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Green Alliances and the Role of Taxation

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Abstract

We examine two alternative strategies that an environmental group can embark when interacting with a firm. The first one which is already discussed in the literature is when the group campaigns against the firm. The second one which has not been modelled in the literature is when the group collaborates with the firm (green alliance) to reduce the cost of the cleaner technology. We look at the case of both options being available for the group in a setting with an environmental tax. One of the main results of the paper argues that for higher taxation the conflict scenario is more likely to happen, implying that collaboration and a more stringent environmental policy are substitutes. This identifies a previously unexamined and possibly adverse effect of public policy on environmental quality because it weakens the impact of the pollution tax on emission intensity. We also characterise the optimal tax that maximises social welfare and find that under pure conflict –when conflict is the only option for the environmentalists– optimal tax is higher than when the group can choose to act against or join forces with the firm, indicating that a less stringent environmental policy is needed in the latter scenario.

Keywords Green alliances · Environmental group · Emission tax · Conflict · Collaboration

JEL Classification L2 · Q58

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1 Introduction

Examples of environmental organisations clashing with businesses are surely not scarce. One of the environmental groups' common practices, which affects market outcomes and consumers' choices as well as environmental quality, is to increase consumers' awareness via campaigns.[1] For instance, Greenpeace campaigned against the construction of a new runway in London Heathrow airport as it would have derailed efforts to cut carbon emissions.[2] Additionally, as part of its campaign for the oil drilling in the Arctic, it has targeted both LEGO over its partnership with oil corporation Shell and the largest oil and gas company in the world, the Russian energy provider Gazprom. After a 3-month campaign, LEGO announced that they would not renew their partnership with Shell.[3]

In recent years the relationship between an environmental group (EG henceforth) and a polluting firm has evolved. "Green alliances", namely partnerships between an EG and a firm have become a new phenomenon for various reasons. From a firm's perspective, its lack of expertise or public trust in addressing adequately environmental problems as well as the attempt to pre-empt attacks from environmental groups, the government and the media, provide substantial incentives to establish cooperation. Alliances with EGs have also been a source of information and knowledge for the firm about innovative ways to rethink production technologies, identify new products and address stakeholder concerns. In fact, it may even be the only choice to access the knowledge held by the environmentalists, since firms' internal development of such expertise may be too costly, inefficient or time-consuming, and merger with or acquisition of an EG is highly unlikely (Rondinelli and London 2003). For the group, these alliances may offer more effective and efficient solutions than lobbying or campaigning against firms since, in an alliance, firms contribute to setting the environmental goals and hence their commitment to them can be stronger (Hartman and Stafford 1997). Also, competitors may follow the lead and adopt a similar practice which strengthens even further the benefits of the partnership.

There are different types of green alliances such as licencing, in which case the firm produces using the EG's brand name, or product endorsement where the EG approves a firm's product as being environmentally friendly. In this paper, we are focusing on the so-called "green system alliances" or "task forces", according to which the environmentalists assist the firm to develop and implement economically-feasible environmental programmes for the use of greener technologies.

Historically, the first (and unique at the time) partnership was between the Environmental Defence Fund (EDF) and McDonald's in 1990. The EDF decided to take no money from McDonald's in order to be able to examine their business practices objectively and make the data open to the public. The EG had successfully helped the chain through a waste reduction action plan to administer cost saving programmes such as replacing polystyrene clamshell boxes with recycled materials. According to the EDF, McDonald's recycled one million tons of corrugated boxes, reduced packaging by £300 million and decreased waste from restaurants by 30%. Since then, partnerships have become more

[1] Other tools for educating consumers about the environmental impacts of a product's manufacture apart from an EG's campaign include price signalling of the high quality/ greener good (see e.g. Mahenc 2008), ecolabels (see e.g. Teisl et al. 2002) and firms' own advertising to assist buyers to learn about the intangible characteristics of a product.

[2] www.greenpeace.org.uk/10-reasons-heathrow/.

[3] www.greenpeace.org/international/story/6999/how-lego-got-awesome-to-savethearctic/.

popular. For example, the EDF joined forces with more firms i.e., FedEx, Walmart and the private equity firm KKR.

In line with the aforementioned reasons why there can be a partnership between a firm and a group, in that first partnership and the ones thereafter, one of the main strengths that EGs were bringing to corporations was their specialised technical expertise as many possess knowledge that the companies lack (Yaziji and Doh 2009). Also, the EGs may know about a new technology that is superior only in its environmental impact which escaped firms' attention. For example, in response to the Montreal Protocol's call for eliminating ozone-destroying chlorofluorocarbons, the chemical industry had encouraged appliance makers to replace them with hydrochlorofluorocarbons (HCFCs), a less-harmful gas. DuPont and ICI invested more than $ 500 million in research into HCFCs. However, Greenpeace created a team of engineers who within a few months developed a refrigerator prototype that was efficient and good for the environment, the ozone layer and the climate. It was a mix of natural hydrocarbons. Greenpeace then collaborated with Foron who started designing GreenFreeze refrigerators. Generally, and as discussed above, environmental groups can provide corporations with ecological, scientific and legal expertise (Milne et al. 1996; Hartman and Stafford 1997) and hence we model collaboration as a reduction in the greener technology cost for the firm.

To the best of our knowledge, albeit the conflict scenario is used in the literature, the collaboration case has not been modelled yet. There are papers and reports, mainly in the managerial literature which focus on such an endeavour, evaluating its benefits and weaknesses and providing suggestions for future initiatives e.g., Arts (2002), Hartman and Stafford (1997), Glasbergen and Groenenberg (2001), amongst others. However, no economic model exists which describes the EG's strategy when both options are available and what affects its decision. Therefore, this paper provides the first formal analysis of green alliances in a setting with an environmental tax.

The idea of environmentalists conflicting with firms and how this antagonistic relationship can affect environmental quality and social welfare have already been investigated by a large strand of literature (see e.g., Friehe 2013; Sartzetakis et al. 2012; Petrakis et al. 2005; Heyes and Maxwell 2004; Liston-Heyes 2001). The present paper is closest to Heijnen and Schoonbeek (2008) who examine a market in which a monopolistic firm supplies an environmentally unfriendly good. They characterise the equilibrium of an entry deterrence game, where an EG can enter the market and set up a campaign to inform consumers about the environmental damage. They find that the aggregate environmental damage is lowest if the firm is able to deter entry of the environmentalists and the group's fixed entry cost is small enough. In the present paper we too consider conflict (campaigning by the EG), but add two aspects, namely, the presence of an emission tax, and the possibility of collaboration. Even though we do not model deterrence, our analysis indicates that damages are indeed lower if the EG and polluting firm do not go into conflict. But we also show that the presence of the tax makes campaigning by the EG (conflict) more likely.

Furthermore, Heijnen (2013) investigates the incentives that the group has to inform consumers while Van der Made (2014) studies how these incentives are affected by the level of competition in the market. We add to these works by examining the incentives to inform consumers (i.e., campaigning by the EG) arising from the presence of an emission tax. Overall, the literature has not characterised the optimal emission tax in the presence of an EG and a polluting firm, where these may go into conflict or collaborate with each other.[4] Surprisingly, the characterisation of the optimal tax in this setting is new to the literature, despite an important number of industries where this sort of policy is widely used (e.g., Tietenberg 2013) and, at the same time, examples where an EG and a polluting firm collaborate/go into conflict.

We present a model in which the environmental group has two options: to campaign against a polluting firm which would shrink consumers' demand for the firm's product or to join forces with the firm which would reduce the cost of implementing a greener technology. The group bases its decision on which option results in lower total emissions. In the model the environmentalists' decision is affected by an environmental tax set at the outset by the government. One of the main results of the analysis is that higher taxation makes the conflict option more likely to be adopted by the EG. The reason behind this result is that under conflict taxation is more effective in lowering emissions and, therefore, the likelihood of the EG of opting for conflict is higher given that they care about the environmental quality. In other words, we find that collaboration and a more stringent environmental policy are substitutes. Since emissions intensity is higher under conflict than under collaboration, this result uncovers a previously unexplored, possibly adverse effect of strengthening emissions taxation on environmental quality.

The government sets the environmental tax and aims to maximise social welfare which is defined as the sum of consumer and producer surplus minus the negative externality from pollution, in the presence of uncertainty about the possibility of conflict and collaboration. This setup also captures the idea that the government will not directly encourage collaboration or conflict, a role associated with the presence of the EG who decides whether to collaborate or go into conflict with the polluting firm. We find that the optimal tax rate in the case where conflict is the only option for the environmentalists (i.e., the case examined in the literature) is higher compared to the case where taxation affects the EG's choice between conflict and collaboration. The optimised level of social welfare is higher in the latter case. These results point to the extent of substitutability between taxation and collaboration: with a chance for collaboration there is room to set a smaller tax since emissions are lower due to the transfer of know-how from the EG to the polluting firm.

The analysis also indicates that a lower degree of transfer of technological know-how from the EG to the polluting firm raises the likelihood of conflict, where emissions are higher, thereby resulting in higher taxation. This result is relevant given the increasingly important role of technology in addressing damages from pollution (e.g., Stern 2006; Barrett 2006; Hoel and De Zeeuw 2010). Our analysis therefore contributes to a branch of the literature which examines the role of technology by pointing to the transfer of know-how as a way to reduce the likelihood of conflict and, potentially, the need for aggressive taxation.

The remaining of the paper is organised as follows. Section 2.1 presents the model, while in Sect. 2.2, we solve for the firm's optimal choice. In Sect. 2.3, we solve for the environmental group's optimal decision and discuss how it is affected by the environmental tax. In Sect. 2.4, we introduce the social welfare function the government aims to maximise and Sect. 2.5 characterises optimal policy. We also present numerical examples of

[4] There are other papers in the literature which examine the role of an EG. For example, Van der Made and Schoonbeek (2009) consider a model of vertical product differentiation where consumers care about the environmental damage their consumption causes. Similar to the Heijnen and Schoonbeek (2008) paper, an EG is present and capable of increasing consumers' environmental concern via a campaign. However, in the present paper we do not consider product differentiation and the effects of campaigning by the EG and the role cleaner technology separately.

the optimal tax rate and show how the optimal tax rate is affected by changes in relevant parameters of the model (Sect. 2.6). Section 3 concludes.

2 The Model

In this section we present the model, and the firm's and environmental group's optimal choices.

2.1 Preference, Technology and Strategies

Consider a market with a profit-maximising monopolist whose production of a single good pollutes the environment with an emission intensity (i.e., emissions per unit of product) denoted by $e > 0$. For simplicity, market demand is linear, $p = a^i - q$, where $a^i > 0$ and q denotes quantity. We denote by $\gamma > 0$ the component of the monopolist's unit cost of production which is independent of the environmental characteristics of the production technology chosen by the firm. Moreover, we assume that the monopolist's unit cost of production has a second component, inversely related to the emission intensity of the adopted technology, $z^i \frac{1}{e}$, where $z^i > 0$. The firm's emissions are taxed by the government at the tax rate, t.

In this market, an environmental group (EG) aims at minimising total emissions, eq, by choosing between two options.[5] It can conflict with the monopolist by campaigning against it. In such a case, the campaign will induce a certain degree of environmental awareness among consumers which will cause a reduction of the demand parameter a^i from $a > 0$ to $a\delta$ where δ is a random variable uniformly distributed over the interval $[h, 1]$ with density function $f(\delta)$. The alternative option for the EG is to collaborate with the firm by sharing its know-how on the adoption of the greener technology, thus facilitating the firm in reducing the unit cost of adopting a cleaner technology. Formally, with collaboration with the EG the second component of the monopolist's cost of production, $z^i \frac{1}{e}$, reduces the parameter z^i from $z > 0$ to zm where $m \in (0, 1)$. Based on these building blocks, the firm's profits can be written as follows:

$$\Pi_i = (a^i - q)q - teq - z^i \frac{1}{e} q - \gamma q$$

for $i = \{conf, coll\}$ which is an index denoting the EG's decision between conflict and collaboration.

The timing of events is as follows. In stage one, the government sets the emissions tax rate t. In stage two, uncertainty on δ (i.e., the inverse measure of effectiveness of the conflict option) is resolved and, based on this, the EG decides whether to conflict or collaborate with the firm.[6] In the third stage, the firm chooses the emission intensity, e, and output, q, simultaneously. The timing of the game is relevant to the examples discussed in

[5] We assume that both options entail the same cost for the group (either monetary or psychological). This is assumed for tractability and to guarantee a closed form solution for δ.

[6] As in the example with Greenpeace and Foron discussed in the Introduction, the EG can assess how effective a campaign would be under these particular circumstances and their objective to reduce total emissions. Hence uncertainty on δ is resolved and then the group decides whether it is best to conflict or collaborate with the firm.

the Introduction - looking at the Greenpeace and Foron collaboration example, the group moved before the firm choosing whether to campaign or collaborate with the firm and then the firm made the production decisions.[7] The model is solved via backward induction.

2.2 The Monopolist's Decision

The maximisation of the monopolist's profits with respect to q and e gives

$$\frac{\partial \Pi_i}{\partial q} = a^i - \gamma - 2q - te - \frac{z^i}{e} = 0 \Leftrightarrow q = \frac{a^i - \gamma - te - \frac{z^i}{e}}{2}, \tag{1}$$

$$\frac{\partial \Pi_i}{\partial e} = -tq + \frac{z^i}{e^2}q = 0 \Leftrightarrow e = \sqrt{\frac{z^i}{t}}. \tag{2}$$

Substituting (2) into (1) we obtain the profit-maximising quantity

$$q_i = \frac{a^i - \gamma - 2\sqrt{z^i t}}{2}$$

or explicitly, under the two alternative scenarios of conflict or collaboration,

$$q_{conf} = \frac{a\delta - \gamma - 2\sqrt{zt}}{2} \qquad \text{and} \qquad q_{coll} = \frac{a - \gamma - 2\sqrt{zmt}}{2}. \tag{3}$$

From (3) the quantity produced in the collaboration case is positively affected by the reduction of the unit cost of employing a greener technology. In other words, collaboration reduces the firm's emission intensity but increases its total production. On the contrary, in the conflict case the action of the EG just causes a contraction in demand (via δ) and hence in firm's total production, for given emission intensity. Therefore, output under collaboration is higher than the output under conflict.

Firm's profits can be written as

$$\Pi_i = \frac{(a^i - \gamma - 2\sqrt{z^i t})^2}{4}$$

and as they are the square of the expression for the output, we can see that profits are higher under collaboration than conflict. Total emissions are

$$e_i q_i = \frac{a^i - \gamma - 2\sqrt{z^i t}}{2}\sqrt{\frac{z^i}{t}}.$$

It is easy to show that equilibrium quantity, emission rate, profits and total emissions are all negatively affected by the environmental tax. As the tax rate increases, the firm has a stronger incentive to lower emissions by employing a cleaner technology. In addition, the overall unit cost of production increases causing a reduction in the equilibrium production level and firm's profits.

[7] Our results are robust to changes in the timing of events. For example, if the firm was making the technology (e) and the production (q) decisions at different stages and not simultaneously.

2.3 The EG's Decision

The EG will choose to collaborate with the firm if the total emissions generated under collaboration are lower than total emissions under conflict, $e_{coll}q_{coll} < e_{conf}q_{conf}$; that is,

$$\frac{a-\gamma-2\sqrt{zmt}}{2}\sqrt{\frac{zm}{t}} < \frac{a\delta-\gamma-2\sqrt{zt}}{2}\sqrt{\frac{z}{t}}. \tag{4}$$

From the inequality in (4) we derive a threshold value for δ, $\hat{\delta}$, above (below) which the EG prefers to collaborate (conflict) with the firm:

$$e_{coll}q_{coll} < (>)e_{conf}q_{conf}, if\, \delta > (<)\frac{(a-\gamma-2\sqrt{zmt})\sqrt{m}+\gamma+2\sqrt{zt}}{a} \equiv \hat{\delta} \tag{5}$$

Hence, we define the ranges of δ for which the EG will choose to collaborate or go into conflict as follows:

$$\begin{cases} \text{conflict} & \text{if } \delta \in [h, \hat{\delta}) \\ \text{collaborate} & \text{if } \delta \in (\hat{\delta}, 1] \end{cases}$$

It is noteworthy that the aforementioned ranges are consistent with the fact that δ is distributed between h and 1.[8]

Next, we analyse the effect of the tax on the threshold value $\hat{\delta}$. In particular, from (5) it is easily shown that an increase in the tax rate increases the critical value of δ, $\hat{\delta}$:

$$\frac{\partial\hat{\delta}}{\partial t} = \frac{-2m\sqrt{z}\frac{1}{2\sqrt{t}}+2\sqrt{z}\frac{1}{2\sqrt{t}}}{a} = \frac{(1-m)\sqrt{\frac{z}{t}}}{a} > 0$$

since $m < 1$.

Proposition 1 *A higher environmental tax makes the scenario of the EG conflicting with the firm more likely.*

Proposition 1 presents a result according to which a higher tax will move $\hat{\delta}$ to the right making the interval $[h, \hat{\delta})$ bigger so that the event of conflict is now more likely to happen. This result is in line with the evolution of the Environmental Policy Stringency Index[9] and the anecdotal evidence about partnerships and the number of campaigns against firms. Even though partnerships are more likely to be supported in industrialised countries (Chan 2002, p. 116), the relationship between corporations and non-for-profits "has typically remained tense" (Rondinelli and London 2003).

The intuition here lies in the environmentalists' objective. The group cares about the environment and in particular emissions. When taxation increases, total emissions under conflict fall at a higher rate compared to the decrease in emissions under collaboration. Therefore, the group will be more likely to decide to conflict with the firm since such an action will imply less pollution. That is,

[8] In particular, since $\delta \in (h, 1)$, then (i) $\delta > \hat{\delta}$ implies $\hat{\delta} < 1$, and (ii) $\delta < \hat{\delta}$ implies $\hat{\delta} > h$.

[9] https://stats.oecd.org/Index.aspx?DataSetCode=EPS.

$$\frac{\partial e_{conf}}{\partial t} = -\frac{\sqrt{z}}{2t^{3/2}}, \qquad \frac{\partial e_{coll}}{\partial t} = -\frac{\sqrt{zm}}{2t^{3/2}}$$

where $\partial e_{conf}/\partial t > \partial e_{coll}/\partial t$ in absolute terms since $m < 1$, implying that the effect of an increase in the tax rate on emission intensity will be bigger under conflict. Similarly, for the quantities we obtain

$$\frac{\partial q_{conf}}{\partial t} = -\frac{\sqrt{z}}{2\sqrt{t}}, \qquad \frac{\partial q_{coll}}{\partial t} = -\frac{\sqrt{zm}}{2\sqrt{t}}$$

where $\partial q_{conf}/\partial t > \partial q_{coll}/\partial t$ in absolute terms since $m < 1$ meaning that the effect of an increase in the tax rate on output is stronger under conflict.

The effect of the tax on emission intensity under conflict is stronger since under collaboration, the technology chosen by the firm is already greener due to the alliance with the EG and thus the effect of taxation in this case is weaker. For the same reason, the effect of the tax on output is larger under conflict. Hence, total emissions fall at a higher rate when the environmentalists clash with the firm. The intuition of this proposition lies in the effect of an increase in the tax rate on emission intensity. On the one hand it incentivises the firm to adopt a greener technology, and on the other hand under the collaboration case this effect is already milder due to the already reduced emission intensity. Therefore, a higher tax is more effective under the conflict case.

It is also worth noting that Proposition 1 identifies a previously unexplored, possibly adverse effect of public policy on environmental quality. Particularly, a more stringent environmental policy increases the likelihood that the environmentalists will not collaborate with the firm, an effect that not only mitigates the impact of the pollution tax on emission intensity, but also leads to lower output.

We conclude this section by stating the following assumption which ensures that the production-expanding effect of collaboration is dominated by the reduction in the emission intensity so that, for *given* demand conditions, collaboration always decreases total emissions.

Assumption 1 The parameter space is restricted by the following inequality $ah - \gamma \geq 4\sqrt{zt}$.

This assumption says that the transfer of know-how from the EG to the monopolist results in lower emissions than conflict, i.e., the EG would always prefer collaboration, *for given demand conditions*. Of course, the EG's decision will depend on the realisation of δ and whether it will be greater or lower than $\hat{\delta}$. The relevance of this assumption will be apparent in Sect. 2.5.4. See "Appendix" for a proof.

2.4 Social Welfare

We define the social welfare function as the sum of consumer and producer surplus, and tax revenue minus the negative externality from pollution under each case. Specifically, consumer surplus is given by

$$CS_i = \int_h^1 \Big[\frac{(\frac{a^i-\gamma-2\sqrt{z^i t}}{2})^2}{2}\Big] f(\delta)d\delta,$$

the producer surplus as the firm's profits

$$\Pi_i = \int_h^1 \Big[\frac{(a^i - \gamma - 2\sqrt{z^i t})^2}{4}\Big] f(\delta) d\delta,$$

tax revenue as

$$te_i q_i = \int_h^1 \Big[t \frac{a^i - \gamma - 2\sqrt{z^i t}}{2} \sqrt{\frac{z^i}{t}}\Big] f(\delta) d\delta$$

and the negative externality from pollution as total emissions[10]

$$e_i q_i = \int_h^1 \Big[\frac{a^i - \gamma - 2\sqrt{z^i t}}{2} \sqrt{\frac{z^i}{t}}\Big] f(\delta) d\delta$$

where $f(\delta) = \frac{1}{1-h}$.

It is important to note that the government cares about the perceived welfare of citizens, and that the government will not directly campaign against pollution or will directly help the firm to implement greener technologies; this is a role already associated with the presence of the EG. Therefore, the social welfare function that the government maximises can be written as

$$SW = \underbrace{\int_h^{\hat{\delta}} [(CS_{conf} + te_{conf} q_{conf}) + \Pi_{conf} - e_{conf} q_{conf}] f(\delta) d\delta}_{\text{SW under conflict}} + \underbrace{\int_{\hat{\delta}}^1 [(CS_{coll} + te_{coll} q_{coll}) + \Pi_{coll} - e_{coll} q_{coll}] f(\delta) d\delta}_{\text{SW under collaboration}}$$

The SW function aims to examine the scenario where the group has the choice to collaborate or conflict with the firm rather than the conflict-only case. The function can be re-written as

$$\begin{aligned} SW = &\int_h^{\hat{\delta}} \Big[\Big(\frac{q_{conf}^2}{2} + te_{conf} q_{conf}\Big) + q_{conf}^2 - e_{conf} q_{conf}\Big] f(\delta) d\delta \\ &+ \int_{\hat{\delta}}^1 \Big[\Big(\frac{q_{coll}^2}{2} + te_{coll} q_{coll}\Big) + q_{coll}^2 - e_{coll} q_{coll}\Big] f(\delta) d\delta \end{aligned} \quad (6)$$

Hence, substituting into (6) the expressions for q_{coll}, q_{conf}, e_{coll}, e_{conf}, letting $\eta \equiv \gamma + 2\sqrt{zt}$ for notational simplicity and integrating yields (see section I of the online Appendix for a detailed derivation):

[10] We assume linear damage from emissions.

$$
\begin{aligned}
(1-h)SW =& \left(\hat{\delta}^3 - h^3\right)\frac{a^2}{12}\left(\frac{1}{2}+1\right) \\
&- \left(\hat{\delta}^2 - h^2\right)\frac{a}{4}\left(\frac{1}{2}\eta + \eta + e_{conf} - e_{conf}t\right) \\
&+ \left(\hat{\delta} - h\right)\frac{\eta}{2}\left(\frac{1}{4}\eta + \frac{1}{2}\eta + e_{conf} - e_{conf}t\right) \\
&+ \left(1-\hat{\delta}\right)\left(\frac{1}{2}q_{coll}^2 + q_{coll}^2 - e_{coll}q_{coll} + e_{coll}q_{coll}t\right)
\end{aligned} \tag{7}
$$

2.5 Optimal Taxation

In this section we characterise the optimal tax and examine the role of the conflict and collaborate components of the welfare function (case 1, Sect. 2.5.1), but also how the likelihood of conflict affects this characterisation (case 2, Sect. 2.5.2). Differentiation of (7) with respect to the tax gives (see section I of the online Appendix for a detailed derivation):

$$
\begin{aligned}
(1-h)\frac{\partial SW}{\partial t} = (1-t)H + \Bigg[&\frac{1}{8}e_{conf}\left(\hat{\delta}-h\right)\left(-a(\hat{\delta}+h)+2\eta\right) + \left(1-\hat{\delta}\right)q_{coll}\frac{\partial q_{coll}}{\partial t} \\
&+\frac{\partial\hat{\delta}}{\partial t}\frac{3}{2}q_{coll}^2(m-1)\Bigg]
\end{aligned} \tag{8}
$$

where $H > 0$, $\hat{\delta} - h > 0, 1 - \hat{\delta} > 0$, $a(\hat{\delta} + h) - 2\eta > 0$, $m - 1 < 0$, $\partial\hat{\delta}/\partial t > 0$, $\partial q_{coll}/\partial t < 0$.

Setting $\partial SW/\partial t = 0$ and solving for t (i.e., $(1-t)H$) gives

$$
t = 1 + \left[\frac{1}{8}e_{conf}\left(\hat{\delta}-h\right)\left(-a(\hat{\delta}+h)+2\eta\right) + \left(1-\hat{\delta}\right)q_{coll}\frac{\partial q_{coll}}{\partial t} + \frac{\partial\hat{\delta}}{\partial t}\frac{3}{2}q_{coll}^2(m-1)\right]/H \tag{9}
$$

Equation (9) characterises the optimal tax.[11]

2.5.1 Case 1: $\partial\hat{\delta}/\partial t = 0$

To analyse the optimal tax, first let's assume $\partial\hat{\delta}/\partial t = 0$; we look at the role of $\partial\hat{\delta}/\partial t$ in Sect. 2.5.2.

In (9) the first term puts an upward pressure on the tax to address damages from pollution from both the collaborate and conflict components in the welfare function. Moreover, the term, $(\hat{\delta} - h)(-a(\hat{\delta} + h) + 2\eta)e_{conf} < 0$, captures (from the conflict component) the downward pressure on the tax to increase consumer surplus, tackle the output distortion and raise profits. Analogously, the third term captures the downward pressure on the tax due to consumer surplus, output distortion and profits effects (from the collaboration

[11] Second-order condition holds (see section 2 of the online Appendix).

component) i.e., $(1-\hat{\delta})q_{coll}(\partial q_{coll}/\partial t) < 0$. The tax revenue effects (from the conflict and collaboration components) are completely offset and thus do not show up in (9).[12]

Overall, the presence of the possibility of collaboration between the EG and monopolist puts a downward pressure on the tax because the possibility of collaboration implies lower emissions via the transfer of know-how.

2.5.2 Case 2: $\partial\hat{\delta}/\partial t > 0$

The presence of the term $\partial\hat{\delta}/\partial t$ further puts a downward pressure on the tax. This is because a higher chance of conflict ($\partial\hat{\delta}/\partial t > 0$) results in lower profits and gains from consumer surplus.

Since $\partial\hat{\delta}/\partial t$ is positive it indicates how the presence of the tax increases the chances of conflict. This is because in the intervals for conflict and collaboration a higher $\hat{\delta}$ (due to the presence of the tax) renders the range $[h, \hat{\delta})$ larger, and the range $(\hat{\delta}, 1]$ smaller. With this in mind, the term $(\partial\hat{\delta}/\partial t)q^2_{coll}(m-1) < 0$ in (9) further puts an downward pressure on the tax. This is because with a higher chance of conflict the gains in consumer surplus that would have resulted from collaboration decrease (since under collaboration output is higher relative to conflict) and so the government lowers the tax to offset this. Moreover, the term $(\partial\hat{\delta}/\partial t)(m-1)q^2_{coll} < 0$ also indicates that with higher chances of conflict due to the presence of the tax, profits fall (since output is likely to be smaller in conflict) and so the government lowers the tax to offset profit loss. It is noteworthy that the reason the effects from damages via the term $\partial\hat{\delta}/\partial t$ do not show up in (9) is because the damage-reducing effect from the collaboration component (emissions are lower under collaboration) in the welfare function is just offset by the damage-increasing effect coming from the conflict component.

Overall, the term in brackets in (9) is negative, and so the implication is that the tax is set below marginal damages. This is consistent with the literature e.g., Barnett (1980), Requate (2006).

Proposition 2 *The optimal tax is set below marginal damages.*

Proposition 3 *The higher the chance for conflict (i.e.,* $\partial\hat{\delta}/\partial t > 0$*) the smaller the optimal tax.*

2.5.3 Taxation: Conflict vis-à-vis Conflict/Collaboration

This section compares the optimal tax in the case where the EG can only go into conflict with the monopolist (thereafter also referred to as *first scenario*) with the case where the EG has a choice of conflict or collaboration (thereafter also referred to as *second scenario*). We show that the optimal tax under the first scenario is larger than the optimal tax in the second scenario. The reason for this result is that taxation is lower given the possibility of

[12] From the collaboration component emissions per unit of output are lower (due to the transfer of know-how from the EG to the monopolist) and so the government raises the tax to recover lost revenue; and from the conflict component the effect is in general ambiguous. This is because there are two effects at play. On the one hand, due to conflict output falls and so does tax revenue thus prompting the government to raise the tax. But on the other, emissions per unit of output rise thereby reducing the need to raise the tax to raise revenue. These revenue effects are completely offset by consumer and profit effects.

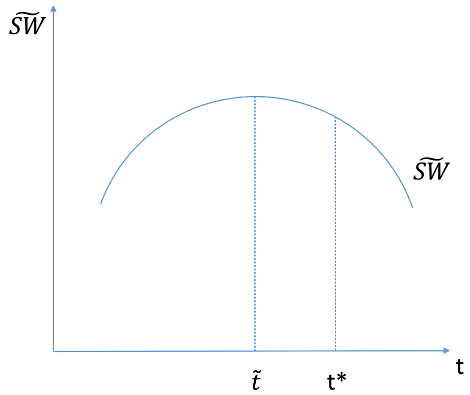

Fig. 1 Optimal tax: conflict-only and conflict/collaboration

collaboration since under collaboration emissions are lower, thereby offering extra room for a lower tax.

The strategy here is to first characterise the tax in the conflict-only case. We then evaluate the first-order condition of the welfare function where the EG has the choice of going into conflict or collaboration at the conflict-only tax. At the conflict-only tax, if the first-order condition of the welfare function where the EG has the choice of going into conflict or collaboration is negative (positive), then the tax in the conflict-only case is greater (smaller) than the tax in the case where the EG has the choice of going into conflict or collaboration. We assume strict concavity of the welfare functions. Figure 1 illustrates the key result from the analysis.

Assumption 2 Suppose the welfare functions are strictly concave.

First, consider the welfare function for the conflict-only case, SW^*:

$$\begin{aligned}(1-h)SW^* = & \left(1^3 - h^3\right)\frac{a^2}{12}\left(\frac{1}{2}+1\right) \\ & - \left(1^2 - h^2\right)\frac{a}{4}\left(\frac{1}{2}\eta + \eta + e_{conf} - e_{conf}t\right) \\ & + (1-h)\frac{\eta}{2}\left(\frac{1}{4}\eta + \frac{1}{2}\eta + e_{conf} - e_{conf}t\right)\end{aligned} \tag{10}$$

where variable definitions are the same as before. Differentiation of (10) gives

$$(1-h)\frac{\partial SW^*}{\partial t} = (1-t)H^* + \frac{(1-h)}{8}\frac{\sqrt{z}}{\sqrt{t}}(-a(1+h)+2\eta) \tag{11}$$

where $H^* > 0$ (see section I of the online Appendix). Setting Eq. (11) equal to zero, and under assumption 2, yields an optimal tax, t^*, when the EG goes into conflict only.[13]

[13] Second-order condition holds (see section 2 of the online Appendix).

Next, setting (11) equal to zero and evaluating it into (8) gives (see section I of the online Appendix for a detailed derivation):

$$(1-h)\left.\frac{\partial SW}{\partial t}\right|_{\frac{\partial SW^*}{\partial t}=0} < 0 \tag{12}$$

This leads us to the following proposition.

Proposition 4 *Taxation in the conflict-only case, t^*, is greater than taxation in the case where the EG has the choice of conflict or collaboration i.e., $t^* > t$.*

According to Proposition 4, in the case where conflict is the only option for the environmentalists the optimal tax is higher relative to the case where the group has the option of conflict or collaboration with the firm, implying that a less stringent environmental policy is required in the second scenario. This is due to the way that the environmental tax alters the probability of conflict compared to collaboration in favour of the former.

2.5.4 Taxation Under Conflict/Collaboration and Changes in *m*

This section examines the extent to which changes in m affect optimal taxation in the case where the EG has the choice of conflict or collaboration. We show that the effects of m on t depend on two factors: (i) the relative weight the government puts on damages from pollution and (ii) the degree to which changes in m affect the threshold level of $\hat{\delta}$.

The idea here is that changes in m affect the threshold level of $\hat{\delta}$ and therefore the role of the conflict and collaboration components which characterize the optimal tax. An increase in m increases the chance of conflict (i.e., the ranges $[h, \hat{\delta})$ and $(\hat{\delta}, 1]$ change since $\hat{\delta}$ changes with m), lowers the transfer of know-how from the EG to the monopolist and increases total emissions (by Assumption 1 emissions increase since emissions per unit of output increase sufficiently to offset any reductions in output resulting from an increase in m). In turn, these affect the characterization of the optimal tax, where the optimal tax is likely to be adjusted upwards, particularly if the government puts a relatively large weight on damages from pollution. This is because with a higher threshold, $\hat{\delta}$, the EG is more likely to conflict and thus the transfer of know-how from the EG to the monopolist diminishes, and at the same time emissions rise.

To see these results, we differentiate the first-order condition in Eq. (8) $SW_t(t(m), m) = 0$ (subscripts denote partial derivatives), which yields $-SW_{tt}t_m = SW_{tm}$, where $SW_{tt} < 0$. The sign of SW_{tm} dictates the sign of t_m. In particular,

$$\begin{aligned}(1-h)SW_{tm} =&(1-t)\frac{\partial H}{\partial m} + \frac{\partial \hat{\delta}}{\partial t}\frac{3}{2}\left(2q_{coll}(m-1)\frac{\partial q_{coll}}{\partial m} + q_{coll}^2\right) + \frac{\partial^2 \hat{\delta}}{\partial t \partial m}\frac{3}{2}(m-1)q_{coll}^2 \\ &+ (1-\hat{\delta})\left(q_{coll}\frac{\partial^2 q_{coll}}{\partial t \partial m} + \frac{\partial q_{coll}}{\partial t}\frac{\partial q_{coll}}{\partial m}\right) \\ &>0, \quad \text{if} \quad a\hat{\delta} > a - (1-m)^2 4\sqrt{zt} > 0\end{aligned} \tag{13}$$

where $1-t>0$, $\partial H/\partial m>0$, $\partial\hat{\delta}/\partial t>0$, $\partial q_{coll}/\partial m<0$, $m-1<0$, $\partial^2\hat{\delta}/\partial t\partial m<0$, and $q_{coll}(\partial^2 q_{coll}/\partial t\partial m)+(\partial q_{coll}/\partial t)(\partial q_{coll}/\partial m)<0$ (see section I of the online appendix for a detailed derivation).[14]

The sign of (13) is in general ambiguous. The first and second terms (each positive) denote adjustments in the tax arising from changes in damages from pollution both because conflict is more likely and thus emissions are higher, and the transfer of know-how from the EG to the monopolist is smaller. The third term (positive) indicates adjustments in the tax due to changes in the effectiveness of the tax in altering the threshold $\hat{\delta}$ (see Proposition 1): with an increase in m the ability of the tax to serve as a substitute for collaboration diminishes (since there is a loss in the EG's transfer of know-how to the monopolist due to higher m), thereby pushing the tax upwards. And the fourth term, $q_{coll}(\partial^2 q_{coll}/\partial t\partial m)+(\partial q_{coll}/\partial t)(\partial q_{coll}/\partial m)<0$, denotes the downward adjustment in the tax because output falls with a diminished transfer of know-how.

Overall the sign of (13) is positive (i.e., $t_m>0$) if damages from pollution and the loss in the transfer of know-how from the EG to the monopolist are large i.e., if chances of conflict are sufficiently large, $a\hat{\delta}>a-(1-m)^2 4\sqrt{zt}>0$. This is because with a sufficiently large threshold $\hat{\delta}$ emissions are likely to rise (because conflict is more likely to have higher emissions per unit of output). But also with conflict more likely there is a higher chance of losing the transfer of know-how. As a result, the government is more likely to adjust the tax upwards to address the loss of transfer and increase in damages from pollution.

Proposition 5 *Consider an increase m. Then, the tax is adjusted upwards if the loss in the transfer of know-how from the EG to the monopolist and damages from pollution are sufficiently large.*

2.6 Numerical Exercise: Pure Conflict versus Conflict or Collaboration

In this section, we undertake a numerical exercise to explore the effect of changes in the parameters on the optimal tax and social welfare, as well as further check our result that environmental policy should be less stringent when the EG faces the option between collaboration and conflict. In line with section 2.5.3, we begin by looking at the *first scenario* (using Eq. 10) where the only option for the group is to conflict with the firm; in other words, environmentalists only act against the firm – the scenario commonly presented by scholars. This is then compared with the *second scenario* (using Eq. 7) which is presented as the case where the environmentalists face two options, to either join forces with the firm or clash with it. For these two scenarios, we calculate the optimal tax rate for different values of the parameters and the corresponding social welfare level in each case.

In the following table we show that for different parameter values[15] the optimal tax rate in the first scenario, t^*, is higher than in the second one, t^{**} (i.e., $t^*>t^{**}$) indicating that a more stringent environmental policy is needed when the only strategy for the environmentalists is to conflict with the firm or, in other words, that collaboration and a more stringent policy are substitutes. This result supports Proposition 4 and is in line with Proposition 1 since higher taxation is in favour of having conflict between the group and the firm. Thus, in the case in which

[14] In (13) the term $\partial\hat{\delta}/\partial m(\cdot)=0$. The effects via $\partial\hat{\delta}/\partial m(\cdot)$ vanish since two effects cancel each other out: an upward tax adjustment to offset the reduction in tax revenue (the loss in revenue since output falls with a higher m) cancels out a downward tax adjustment due to reductions in output because of the higher chances for conflict.

[15] These values are random values from the parameter space.

Table 1 Optimal tax for different parameter values

Values of m	$a = 100, z = 20,$ $\gamma = 10, \mathbf{m} = 0.6,$ $h = 0.4$	$a = 100, z = 20,$ $\gamma = 10, \mathbf{m} = 0.7,$ $h = 0.4$	$a = 100, z = 20,$ $\gamma = 10, \mathbf{m} = 0.8,$ $h = 0.4$
Optimal tax for $SW_{firstscenario}$	$t^* = 0.529$ (1, 108)	$t^* = 0.529$ (1, 108)	$t^* = 0.529$ (1, 108)
Optimal tax for $SW_{secondscenario}$	$t^{**} = 0.412$ (1, 294)	$t^{**} = 0.458$ (1, 206)	$t^{**} = 0.496$ (1, 149)
Values of a	$\mathbf{a} = 50, z = 20,$ $\gamma = 10, m = 0.7,$ $h = 0.4$	$\mathbf{a} = 100, z = 20,$ $\gamma = 10, m = 0.7,$ $h = 0.4$	$\mathbf{a} = 150, z = 20,$ $\gamma = 10, m = 0.7,$ $h = 0.4$
Optimal tax for $SW_{firstscenario}$	$t^* = 0.579$ (130)	$t^* = 0.529$ (1, 108)	$t^* = 0.518$ (3, 062)
Optimal tax for $SW_{secondscenario}$	$t^{**} = 0.507$ (143)	$t^{**} = 0.458$ (1, 206)	$t^{**} = 0.447$ (3, 323)
Values of z	$a = 100, \mathbf{z} = 10,$ $\gamma = 10, m = 0.7,$ $h = 0.4$	$a = 100, \mathbf{z} = 20$ $\gamma = 10, m = 0.7,$ $h = 0.4$	$a = 100, \mathbf{z} = 30,$ $\gamma = 10, m = 0.7,$ $h = 0.4$
Optimal tax for $SW_{firstscenario}$	$t^* = 0.520$ (1, 207)	$t^* = 0.529$ (1, 108)	$t^* = 0.536$ (1, 036)
Optimal tax for $SW_{secondscenario}$	$t^{**} = 0.450$ (1, 310)	$t^{**} = 0.458$ (1, 206)	$t^{**} = 0.465$ (1, 129)
Values of h	$a = 100, z = 20,$ $\gamma = 10, m = 0.7,$ $\mathbf{h} = 0.3$	$a = 100, z = 20,$ $\gamma = 10, m = 0.7,$ $\mathbf{h} = 0.4$	$a = 100, z = 20,$ $\gamma = 10, m = 0.7,$ $\mathbf{h} = 0.5$
Optimal tax for $SW_{firstscenario}$	$t^* = 0.532$ (965)	$t^* = 0.529$ (1, 108)	$t^* = 0.526$ (1, 277)
Optimal tax for $SW_{secondscenario}$	$t^{**} = 0.465$ (1, 048)	$t^{**} = 0.458$ (1, 206)	$t^{**} = 0.450$ (1, 394)

the group faces the option to either cooperate or clash with the firm, the optimal policy should be less stringent and therefore result in higher consumer surplus due to the smaller decrease of output relative to the first scenario (conflict only).

Table 1 shows the optimal tax rate under the two scenarios while changing the parameter values m, z, a, h and, in parentheses, the corresponding social welfare values.

Starting with changes in m, we can see that a higher m, i.e., the firm being benefited less from the cooperation with the group, increases the optimal tax rate in the second scenario which is in line with Proposition 5. This can be explained by considering a higher m as less transfer of the group's know-how and thus a higher optimal tax rate is required to discourage the firm from producing with a higher emission intensity. We also find that this tax rate is lower than the tax rate in the pure conflict case. Of course, in the first scenario the changes in m do not affect the tax since there is not a possibility of cooperating with the firm.

We repeat this comparative statics exercise for the other parameters. Having a higher optimal tax rate for the pure conflict case (first scenario) relative to the second scenario also holds for different values of the demand parameter a. It is interesting to see that, for higher values of a, the optimal tax rate is decreasing in both cases. This may seem counter-intuitive, however it can be explained when taking into account the effect of a on $\hat{\delta}$. In particular, using equation (5) and taking the derivative of $\hat{\delta}$ with respect to a, we obtain

$$\begin{aligned}\frac{\partial \hat{\delta}}{\partial a} &= \frac{a\sqrt{m} - (a\sqrt{m} - \gamma\sqrt{m} - 2\sqrt{ztm} + \gamma + 2\sqrt{zt})}{a^2} \\ &= \frac{(\gamma + 2\sqrt{zmt})\sqrt{m} - (\gamma + 2\sqrt{zt})}{a^2} < 0\end{aligned}$$

since $m \in (0, 1)$. This implies that changes in the demand parameter a have a negative effect in the threshold value of $\hat{\delta}$. Therefore, an increase in the market size will decrease $\hat{\delta}$ in which case the interval $[h, \hat{\delta})$ becomes smaller i.e., conflict is less likely to happen and thus, it is accompanied by lower taxation.

For an increase in z, the tax is increasing indicating that when the cost of the cleaner technology is higher the optimal tax rate is increased to still provide incentives to the firm to employ a cleaner technology. This holds for both scenarios since, regardless of whether there is a possibility of collaboration with the group or not, an increase in the cost for adopting a less polluting technology unaccompanied by an increase in the tax would discourage the firm from incurring that higher cost.

Finally, looking at changes in h, we can see that a smaller h requires a less stringent environmental policy. Recall that h is the lower bound of the interval that δ can take values from. In other words, a smaller h makes the range of the values that δ can take larger suggesting that the EG can be more effective in its campaign against the firm shrinking more the demand. Therefore, it implies a lower optimal tax rate in both scenarios. Again, tax under pure conflict is higher than the case where both collaboration and conflict are the EG's options.

All in all, the results of this numerical exercise offer a comparative static analysis as well as support our finding that environmental policy should be less stringent when the EG faces the choice between collaboration and conflict –which is indeed a decision that groups in reality, at least to some extent, face. Looking at the numbers in parentheses, i.e., the SW values after substituting the parameters values to Eqs. 7 and 10, we also find that SW is higher in the second scenario as the optimal tax is lower compared to the first, pure conflict, scenario.

3 Conclusion

The idea of environmentalists clashing with firms is not new; what is novel in recent years is the phenomenon of green alliances, the collaboration between a firm and an environmental group in developing and implementing a cleaner production technology. The former notion has already been well examined in the literature. However, to the best of our knowledge, the option of cooperation between these two players has not been modelled and thus this paper signifies a first attempt towards this direction.

In particular, environmentalists can either act against the firm and the consequences of its polluting production which will reduce emissions via a contraction in demand or join forces with the firm and share their know-how which will provide incentives to the firm to employ a cleaner technology through the decrease in its cost of adoption. The group makes its decision based on which option entails less pollution and it is affected by an environmental tax set by the government. This, then, impacts firm's choices on output and emission intensity.

We have shown that higher taxes make the conflict case more likely to happen, indicating that collaboration and a more stringent environmental policy are substitutes. This sheds light to a previously unexplored, possibly adverse effect of public policy on environmental quality because it mitigates the impact of the pollution tax on emission intensity since the latter is higher under conflict and leads to lower output.

We also characterise analytically and by means of numerical examples the optimal tax. We find that in the case where conflict is the only option for the environmentalists the tax is higher relative to the case where the group can choose either to conflict or collaborate with the firm, implying that a less stringent environmental policy is required in the second scenario. This is due to the way that the environmental tax alters the probability of conflict compared to collaboration in favour of the former.

Our analysis provides a first attempt to embrace the changing landscape in the relationship between a firm and an environmental group and opens the way for future research. For instance, it would be interesting to examine a framework where the firm would not be always willing to collaborate with the group or having more than one firm in the market to explore the interactions between them e.g., monopolistic competition, multi-firm oligopoly. This setup would open the door to the understanding of which firm will manage to collaborate with the environmentalists and the effects on pollution and welfare since attention has been restricted in the monopoly scenario in this model. As a second potential future line of research, it would make sense to allow for the EG to have the ability to both collaborate by transferring know-how and conflict (most likely at an industry-level) by lowering demand, particularly as the aim of the EG is to minimise emissions. In this paper we are restricting the decision space of the EG by having it either collaborating or conflicting; however, modelling this sort of "combined" decision by the EG may help expand the applicability of the model along with its implications for policy.

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Appendix

Assumption 1 This assumption implies that, for given demand conditions, collaboration always reduces total emissions. Formally,

$$\frac{a^i-\gamma-2\sqrt{zmt}}{2}\sqrt{\frac{zm}{t}}<\frac{a^i-\gamma-2\sqrt{zt}}{2}\sqrt{\frac{z}{t}}\Rightarrow$$
$$(a^i-\gamma-2\sqrt{zmt})\sqrt{m}<a^i-\gamma-2\sqrt{zt}.$$

The LHS of the inequality is a function of m. In particular,

$$\frac{\partial(LHS)}{\partial m}=\frac{1}{2\sqrt{m}}(a^i-\gamma-2\sqrt{zmt})-\frac{1}{2\sqrt{m}}2\sqrt{zt}\sqrt{m}$$
$$=\frac{1}{2\sqrt{m}}(a^i-\gamma-2\sqrt{zmt})-\sqrt{zt}$$

$$=\frac{1}{2\sqrt{m}}(a^i-\gamma-2\sqrt{zmt})-\frac{2\sqrt{zmt}}{2\sqrt{m}}=\frac{1}{2\sqrt{m}}(a^i-\gamma-4\sqrt{zmt}).$$

This expression is decreasing in m. As long as $a^i - \gamma > 4\sqrt{zt}\ \forall a^i$ then $\frac{\partial(LHS)}{\partial m} > 0$ $\forall m \in (0, 1)$. Thus, the inequality $(a^i - \gamma - 2\sqrt{zmt})\sqrt{m} < a^i - \gamma - 2\sqrt{zt}$ holds $\forall m \in (0, 1)$. Note that assuming $ah - \gamma > 4\sqrt{zt}$ is sufficient for the non-negativity constraint on output $ah - \gamma \geq 2\sqrt{zt}$ (Eq. 3) to hold in order avoid a corner solution.

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