Environmental policy and Corporate Social Responsibility[1]

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Abstract

We analyze environmental policy design in a differentiated Cournot duopoly where firms differ in their Corporate Social Responsibility (CSR) motivations and one firm faces a break-even constraint due to fixed costs. Consumers are environmentally aware, so emissions reduce willingness to pay. A strategic (b-CSR) firm internalizes environmental concerns only through demand, while a welfare-oriented (w-CSR) firm maximizes social welfare subject to non-negative profits.

We show that, absent policy intervention, the w-CSR firm implements the first-best Pigouvian emissions rule as long as its break-even constraint is slack. However, when fixed costs are sufficiently high, the constraint binds and the firm increases emissions above the socially optimal level in order to remain viable. Thus, financial sustainability may undermine intrinsic CSR commitments.

We then examine emissions taxes and output subsidies, both uniform and targeted, with and without government budget-balance. Uniform emissions taxes reduce emissions but may lower welfare by exacerbating the output distortion inherent in imperfect competition. Uniform output subsidies can increase welfare despite raising emissions. Targeted instruments generate heterogeneous effects and are often welfare-reducing. By contrast, certain budget-balanced tax–subsidy schemes can improve welfare by jointly correcting environmental and output distortions while preserving the w-CSR firm's viability.

Our results show that CSR cannot substitute for environmental regulation and that optimal policy must account for market power, heterogeneous motivations, and financial constraints.

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1 Introduction

Corporate Social Responsibility (CSR) refers to a company's commitment to operate in an ethical, sustainable, and socially conscious manner. While CSR adherence has increased in recent years, firms' intrinsic motivations differ widely. Some adopt CSR for purely strategic reasons (e.g. see Arora and Gangopadhy, 1995), caring about emissions only insofar as they affect demand and profits.[1] Others—particularly mission-oriented firms such as La Poste Groupe—take a broader view that incorporates wider stakeholder concerns and internalize environmental externalities in their decision-making. Understanding how such heterogeneous motivations interact with competition and environmental regulation is crucial for policy design.

This paper relates to three strands of literature. First, it connects to the extensive literature on environmental policy under imperfect competition. In perfectly competitive markets, the Pigouvian prescription—setting an emissions tax equal to marginal environmental damage—achieves first-best efficiency. However, when firms possess market power, environmental policy interacts with pre-existing output distortions. As emphasized in the survey by Requate (2005) and in contributions such as Fujiwara (2009), there is generally no simple "one-size-fits-all" adjustment of the Pigouvian rule in oligopolistic markets. Emissions taxes may reduce emissions but also exacerbate underproduction, potentially lowering welfare. Our framework builds directly on this insight and shows how these distortions are reshaped when firms differ in their CSR motivations.

Second, we contribute to the growing literature modeling CSR as a modification of firms' objectives in competitive environments. Our framework is thus strongly linked to the literature on markets with competition between for-profit and nonprofit firms (see Brown and Slivinski, 2018 for an overview). In Borsenberger et al. (2025), firms differ in their degree of CSR commitment in a Cournot market. That paper shows that CSR may, under certain conditions, backfire—reducing welfare and potentially driving the fully committed firm out of the market. More broadly, the literature on mission-

[1] See Kitzmueller and Shimshack (2012) for an extensive overview of the literature on strategic CSR motivations.

oriented or stakeholder firms analyzes organizations that maximize welfare or broader objectives rather than pure profits. However, most theoretical models abstract from explicit financial viability constraints. In practice, mission-driven firms must remain profitable to survive.

This observation motivates the main departure from Borsenberger et al. (2025). While that paper provides a positive analysis of heterogeneous CSR under competition, we introduce two new elements that fundamentally alter the policy implications. First, we incorporate fixed production costs and model the welfare-oriented (w-CSR) firm as maximizing social welfare subject to a break-even constraint. This captures the dual objective faced by mission-driven firms: they internalize externalities but must remain financially viable. Second, we move from a descriptive analysis of equilibrium behavior to a normative study of environmental policy design. We examine emissions taxes and output subsidies—uniform and targeted, government budget-balanced and non-balanced—and analyze how they affect equilibrium outcomes and welfare.

Third, our paper relates to the literature on environmental awareness and demand-side internalization of externalities. Following Borsenberger et al. (2023), we model consumers as environmentally conscious: emissions reduce willingness to pay. As a result, even purely profit-maximizing firms partially internalize environmental damages through market demand as in the theoretical literature of CSR take-up by firms. However, consumer awareness alone does not generally restore efficiency, particularly under imperfect competition. The interaction between demand-side pressure, heterogeneous CSR motivations, and public policy is at the core of our analysis.

Our framework yields several new insights. In the absence of policy intervention, the w-CSR firm implements the first-best Pigouvian emissions rule as long as its break-even constraint is slack. However, when fixed costs exceed a critical threshold, the constraint binds and the firm increases emissions above the socially optimal level in order to reduce costs and remain viable. Thus, intrinsic CSR is fragile: financial sustainability considerations can undermine socially optimal behavior. This mechanism is absent from our earlier framework.

Turning to policy design, we show that uniform emissions taxes reduce both output and total emissions but may decrease welfare because they exacerbate the output distortion inherent in Cournot competition. Uniform output subsidies, in contrast, may increase welfare despite raising emissions, as they mitigate underproduction. Targeted instruments produce more nuanced effects: emissions taxes imposed solely on the strategic firm reduce emissions but may lower welfare if output effects dominate. Subsidies targeted to the w-CSR firm are neutral when its break-even constraint is slack, as they do not alter its objective. However, certain mixed and government budget-balanced tax–subsidy schemes can improve welfare by simultaneously correcting environmental and output distortions while preserving firm viability.

We also provide an additional section that further explores the welfare effects of targeted environmental policies when firms face fixed costs. While the main analysis highlights situations in which such policies may reduce welfare, this extension shows that the conclusion need not hold universally. In particular, when fixed costs are sufficiently large, the targeted policy can improve welfare relative to the *laissez-faire*. This result illustrates how the interaction between market structure, firms' CSR motivations, and the cost structure of production shapes the desirability of policy intervention.

Overall, our results demonstrate that CSR cannot substitute for environmental regulation and that the standard Pigouvian prescription must be adapted in markets characterized by imperfect competition, heterogeneous firm motivations, and financial constraints. Optimal environmental policy must jointly address externalities, market power, and the sustainability of mission-oriented firms.

2 Model

2.1 Demand

The model is based on Borsenberger et al. (2025) which in turn uses the notion of consumer's environmental awareness considered by Borsenberger et al. (2023). Consider a market with two differentiated products, x_1 and x_2, and where consumers' preferences are given by

$$u(x_1, x_2) - p_1 x_1 - p_2 x_2 - \sigma x_1 e_1 - \sigma x_2 e_2, \tag{1}$$

where p_i are prices and e_i per unit emissions associated with the production of good i. The parameter σ represents the consumers' environmental awareness. Specifically $\sigma x_i e_i$ measures the (monetary) utility cost of the total emissions associated with their consumption of good i.

Maximizing (1) with respect to x_1 and x_2 yields the demand functions $x_1(q_1, q_2)$ and $x_2(q_1, q_2)$, which are determined by

$$u_1(x_1, x_2) = p_1 + \sigma e_1 = q_1, \tag{2}$$

$$u_2(x_1, x_2) = p_2 + \sigma e_2 = q_2, \tag{3}$$

where

$$u_j = \frac{\partial u}{\partial x_j}, \qquad j = 1, 2,$$

and q_j denotes the "full price" including environmental damage. Defining

$$u_{ij} = \frac{\partial^2 u}{\partial x_i \partial x_j}, \qquad i, j = 1, 2,$$

one can easily check that the goods are substitutes, independent or complements according to

$$u_{12} = u_{21} \lesseqqgtr 0.$$

In other words

$$\frac{dx_1}{dq_2} = \frac{dx_2}{dq_1} \gtreqqless 0 \qquad \Longleftrightarrow \qquad u_{12} = u_{21} \lesseqqgtr 0. \tag{4}$$

Note that the symmetry arises because preferences are quasi-linear so that Marshalian demands are also Hicksian demands (which are symmetric). We can define the inverse demand function as

$$q_i(x_1, x_2) = u_i(x_1, x_2) \qquad i = 1, 2,$$

or alternatively

$$p_i(x_1, x_2, e_i) = u_i(x_1, x_2) - \sigma e_i. \tag{5}$$

2.2 Cost

We assume that there are two firms, each producing one of the goods with cost functions

$$C_i(x_i, e_i) = c_i(x_i) - \gamma_i(e_i) x_i + F_i, \tag{6}$$

where F_i is the fixed cost and we assume $c_i^{\prime}(x_i) > 0$, $c^{\prime\prime}(x_i) > 0$, $\gamma_i^{\prime\prime}(e_i) < 0$ and $\gamma_i^{\prime}(e_i) > 0$, for $e_i < \bar{e}_i$ and $\gamma_i^{\prime}(e_i) = 0$, for $e_i \geq \bar{e}_i$. In words, marginal costs are increasing (in quantity) and cost decreases with e_i up to $\bar{e}_i$ so that producing in a less polluting way is more costly. Total emissions are given by $E = x_1e_1 + x_2e_2$ and their social cost is $\psi(E)$.

2.3 First best (FB)

The FB allocation which represents a useful benchmark is obtained by solving the following problem

$$\max_{x_1,e_1,x_2,e_2} SWF = u(x_1, x_2) - c(x_1) - c(x_2) + x_1\gamma_1(e_1) + x_2\gamma_2(e_2) \\ - \psi(x_1e_1 + x_2e_2). \tag{7}$$

The FOCs with respect to e_i and x_i can be written as

$$\gamma_i^{\prime}(e_i^*) = \psi^{\prime}(E^*), \tag{8}$$

$$u_i(x_1^*, x_2^*) = c_i^{\prime}(x_i^*) - \gamma_i(e_i^*) + e_i^*\psi^{\prime}(E^*) \text{ for } i = 1, 2. \tag{9}$$

Condition (8) requires that the marginal benefit of emissions (as measured by the reduction in cost) must be equal to their marginal social cost. Equation (9) states that the marginal utility of any good (that is its full price) must equal it's marginal social cost (private and that associated with global emissions).

3 Cournot duopoly

Consider two firms that compete in a Cournot duopoly. Firms exhibit CSR but their motivations may differ. When a firm is b-CSR, it maximizes its profits by taking into account that its emissions affect demand. In other words, a b-CSR firm does care about its environmental impact but only to the extent that it affects its profits via the consumers environmental awareness. A w-CSR firm by contrast takes into account its impact on all the relevant stakeholders so that it effectively maximizes social welfare (but is subject to a break-even constraint). We consider two scenarios: one in which both firms are b-CSR and a mixed duopoly in which one of the firms is b-CSR, while the other one is w-CSR. In all scenarios we assume that firm 1 is a b-CSR firm so that the scenarios are characterized by firm 2's objective.

We assume that the strategic variables are (x_i, e_i) and that they are chosen simultaneously. We study the Nash equilibrium.

In each scenario profits are given by

$$\pi_i = p_i(x_1, x_2, e_i)x_i - C_i(x_i, e_i) - F_i, \tag{10}$$

where p_i is defined by (5).

Borsenberger et al. (2025) have studied both scenarios for the case where there is no fixed cost and absent of any policy intervention. They have shown that in either case the equilibrium is not socially optimal and may even result in the exit of the w-CSR firm (even in the absence of a fixed cost). In our setting with a fixed cost the potential conflict between responsibility and profitability (viability) is likely to become even more evident.

This may call for a policy intervention and we consider two instruments: emissions taxes and output subsidies where both can be either uniform or firm specific.

The first step is now to define and characterize the equilibrium with these two instruments. Then we can examine the impact of a policy and its optimal design. To focus on CSR we assume that the two firms have the same cost functions.

4 Equilibrium with emissions taxes and output subsidies

4.1 Two b-CSR firms

We now introduce a proportional tax on emissions τ_i and a subsidy s_i on output. The problem of each firm i is given by.

$$\max_{x_i, e_i} \quad \pi_i = p_i(x_1, x_2, e_i)x_i - c(x_i) + \gamma(e_i)x_i - \tau_i x_i e_i + s_i x_i - F_i. \tag{11}$$

Note that the fixed cost does not affect the solution as long as the firm's profit is positive. We assume that this is always true for a b-CSR firm in equilibrium. The FOCs with respect to x_i and e_i are respectively:

$$p_i\left(x_1,x_2,e_i\right)+x_i\frac{\partial p_i\left(x_1,x_2,e_i\right)}{\partial x_i}-c'\left(x_i\right)+\gamma\left(e_i\right)-\tau_i e_i+s_i=0, \tag{12}$$

$$x_i\frac{\partial p_i\left(x_1,x_2,e_i\right)}{\partial e_i}+x_i\gamma'\left(e_i\right)-\tau_i x_i=0 \text{ for } i=1,2. \tag{13}$$

Equation (12) is the standard condition requiring that marginal revenues (the two first terms) equal marginal costs (including any taxes and subsidies). Simplifying (13) yields

$$\gamma'\left(e_i\right)=\sigma+\tau_i. \tag{14}$$

Consequently, e_i is independent of the other firm's strategy so that we return to a standard Cournot game where the cost is given by $c(x_i)-\gamma_i(\widetilde{e}_i(\tau_i))x_i$ where $\widetilde{e}_i(\tau_i)$ is the solution to (14). Note that $\widetilde{e}_i$ decreases with τ_i so that the firms' total and marginal costs increase with emissions taxes. The overall impact of the policy on the marginal cost of x_i (for a given e_i), however, is ambiguous because the emissions tax increases the marginal cost while the output subsidy decreases it.

4.2 The w-CSR firm

Let $i=1$ refer to the b-CSR firm. For this firm equations (12) and (14) continue to apply. Specifically, (14) determines e_1 irrespective of the other firm's strategy, while (12) determines the firm's best reply for x_1, as a function of x_2 and of course τ_1 and s_1.

We now turn to firm 2 which is w-CSR so that it maximizes social welfare subject to a break even constraint. Accounting for taxes and subsidies welfare is given by

$$\begin{aligned} SWF = & u\left(x_1,x_2\right)-\left[c(x_2)-\gamma(e_2)x_2-s_2x_2+\tau_2x_2e_2+F_2\right]-\left[c(x_1)-\gamma(e_1)x_1-s_1x_1+\tau_1x_1e_1+F_1\right] \\ & -\psi\left(x_1e_1+x_2e_2\right)+\left[\tau_1x_1e_1+\tau_2x_2e_2-s_1x_1-s_2x_2\right] \end{aligned} \tag{15}$$

where the two first terms in brackets are firm 2 and firm 1's after tax cost, while the last term is the (positive or negative) tax revenue net of subsidies. Note that in this expression the tax and subsidy terms cancel out which implies that the policies have no *direct* effect on welfare. They affect welfare only indirectly via their impact on the equilibrium. Furthermore, the terms pertaining to firm 1 are considered as given by firm 2. Consequently, the problem of the w-CSR firm is given by

$$\max_{x_2,e_2} WE = u\left(x_1, x_2\right) - c(x_2) + \gamma(e_2)x_2 - \psi\left(x_1e_1 + x_2e_2\right) \tag{16}$$

$$\text{s.t. } \pi_2 = p_2(x_1, x_2, e_2)x_2 - c(x_2) + \gamma(e_2)x_2 - \tau_2x_2e_2 + s_2x_2 - F_2 \geq 0. \tag{17}$$

Note that the tax and subsidy terms and the fixed cost only affect the budget constraint and not the objective function. Consequently, when the budget constraint is not binding, the firm's behavior is not affected by τ_2 and s_2.

Let $\lambda \geq 0$ denote the Lagrange multiplier associated with the break-even constraint (17). The FOCs with respect to x_2 and e_2 are respectively given by

$$\begin{aligned} & p_2 + \sigma e_2 - c'\left(x_2\right) + \gamma(e_2) - e_2\psi'\left(x_1e_1 + x_2e_2\right) \\ & +\lambda\left[\frac{\partial p_2\left(x_1, x_2, e_2\right)}{\partial x_2}x_2 - c'(x_2) + \gamma(e_2) - e_2\psi'\left(x_1e_1 + x_2e_2\right) - \tau_2e_2 + s_2\right] = 0, \end{aligned} \tag{18}$$

$$\gamma'(e_2)x_2 - x_2\psi'\left(x_1e_1 + x_2e_2\right) + \lambda\left[-\sigma x_2 + \gamma'(e_2)x_2 - \tau_2x_2\right] = 0. \tag{19}$$

When the break even constraint is not binding so that $\lambda = 0$, the term in brackets in equation (18) vanishes. Consequently, price is equal to the private marginal cost plus the environmental cost that is not taken into account by consumers. So implicitly the firm imposes a Pigouvian tax on itself. Consequently, it sets its prices above its private marginal cost so that when these are constant the firm makes a profit *gross of fixed costs* of $\widehat{e}_2\widehat{x}_2[\psi' - \sigma - \tau_2] + s_2\widehat{x}_2$, where $\widehat{e}_2$ and $\widehat{x}_2$ denote equilibrium (per unit) emissions and output. Absent of a policy intervention this gross profit is always positive, but it may become negative when the emissions tax is sufficiently large while the output subsidy is sufficiently small.

The equilibrium allocation (x_1, x_2, e_1, e_2) is now the solutions to equations (12), (14), (18) and (19). Note that as long as the break-even constraint is not binding, firm 2's strategies and thus the equilibrium do not depend on F_2. Consequently, absent of a policy intervention, there exists a critical level of fixed cost $\overline{F}$ so that the break even constraint is binding if and only if $F > \overline{F}$. Under a tax and subsidy policy, firm 2's gross profit $\widehat{e}_2\widehat{x}_2[\psi' - \sigma - \tau_2] + s_2\widehat{x}_2$ may be negative in which case the break-even constraint is always binding. When it is positive, the critical level $\overline{F}$ continues to exist but now depends on τ_i and s_i.

The level of e_2 is now determined by a modified emissions rule:

$$\gamma'(e_2) + \lambda \left[\gamma'(e_2) - \tau_2 - \sigma\right] = \psi'\left(x_1 e_1 + x_2 e_2\right). \tag{20}$$

When the break even constraint is not binding so that $\lambda = 0$, condition (20) is simply the first-best Pigouvian rule defined in (8). Note that when ψ is linear so that ψ' is constant, the level of e_2 does not depend on the other firm's strategy nor on x_2. The sign of the expression in brackets is ambiguous and depends on τ_2. When $\tau_2 = \psi' - \sigma$ (that is the FB Pigouvian rule) equation (20) becomes

$$(1 + \lambda)\gamma'(e_2) = (1 + \lambda)\psi'.$$

Consequently, when ψ' is constant, firm 2 sets the optimal emissions level $e_2 = e_2^*$. Since (20) implies (again for ψ' constant) that $de_2/d\tau_2 < 0$ this means that we have $e_2 > e_2^*$ when τ_2 is lower than the Pigouvian level. In the illustrative examples $\psi' = 1$ and $\sigma = 0.2$ so that $\psi' - \sigma = 0.8$ and the maximum emissions tax we consider is 0.7 so $e_2 > e_2^*$ holds in our examples. Intuitively the binding break-even constraint ($\lambda > 0$) amounts to putting a larger weight on profits. And when the tax is smaller than the Pigouvian level increasing e increases profits. The reduction in marginal cost it implies is larger than the extra tax. Since e_2 increases, we can expect a higher level of global emissions (e.g. see table 3 below for an example).

5 Numerical illustrations

5.0.1 Demand

We consider the quadratic utility function used by Singh and Vives (1984). Their utility function is given by

$$u(x_1, x_2) = \alpha_1 x_1 + \alpha_2 x_2 - (\beta_1 x_1^2 + 2\eta x_1 x_2 + \beta_2 x_2^2)/2$$

where α_i and β_i are positive, $\beta_1\beta_2 - \eta^2 > 0$ and $\alpha_i\beta_j - \alpha_j\eta > 0$ for $i \neq j$. This yields linear demand functions and the inverse demands are given by

$$q_1 = p_1 + \sigma e_1 = \alpha_1 - \beta_1 x_1 - \eta x_2,$$

$$q_2 = p_2 + \sigma e_2 = \alpha_2 - \beta_2 x_2 - \eta x_1.$$

Parameters	interpretation	values
α	demand max price	25
β	demand sensitivity to own quantity	1
σ	demand sensitivity to e	0.2
η	demand degree of complementarity	0.2
μ	cost impact of e	1
k	direct production cost	1
$\bar{e}$	max emissions	5

Table 1: Parameter values.

Note that from (4), the goods are substitutes if $\eta > 0$ and complements if $\eta < 0$. Defining $\delta = \beta_1\beta_2 - \eta^2 > 0$, $a_i = (\alpha_i\beta_j - \alpha_j\eta)/\delta$, $b_i = \beta_j/\delta$ for $i \neq j$ and $\theta = \eta/\delta$ we can write direct demand functions as

$$x_1 = a_1 - b_1q_1 + \theta q_2,$$
$$x_2 = a_2 - b_2q_2 + \theta q_1.$$

To concentrate on CSR issues we assume that the firms not only have identical cost functions (including the fixed cost) but that demands are also symmetric so that $\alpha_1 = \alpha_2 = \alpha$ and $\beta_1 = \beta_2 = \beta$ which implies $a_1 = a_2 = a$ and $b_1 = b_2 = b$.

5.0.2 Cost

We use the simplest specification compatible with our assumptions given by

$$C(x_i, e_i) = kx_i + \mu x_i \left(e_i - \bar{e}_i\right)^2,$$

that is a constant marginal cost which is decreasing in e_i. The quadratic specification is adopted to ensure that cost is concave in e_i.

In the following set of illustrations we assume that $\psi(E) = E = x_1e_1 + x_2e_2$ so that the social environmental cost is linear i.e. $\psi' = 1$. The remaining parameter values are given in Table 1.

We then determine the fixed cost $\bar{F}$ such that, without taxes nor subsidies, the equilibrium profit of firm 2 is exactly equal to 0 in the w-CSR equilibrium developed in section 4.2. This is simply the equilibrium profit of a w-CSR firm (competing with a

	x_1	x_2	e_1	e_2	π_1	π_2	E	W
FB	16.04	16.04	4.5	4.5			144.37	184.27
$b-CSR$	10.45	10.45	4.9	4.9	47.13	47.13	102.49	143.53
$w-CSR$	9.77	17.29	4.9	4.5	33.29	0	125.72	163.86

Table 2: Equilibrium with $F = 62.26$ and $\tau_i = s_i = 0$.

τ		x_1	x_2	e_1	e_2	π_1	π_2	E	W
0.25	$b-CSR$	9.90	9.90	4.77	4.77	35.93	35.93	94.63	137.65
	$w-CSR$	9.30	15.98	4.77	4.52	24.26	0	116.80	160.771
0.7	$b-CSR$	8.95	8.95	4.55	4.55	10.30	10.30	81.49	123.98
	$w-CSR$	8.51	13.32	4.55	4.51	10.3	0	98.94	148.18

Table 3: Uniform emissions taxes and no output subsidy.

b-CSR firm) absent of policy intervention and of fixed cost; it is equal to 62.26. With this level of fixed cost, we obtain the equilibrium described in Table 2 when there is no policy intervention. Note that in this case, which describes the *laissez-faire (LF)* for this level of fixed cost, the break-even constraint is just satisfied but $\lambda = 0$. Consequently per-unit emissions of firm 2 remain at their first-best level.

In the next sub-section we first examine the effects of emissions taxes and production subsidies that are not budget balanced. Consequently, the proceeds of an emissions tax are redistributed to the consumers via a lump-sum transfer. Similarly an output subsidy is financed by a lump-sum tax. We then turn to the case where emissions taxes and subsidies are budget balanced: tax revenues are used to finance the output subsidy.

5.1 No budget balancing requirement for s and τ

5.1.1 Uniform policies

Consider first a uniform emissions tax $\tau = 0.25$ or $\tau = 0.7$, but no output subsidy $s = 0$. The equilibria with two b-CSR firms and for a mixed market are reported in Table 3.

The uniform emissions tax decreases the level of output and decreases the per-unit level of emissions of a b-CSR firm in either scenario. Its impact on per-unit emissions of the w-CSR firm is, however, non-monotonic. When moving from $\tau = 0$ to $\tau = 0.25$

s		x_1	x_2	e_1	e_2	π_1	π_2	E	W
0.25	$b-CSR$	10.57	10.57	4.9	4.9	49.52	49.52	103.61	145
	$w-CSR$	9.90	17.26	4.9	4.5	35.80	4.22	126.23	164.60
0.7	$b-CSR$	10.77	10.77	4.9	4.9	53.88	53.88	105.61	147.57
	$w-CSR$	10.13	17.22	4.9	4.5	40.40	11.79	127.15	165.89

Table 4: Uniform output subsidy and no emissions tax.

its per-unit emissions increase but then they decrease as τ is increased to 0.7. This is because the emissions tax has two conflicting effects on the profitability of the w-CSR firm. First, it increases its cost which starting from the LF forces it to increase emissions to be able to meet its break even constraint. But the tax also increases the competitor's cost and thus decreases its output which relaxes the w-CSR firm's profit constraint which allows it to lower its emissions in line with its welfare objective. Comparing Table 2 and 3 we see the first effect dominates for the smaller tax $\tau = 0.25$, but for the higher tax $\tau = 0.7$ the second one dominates. However, total emissions are monotonically decreasing with the tax because of the output effect. Finally, the overall effect on welfare is negative. Here again the tax has two conflicting effects. The first effect is detrimental to welfare since total output which is already too small in the LF further decreases. But the tax also decreases overall emissions which enhances welfare. Our results show that the first effect dominates so that welfare decreases with the emissions tax.

Now consider a uniform output subsidy $s > 0$, and no emissions tax $\tau = 0$. The results are reported in Table 4.

The output subsidy increases the level of production and has no impact on per-unit emissions. This is obvious for firm 1. Regarding the w-CSR, since both firm's profits increase, its budget constraint remains non-binding so that it can maintain its per-unit emissions at its first-best level. Due to the increase in output, with per-unit emissions unchanged, total emissions will of course increase. While this in itself has a negative effect on welfare, this effect is outweighed by the increase in total output so that welfare is higher than in the LF and increases with the subsidy.

τ_1		x_1	x_2	e_1	e_2	π_1	π_2	E	W
0.25	$w-CSR$	9.15	17.41	4.77	4.5	21.61	0.44	122.11	160.84
0.7	$w-CSR$	8.08	17.63	4.55	4.5	3.15	1.21	116.14	153.89

Table 5: Targeted emissions tax on firm 1 and no output subsidy.

5.1.2 Targeted policies

We now study two targeted policies. First, the emissions tax is imposed only on firm 1 and then the production subsidy applies only to firm 2. We focus on the equilibrium with a $w-CSR$ competing with a $b-CSR$ firm, since in a symmetric equilibrium, there is no reason to treat firms differently.

First, consider an emissions tax which is solely imposed on firm 1 so that $\tau_1 > 0$ and $s_1 = s_2 = \tau_2 = 0$.

The results are presented in Table 5. Compared to the *LF*, both levels of the tax decrease total emissions. Furthermore, they decrease with the level of the tax. This is not surprising because facing the tax firm 1 reduces its emissions. Firm 2's profits are now strictly positive so that the break-even constraint no longer binds. However, the level of welfare decreases with respect to the LF in Table 2: total production and total emissions decrease with the tax rate. This mirrors the results obtained in Table 3: the welfare impact of the decrease in total production dominates that of the decrease in the level of per-unit and total emissions so that welfare decreases as compared to the LF. Furthermore, comparing Table 5 to Table 3 shows that a given targeted emissions tax on firm 1 always yields a higher level of welfare than a uniform emissions tax. More surprisingly, total emissions are larger under the targeted tax even though e_2 is smaller. This is because of the increase in output of firm 2. While this firm is cleaner, the output's increase compared to a uniform tax is so drastic that global emissions increase.

Second consider an output subsidy targeted towards firm 2: $s_2 > 0$ and $s_1 = \tau_1 = \tau_2 = 0$.

The results are presented in Table 6. Note that as long as the break-even constraint is not binding the objective of firm 2 is not affected by increases in the production

s_2		x_1	x_2	e_1	e_2	π_1	π_2	E	W
0.25	$w - CSR$	9.77	17.29	4.9	4.5	33.29	4.32	125.72	163.86
0.7	$w - CSR$	9.77	17.29	4.9	4.5	33.29	12.10	125.72	163.86

Table 6: Output subsidy targeted on firm 2 and no emissions tax.

$s = 0.25, \tau_1 = 0.25$
$s = 0.7, \tau_1 = 0.25$
$s = 0.25, \tau_1 = 0.7$
$s = 0.7, \tau_1 = 0.7$

Table 7: Scenarios with emissions tax on firm 1 and uniform output subsidy.

subsidy. The objective of firm 1 is of course also not affected. Consequently, the equilibrium outputs and emissions levels are not affected. Recalling expression (15) and its discussion explains that the targeted subsidy has no impact on welfare. It does increase profits π_2 but this is exactly offset by the increase in government expenditures.

The results presented so far in this subsection show that a targeted output subsidy on firm 2 has no impact on welfare and the discussion has explained that this is a general result; it is not specific to the examples. A targeted emissions tax decreases welfare and this is mainly due to the reduction in output. On the other hand, the previous subsection has shown that a uniform output subsidy is welfare improving because it does affect output. This suggests that a targeted emissions tax along with a uniform output subsidy *might* do better. We have checked the scenarios defined in Table 7.

None of these scenarios lead to a higher welfare. Interestingly, a smaller emissions tax τ_1 does increase welfare when combined with a sufficiently large output subsidy such as $s = 0.7$ ($s = 0.25$ is not sufficient); see Table 8.

s	τ_1		x_1	x_2	e_1	e_2	π_1	π_2	E	W
0.7	0.1	$w - CSR$	9.88	17.27	4.85	4.5	35.43	12.01	125.66	164.86
0.7	0.15	$w - CSR$	9.76	17.29	4.82	4.5	33.00	12.11	124.93	164.31

Table 8: An example where the emissions tax on firm 1 combined with a uniform output subsidy is welfare improving.

τ		x_1	x_2	e_1	e_2	π_1	π_2	s	E	W
0.25	b	10.45	10.45	4.77	4.77	46.98	46.98	1.19	99.81	145.20
	$w-CSR$	9.75	17.24	4.77	4.51	32.81	0	1.15	124.19	164.54
0.7	b	10.40	10.40	4.55	4.55	45.97	45.94	3.18	94.67	146.08
	$w-CSR$	9.70	17.28	4.55	4.51	31.91	0	3.16	121.95	164.97

Table 9: Uniform emissions tax $\tau = \tau_1 = \tau_2$ financing a uniform subsidy $s = s_1 = s_2$.

Note that while in both cases welfare is higher than in the LF the example shows that welfare decreases as the tax increases beyond 0.1. Intuitively, this is in line with our observation that the output effect dominated in the examples above. This effect can be neutralized by a sufficiently large output subsidy.

5.2 Budget balanced instruments

In all the examples considered so far the policies were not designed to be budget balanced. We now consider the same scenarios as in the previous subsection but mix subsidies and taxes so that they are budget neutral for the government. We start with a uniform emissions tax $\tau = \tau_1 = \tau_2$ financing a uniform subsidy $s = s_1 = s_2$. Note that since the policy is designed such that tax revenues are equal to expenditures on subsidies the level of s is endogenous and depends on τ. The results are presented in Table 9.

In this example, a budget balanced uniform τ is always better than the LF and better than a uniform τ without production subsidy (see Table 3). On top of that, welfare increases with τ. Intuitively, the subsidy mitigates the production effect so that it is dominated by the emissions tax effect. Note that the equilibrium value of s is large compared to the values studied in the preceding section where no budget-balance was imposed.

Next we reconsider a uniform subsidy $s = s_1 = s_2$ but now financed by a uniform emissions tax $\tau = \tau_1 = \tau_2$. The results are presented in Table 10.

In all considered cases a budget-balanced uniform s is better than the LF. Moreover, welfare increases with s. As in the Table 8 the output effect is sufficiently mitigated to be dominated by reduction in emissions. To understand this, note that the equilibrium

s		x_1	x_2	e_1	e_2	π_1	π_2	τ	E	W
0.25	b	10.45	10.45	4.87	4.87	47.12	47.12	0.05	101.96	143.94
	$w-CSR$	9.76	17.29	4.87	4.5	33.16	0.13	0.05	125.43	164.03
0.7	b	10.45	10.45	4.82	4.82	47.08	47.08	0.14	100.95	144.60
	$w-CSR$	9.75	17.29	4.82	4.5	32.92	0.32	0.15	124.91	164.29

Table 10: Uniform subsidy $s = s_1 = s_2$ financed by a uniform emissions tax $\tau = \tau_1 = \tau_2$.

s_1		x_1	x_2	e_1	e_2	π_1	π_2	τ	E	W
0.25	$w-CSR$	9.77	17.29	4.87	4.5	33.29	0+	0.05	125.47	164.06
0.7	$w-CSR$	9.77	17.29	4.82	4.5	33.24	0+	0.14	125.00	164.36

Table 11: Targeted subsidy on firm 1 $s_1 > 0$, $s_2 = 0$ financed by a uniform emissions tax $\tau = \tau_1 = \tau_2$.

value of τ is very low (lower than 0.2) which mirrors the last table of the preceding section (Table 8).

Appendix A presents some additional examples of policies that are not welfare improving: *(i)* a targeted emissions tax on firm 1 $\tau_1 > 0$, $\tau_2 = 0$ with uniform subsidy $s = s_1 = s_2$; *(ii)* targeted emissions tax on firm 1 τ_1 with subsidy s_2 only on firm 2 and *(iii)* targeted subsidy on firm 2 with a targeted emissions tax τ_1. In all these examples the output effect dominates which explains the decrease in welfare.

Finally, Table 11 provides an example of a welfare improving targeted policy. The previous examples have shown that output effect related to imperfect competition is crucial and that when its break-even constraint is not binding a subsidy on the $w-CSR$ firm cannot affect outputs. On the other hand, a subsidy on firm 1 combined with a budget balanced uniform emissions tax can be welfare improving.

6 The role of the fixed cost

So far we have concentrate on a single level of fixed cost, namely $F = 62.26$ which is such that equilibrium profits of the $w-CSR$ firm are exactly zero. In other words this is the largest fixed cost for which its break-even constraint is not binding in the *LF*. This has allowed us to concentrate on the impact of policies on the profitability of the

	x_1	x_2	e_1	e_2	π_1	π_2	E	W
$w-CSR$	9.91	15.85	4.9	4.54	18.39	0	120.68	128.19

Table 12: LF with $F = 80$, when a $b-CSR$ and a $w-CSR$ firm compete.

s_2		x_1	x_2	e_1	e_2	π_1	π_2	E	W
0.25	$w-CSR$	9.88	16.21	4.9	4.53	17.68	0	121.95	128.43
0.7	$w-CSR$	9.82	16.84	4.9	4.51	16.43	0	124.17	128.55

Table 13: Output subsidy targeted on firm 2 and no emissions tax when $F = 80$.

$w-CSR$ firm. Considering larger levels of fixed cost has otherwise no impact on most of our results.

One of our results, however, would change for larger levels of fixed costs. Specifically, when the break-even constraint of the $w-CSR$ firm is binding in the *LF,* a targeted subsidy on its output would affect the equilibrium and potentially be welfare improving.

To illustrate this consider now a fixed cost $F = 80$. Since this fixed cost is higher than the one considered in Table 2 ($F = 62.26$), the profit constraint of firm 2 is now strictly binding. As shown in section (4.2), $\lambda > 0$ and the *laissez faire* allocation in the $w-CSR$ scenario is now as described in Table 12.

As expected the per-unit emissions levels are higher and the production of the $w-CSR$ firm is lower than the ones described in Table 2. (the first-best allocation is the same as in Table 2, but welfare is lower because of higher fixed costs). Let us now revisit the impact of a non budget balanced subsidy s_2 considered in Table 6 with the larger level of fixed cost. The new allocations are described in Table 13.

Now thanks to this subsidy, the profit constraint of the $w-CSR$ is relaxed (but continues to be binding) so that its production level increases with s_2 and the per-unit level of emissions decreases. As a result welfare strictly increases with the subsidy as opposed to the results obtained in Table 6 where allocations as well as welfare are not affected by the subsidy.

7 Conclusion

This paper analyzes environmental policy design in a differentiated duopoly where firms differ in their CSR motivations and where one firm faces a break-even constraint due to fixed costs. By combining strategic interaction, environmental externalities, and financial viability considerations, we show that the presence of mission-oriented firms does not eliminate the need for carefully designed public policy.

Our theoretical analysis establishes that a w-CSR firm internalizes environmental externalities and implements the first-best Pigouvian emissions rule as long as its budget constraint is non-binding. However, when fixed costs are sufficiently high or when policy instruments reduce profitability, the break-even constraint binds. In that case, the firm increases emissions above the socially optimal level in order to reduce costs and survive. Thus, financial viability considerations can undermine intrinsic CSR commitments.

The numerical simulations further highlight the complexity of policy design in imperfectly competitive markets. Uniform emissions taxes reduce emissions but often decrease welfare because they exacerbate the output distortion already present under Cournot competition. Uniform output subsidies, while environmentally detrimental, can raise welfare by correcting underproduction. Targeted instruments produce heterogeneous effects: emissions taxes on the strategic firm reduce emissions but may lower welfare; subsidies directed at the w-CSR firm are neutral when its break-even constraint is slack. Importantly, certain mixed and budget-balanced policies—such as uniform emissions taxes financing uniform subsidies, or a subsidy to the strategic firm combined with a uniform tax—can increase welfare by appropriately balancing emissions and output effects.

Two broad lessons emerge. First, CSR cannot substitute for environmental policy: even welfare-oriented firms may deviate from first-best behavior when financial constraints bind. Second, the classical Pigouvian prescription must be adapted in markets with imperfect competition and heterogeneous firm motivations. Optimal policy must jointly address environmental externalities, output distortions, and the sustainability of mission-oriented firms.

The additional examples presented in the paper also show that the welfare implications of targeted environmental policies depend crucially on firms' cost structure. In particular, when fixed costs are sufficiently large, the targeted policy can lead to higher welfare compared to laissez–faire. This qualification highlights that the negative welfare results obtained in the baseline framework are not universal, but rather reflect the interaction between imperfect competition, CSR behavior and the absence of fixed production costs.

These findings contribute to the growing literature on environmental regulation under imperfect competition by showing how heterogeneous CSR motivations and viability constraints reshape standard results. They also offer practical implications for policymakers seeking to regulate industries where public or mission-driven firms coexist with profit-maximizing competitors. Designing effective environmental policy in such contexts requires a nuanced approach that integrates economic incentives with institutional realities.

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Appendix

A Further examples of welfare decreasing targeted policies

Tables 12–14 provide some further examples of targeted (and budget balanced) policies which lead to a decrease in welfare because the output effect dominates.

τ_1		x_1	x_2	e_1	e_2	π_1	π_2	s	E	W
0.25	$w-CSR$	9.37	17.37	4.77	4.5	25.57	7.55	0.41	122.94	162.21
0.7	$w-CSR$	8.62	17.52	4.55	4.5	12.11	19.23	1.05	118.10	157.84

Table 14: Targeted subsidy emission tax on firm 1 $\tau_1 > 0$, $\tau_2 = 0$ used to finance a unifrm output subsidy $s = s_1 = s_2$.

τ_1		x_1	x_2	e_1	e_2	π_1	π_2	s_2	E	W
0.25	$w-CSR$	9.15	17.41	4.77	4.5	21.61	11.37	0.62	122.11	160.84
0.7	$w-CSR$	8.08	17.63	4.55	4.5	3.15	26.97	1.46	116.14	153.89

Table 15: Targeted subsidy emission tax on firm 1 $\tau_1 > 0$, $\tau_2 = 0$ used to finance an output subsidy on firm 2 $s_1 = 0$ and $s_2 > 0$.

s_2		x_1	x_2	e_1	e_2	π_1	π_2	τ_1	E	W
0.25	$w-CSR$	9.54	17.34	4.85	4.5	28.79	4.5	0.09	124.34	162.81
0.7	$w-CSR$	9.07	17.43	4.75	4.5	20.17	12.70	0.28	121.66	160.40

Table 16: Targeted subsidy firm 2 $s_1 = 0$ and $s_2 > 0$ with a targeted emissions tax $\tau_1 > 0$, $\tau_2 = 0$.

B Considering higher fixed cost

Consider now a fixed cost $F = 80$. Since this fixed cost is higher than the one considered in Table 2 ($F = 62.26$), the profit constraint of firm 2 is now strictly binding. As shown in section (4.2), $\lambda > 0$ and the *laissez faire* allocation in the $w-CSR$ scenario becomes:

	x_1	x_2	e_1	e_2	π_1	π_2	E	W
$w-CSR$	9.91	15.85	4.9	4.54	18.39	0	120.68	128.19

As expected the per-unit emissions levels is higher and the production of the $w-CSR$ firm is lower than the ones described in Table 2. (the first best allocation is the same as in Table 2 but welfare is lower because of higher fixed costs). Let us now replicate the implementation of a non budget balanced subsidy s_2 as in table table 6. The allocations become:

s_2		x_1	x_2	e_1	e_2	π_1	π_2	E	W
0.25	$w-CSR$	9.88	16.21	4.9	4.53	17.68	0	121.95	128.43
0.7	$w-CSR$	9.82	16.84	4.9	4.51	16.43	0	124.17	128.55

Now thanks to this subsidy, the profit constraint of the $w-CSR$ is relaxed (but still binding) so that its production level increases with s_2 and the per-unit level of emissions decreases. As a result welfare strictly increases with the subsidy as opposed to the results obtained in Table 6 where allocations as well as welfare are not affected by the subsidy.