\omega}$ be the unique value of ω that equalizes the neutral consumers' utility with a unique good provided with $x = x^{FB}$, and with a brown good x_0^{SV} and a green good x_1^S–i.e., where

$$b(\alpha x_1^S + (1-\alpha)x_0^{SV}) - c(x_0^{SV}) = b(x^{FB}) - c(x^{FB}), \tag{9}$$

with x_1^S, x_0^{SV} and x^{FB} defined by (4), (8) and (1) respectively. We establish the following result.

Proposition 3 *If $\omega < \tilde{\omega}$, the unanimity chosen standard implements the first-best environmental protection level x^{FB}. If $\omega > \tilde{\omega}$, green consumerism leads to a suboptimal standard $x_0^{SV} < x^{FB}$ with green goods.*

Proof: See Appendix A

The citizens' choice of standard depends on green consumers' willingness to pay for environmental quality. If ω is low, the green version of the good is not supplied. All citizens vote for the first-best standard. Environmental protection is at the efficient level. All the benefit from production goes to consumers. When ω is high enough, supplying a green version of the product becomes profitable. Products are differentiated on environmental quality: one version with the standard quality $x_0 = x_0^{SV}$ and the green version with quality s_1^S. The green good supplier makes profit by extracting the green consumer's willingness to pay for higher environmental quality. All consumers vote for a standard x_0^{SV} which is lower than x^{FB}, but for different reasons. The green consumers lower the standard from x^{FB} to reduce the price paid for the green good. The neutral consumers free-ride on the environmental protection driven by the green consumers' demand. Overall the standard fails to fix the two market failures that are the environmental externalities and the market power exerted by the green firm.

Figure 1 recapitulates most of the results obtained with a standard, and shows how the first-best, second-best and majority chosen standard levels and average environmental quality in the economy vary with the willingness to pay for green products ω.

Insert Figure 1

The first-best standard and corresponding environmental protection $X^{FB} = x^{FB}$ do not vary with the willingness to pay for environmental quality ω.

When $\omega < \tilde{\omega}$, the first-best standard is unanimity preferred to any other and a single good is produced at the voting equilibrium. When ω reaches $\tilde{\omega}$, both a brown and a green goods are supplied at the voting equilibrium. The economy switches to an equilibrium with differentiated products and a lower standard x_0^{SV}. Lemma 7 in the proof of Proposition 3 implies that $x_1^S < x^{FB}$ when $\omega = \tilde{\omega}$. The switch towards a new majority voting equilibrium then occurs discontinuously, with a decrease in the environmental quality of both goods (compared to the unique first best level) which reduces overall environmental protection $X^{SV} = \alpha x_1^S + (1 - \alpha) x_0^{SV}$. In other words, the environmental quality decreases discontinuously at the precise point where the green good is supplied.

As green consumerism ω increases beyond $\tilde{\omega}$, the environmental quality of the green good x_1^S improves while the standard x_0^{SV} becomes laxer. Average environmental protection X^{SV} improves driven by the demand for environmental quality by green consumers, although it is still under-provided. It reaches first-best when the taste for environmental quality ω becomes high enough that the green consumer's demand compensates the lower standard. In particular, the environmental quality of green goods should exceed the first-best level $x_1^S > x^{FB}$ at that point. Average environmental quality may exceed its first-best level. This case happens for sure when ω is large enough that $x_0^{SV} = 0$, as the next proposition shows.

Proposition 4 $X^{SV} > X^{FB}$ *for* ω *large enough (and for sure for* $\omega \geq \omega_2^S$*).*
Proof: *At* $\omega = \omega_2^S$, $x_0^{SV} = X_0^{SB}$ *which implies that* $X_0^{SV} = X_0^{SB}$*, which is larger than* X^{FB} *by Proposition 2. By continuity, we then have that* $X^{SB} > X^{FB}$ *for* ω *slightly lower than* ω_2^S*.*

Moving to the second-best quality, it is equal to the first-best one as long as $\omega < \omega_1^S$ (see Definition 1) with $\omega_1^S > \tilde{\omega}$ (see Lemma 7 in the proof of Proposition 3). From ω_1^S on, the second-best standard decreases with ω while x_1^S increases, so that average quality increases with ω and exceeds first-best quality (see Proposition 2). We obtain that the unanimity chosen standard is lower than both the second-best and first-best ones (when $\omega > \tilde{\omega}$), and that environmental quality with majority voting is lower than the second-best one, but may become larger than the first-best level when ω is large enough, as shown in the next proposition.

Proposition 5 *We have $x_0^{SV} < x_0^{SB}$ and $x_0^{SV} < x_0^{FB}$ for $\tilde{\omega} < \omega < \omega_2^S$, and that $X_0^{SV} < X_0^{SB}$ for $\tilde{\omega} < \omega < \omega_2^S$.*

Proof: *See Appendix.*

4 Environmental performance with tax

4.1 Supply of environmental quality

We now move to another policy instrument to mitigate environmental externalities: a tax on environmental damage (or equivalently on pollution or emissions). We denote by e the environmental damage in the absence of any effort by firms, namely when they produce a good of quality $x = 0$. Environmental quality x then corresponds to the reduction in damages from that point. The planner taxes the environmental damage at a linear rate τ. The total cost of supplying one unit of the product with environmental performance x is $c(x) + \tau(e - x)$. The brown good producers choose the value of x that minimizes their cost given the price of their product p_0. The environmental performance they choose is denoted by x_0^τ and satisfies the following first-order condition:

$$\tau = c'(x_0^\tau), \tag{10}$$

where the marginal cost of pollution abatement equals the tax rate. The competitive price per unit of product is defined by the zero-profit condition:

$$p_0^\tau = c(x_0^\tau) + \tau(e - x_0^\tau). \tag{11}$$

As before, a firm supplying green goods of quality x_1 is able to charge to green consumers a maximal price of:

$$p_1^\tau = \omega x_1 + p_0^\tau = \omega x_1 + c(x_0^\tau) + \tau(e - x_0^\tau), \tag{12}$$

with x_0^τ and p_0^τ defined by (10) and (11). Firm 1's profit with environmental performance x_1 is:

$$\pi_1 = \alpha[p_1^\tau - c(x_1) - \tau(e - x_1)] = \alpha[\omega x_1 + c(x_0^\tau) - c(x_1) + \tau(x_1 - x_0^\tau)], \tag{13}$$

where the last equality is obtained by substituting p_1^τ as defined by (12). Differentiating π_1 with respect to x_1 yields:

$$\frac{\partial \pi_1}{\partial x_1} = \alpha \left[\omega - c'(x_1) + \tau\right],$$

so that profit is maximized at quality level x_1^τ satisfying the following first-order condition:

$$\tau + \omega = c'(x_1^\tau). \tag{14}$$

Environmental performance increases profits through two channels: higher revenue (thanks to a larger price made possible by the green consumer's preference for greener goods) and lower tax paid. The best green strategy equalizes marginal cost to the sum of the green consumer's willingness to pay and the tax rate. Firm 1 chooses $x_1^\tau = c'^{-1}(\omega + \tau)$ and charges $p_1^\tau = \omega x_1^\tau + c(x_0^\tau) + \tau(e - x_0^\tau)$. Firm 1's profit with the tax is thus $\pi_1 = \alpha[\omega x_1^\tau + c(x_0^\tau) - c(x_1^\tau) + \tau(x_1^\tau - x_0^\tau)]$. The following lemma shows that firm 1's profit is always positive when it chooses $x_1 = x_1^\tau$.[4]

Lemma 3 *With a tax, we have that $\pi > 0$ with $x_1 = x_1^\tau > x_0^\tau$ for all $\omega > 0$.*

***Proof**: Firm 1's profit function is concave in x_1, with a maximum at $x_1 = x_1^\tau > x_0^\tau$ when $\omega > 0$. From (13), we obtain that*

$$\lim_{x_1 \to x_0^{\tau+}} \pi_1 = \alpha\omega x_0^\tau > 0,$$

so that π_1 is a fortiori positive when maximized at $x_1 = x_1^\tau$.

Intuitively, as soon as firm 1 produces a good greener than x_0, it can increase discontinuously its price by ωx_1, while the other terms in its profit function (the gain in tax bill and the increase in production costs) are continuous in x_1.

A fundamental difference between the environmental tax and the standard is their impact on environmental performance for the green product. In Section 3, we have shown that the standard x_0 has no direct impact on the level of environmental quality imbedded in the green good x_1^S, see (4). The standard only affects the decision whether to supply a greener good or not through the price that can be charged for a greener good p_1. In contrast, here the tax

[4] Provided of course that consumers' willingness to pay is high enough to compensate for the tax paid: $v \geq p_0^\tau$ and $v + \omega x_1^\tau \geq p_1^\tau$.

impacts directly the green good's environmental performance x_1^τ as shown in (14). It means that a higher tax would increase both environmental performances x_0^τ and x_1^τ while a higher standard x_0 does not change x_S^1 as long as supplying the green good is profitable.

It is worth mentioning that, although both environmental qualities x_0^τ and x_1^τ depend on the tax rate, the incremental environmental quality of green goods, $x_1^\tau - x_0^\tau$, does not. More precisely, the difference between marginal costs of production always equals the green consumers' willingness to pay for environmental quality ω at equilibrium, namely $c'(x_1^\tau) - c'(x_0^\tau) = \omega$.

Observe that, if both instruments were to induce the same qualities for both goods ($x_0 = x_0^\tau$ and $x_1^S = x_1^\tau$), then firm 1's profit under tax (see (13)) would be higher than under a standard (see (3)) by $\alpha\tau(x_1^\tau - x_0^\tau)$ –*i.e.*, the amount of pollution taxes saved by supplying a greener product. As a consequence, the marginal benefit of providing a higher environmental quality is higher under a tax ($\tau + \omega$, see the first-order condition (17)) than under a standard (ω, see (4)). We then obtain the following proposition.

Proposition 6 *For any given $x_0 = x_0^\tau$, the environmental quality is higher with a tax than with a standard: $x_1^\tau > x_1^S$ and therefore $X^\tau > X^S$, with $X^\tau = \alpha x_1^\tau + (1-\alpha)x_0^\tau$.*

4.2 The second-best environmental tax

Before investigating the tax rate preferred by consumers, we characterize the second-best environmental tax τ^{SB} with the corresponding second-best levels of environmental quality $x_0^{\tau B}$ and $x_1^{\tau B}$ defined by (10) and (14) with $\tau = \tau^{SB}$.

We proceed as previously and consider a "paternalistic" definition of welfare by ignoring the warm-glow part of the utility of green consumers. Welfare is defined as sum of the benefit from consuming the good, v, and of protecting the environment, $b(X)$, net of production costs:

$$W(\tau) = v - \alpha c(x_1^\tau) - (1-\alpha)c(x_0^\tau) + b(X^\tau).$$

Differentiating with respect to τ, we obtain the following first-order condition

$$\alpha[b'(X^\tau) - c'(x_1^\tau)]\frac{dx_1^\tau}{d\tau} + (1-\alpha)[b'(X^\tau) - c'(x_0^\tau)]\frac{dx_0^\tau}{d\tau} = 0.$$

The following assumption will prove especially useful, because it guarantees that τ has the same impact on both qualities.

Assumption 1 *Let* $c(x) = \gamma \frac{c^2}{2}$.

Under Assumption 1, we have that $dx_0^\tau/d\tau = dx_1^\tau/d\tau = 1/\gamma$ and the FOC becomes

$$b'(X^{\tau B}) = \alpha c'(x_1^{\tau B}) + (1-\alpha)c'(x_0^{\tau B}) \tag{15}$$

The second-best tax equalizes the marginal benefit from abatement with its marginal cost, which takes into account that two variants of the goods are produced. Note from (15) that the only case where the second-best allocation corresponds to the first best one given by (1) is when $\omega = 0$, since it is the only case where $x_0^\tau = x_1^\tau$ for any value of τ. In that case, we have that $x_0^{\tau B} = x_1^{\tau B} = x^{FB}$.

The following lemma compares the second best allocation with a tax and with a standard **(why not a proposition?)**.

Lemma 4 *Under Assumption 1, and assuming interior solutions for all variables, we have*
(a) $x_0^{\tau B} < x_0^{SB}$,
(b) $X^{\tau B} = X^{FB}$,
(c) $x_1^{\tau B} > x_1^S$,
(d) τ^{SB} *(and so* $x_0^{\tau B}$*) decreases with* α *and with* ω*, while* $x_1^{\tau B}$ *increases with both.*

The tax allows to obtain the FB total environmental quality, but with productive inefficiencies since x_0 is set "too low" and x_1 "too high". These inefficiencies increase with both the proportion of green voters, α, and the extent of the green consumers' willingness to pay for the environment, ω. The second best tax rate decreases with these two parameters, as the planner relies more on the green consumers' behavior. We defer to section 5.1 for the normative comparison of second best tax and standard.

Alternatively, defining welfare as the sum of *unlaundered* consumer's utilities and firm's profits, we have:

$$W(\tau) = v - \alpha c(x_1^\tau) - (1-\alpha)c(x_0^\tau) + b(X^\tau) + \alpha\omega x_1^\tau$$

The first-order condition yields:

$$b'(X^{\tau B}) + \alpha\omega = \alpha c'(x_1^{\tau B}) + (1-\alpha)c'(x_0^{\tau B})$$

The marginal benefit of taxing now includes the warm-glow parameter in the left-hand side because it increases firm 1's profit (see (13)). Hence taxation is higher compared to the paternalistic notion of welfare because a higher tax increases firm 1's profit.

4.3 Collective choice of the environmental tax

To compute the utility of both types of consumers, we need to specify how the revenue collected by taxing pollution is redistributed. Let us assume first a lump-sum redistribution to all consumers as a benchmark.[5] After redistributing the revenues from taxing the green firm 1, $\alpha\tau(e - x_1^\tau)$, and the brown good producers, $(1-\alpha)\tau(e - x_0^\tau)$, we end up with utilities

$$U_n^\tau(\tau) = v - p_0^\tau + b(X^\tau) + \tau[\alpha(e - x_1^\tau) + (1-\alpha)(e - x_0^\tau)],$$

for neutral consumers, and

$$U_g^\tau(\tau) = v + \omega x_1^\tau - p_1^\tau + b(X^\tau) + \tau[\alpha(e - x_1^\tau) + (1-\alpha)(e - x_0^\tau)],$$

for green consumers. Substituting the prices p_0^τ and p_1^τ defined in (11) and (12) respectively, we end up with the following utility for both consumers'types, $i \in \{n, g\}$:

$$U_i^\tau(\tau) = v - c(x_0^\tau) - \alpha\tau(x_1^\tau - x_0^\tau) + b(\alpha x_1^\tau + (1-\alpha)x_0^\tau). \tag{16}$$

As with the environmental standard, we obtain the same utility for both types of consumers, because the warm-glow effect is fully captured by firm 1's pricing. By contrast, firm 1's profit differs and is higher than with the standard. Indeed, firm 1 obtains a further gain from supplying a greener good which is the tax saved: $\alpha\tau(x_1^\tau - x_0^\tau)$ dollars that are lost by consumers.

Majority voting over the tax rate will then result in a unanimous decision. We now maximize the consumers' utility defined in (16) with respect to τ to determine their most-preferred tax rate. Differentiating (16) with respect to τ, we obtain:

$$[-c'(x_0^\tau) + \tau\alpha + (1-\alpha)b'(X^\tau)]\frac{dx_0^\tau}{d\tau} - \alpha(x_1^\tau - x_0^\tau) + [-\tau\alpha + \alpha b'(X^\tau)]\frac{dx_1^\tau}{d\tau} = 0.$$

Under Assumption 1, we have that $dx_0^\tau/d\tau = dx_1^\tau/d\tau = 1/\gamma$ and the FOC simplifies to

$$c'(x_0^{\tau V}) + \alpha\gamma(x_1^{\tau V} - x_0^{\tau V}) = b'(\alpha x_1^{\tau V} + (1-\alpha)x_0^{\tau V}), \tag{17}$$

[5] Other popular ways to recycle tax revenue are discussed in Appendix B. They are all detrimental to consumers and potentially more distortionary.

where the superscript τV refers to the allocation obtained when the tax rate is set at its most-preferred level by consumers. The left-hand term is the marginal cost of increasing environmental quality through a higher tax while the right-hand term is the marginal benefit. A higher tax increases the environmental performance of the two goods. The cost is twofold: higher production costs and more revenue from the tax captured by the green firm.

The comparison of the first-order condition for the standard in (8) with the one with tax (17) is instructive, as we can see that $x_0^{\tau V}$ differs from x_0^{SV} for two reasons. First, the tax impacts both x_0 and x_1 while the standard has no impact on x_1. Consequently, the full marginal benefit and not only the share $1 - \alpha$ is considered in the first-order condition (17). Second, taxing is more costly than the standard because part of the welfare saved by improving environmental quality is captured by the green firm. The first effect favors a higher environmental performance with tax than standard while the second goes in the opposite direction. [**Do we resolve this comparison in the next sections?**]

Let us denote by τ^V the tax rate that maximizes $U_i^{\tau}(\tau)$ as defined in (16). We now compare it with the second-best tax τ^{SB} defined in (15) .

Lemma 5 *Under Assumption 1,* $\tau^V = \tau^{SB}$.

Proof: Using (10) and (14), we can write down (15) as (17).

Assumption 1 guarantees that (i) the impact of the tax is the same on both qualities (as $dx_0^{\tau}/d\tau = dx_1^{\tau}/d\tau = 1/\gamma$) and (ii) the marginal cost is linear in quality (as $c'(x) = \gamma x$). With these two simplifications, we obtain that the unanimity chosen tax rate is second-best $\tau^V = \tau^{SB}$ with a paternalistic welfare (and lower than second-best with non-paternalistic welfare).

Figure 2 summarizes the results obtained so far with a tax.

Insert Figure 2

Lemma 5 has shown that $\tau^V = \tau^{SB}$, so that $x_0^{\tau V} = x_0^{\tau B}$ and $x_1^{\tau V} = x_1^{\tau B}$. We also know from (15) that $x_0^{\tau B} = x_1^{\tau B} = x^{FB}$ when $\omega = 0$, and from Lemma 4 that $x_0^{\tau B}$ decreases with ω

while $x_1^{\tau B}$ increases with ω, while $X^{\tau B} = X^{\tau V} = X^{FB}$, as long as all solutions are interior. We now introduce the following threshold level for ω.[6]

Definition 3 *We define by ω_1^τ the unique value of ω such that $\tau^{SB} = x_0^{\tau B} = 0$ (if $x_0^{\tau B} > 0$ for all ω, then we set $\omega_1^\tau = \infty$).*

As soon as $\omega \geq \omega_1^\tau$, we have $x_0^{\tau V} = x_0^{\tau B} = 0$ and $x_1^{\tau V} = x_1^{\tau B} = x_1^S$ (since conditions (4) and (14) are quivalent when $\tau = 0$). We then have that $x_1^{\tau V}$ and $x_1^{\tau B}$ are increasing in ω, so are $X^{\tau V} = X^{\tau B} = \alpha x_1^{\tau V} > X^{FB}$.

We now compare the tax and the standard.

5 Comparison of instruments

We consider sequentially two approaches: normative and positive. We first compare the welfare levels attained with the standard and with the tax. We then move to the voting game to figure out which of the two instruments would be collectively chosen by citizens.

5.1 Welfare analysis of instrument choice

To compare the two instruments, it is convenient to assume that Assumption 1 holds throughout this section.

The following lemma ranks the threshold levels of the willingness to pay for the environment, ω, that we have introduced in the previous sections.

Lemma 6 *Under Assumption 1, $\omega_1^S < \omega_1^\tau < \omega_2^S$.*

We first compare the welfare levels at the second best allocation with the two instruments.

Proposition 7 *Under Assumption 1, the second-best welfare is higher with a standard than with a tax when $\omega < \omega_1^S$ and when $\omega_1^\tau < \omega < \omega_2^S$, and equivalent if $\omega > \omega_2^S$. [**Not complete**]*

[6] Note that, under Assumption 1, ω_1^τ is such that $b'(\alpha\omega_1^\tau/\gamma) = \alpha\omega_1^\tau$, which exists provided that $b(.)$ is concave enough, for instance if $\lim_{x\to\infty} b'(x) = 0$.

The intuition for this proposition runs as follows (see also Figure 3). When $\omega < \omega_1^S$, the second-best outcome with a standard corresponds to the first-best allocation (since the green good is not produced) and dominates, from a welfare perspective, the second-best outcome with a tax (where the total environmental quality is first-best, but obtained with x_0 too low and x_1 to high). When $\omega_1^S < \omega < \omega_1^\tau$, the second-best qualities with the tax are both more extreme than with the standard, but the average quality is first-best with the tax, and too large with a standard. There is a trade-off between allocative and productive efficiencies, and we cannot rank the welfare levels obtained with the two instruments. When $\omega_1^\tau < \omega < \omega_2^S$, the green good quality is the same with the two instruments, the second-best tax is nil (so that $x_0^{\tau B} = 0$) while the second-best standard is binding ($x_0^{SB} > 0$), so that the second-best standard dominates the tax from a welfare viewpoint. When $\omega > \omega_2^S$, the two instruments generate the same second-best allocation (with $x_0 = 0$ and $x_1 > X > X^{FB}$), and are thus equivalent.

Insert Figure 3

We now move to the comparison of voters' utilities across instruments.

5.2 Political economy of instrument choice

Under Assumption 1 (quadratic cost function), and assuming that both goods are produced under the standard (*i.e.*, $\omega > \tilde{\omega}$ so that $x_1^S > x_0$), we can express consumers' utility as a function of minimal quality x_0 as the only endogenous variable for both instruments. With $c(x) = \gamma x^2/2$, the environmental qualities of both types of goods characterized in (4), (10) and (14) bowl down to $x_1^S = \omega/\gamma$, $x_0^\tau = \tau/\gamma$ and $x_1^\tau = (\omega + \tau)/\gamma$. We therefore obtain a simple relationship between the incremental environmental quality of the green good with tax, the green consumerism parameter and the green good environmental quality with a standard:

$$x_1^\tau - x_0^\tau = \frac{\omega}{\gamma} = x_1^S.$$

Substituting into the first line of (7) and (16) yields the utility of both types of consumers as a function of the neutral good quality x_0 with standard:

$$U^S(x_0) = b\left(\alpha\frac{\omega}{\gamma} + (1-\alpha)x_0\right) - c(x_0). \tag{18}$$

and with tax:

$$U^{\tau}(x_0) = b\left(\alpha\frac{\omega}{\gamma} + x_0\right) - \alpha\omega x_0 - c(x_0), \tag{19}$$

A closer look at the two functions U^S and U^{τ} highlights the trade-off in the choice of instruments. On the one hand, the tax has a higher impact on average environmental protection than the standard because it drives the environmental quality of both types of goods instead of only the brown one. This *environmental protection effect* shows up into the benefit functions in (18) and (19) where the minimal environmental quality x_0 is impacting fully environmental protection $X^{\tau} = \alpha\frac{\omega}{\gamma} + x_0$ with tax in (19) but only a fraction $1 - \alpha$ (the share of neutral consumers) with standard as $X^S = \alpha\frac{\omega}{\gamma} + (1 - \alpha)x_0$ in (18). On the other hand, there is an extra cost of increasing environmental quality with tax as all the fiscal benefit of providing higher environmental quality is captured by the green firm and therefore lost by consumers. This *tax stealing effect* shows up in the welfare through the extra term $\alpha\omega x_0$. It depends solely on two parameters: the share of green consumers α and their willingness to pay ω.

Proposition 8 *Assume that voters first vote over whether the instrument used should be the tax or the standard, and then vote over the level of the majority chosen instrument. There exists a threshold value of* ω*, denoted by* $\hat{\omega}$*, with* $\tilde{\omega} < \hat{\omega} < \omega_1^{\tau}$*, such that (a) all voters prefer a tax to a standard if* $\omega < \hat{\omega}$*, (b) all voters prefer a standard to a tax if* $\hat{\omega} < \omega < \omega_2^S$*, all voters are indifferent between tax and standard if* $\omega \geq \omega_2^S$*.*

A Proofs

Proof of Proposition 2

ω_2^S is defined by

$$b'\left(\alpha x_1^S\right) = c'(0) = 0.$$

At $\omega = \omega_1^S$, we have that $b'(\alpha x_1^S) > b'(x_1^S) = c'(x^{FB}) > 0$. Since $b(.)$ is concave while x_1^S increases with ω, we then have that $\omega_1^S < \omega_2^S$.
Observe that the two FOCs for x_0^{SV} (equation (8)) and x_0^{SB} (equation (6)) are identical and satisfied for $x_0 = 0$ for $\omega \geq \omega_2^S$.

Proof of Proposition 3

To show that $\tilde{\omega}$ is unique, remark that x^{FB} does not depend on ω, therefore the right-hand side of (9) does not vary with ω. On the other hand, the left-hand side increases with ω since its derivative with respect to ω equals $\alpha b'(\alpha x_1^S + (1-\alpha)x_0^{SV})\frac{dx_1^S}{d\omega} > 0$ by making use of (8). Furthermore, $x_1^S = 0$ when $\omega = 0$, and therefore $b(\alpha x_1^S + (1-\alpha)x_1^{SV}) - c(x_0^{SV}) = \max_x\{b((1-\alpha)x) - c(x)\} < \max_x\{b(x) - c(x)\} = b(x^{FB}) - c(x^{FB})$ by definition of x_0^{SV} and x^{FB}. For ω high enough that $x_1^S = x^{FB}$, we have $b(\alpha x_1^S + (1-\alpha)x_0^{SV}) - c(x_0^{SV}) = \max_x\{b(\alpha x_1^{FB} + (1-\alpha)x) - c(x)\} \geq b(x^{FB}) - c(x^{FB})$. Therefore $b(\alpha x_1^S + (1-\alpha)x_0^{SV}) - c(x_0^{SV})$ is lower than $b(x^{FB}) - c(x^{FB})$ for $\omega < \tilde{\omega}$ and becomes higher for $\omega > \tilde{\omega}$.

Note that the penultimate step in the preceding paragraph has proved the following lemma, which will prove useful later on in the paper.

Lemma 7 $\tilde{\omega} < \omega_1^S$

We know that x^{FB} is constant with ω (see (1)), that $x_0^{SV} < x^{FB}$ and is decreasing with ω (see Lemma 1), that x_1^S is increasing in ω and may be lower or larger than x^{FB} (since $x_1^S = 0$ when $\omega = 0$, while it tends towards infinity as ω grows). Hence, the following three cases exhaust all the possible ones.

Case (a) $x_1^S < x_0^{SV} < x^{FB}$
In this case, we can show that $x_0^{SV} \leq x^{FB}$. For any standard $x_0 < x_1^S$, the utility $U_n(x_0)$,

defined in the first line of (7), is increasing with x_0 up to x_1^S. It also increasing with x_0 above x_1^S– i.e., as defined in the second line of (7), up to $x_0 = x^{FB}$. It is then decreasing above x^{FB}. Therefore $U_n(x_0)$ is single-peaked at $x_0 = x^{FB}$.

Note that $x_1^S < x_0^{SV}$ implies $\omega < \tilde{\omega}$ because then $b(\alpha x_1^S + (1-\alpha)x_0^{SV}) - c(x_0^{SV}) < b(x_0^{SV}) - c(x_0^{SV}) \leq b(x^{FB}) - c(x^{FB})$ where the last inequality is due to the definition of x^{FB} which maximizes $b(x) - c(x)$ with respect to x.

Case (b) $x_0^{SV} < x^{FB} < x_1^S$

For any standard $x_0 < x_1^S$, the utility $U_n(x_0)$ -defined in the first line of (7)- is increasing up to x_0^{SB} and then decreasing for $x_0 > x_0^{SB}$. When $x_0 > x_1^S$, $U(x_0)$ - defined in the second line of (7)- is decreasing with x_0 because $x_0 > x^{FB}$ by assumption. Hence $U_n(x_0)$ is single-peaked at $x_0 = x_0^{SV}$. Now $x_1^S > x^{FB}$ implies $\omega > \tilde{\omega}$ because $\max_x b(\alpha x_1^S + (1-\alpha)x) - c(x) > b(\alpha x^{FB} + (1-\alpha)x^{FB}) - c(x^{FB}) = b(x^{FB}) - c(x^{FB})$.

Case (c) $x_0^{SV} < x_1^S < x^{FB}$

Then $U(x_0)$ is double-peaked: a first peak at $x_0 = x_0^{SV}$ on the range $[0, x_1^S]$ - when $U_n(x_0)$ is defined by the first line of (7)- and a second peak at $x_0 = x^{FB}$ for x_0 above x_1^S. The two peaks have respective values $v - c(x_0^{SV}) + b(\alpha x_1^S + (1-\alpha)x_0^{SV})$ and $v - c(x^{FB}) + b(x^{FB})$. As shown at the beginning of the proof, the first peak is lower than the second peak when $\omega < \tilde{\omega}$ and becomes higher when $\omega > \tilde{\omega}$. □

Proof of Proposition 5

(i) For $\tilde{\omega} < \omega < \omega_1^S$, we have $x_0^{SB} = x^{FB} > x_0^{SV}$ by Lemma 1.

(ii) For $\tilde{\omega} < \omega < \omega_1^S$, the FOCs for x_0^{SB} and x_0^{SV} can be expressed as

$$(1-\beta)b'(\alpha x_1^S + (1-\alpha)x) - c'(x) = 0, \tag{20}$$

where $\beta = 0$ for $x = x_0^{SB}$, and $\beta = \alpha$ for $x = x_0^{SV}$. Using the implicit function theorem on (20), we obtain that the sign of the derivative of x with respect to β is equal to the derivative of (20) with respect to β, which is

$$-b'(\alpha x_1^S + (1-\alpha)x) < 0,$$

so that x_0^{SV} (with $\beta = \alpha$) is lower than x_0^{SB} (with $\beta = 0$).

This implies that $x_0^{SV} < x_0^{FB}$ for $\tilde{\omega} < \omega < \omega_2^S$ by Lemma 1, and that $X_0^{SV} < X_0^{SB}$ for $\tilde{\omega} < \omega < \omega_2^S$.

Proof of Lemma 4

(a) Suppose the reverse: $x_0^{\tau B} \geq x_0^{SB}$, where the second-best standard x_0^{SB} is defined by (6). Then $c'(x_0^{\tau B}) \geq c'(x_0^{SB})$ by convexity of the $c(.)$ function. Furthermore, $x_1^{\tau B} > x_0^{\tau B}$ implies $c'(x_1^{\tau B}) > c'(x_0^{\tau B})$. Therefore $\alpha c'(x_1^{\tau B}) + (1-\alpha)c'(x_0^{\tau B}) > c'(x_0^{SB})$ which, combined with (15) and (6), yields $b'(X^{\tau B}) > b'(X^{SB})$. By concavity of b, the last inequality implies $X^{\tau B} < X^{SB}$. Combined with $X^{\tau B} = \alpha x_1^{\tau B} + (1-\alpha)x_0^{\tau B}$, $X^{SB} = \alpha x_1^S + (1-\alpha)x_0^{SB}$ and $x_0^{\tau B} \geq x_0^{SB}$, it yields $x_1^{\tau B} < x_1^S$, a contradiction given (4) and (14).

(b) Under Assumption 1, the FOC (15) simplifies to

$$b'(X^{\tau B}) = \gamma X^{\tau B} = c'(X^{\tau B}).$$

(c) follows from (a) and (b).

(d) Under Assumption 1, and using (10) and (14), we have that

$$X^{\tau B} = \frac{\tau^{SB} + \alpha\omega}{\gamma} = X^{FB},$$

which does not depend on α nor on ω, so that τ^{SB} (and thus $x_0^{\tau B}$) decreases with α and with ω. Since $X^{\tau B}$ does not change with α nor ω, we then have that $x_1^{\tau B}$ increases with both.

Proof of Lemma 6

Since $x_1^S = \frac{\omega}{\gamma}$ and x^{FB} is defined by $b'(x^{FB}) = c'(x^{FB})$, $x_1^S = x^{FB}$ at $\omega = \omega_1^S$ implies:

$$b'\left(\frac{\omega_1^S}{\gamma}\right) = c'\left(\frac{\omega_1^S}{\gamma}\right), \tag{21}$$

while equation (15) implies that ω_1^τ is such that

$$b'\left(\alpha\frac{\omega_1^\tau}{\gamma}\right) = \alpha c'\left(\frac{\omega_1^\tau}{\gamma}\right), \tag{22}$$

when it exists (otherwise we set $\omega_1^\tau = \infty$) and equation (6) implies that ω_2^S is such that

$$b'\left(\alpha\frac{\omega_2^S}{\gamma}\right) = c'(0) = 0, \tag{23}$$

when it exists, otherwise we set $\omega_2^S = \infty$.

Note that (21) and (22) can be rewritten as

$$b'(\beta x) - \beta c'(x) = 0, \tag{24}$$

with $x = \omega_1^S$ when $\beta = 0$, and $x = \omega_1^\tau$ when $\beta = \alpha$. Applying the implicit function theorem

on (24), we obtain that x is decreasing with β, so that $\omega_1^S < \omega_1^\tau$.
Comparing (22) and (23), and using the concavity of $b(.)$, we obtain that $\omega_1^\tau < \omega_2^S$.
Note that $\omega_1^\tau = \infty$ implies that $\omega_2^S = \infty$, while the reverse is not true.

Proof of Proposition 7

Proof: Recall from Lemma 6 that $\omega_1^S < \omega_1^\tau < \omega_2^S$.
(a) When $\omega < \omega_1^S$, we obtain the first-best welfare level with the standard (since $x_1^S = x_0^{SB} = x^{FB}$), while with the tax, the environmental qualities of both goods are distorted (with $x_0^{\tau B} < x^{FB}$ and $x_1^{\tau B} > x^{FB}$). Welfare is thus higher with the standard than with the tax.
(b) When $\omega_1^S < \omega < \omega_1^\tau$, we have that $x^{FB} < x_1^S = \omega/\gamma < x_1^{\tau B} = (\tau^{SB} + \omega)/\gamma$ since $\tau^{SB} > 0$. Recall that $x_0^{SB} > 0$ is the value of x_0 maximizing welfare under the constraint that $x_1 = \omega/\gamma$. Comparing with the tax setting, we obtain that the second-best tax maximizes the same welfare function, but with (i) a more binding constraint (since $x_1^{\tau B}$ is further away from x^{FB} than x_1^S) and (ii) the inability to control x_0 separately from x_1 (as τ affects simultaneously x_0^τ and x_1^τ), unlike in the standard setting.
(c) When $\omega_1^\tau < \omega < \omega_2^S$, we have that $x_1^S = \omega/\gamma = x_1^{\tau B}$ since $\tau^{SB} = 0$. Recall that $x_0^{SB} > 0$ is the value of x_0 which maximizes welfare under the constraint that $x_1 = \omega/\gamma$, while $x_0^{\tau B} = 0$ since $\tau = 0$. Hence, welfare is higher under the standard.
(d) When $\omega > \omega_2^S$, we have that $x_0^{SB} = x_0^{\tau B} = 0$ and that $x_1^S = \omega/\gamma = x_1^{\tau B}$ when $\tau^{SB} = 0$. The welfare levels attained by the tax and by the standard are thus the same.□

Proof of Proposition 8

Recall that all individuals have the same utility function when voting over the instrument. We then define the utility level attained at the majority voting equilibrium by voters as $U^{\tau V} = U^\tau(\tau^V)$ with a tax, and $U^{SV} = U^S(x_0^{SV})$ with a standard. We now study the comparative statics of $U^{\tau V}$ and U^{SV} as function of ω, starting with U^{SV}.

(i) $\omega < \tilde{\omega}$

$$U^{SV} = v + b(x^{FB}) - c(x^{FB}) = W^{FB}$$

(ii) $\tilde{\omega} < \omega < \omega_2^S$

We have

$$U^{SV} = v + b(X^{SV}) - c(x_0^{SV}),$$

so that, using the envelope theorem,

$$\frac{dU^{SV}}{d\omega} = \frac{\alpha}{\gamma} b'(X^{SV}) > 0, \tag{25}$$

and

$$\frac{d^2U^{SV}}{d\omega^2} = \frac{\alpha^2}{\gamma^2} b''(X^{SV}) < 0,$$

so that U^{SV} is increasing and concave over $\tilde{\omega} < \omega < \omega_2^S$.

(iii) $\omega \geq \omega_2^S$

We have $x_0^{SV} = 0$ and $x_1^{SV} > 0$, so that

$$U^{SV} = v + b(\alpha \frac{\omega}{\gamma}),$$

with

$$\frac{dU^V}{d\omega} = \frac{\alpha}{\gamma} b'(\frac{\alpha\omega}{\gamma}) > 0,$$

and

$$\frac{d^2U^V}{d\omega^2} = \left(\frac{\alpha}{\gamma}\right)^2 b''(\frac{\alpha\omega}{\gamma}) < 0$$

so that U^{SV} is increasing and concave.

We now move to the comparative statics of $U^{\tau V}$.

(iv) $\omega < \omega_1^\tau$

We have

$$U^{\tau V} = v + b(X^{\tau V}) - c(x_0^{\tau V}) - \alpha \tau^V \frac{\omega}{\gamma}$$

so that, using the envelope theorem,

$$\begin{aligned} \frac{dU^{\tau V}}{d\omega} &= \frac{\alpha}{\gamma} \left[b'(X^{\tau V}) - \tau^V \right], \\ &= \frac{\alpha^2 \omega}{\gamma} > 0, \end{aligned}$$

where we have made use of the FOC (17) for τ^V to obtain the second line. We then have that

$$\frac{d^2U^{\tau V}}{d\omega^2} = \frac{\alpha^2}{\gamma} > 0,$$

so that $U^{\tau V}$ is increasing and convex over $\omega < \omega_1^{\tau}$.

(v) $\omega_1^{\tau} < \omega < \omega_2^{S}$

We have

$$U^{\tau V} = v + b(\frac{\alpha\omega}{\gamma}),$$

so that

$$\frac{dU^{\tau V}}{d\omega} = \frac{\alpha}{\gamma}b'(\frac{\alpha\omega}{\gamma}) > 0, \tag{26}$$

and

$$\frac{d^2U^{\tau V}}{d\omega^2} = \frac{\alpha^2}{\gamma^2}b''(\frac{\alpha\omega}{\gamma}) < 0,$$

so that $U^{\tau v}$ is increasing concave. Moreover, we have that $X^{SV} > X^{\tau V}$ (since $x_1^{\tau V} = x_1^{SV} > 0$ and $x_0^{SV} > x_0^{\tau V} = 0$), so that comparing (25) and (26), we have that

$$\frac{dU^{SV}}{d\omega} < \frac{dU^{\tau V}}{d\omega}.$$

(vi) $\omega \geq \omega_2^{S}$

We have $x_1^{\tau V} = x_1^{SV} > 0$ and $x_0^{SV} = x_0^{\tau V} = 0$, so that

$$U^{SV} = U^{\tau V} = v + b(\alpha\frac{\omega}{\gamma}),$$

and U^{SV} is then increasing and concave.

We now put all the pieces together. We have that $U^{SV} = U^{tV} = W^{FB}$ for $\omega = 0$. For $0 < \omega < \tilde{\omega}$, we have that $U^{SV} = W^{FB} < U^{\tau V}$. For $\omega \geq \omega_2^{S}$, we have that $U^{\tau V} = U^{SV}$. U^{SV} and $U^{\tau V}$ are both concave and increasing over $\omega \in [\omega_1^{\tau}, \omega_2^{S}]$, with a larger slope for $U^{\tau V}$. It then means that $U^{SV} > U^{\tau V}$ for $\omega = \omega_1^{\tau}$. Since both $U^{\tau V}$ and U^{SV} are continuously increasing over $\omega \in [\tilde{\omega}, \omega_1^{\tau}]$, there is a unique threshold value of ω , denoted by $\hat{w}$, belonging to this interval, so that voters are better off with a majority-chosen tax if $\omega < \hat{w}$, and better off with a majority chosen standard if $\hat{w} < \omega < \omega_2^{S}$. Voters are equally well off with the two instruments if $\omega \geq \omega_2^{S}$, since they both result in the same allocation.□

Not used for the moment in the paper

Similarly, we can express welfare as a function of x_0 with both instruments:[7]

$$W^S(x_0) = b\left(\alpha\frac{\omega}{\gamma} + (1-\alpha)x_0\right) - \alpha c(x_0) - (1-\alpha)c\left(\frac{\omega}{\gamma}\right).$$

$$W^\tau(x_0) = b\left(\alpha\frac{\omega}{\gamma} + x_0\right) - \alpha c(x_0) - (1-\alpha)c\left(\frac{\omega}{\gamma} + x_0\right),$$

Note that for the same x_0, environmental protection is higher with the tax $X^\tau > X^S$ because the green quality is higher, i.e. $\frac{\omega}{\gamma}+x_0 > \frac{\omega}{\gamma}$, which implies that the cost of higher environmental protection is fully incurred by the green consumers.

B Tax recycling

B.1 Earmarked tax to firms

If the money collected $R = \alpha(e - x_1) - (1-\alpha)(e - x_0)$ is redistributed to firms, the brown good producers obtain $(1-\alpha)[p_0 - c(x_0) - \tau(e - x_0) + R] = (1-\alpha)[p_0 - c(x_0) - \alpha\tau(x_1 - x_0)]$. The zero-profit condition leads to a price $p_0^\tau = c(x_0) + \alpha\tau(x_1 - x_0)$. It is obviously lower than when revenue is refunded to consumers because the net tax payment of each brown firm is $\alpha\tau(x_1 - x_0)$ which is lower than $\tau(e - x_0)$ because by definition $e > x_1$ and $\alpha < 1$. Firm 1 has to cut the price of its green good to $p_1^\tau = p_0^\tau + \omega(x_1 - x_0) = \omega(x_1 - x_0) + c(x_0) + \alpha\tau(x_1 - x_0)$. Its profit is thus:

$$\pi_1 = \alpha(p_1^\tau - c(x_1) - \tau(e - x_1) + R) = \alpha(p_1 - c(x_1) + \tau(1-\alpha)(x_1 - x_0)).$$

With this refunded rule, Firm 1 is refunded more that it pays. The net revenue is increasing with incremental abatement $x_1 - x_0$. The tax should thus provide incentive to abate at the margin. Differentiating with respect to x_1, we obtain:

$$\frac{d\pi_1}{dx_1} = \alpha[\frac{dp_1}{dx_1} - c'(x_1) + \tau(1-\alpha)],$$

with

$$\frac{dp_1}{dx_1} = \omega + \tau\alpha.$$

It yields the usual first-order condition with tax $c'(x_1^\tau) = \omega + \tau$. Substituting prices into the utility functions shows that both types of consumers obtain the same welfare than if the tax revenue is earmarked to them in (16). They obtain this revenue through lower prices.

[7] Note that $W^\tau(0) = W^S(0)$, i.e. the two functions coincide without regulation.

Proposition 9 *Earmarking tax to firms yield the same utility to consumers than if it is earmarked to them.*

B.2 Feebate

A feebate refunds the revenue collected from taxing brown producers with subsidy σ per units of abatement above a threshold $\hat{x}$. Both σ and $\hat{x}$ have to be defined. They are linked to the tax rate τ by the budget balance condition:

$$\tau(1-\alpha)(\hat{x}-x_0) = \sigma\alpha(x_1-\hat{x}). \tag{27}$$

The brown producers' profit is the same than with the tax and, therefore, so are the prices $p_0^\sigma = c(x_0) + \tau(\hat{x} - x_0)$ and $p_1^\sigma = \omega x_1 + p_0$. The green producer's profit becomes

$$\pi_1 = \alpha[p_1^\sigma + \sigma x_1) - c(x_1)] = \alpha[\omega x_1 + c(x_0) + \tau(e - x_0) + \sigma(x_1 - \hat{x}) - c(x_1)].$$

Environmental performance increases revenue through two channels: a higher price p_1^σ and more subsidies for performance above $\hat{x}$. The first-order condition yields: $c'(x_1^\sigma) = \omega + \sigma$. The subsidy provides similar incentives than the tax. In particular, if $\hat{x}$ is set such that $\sigma = \tau$ in (27), we obtain $x_1^\sigma = x_1^\tau$. Yet $\hat{x}$ can be increased to push up σ. Let assume that $\hat{x}$ is set so that (27) holds for $\sigma = \tau$. Substituting $\sigma = \tau$ in (27) leads to $\hat{x} = \alpha x_1 + (1-\alpha)x_0 = X$.

The utility of both types of consumers is:

$$U_i^F(\sigma) = v - c(x_0^\tau) - \tau(\hat{x} - x_0^\tau) + b(\alpha x^\tau + (1-\alpha)x_0^\tau). \tag{28}$$

With $\hat{x} = \alpha x_1 - (1-\alpha)x_0$, we obtain:

$$U_i^F(\sigma) = v - c(x_0^\tau) - \tau\alpha(x_1^\tau - x_0^\tau) + b(\alpha x^\tau + (1-\alpha)x_0^\tau). \tag{29}$$

which is the same utility when the tax is refunded to consumers in (16),

C Perfect competition

To isolate the effect of market power exerted by Firm 1, let's assume that green consumers can find green good for all levels of environmental protection at competitive price (as in Calveras et al. 2007).

C.1 Standard

The good is priced at production cost for all level of environmental qualities: $p_1 = c(x_1)$ and $p_0 = c(x_0)$. The green consumer's utility when buy the green good $x_1 > x_0$ at price $p_1 = c(x_1)$ at is $v + \omega x_1 - c(x_0)$. Maximizing with respect to x_1 yields x_1^S defined as $c'(x_1^S) = \omega$, i.e. the same than with market power. The market equilibrium is with product differentiation if $x_1^S > x_0$ and $v - p_1 + \omega x_1^S > v - p_0$, which leads to which leads to $\omega x_1^S > c(x_1^S) - c(x_0)$. It means that the taste for greener quality ω should be such $\omega > c'^{-1}(x_0)$ and $c(x_0) > c(c'^{-1}(\omega)) - \omega c'^{-1}(\omega)$. If $c(x) = \frac{x^2}{2\gamma}$, the first condition leads to $\gamma\omega > x_0$ while the second is always met. We can therefore define the threshold welfare $\tilde{\omega}_n^c(x_0) = \frac{x_0}{\gamma}$.

Note that the welfare under product differentiation is as before:

$$W(x_0) = v - \alpha c(x_1^S) - (1-\alpha)c(x_0) + b(\alpha x_1^S + (1-\alpha)x_0)$$

The first-order condition yields the second-best standard x_0^{SB} defined in (6).

The green consumer's utility with product differentiation is:

$$U_g(x_0) = v - c(x_1^S) + \omega x_1^S + b(\alpha x_1^s + (1-\alpha)x_0).$$

Maximizing the above utility yields a corner solution: a green consumers is in favor of the highest standard that allow enjoying the warm-glow effect which holds as long as $x_1^S > x_0$. The preferred standard is $x_1^S - \epsilon$ with $\epsilon \to 0$, which yields approximately $U_g(x_1^S) = v - c(x_1^S) + \omega x_1^S + b(x_1^s)$.

The neutral consumer's utility:

$$U_n(x_0) = v - c(x_0) + b(\alpha x_1^S + (1-\alpha)x_0).$$

Since the utility is the same than with market power, the preferred standard is x^{SV} defined in (9). It is lowest than the second-best defined in (6) because of the free-riding effect. Under product differentiations, consumers disagree on the standard to implement, the green ones being in favor of a highest one. The elected standard depends on the relative share of each population α as in Calveras et al. (2007).

- *Neutral consumers majority*: $\alpha < 1/2$.

  The elected standard depends on green consumers' purchase. It is first-best x^{FB} for low ω such that green consumers do not buy greener goods, that is if $\omega \leq \tilde{\omega}_n^c(x^{FB})$.

Otherwise, the elected standard is x^{SV} and the market equilibrium is with differentiated product.

- *Green consumers majority*: $\alpha > 1/2$.
  Under product differentiation, the green consumers prefer the highest standard lower than their quality choice x_1^S which yields them $U_g(x_1^S) = v - c(x_1^S) + \omega x_1^S + b(x_1^S)$. The utility with product differentiation is higher if $U_g(x_1^S) > v - c(x^{FB}) + b(x^{FB})$. That is with ω higher than a threshold $\tilde{\omega}_g^c(x^{FB})$ such that $U_g(x_1^S) = v - c(x^{FB}) + b(x^{FB})$ which leads to:

$$b(x^{FB}) - c(x^{FB}) = b(x_1^S) - c(x_1^S) + \omega x_1^S.$$

  The elected standard is x^{FB} for $\omega < \tilde{\omega}_g^c(x^{FB})$ and $x_1^S - \epsilon$ if $\omega > \tilde{\omega}_g^c(x^{FB})$.

C.2 Tax

Equilibrium prices are $p_1 = c(x_1) + \tau(e - x_1)$ and $p_0 = c(x_0) + \tau(e - x_0)$. Green consumers' utility is $v + \omega x_1 - c(x_1) - \tau(e - x_1)$. It is maximized at x_1^τ defined as before in (14). Same for $x_0 = x_0^\tau$ defined in (10).

The consumer's utility are:

$$U_g(\tau) = v + \omega x_1^\tau - c(x_1^\tau) + b(\alpha x_1^\tau + (1-\alpha)x_0^\tau) + \tau(1-\alpha)(x_1^\tau - x_0^\tau)$$

$$U_n(\tau) = v - c(x_0^\tau) + b(\alpha x_1^\tau + (1-\alpha)x_0^\tau) + \tau(1-\alpha)(x_1^\tau - x_0^\tau)$$

The FOCs characterize the preferred tax. Under Assumption 1, the preferred tax for the green consumers is such that:

$$b'(X^\tau) + (1-\alpha)\gamma(x_1^\tau - x_0^\tau) = c_1'^\tau),$$

where $(1-\alpha)(x_1^\tau - x_0^\tau)$ is the marginal benefit of having more revenue assigned to green consumers from increasing tax. Symmetrically, the tax preferred by neutral consumers is such that:

$$b'(X^\tau) = c_0'^\tau) + \alpha\gamma(x_1^\tau - x_0^\tau),$$

where $\alpha(x_1^\tau - x_0^\tau)$ is the direct marginal cost of a tax increase. Using $x_1^\tau - x_0^\tau = \omega$, we can rewrite the first-order conditions for the preferred tax respectively:

$$b'(X^\tau) = c_1'^\tau) - (1-\alpha)\omega,$$

and

$$b'(X^{\tau}) = c_1'^{\tau}) + \alpha\omega,$$

which shows that neutral consumers' preferred tax rate is lower than the one preferred by green consumers. Furthermore, by comparing with (17) shows that the neutral consumers' preferred tax rate is the same with and without market power.

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