Green alliances and the role of taxation

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Abstract

I examine two alternative strategies that an environmental group can embark when interacting with a firm. The first one which is already extensively discussed in the literature is when the group campaigns against the firm. The second one which has not been modelled in the literature yet is when the group collaborates with the firm (green alliance) by sharing its know-how in order to reduce the implementation cost of the cleaner technology. The main result 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 desirable impact of the pollution tax on emission intensity since the latter is higher under conflict and reinforces the, already negative, effect of environmental policy on output. Due to the complexity of the problem, I undertake numerical examples to calculate the optimal tax that maximises Social Welfare and I find that tax under pure conflict –when conflict is the only option for the environmentalists – is higher than in the case where the group can choose to either act against or join forces with the firm, indicating that a more stringent environmental policy is needed in the first scenario.

1 Introduction

Examples of environmental organisations clashing with businesses are surely not scarce. One of the environmental groups' common practices which affect 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. 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.

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 Friehe, 2013; Sartzetakis *et al.*, 2012; Petrakis *et al.*, 2005; Heyes and Maxwell, 2004; Liston-Heyes, 2001 among others). Heijnen and Schoonbeek (2008) examine a market in which a monopolistic firm supplies an environmentally unfriendly good and characterise the equilibrium of an entry deterrence game where an environmental group (EG henceforth) 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. Van der Made and Schoonbeek (2009) consider a model of vertical product differentiation where consumers care about the environmental damage their consumption causes. Similarly to the previously mentioned paper, an EG is capable of increasing consumers' environmental concern via a campaign and they show that a prospect of such a campaign can induce entry by a firm that employs a cleaner production practice and may result in higher aggregate pollution due to an increase in production offsetting the decline in emissions. 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. On the empirical side, Binder and Neumayer (2005) find that an EG's strength is effective in reducing air pollution levels in the form of SO_2, smoke and heavy particulates in a setting where the group can influence the policymakers.

However, in recent years this relationship has evolved. "Green alliances", namely partnerships between an EG and a firm have become a popular 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 can also be a source of information and knowledge about innovative ways to rethink production technologies, identify new products and address stakeholder concerns. In fact, it may even be the only choice to

[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.

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, I am 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. 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. As a result, McDonald's recycled one million tons of corrugated boxes, reduced packaging by £300 million and decreased waste from restaurants by 30 percent. Since then, partnerships have become more popular. EDF joined forces with more firms i.e., FedEx, Walmart and the private equity firm KKR. Greenpeace also followed the initiative by helping Npower –a company owned by RWE, the German utility company– to promote Juice, a renewable energy product, to thousands of consumers in the UK as a clean energy option. The other two partnerships it did were a campaign with the Co-op Bank to remove PVC in credit cards and another with the retailer Iceland to promote their greenhouse gas friendly "Kyoto" refrigerators.

To the best of my knowledge, albeit the conflict scenario is well explored 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. However, no economic model exists which describes the EG's strategy and what affects its decisions. Therefore, this paper provides the first formal analysis of green alliances. In particular, I 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 my analysis is that higher taxation makes the conflict option more likely to be adopted by the EG. In other words, 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. These three components are attached with weights which represent the "ideological" inclination of the government or the relative importance of each for the government. Due to the complexity of the problem, I resort to numerical examples to calculate the optimal tax rate that maximises social welfare. I find that the optimal tax rate in the case where conflict is the only option for the environmentalists (i.e., the only case examined by the previous 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 also higher in the latter case.

The remaining of the paper is organised as follows. Subection 2.1 presents the model, while in subsection 2.2, I solve for the firm's optimal choice. In the next subsection (2.3), I solve for the environmental group's optimal decision and discuss how it is affected by the environmental tax. In subsection 2.4, I introduce the social welfare function the government aims to maximise and I present numerical examples of the optimal tax rate. I also show how the optimal tax rate is affected by changes in relevant parameters of the model (subsection 2.5). Section 3 concludes.

2 The model

In this section I present the model and the firm's and environmental group's optimal choices and discuss how the EG's decision is affected by the environmental tax.

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. I 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. The firm's emissions are taxed by the government at the tax rate $t \geq 0$.

In this market, an environmental group (EG) aims at minimising total emissions, eq, by choosing between two options[2]. 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

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

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, I 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. Collaboration with the EG reduces the parameter z^i from $z > 0$ to zm where $m \in (0, 1)$. Based on these assumptions, 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 optimal 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. In the third stage, the firm optimally chooses the emission intensity e and output q.

2.2 The monopolist's decision

Proceeding by backward induction from the third stage, the maximisation of the monopolist's profits with respect to q and e gives us:

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

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

Substituting (2) in (1) we obtain the optimal quantity

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

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

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

As we can see 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 (by the factor δ) and hence in firm's total production, for given

emission intensity. Therefore, it is apparent that the 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 total emissions as

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

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. However, the overall unit cost of production increases causing a reduction in the optimal production level and in the firm's profits.

By comparing the firm's equilibrium profits under the two alternative scenarios of conflict and collaboration, it is easy to see that the firm always prefers collaborating with the EG:

$$\Pi_{coll} = \frac{(a - \gamma - 2\sqrt{zmt})^2}{4} > \Pi_{conf} = \frac{(a\delta - \gamma - 2\sqrt{zt})^2}{4}.$$

2.3 The EG's decision

On the environmentalists' side, the following assumption 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. Recalling that the objective of the EG is simply to minimise total emissions, it is clear that without Assumption 1 the EG would trivially prefer to conflict with the firm.

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

In the Appendix, I show that Assumption 1 implies that, for given demand conditions, collaboration always reduces total emissions (see Appendix I).

The EG will choose to collaborate with the firm if the total emissions generated under collaboration are lower than total emissions under conflict, $eq_{coll} < eq_{conf}$, which requires

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

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

$$(a - \gamma - 2\sqrt{zmt})\sqrt{m} < a\delta - \gamma - 2\sqrt{zt} \Rightarrow (a - \gamma - 2\sqrt{zmt})\sqrt{m} + \gamma + 2\sqrt{zt} < a\delta$$

$$\delta > \frac{(a-\gamma-2\sqrt{zmt})\sqrt{m}+\gamma+2\sqrt{zt}}{a} \equiv \hat{\delta}. \tag{5}$$

Hence, the EG will choose

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

We can easily check that Assumption 1 guarantees that $\hat{\delta} < 1$:

$$\frac{(a-\gamma-2\sqrt{zmt})\sqrt{m}+\gamma+2\sqrt{zt}}{a} < 1 \Rightarrow (a-\gamma-2\sqrt{zmt})\sqrt{m} < a-\gamma-2\sqrt{zt}$$

which holds as long as $(ah-\gamma) > 4\sqrt{zt}$ (see Assumption 1).

Let us now investigate the condition under which $\hat{\delta} > h$. Recall that the parameter m (i.e. the inverse measure of effectiveness of collaboration) was initially assumed to be restricted in the interval $(0,1)$. We show below that m should be above a threshold value $0 < m^* < 1$ to guarantee that $\hat{\delta} > h$ holds; in other words, $m \in (m^*, 1)$.

Imposing

$$\hat{\delta} = \frac{(a-\gamma-2\sqrt{zmt})\sqrt{m}+\gamma+2\sqrt{zt}}{a} > h \Rightarrow$$

we get

$$-2m\sqrt{zt} + (a-\gamma)\sqrt{m} - [ah-\gamma-2\sqrt{zt}] > 0. \tag{6}$$

The LHS of Eq. (6) can be rewritten as

$$-m + \frac{a-\gamma}{2\sqrt{zt}}\sqrt{m} - \left(\frac{ah-\gamma}{2\sqrt{zt}} - 1\right).$$

Defining $\sqrt{m} = \mu$, we find the two following roots of this quadratic polynomial[3] which read

$$\mu^*_{1,2} = \frac{\frac{a-\gamma}{2\sqrt{zt}} \pm \sqrt{\left(\frac{a-\gamma}{2\sqrt{zt}}\right)^2 - 4\left(\frac{ah-\gamma}{2\sqrt{zt}} - 1\right)}}{2}.$$

Since $m \in (0,1)$ then $\mu \in (0,1)$. One of the roots is ruled out since it exceeds 1 (recall that $a-\gamma > 2\sqrt{zt}$). Thus, the only root is

$$\mu^* = \frac{\frac{a-\gamma}{2\sqrt{zt}} - \sqrt{\left(\frac{a-\gamma}{2\sqrt{zt}}\right)^2 - 4\left(\frac{ah-\gamma}{2\sqrt{zt}} - 1\right)}}{2}. \tag{7}$$

[3]For these to be real roots

$$\left(\frac{a-\gamma}{2\sqrt{zt}}\right)^2 > 4\frac{ah-\gamma}{2\sqrt{zt}} - 4 \Rightarrow \left(\frac{a-\gamma}{2\sqrt{zt}}\right)^2 + 4 > 2\frac{ah-\gamma}{\sqrt{zt}} \Rightarrow$$

$$\left(\frac{a-\gamma}{2\sqrt{zt}}\right)^2 + 4 - 2\frac{a-\gamma}{\sqrt{zt}} > 2\frac{ah-\gamma}{\sqrt{zt}} - 2\frac{a-\gamma}{\sqrt{zt}} \Rightarrow \left(\frac{a-\gamma}{2\sqrt{zt}} - 2\right)^2 > \frac{2a}{\sqrt{zt}}(h-1)$$

which holds given $h \in (0,1)$.

Using (7) we can check that $\mu^* < 1$ holds

$$\frac{a-\gamma}{2\sqrt{zt}} - \sqrt{\Big(\frac{a-\gamma}{2\sqrt{zt}}\Big)^2 - 4\Big(\frac{ah-\gamma}{2\sqrt{zt}} - 1\Big)} < 2 \Rightarrow$$

$$\frac{a-\gamma}{2\sqrt{zt}} - 2 < \sqrt{\Big(\frac{a-\gamma}{2\sqrt{zt}}\Big)^2 - 4\Big(\frac{ah-\gamma}{2\sqrt{zt}} - 1\Big)} \Rightarrow$$

$$\Big(\frac{a-\gamma}{2\sqrt{zt}}\Big)^2 - \frac{2(a-\gamma)}{\sqrt{zt}} + 4 < \Big(\frac{a-\gamma}{2\sqrt{zt}}\Big)^2 - \frac{2(ah-\gamma)}{\sqrt{zt}} + 4 \Rightarrow$$

$$ah - \gamma < a - \gamma \Rightarrow h < 1$$

Given the above and using (7), the threshold value m^* is equal to

$$m^* = (\mu^*)^2 = \left\{ \frac{\frac{a-\gamma}{2\sqrt{zt}} - \sqrt{\Big(\frac{a-\gamma}{2\sqrt{zt}}\Big)^2 - 4\Big(\frac{ah-\gamma}{2\sqrt{zt}} - 1\Big)}}{2} \right\}^2$$

and thus for $\hat{\delta} > h$ to hold, then $m \in (m^*, 1)$.

Recall now that the government sets an environmental tax; thus, it is interesting to analyse the effect of the tax on the threshold value $\hat{\delta}$.

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

Proof. It is easily shown that an increase in the tax rate increases the critical value of δ, $\hat{\delta}$, below which the EG chooses to conflict with the firm:

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

since $m < 1$. □

Proposition 1 presents a result according to which 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. The intuition here lies in the environmentalists' objective. The group cares about the environment and in particular emissions. As we will see, when taxation is increasing, 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. To show this, recall that total emissions are a product of emission intensity and production. Let us analyse the effect of tax on emission intensity and output separately.

By taking the derivative of emission intensity under conflict and under collaboration with respect to the tax rate we get

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

and we can see that $\frac{\partial e_{conf}}{\partial t} > \frac{\partial e_{coll}}{\partial t}$ 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

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

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

As discussed earlier in subsection 2.2, we have already seen that production, emission intensity and total emissions are negatively affected by an increase in the tax rate. Now, the above calculations show that the decrease in production, emission intensity and total emissions is bigger under conflict than collaboration. In particular, 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. The effect of the tax on output works towards the same direction namely production is decreasing more under conflict and hence total emissions are falling at a higher rate when the environmentalists clash with the firm. In other words, following a given increase in t the decrease in total emissions under conflict is more pronounced. 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 desirable impact of the pollution tax on emission intensity but also leads to lower output.

2.4 Social Welfare

We can now define the social welfare function as the sum of consumer and producer surpluses and tax revenues minus the negative externality from pollution under each case. More specifically, consumer surplus is calculated as

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

the producer surplus as the firm's profits

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

tax revenues as

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

and the negative externality from pollution as the total emission[4]

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

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

At this point, it is important to note that the government is considered as being composed by politicians who care about the perceived welfare of citizens and this could be for electoral reasons. So, by weighting the perceived consumer surplus, profits, the environmental group's loss and the tax revenues in the government's objective function by ϕ_1, ϕ_2, ϕ_3 and ϕ_4 respectively, where $\phi_4 = \phi_1$[5] and the weights add up to 1, i.e., $2\phi_1 + \phi_2 + \phi_3 = 1 \Rightarrow \phi_3 = 1 - 2\phi_1 - \phi_2$, we represent the "ideological" inclination of the government (or the government's perceived relative importance of the four arguments for re-election). This also justifies why 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 will maximise can be written as:

$$SW = \underbrace{\int_h^{\hat{\delta}} [\phi_1(CS_{conf} + te_{conf}q_{conf}) + \phi_2 \Pi_{conf} - (1 - 2\phi_1 - \phi_2) e_{conf} q_{conf}] f(\delta) d\delta}_{\text{SW under conflict}}$$

$$+ \underbrace{\int_{\hat{\delta}}^1 [\phi_1(CS_{coll} + te_{coll}q_{coll}) + \phi_2 \Pi_{coll} - (1 - 2\phi_1 - \phi_2) e_{coll} q_{coll}] f(\delta) d\delta}_{\text{SW under collaboration}}$$

$$\Rightarrow SW = \int_h^{\hat{\delta}} [\phi_1\Big(\frac{q_{conf}^2}{2} + te_{conf}q_{conf}\Big) + \phi_2 q_{conf}^2 - (1 - 2\phi_1 - \phi_2) e_{conf} q_{conf}] f(\delta) d\delta$$

$$+ \int_{\hat{\delta}}^1 [\phi_1\Big(\frac{q_{coll}^2}{2} + te_{coll}q_{coll}\Big) + \phi_2 q_{coll}^2 - (1 - 2\phi_1 - \phi_2) e_{coll} q_{coll}] f(\delta) d\delta \tag{8}$$

$$= \int_h^{\hat{\delta}} \Big[\phi_1\Big(\frac{(\frac{a\delta - \gamma - 2\sqrt{zt}}{2})^2}{2} + \frac{a\delta - \gamma - 2\sqrt{zt}}{2}\sqrt{\frac{z}{t}}\Big) + \phi_2 \frac{(a\delta - \gamma - 2\sqrt{zt})^2}{4}$$

$$-(1 - 2\phi_1 - \phi_2)\frac{a\delta - \gamma - 2\sqrt{zt}}{2}\sqrt{\frac{z}{t}}\Big] f(\delta) d\delta$$

$$+ \int_{\hat{\delta}}^1 \Big[\phi_1\Big(\frac{(\frac{a - \gamma - 2\sqrt{zmt}}{2})^2}{2} + \frac{a - \gamma - 2\sqrt{zmt}}{2}\sqrt{\frac{zm}{t}}\Big) + \phi_2 \frac{(a - \gamma - 2\sqrt{zmt})^2}{4}$$

[4] I assume linear damage from emissions. One interpretation for this can be a political economy interpretation where the Social Welfare is a linear combination of the preferences of the players; a linear combination of the utility function of the consumers, the producer and the group.

[5] In this setup, all tax revenues are allocated to the consumer in the form of a lump sum transfer, i.e., $\phi_4 = \phi_1$

$$-(1-\phi_1-\phi_2)\frac{a-\gamma-2\sqrt{zmt}}{2}\sqrt{\frac{zm}{t}}\Big]f(\delta)d\delta.$$

Hence,

$$SW=\frac{1}{1-h}\Big\{\frac{1}{12}a^2\Big(\frac{1}{2}\phi_1+\phi_2\Big)\Big(\hat{\delta}^3-h^3\Big)$$

$$-\frac{1}{4}a\Big(\frac{1}{2}\phi_1\eta+\phi_2\eta a-(1-2\phi_1-\phi_2)\frac{\sqrt{z}}{\sqrt{t}}-\phi_1\sqrt{zt}\Big)\Big(\hat{\delta}^2-h^2\Big)+\Big(\frac{1}{2}\phi_1\Big(\frac{\eta}{2}\Big)^2$$

$$+\frac{1}{4}\phi_2\eta^2+(1-2\phi_1-\phi_2)\frac{\eta\sqrt{z}}{2\sqrt{t}}-\phi_1\eta\sqrt{zt}\Big)(\hat{\delta}-h)$$

$$+\Bigg(\frac{1}{2}\phi_1\Big(\frac{a-\gamma-2\sqrt{zmt}}{2}\Big)^2+\frac{1}{4}\phi_2(a-\gamma-2\sqrt{zmt})^2$$

$$-\frac{1}{2}(1-2\phi_1-\phi_2)\frac{(a-\gamma-2\sqrt{zmt})\sqrt{zm}}{\sqrt{t}}+\phi_1\sqrt{zmt}\frac{(a-\gamma-2\sqrt{zmt})}{2}\Bigg)\Big(1-\hat{\delta}\Big)\Big\}$$

where $\eta=\gamma+2\sqrt{zt}$.

We know how the function behaves in the two extreme cases; for the minimum value of tax, i.e., $t=0$ and for the maximum value of tax which in this case is $t=\frac{(ah-\gamma)^2}{16z}$. The SW consists of the consumer surplus and the profits subtracting the negative externality from pollution, so in the former case we can see that $e\to\infty$ and thus $SW\to-\infty$ and in the latter case, $q=0$, $e=0$ and $SW=0$. To obtain explicitly the optimal tax rate that maximises the Social Welfare function we should set $\frac{\partial(SW)}{\partial t}=0$. However, it is not possible to find a closed-form solution for t in this setting.

2.5 Pure conflict vs conflict or collaboration

Due to the complexity of this problem, I undertake numerical examples to explore the effect of tax rate on Social Welfare starting with the following parameter values $a=100$, $\gamma=10$, $h=0.4$, $m=0.7$, $z=20$ and $\phi_1=\phi_2=\phi_3=\frac{1}{3}$ (see the shaded rows in the tables below). Let us begin by introducing a benchmark case where the only option for the group is to conflict with the firm (referred to as *first scenario*); in other words environmentalists only act against the firm, i.e., the scenario commonly presented by scholars. In this case,

$$SW_{firstscenario}=\int_h^1[\phi_1(CS_{conf}+te_{conf}q_{conf})+\phi_2\Pi_{conf}-(1-2\phi_1-\phi_2)e_{conf}q_{conf}]f(\delta)d\delta$$

$$=\int_h^1[\phi_1\Big(\frac{q_{conf}^2}{2}+te_{conf}q_{conf}\Big)+\phi_2q_{conf}^2-(1-2\phi_1-\phi_2)e_{conf}q_{conf}]f(\delta)d\delta$$

$$=\int_h^1\Big[\phi_1\Big(\frac{(\frac{a\delta-\gamma-2\sqrt{zt}}{2})^2}{2}+\frac{a\delta-\gamma-2\sqrt{zt}}{2}\sqrt{\frac{z}{t}}\Big)+\phi_2\frac{(a\delta-\gamma-2\sqrt{zt})^2}{4}$$

$$-(1-2\phi_1-\phi_2)\frac{a\delta-\gamma-2\sqrt{zt}}{2}\sqrt{\frac{z}{t}}\Big]f(\delta)d\delta.$$

This is then compared with the scenario which is presented in this model i.e., having the environmentalists facing two options, to either join forces with the firm or clash with it (referred to as *second scenario*). In such case, the SW function is as in Eq. (8). For these two scenarios, I calculate the optimal tax rate (t^* and t^{**} respectively) for different values of the parameters. Note that the numbers in parentheses denote the corresponding Social Welfare level in each case.

All of the following tables show that optimal tax rate in the first scenario is higher than in the second one ($t^* > t^{**}$) 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 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 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: Optimal tax for different values of z

Parameters	Optimal Tax for $SW_{firstscenario}$	Optimal Tax for $SW_{secondscenario}$
$a = 100$, **z=10**, $\gamma = 10, \phi_1 = 0.25$, $\phi_2 = 0.25, m = 0.7$, $h = 0.4$	$t^* = 0.520$ (302)	$t^{**} = 0.450$ (327)
$a = 100$, **z=20**, $\gamma = 10, \phi_1 = 0.25$, $\phi_2 = 0.25, m = 0.7$, $h = 0.4$	$t^* = 0.529$ (277)	$t^{**} = 0.458$ (301)
$a = 100$, **z=30**, $\gamma = 10, \phi_1 = 0.25$, $\phi_2 = 0.25, m = 0.7$, $h = 0.4$	$t^* = 0.536$ (259)	$t^{**} = 0.465$ (282)

Table 1 shows the optimal tax rate under these two scenarios while changing the values for the cost of the greener technology (z). In both cases, it is increasing in z 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 in increase in the tax would discourage the firm from incurring that higher cost.

Table 2: Optimal tax for different values of a

Parameters	Optimal Tax for $SW_{firstscenario}$	Optimal Tax for $SW_{secondscenario}$
a=50, $z = 20$, $\gamma = 10, \phi_1 = 0.25$, $\phi_2 = 0.25, m = 0.7$, $h = 0.4$	$t^* = 0.579$ (32)	$t^{**} = 0.507$ (36)
a=100, $z = 20$, $\gamma = 10, \phi_1 = 0.25$, $\phi_2 = 0.25, m = 0.7$, $h = 0.4$	$t^* = 0.529$ (277)	$t^{**} = 0.458$ (301)
a=150, $z = 20$, $\gamma = 10, \phi_1 = 0.25$, $\phi_2 = 0.25, m = 0.7$, $h = 0.4$	$t^* = 0.518$ (765)	$t^{**} = 0.447$ (831)

As table 2 shows, 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 in $\hat{\delta}$. In particular, using Eq. (5) and taking the derivative of $\hat{\delta}$ with respect to a, we obtain

$$\frac{\partial\hat{\delta}}{\partial a} = \frac{a\sqrt{m} - (a\sqrt{m} - \gamma\sqrt{m} - 2\sqrt{zt}m + \gamma + 2\sqrt{zt})}{a^2}$$

$$= \frac{(\gamma + 2\sqrt{zmt})\sqrt{m} - (\gamma + 2\sqrt{zt})}{a^2} < 0$$

since $m \in (0, 1)$. Therefore, an increase in a will decrease $\hat{\delta}$ in which case conflict is less likely to happen and thus, it is accompanied by lower taxation.

Table 3: Optimal tax for different values of h

Parameters	Optimal Tax for $SW_{firstscenario}$	Optimal Tax for $SW_{secondscenario}$
$a = 100, z = 20$, $\gamma = 10, \phi_1 = 0.25$, $\phi_2 = 0.25, m = 0.7$, **h=0.3**	$t^* = 0.532$ (241)	$t^{**} = 0.465$ (262)
$a = 100, z = 20$, $\gamma = 10, \phi_1 = 0.25$, $\phi_2 = 0.25, m = 0.7$, **h=0.4**	$t^* = 0.529$ (277)	$t^{**} = 0.458$ (301)
$a = 100, z = 20$, $\gamma = 10, \phi_1 = 0.25$, $\phi_2 = 0.25, m = 0.7$, **h=0.5**	$t^* = 0.526$ (319)	$t^{**} = 0.450$ (348)
$a = 100, z = 20$, $\gamma = 10, \phi_1 = 0.25$, $\phi_2 = 0.25, m = 0.7$, **h=0.6**	$t^* = 0.524$ (367)	$t^{**} = 0.438$ (404)

Making the range of the values that δ can take larger, we can see that it reduces the optimal tax rate in both scenarios (see Table 3). In other words, a lower h shrinks more the demand and thus a less stringent environmental policy is required and follows the same reasoning as the impact of the changes in a on the optimal tax. Still, tax under pure conflict is higher than the case where both collaboration and conflict can be EG's strategy.

Table 4: Optimal tax for different values of m

Parameters	Optimal Tax for $SW_{firstscenario}$	Optimal Tax for $SW_{secondscenario}$
$a = 100, z = 20,$ $\gamma = 10, \phi_1 = 0.25,$ $\phi_2 = 0.25,$ **m=0.6**, $h = 0.4$	$t^* = 0.529$ (277)	$t^{**} = 0.412$ (323)
$a = 100, z = 20,$ $\gamma = 10, \phi_1 = 0.25,$ $\phi_2 = 0.25,$ **m=0.7**, $h = 0.4$	$t^* = 0.529$ (277)	$t^{**} = 0.458$ (301)
$a = 100, z = 20,$ $\gamma = 10, \phi_1 = 0.25,$ $\phi_2 = 0.25,$ **m=0.8**, $h = 0.4$	$t^* = 0.529$ (277)	$t^{**} = 0.496$ (287)
$a = 100, z = 20,$ $\gamma = 10, \phi_1 = 0.25,$ $\phi_2 = 0.25,$ **m=0.9**, $h = 0.4$	$t^* = 0.529$ (277)	$t^{**} = 0.520$ (279)

Furthermore, a higher m implies that the firm is benefiting less from the cooperation with the group and as we can see, it increases the optimal tax rate in the second scenario while this tax rate is still lower than the tax rate in the pure conflict case (Table 4). 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. 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.

Table 5: Optimal tax for different values of ϕ

Parameters	Optimal Tax for $SW_{firstscenario}$	Optimal Tax for $SW_{secondscenario}$
$a = 100, z = 20,$ $\gamma = 10, \boldsymbol{\phi_1 = 0.25},$ $\boldsymbol{\phi_2 = 0.25}, m = 0.7,$ $h = 0.4$	$t^* = 0.529$ (277)	$t^{**} = 0.458$ (301)
$a = 100, z = 20,$ $\gamma = 10, \boldsymbol{\phi_1 = 0.4},$ $\boldsymbol{\phi_2 = 0.1}, m = 0.7,$ $h = 0.4$	$t^* = 0.454$ (256)	$t^{**} = 0.365$ (275)
$a = 100, z = 20,$ $\gamma = 10, \boldsymbol{\phi_1 = 0.1},$ $\boldsymbol{\phi_2 = 0.7}, m = 0.7,$ $h = 0.4$	$t^* = 0.074$ (634)	$t^{**} = 0.067$ (688)
$a = 100, z = 20,$ $\gamma = 10, \boldsymbol{\phi_1 = 0.2},$ $\boldsymbol{\phi_2 = 0.2}, m = 0.7,$ $h = 0.4$	$t^* = 1.084$ (195)	$t^{**} = 3.600$ (70)

Finally, we can see that, in both scenarios, the optimal tax rate is higher when consumer surplus is valued more than the other arguments compared to the case where producer surplus is weighted more. It is however lower compared to Social Welfare being more heavily affected by pollution. Again, a more stringent environmental policy is needed under the first scenario where the group only conflicts with the firm (Table 5).

Various combinations of parameter values included in the tables above are also presented in Appendix II in the form of graphs. All in all, the above results indicate that a less stringent environmental policy should be implemented when the group faces an additional option of partnering with the firm relative to when the only option is to conflict. This is can be explained given the way that the environmental tax alters the probability of conflict compared to collaboration in favour of the former. Also it is worth noting that SW (numbers in brackets in the above tables) is higher when the less stringent policy is set (second 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 my knowledge, the option of cooperation between these two players has not been modelled by scholars yet and thus this paper signifies a first attempt towards this direction.

In particular, in this model, 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.

I 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 desirable impact of the pollution tax on emission intensity since the latter is higher under conflict and leads to lower output.

I also undertake by means of numerical examples the calculation of the optimal tax that maximises Social Welfare and I find that in the case 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.

This analysis has a number of limitations. 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 firms in the market and explore the interactions between them, the outcome in terms 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. Nevertheless, in any case, this paper provides an attempt to embrace the changing landscape in the relationship between a firm and an environmental group and opens the way for future research.

Appendix

Appendix I

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.

Appendix II

The following graphs are depicting SW with respect to tax when conflict is the only strategy for the group (first scenario) and when the environmentalists have the option to either conflict or collaborate with the firm (second scenario).

For $a = 100$, $\gamma = 10$, $h = 0.4$, $m = 0.7$, $z = 20$ and $\phi_1 = \phi_2 = \phi_3 = \frac{1}{3}$ (baseline):

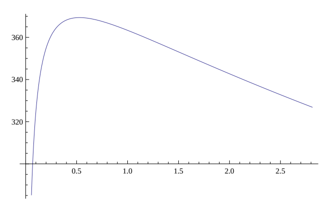

Figure 1: First scenario - baseline

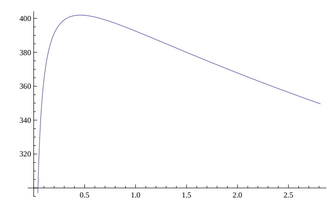

Figure 2: Second scenario - baseline

For $a = 100$, $\gamma = 10$, $h = 0.4$, $m = 0.7$, **z=10** and $\phi_1 = \phi_2 = \phi_3 = \frac{1}{3}$ (corresponding to Table 1):

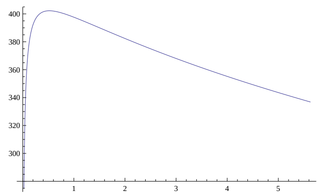

Figure 3: First scenario (z)

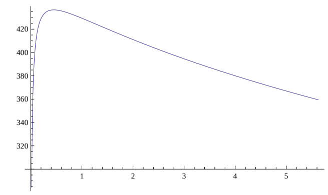

Figure 4: Second scenario (z)

For **a=150**, $\gamma = 10$, $h = 0.4$, $m = 0.7$, $z = 20$ and $\phi_1 = \phi_2 = \phi_3 = \frac{1}{3}$ (corresponding to Table 2):

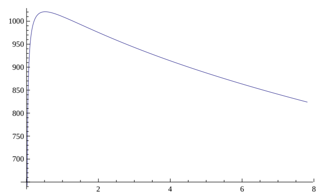

Figure 5: First scenario (a)

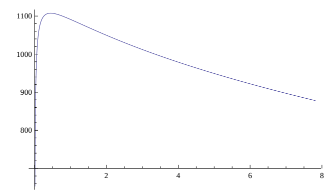

Figure 6: Second scenario (a)

For $a = 100$, $\gamma = 10$, $h = 0.4$, $m = 0.7$, $z = 20$ and $\boldsymbol{\phi_1 = 0.7}$, $\phi_2 = 0.15$, $\phi_3 = 0.15$ (corresponding to Table 5):

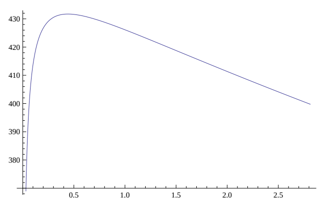

Figure 7: First scenario (ϕ_1)

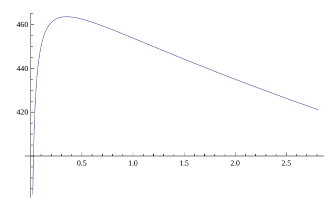

Figure 8: Second scenario (ϕ_1)

For $a = 100$, $\gamma = 10$, $h = 0.4$, $m = 0.7$, $z = 20$ and $\phi_1 = 0.15$, $\boldsymbol{\phi_2 = 0.7}$, $\phi_3 = 0.15$ (corresponding to Table 5):

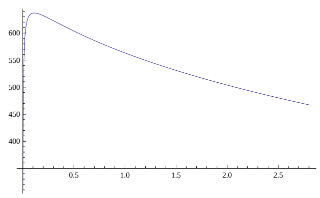

Figure 9: First scenario (ϕ_2)

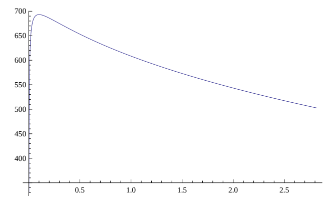

Figure 10: Second scenario (ϕ_2)

For $a = 100$, $\gamma = 10$, $h = 0.4$, $m = 0.7$, $z = 20$ and $\phi_1 = 0.15$, $\phi_2 = 0.15$, $\boldsymbol{\phi_3 = 0.7}$ (corresponding to Table 5):

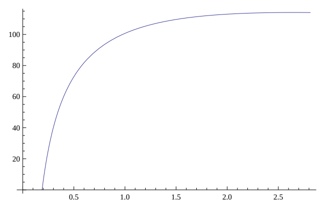

Figure 11: First scenario (ϕ_3)

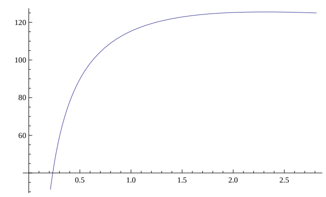

Figure 12: Second scenario (ϕ_3)

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