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## Lobbying against environmental regulation vs. lobbying for loopholes

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# Lobbying against Environmental Regulation vs. Lobbying for Loopholes

Andreas Polk\*  
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**ABSTRACT:** We analyze the determinants of environmental policy when two firms engage in two types of lobbying against a restriction on allowed pollution: General lobbying increases the total amount of allowed pollution, which is beneficial for both firms. Private lobbying increases the individual pollution standard of the lobbying firm, but has a negative or zero effect on the allowed emissions of the competitor. We determine the lobbying equilibrium and discuss the resulting emission level. In many cases, a higher effectiveness of private lobbying is detrimental for firms and beneficial for environmental quality, as it induces firms to turn towards excessive amounts of relatively unproductive private lobbying.

**Keywords:** Environmental Regulation, Pollution Standards, Interest Groups, Lobbying, Policy Making.

**JEL:** D72, D78, L51.

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# 1 Introduction

Often, different lobbies share a common goal, but disagree about specifics. For example, representatives of polluting industries agree that overall emission standards should be lax, but have different preferences about how to distribute the burden of any legally required emissions reduction between them. There are many variants of this theme. For instance, environmental taxes may be uniform across sectors, or they may allow loopholes for specific industries or regions. Among different tax proposals that lead to the same total level of emissions, each industry (region) will prefer the one that leaves a particularly comfortable loophole to itself.<sup>1</sup> Similarly, compared with market entrants, mature firms with large production capacities and little ambition to extend these capacities will prefer a regulation that concentrates on new sources to a uniform treatment of plants. Finally, compared to moderate polluters, firms who have had high emissions in the past will have stronger preferences for grandfathering approaches as opposed to auctions of tradeable permits.

In these settings, an opponent of regulation has to decide whether he should fight regulation as such or whether he should take regulation as inevitable and concentrate on influencing the details in his favor. We analyze this decision in a model with two anti-regulation lobbies, each of which has two instruments to influence the degree to which it is affected by regulation. On the one hand, a group can lobby against regulation as such, thereby providing a benefit to the other anti-environmental lobby as well. On the other hand, it can concentrate on "lobbying for loopholes", so as to affect the precise nature of regulation in its favor, without providing benefits to the other lobby. For instance, particular sectors can lobby for exemptions from environmental taxes, without fighting the tax itself. Firms in depressed

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<sup>1</sup>For instance, apart from a preferential treatment of the manufacturing industry as opposed to the service industry, the German Eco Tax ("Ökosteuer") contains a complicated set of special regulations which amount to loopholes for specific sectors (Friedrich-Ebert-Stiftung 1999, Chapt. 1, Tab. 1, Bundesumweltministerium 2002).

regions can lobby for special treatment. Mature firms may lobby to restrict emission standards to new plants, etc.

In our model, the politician is represented by a policy formation function, which translates individual levels of private and general lobbying into pollution standards. We show how lobbying efforts and the resulting individual pollution levels in the Nash equilibrium depend on a parameter that captures the effectiveness of private lobbying. For *given levels* of each type of lobbying, higher values of this parameter mean that allowed emissions for each firm increase. Our central point is that, because of strategic interactions, greater effectiveness of private lobbying may nevertheless be detrimental to firms and beneficial for the environment. If lobbyists expect that politicians pay a lot of attention to such private lobbying for loopholes, they will tend to focus on this kind of lobbying, rather than on general lobbying against environmental regulation itself. For the lobbyists, general lobbying is a public good. The tendency for underprovision of this public good is enhanced by the existence of the alternative of private lobbying. Thus, somewhat paradoxically, a greater willingness of politicians to pay attention to private lobbying may well be detrimental to lobbyists - and beneficial to the environment.

Our approach has some bearing on a central question of positive environmental economics, namely, what kind of regulation is likely to emerge as the outcome of the political process? This question has at least two dimensions. First, what kind of instruments are likely to be used to improve environmental quality?<sup>2</sup> Second, why are some environmental problems regulated more vigorously than others?<sup>3</sup> For this kind of application one idea is crucial: The effectiveness of private lobbying is not only a function of the politician's

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<sup>2</sup>A large literature investigates this question. For surveys, in particular, on the issue of whether command-and-control or market instruments are more likely to be chosen, see Keohane et al. (2000) and Dijkstra (1999).

<sup>3</sup>For instance, why have emissions such as lead, carbon monoxide, NO<sub>x</sub> and many water pollutants been combatted successfully in many industrial countries whereas in other policy areas (CO<sub>2</sub>, benzene, noise, species extinction) very little has changed despite considerable public attention?

behavior, but also of the particular regulation problem under consideration. Some issues are more likely to generate loophole lobbying than others.

For instance, an economy-wide energy tax, like the German Eco Tax, can be designed in many different ways, with exemptions for various sectors. Thus, there is much scope for loophole lobbying of specific sectors. Such a tax may thus be implemented because industries engage heavily in private lobbying rather than coordinating effectively to fight regulation as such.

At the other extreme, take highway speed regulation. For automobile firms as the anti-regulation lobbyists, there is little scope for disagreement concerning highway speed regulation. A speed limit may be more or less rigid, but that is about as far as regulatory flexibility goes: An individual exemption from speed limits for Porsches or BMWs would be inconceivable, so private lobbying in this area cannot achieve much. Thus, if firms spend effort on lobbying, it must necessarily be directed towards preventing regulation as such rather than towards obtaining loopholes. Even though general lobbying is still subject to free riding, this problem is mitigated by the absence of the alternative, private lobbying. It is therefore not surprising that lobbying of the German auto industry against speed restrictions has been highly successful. Obviously, our argument cannot provide a complete explanation of observed regulatory behavior. With respect to speed regulation, we have little to say about why speed regulation was lax in Germany, but not in other countries. One might resort to an argument that German car firms have stronger incentives to fight regulation than others. It is precisely the strength of our approach that we do not rely on such arguments. We show that for *given* benefits from preventing regulation, differences in objective possibilities for private lobbying might explain why regulation is more severe in some areas than in others.

An alternative application concerns the principle that emission standards must be non-discriminatory rather than differentiating across firms. By familiar textbook arguments, differentiation of standards has efficiency advantages similar to those of taxes or tradeable permits: By differentiating

standards so as to equate the marginal costs of abatement, the total costs of achieving a target level of emissions can be minimized in principle.<sup>4</sup> Our ideas suggest that, nevertheless, firms might prefer a legal environment where differentiated standards are prohibited: Without such differentiation, firms are aware that the only way to secure high emissions standards for themselves is to work towards the common goal of a lax uniform standard. If differentiation is allowed, there is scope for private lobbying, which may prevent them from focussing on fighting regulation as such.

We believe that lobbyists are aware of the conflict between private and general lobbying. For instance, in a recent press release the German Association of the Automotive Industry VDA explicitly demands a common stance of the VDA and the Logistics Industry Association BGL against a heavy vehicle charge rather than "speculation about possible distributive effects of the charge" (VDA 2001). More generally, industry associations are typically members of higher level associations. These associations typically deal with activities that we would describe as general lobbying. For instance, the press releases of the German BDI usually concern general topics such as climate policy, water policy or even abstract concepts like the precautionary principle.<sup>5</sup> The associations can therefore be interpreted as institutional answer to the problem of excessive private lobbying.

Though there is a considerable literature on the explanation of environmental policy,<sup>6</sup> we are not aware of any alternative approach that deals with multi-dimensional lobbying. Beyond environmental policy, the lobbying literature in the tradition of Bernheim and Whinston and Grossman and Helpman does not address the tradeoff between general and private lobbying either. A vaguely related paper is Bennedsen and Feldmann which also analyzes the choice between different types of lobbying activities. There, however, the lobbies choose between informational lobbying and contribution payments rather than general and private lobbying.

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<sup>4</sup>Obviously, informational requirements prohibit a perfect implementation of this idea.

<sup>5</sup><http://www.bdi-online.de>

<sup>6</sup>See Hahn (1990), Fredriksson (1997), Damania (1999) and the survey of Polk (2002).



The paper is organized as follows: Section 2 describes our general framework. Section 3 provides simple versions of the model where private and general lobbying are discrete choices. Section 4 presents comparative statics results under the assumption of a fixed budget for lobbying. Section 5 extends the analysis to an endogenous budget. Section 6 concludes.

## 2 The Framework

### 2.1 General Assumptions

We analyze two firms whose production involves pollution. In a lobbying game, firms can influence environmental policy, which, for simplicity, corresponds directly to an allowed emissions level  $E^i$  for each firm. Profits are given in reduced form as follows.

**Assumption 1** *The profit of firm  $i$  ( $i \equiv 1, 2$ ) is an increasing and concave function  $\pi^i(E^i)$ , that is bounded above by  $S > 0$ .<sup>7</sup>*

Denote the level of *private lobbying* for firm  $i$  as  $p^i \geq 0$ , the level of *general lobbying* as  $g^i \geq 0$ . Both  $p^i$  and  $g^i$  are costs for firm  $i$ . The benefits of lobbying are higher allowed emissions. We suppose individual pollution standards are functions  $E^i(p^i, p^j, g)$  where  $g = g^1 + g^2$  and  $j \neq i$  as follows.

**Assumption 2** *Individual pollution standards are increasing and concave in  $p^i$  and  $g$ , and non-increasing and convex in  $p^j$  for  $j \neq i$ .*

General lobbying efforts of both firms are thus perfect substitutes, so that firms provide a public good through general lobbying.<sup>8</sup> In contrast, private

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<sup>7</sup>This formulation implies that the firms are not active in the same industry, in which case a function  $\pi^i(E^i, E^j)$  with  $\partial \pi^i / \partial E^j < 0$  would be more adequate, as more restrictive environmental standards for competitors would usually be beneficial for other firms.

<sup>8</sup>Obviously, general lobbying is only a public good for the set of firms, not for other groups of society.

lobbying of a firm is not a public good. It increases the individual pollution standard of a firm, but it decreases the level of allowed pollution for the other firm or at least leaves its level unaffected.<sup>9</sup>

Finally, we denote the *net payoff* of firm  $i$  as

$$\Pi^i(p^i, p^j, g^i, g^j) = \pi^i(E^i(p^i, p^j, g)) - g^i - p^i. \quad (1)$$

We analyze the game in which firms simultaneously maximize net payoffs. We often parameterize the emissions function as  $E^i(p^i, p^j, g, \theta)$  such that

$$\frac{\partial E^i}{\partial \theta} \geq 0; \frac{\partial^2 E^i}{\partial p^i \partial \theta} > 0 \text{ for } i = 1, 2; \frac{\partial^2 E^i}{\partial p^j \partial \theta} \leq 0 \text{ for } i = 1, 2, j \neq i. \quad (2)$$

Therefore  $\theta$  reflects increasing absolute and marginal productivity of private lobbying in increasing emissions, and a potential competitive element of lobbying (in that private lobbying by one party reduces the effectiveness of lobbying by the other one).<sup>10</sup> We shall carry out comparative statics with respect to  $\theta$ .

## 2.2 Separable Emissions Functions

Specifically, we often use the separable emissions function

$$E^i(p^i, p^j, g; \theta) = B(g) + l^i(p^i, p^j; \theta). \quad (3)$$

$B$  is a *base level* of allowed pollution that depends only on general lobbying. In accordance with assumption 2,  $B$  is increasing and concave in  $g$ .  $l^i$  is a *loophole* to firm  $i$ , which the politician grants in return for private lobbying. In accordance with assumption 2,  $l^i$  is increasing and concave in  $p^i$  and non-increasing and convex in  $p^j$ . A loophole increases the individual pollution standard of a firm above the base level. Its size depends on private lobbying

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<sup>9</sup>In section 2.3, we discuss more precisely which activities should be considered and general lobbying, respectively.

<sup>10</sup>There is no general assumption on the relation between  $\theta$  and the marginal productivity of general lobbying.

efforts. Both firms compete for loopholes, because the politician has only a limited ability to grant individual exemptions. He is willing to increase individual pollution standards above the basic level of allowed pollution if a firm engages in private lobbying, but he cannot do so arbitrarily, for instance, because he expects to lose reputation if he is too closely aligned to specific firms.

For  $\theta$  to capture the effectiveness of private lobbying as in (2), we postulate

$$\frac{\partial l^i}{\partial \theta} \geq 0; \frac{\partial^2 l^i}{\partial p^i \partial \theta} > 0 \text{ for } i = 1, 2; \frac{\partial^2 l^i}{\partial p^j \partial \theta} \leq 0 \text{ for } i = 1, 2, j \neq i. \quad (4)$$

$\theta$  combines several different effects. Most obviously, this parameter might be inversely related to the moral standards of politicians. The easier it is to bribe policy makers, the higher  $\theta$  should be. Similarly,  $\theta$  might be inversely related to the public attention to the problem and the welfare benefits of environmental improvements: The more the public cares about the environment, the harder it will be to influence politicians by lobbying for loopholes. A final interpretation relates to characteristics of the problem itself: As discussed in the introduction, some kinds of problems simply allow less scope for loopholes than others. It is this last interpretation that is most fruitful to explain why different environmental issues are regulated more vigorously than others.

The specification described by (3) and (4) clearly is an oversimplification. Politicians have limited capacities to react to lobbying capacities: if they are overwhelmed by high levels of private lobbying activity, they will not pay as much attention to general lobbying activities as when emissions are low. In section 5.3, we therefore also consider an example of a non-separable emissions function, which satisfies (2), but not (3) and (4).

### 2.3 Some remarks on Interpretation

In real-world applications, the interpretation of our concepts private and general lobbying depends very much on the precise setting.

First, the set of agents considered matters a lot. In one interpretation, the lobbies could be different firms from one industry. In another interpretation, each lobby could correspond to a different industry association. In the former case, activities directed towards reducing emissions of the particular industry would be classified as general lobbying, in the latter case as private lobbying.

Second, the interpretation depends on the types of environmental regulation against which private lobbying might be directed. Take the German Eco Tax as an example. To recall, this is an economy-wide energy tax which was (and still is) opposed by most industries in the country. Thus, if a representative of one industry fights successfully to reduce the overall tax, the other industries benefit as well, so that we can speak of general lobbying. What we consider as private lobbying, however, is ambiguous. In a narrow interpretation, private lobbying activities would correspond to all activities directed at achieving reduced tax rates for the specific industry.<sup>11</sup> Alternatively, instead of interpreting private lobbying as an attempt to prevent the sector-specific effects of economy-wide regulation, we could also consider it as directed towards fighting sector-specific regulation. In Germany, for instance, the food industry association BVE recently engaged in campaigns against a mandatory deposit on beverage cans, against mandatory consumer information on food quality and for a more liberal treatment of genetic food.<sup>12</sup> The auto industry represented by the VdA fought against a charge on heavy vehicles, against highway speed regulations and against an obligation to take back old cars.<sup>13,14</sup> Our following analysis will be applicable both with the narrower

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<sup>11</sup>As an extreme case, an industry may explicitly demand exemptions from regulation. As an intermediate case between private and general lobbying, an industry might argue against the tax as such, but emphasize the detrimental effects on the particular sector. When German industry associations argue against the Eco Tax, they usually take this approach: The chemical industry association VCI emphasizes the cost increase for basic inputs (see <http://www.vci.de>), the mineral oil industry association MWV highlights the increased costs of steel production (see <http://www.mwv.de>), etc.

<sup>12</sup>See <http://www.bve.de>.

<sup>13</sup>See <http://www.vda.de>.

<sup>14</sup>The distinction between private lobbying (interpreted as sector-specific lobbying) and

and the broader interpretation of private information.

A last remark concerns the channels of influence by which private and general lobbying take place. Both types of lobbying can take various forms: information campaigns, legal or illegal contribution payments, or the promise of cooperation in other policy areas. Very roughly, one would expect general lobbying to be more secretive: The smaller the group of society whose interests the lobbying activities represents, the less likely it is that public information campaigns receive much attention.

### 3 An Example: Discrete Choice

We illustrate our main ideas in a simplified version of the model. Suppose that both private and general lobbying levels can only be chosen as 0 or 1. Thus,  $g^i \in \{0, 1\}, p^i \in \{0, 1\}$ . We further specify

$$E^i = \gamma (g^1 + g^2) + \theta p^i \quad (5)$$

where  $\gamma > 0, \theta > 0$ . The parameters  $\gamma$  and  $\theta$  measure the effectiveness of general and private lobbying, respectively.<sup>15</sup> Finally, we specify

$$\pi^i (E^i) = \sqrt{E^i}. \quad (6)$$

#### 3.1 Fixed Budget

We first consider the additional simplification that each firm  $i$  has a fixed lobbying budget (1 unit), which can either be allocated to general or to private lobbying. Thus,  $g^i = 1 - p^i$  is the amount of general lobbying by firm  $i$ . Using (5), firm  $i$ 's emissions are  $E^i = \gamma (2 - p^1 - p^2) + \theta p^i$ . Suppressing general lobbying is gradual: For instance, in its struggle against the mandatory deposit, the food industry received support from the metal industry as producers of beverage cans (<http://www.stahl-online.de>).

<sup>15</sup>In this specification, emissions are 0 without lobbying. Nothing of substance depends on this convenient property of the function.

	P	G
P	$\sqrt{\theta}, \sqrt{\theta}$	$\sqrt{\theta + \gamma}, \sqrt{\gamma}$
G	$\sqrt{\gamma}, \sqrt{\theta + \gamma}$	$\sqrt{2\gamma}, \sqrt{2\gamma}$

Figure 1: Payoffs in the Discrete Fixed Budget Example

lobbying costs, which are 1 for each firm and strategy profile, the game has the payoff matrix described in Table 1, where  $P$  corresponds to  $p^i = 1$  and  $G$  corresponds to  $p^i = 0$ .

The equilibrium structure is described by Figure 2. As long as  $\theta < \gamma$ , that is, to the left of the diagonal, both firms engage in general lobbying, with resulting total emissions level  $2\gamma (g^1 + g^2) = 4\gamma$ . For  $\theta > \gamma$ , the equilibrium switches, as both firms engage in private lobbying, with resulting total emissions level  $\theta (p^1 + p^2) = 2\theta$ . Thus, in the cone between the diagonal  $\theta$  and the dashed line  $\gamma = \theta/2$ , the equilibrium is inefficient from the firms' point of view: If both switched to general lobbying, the emissions and thus firm payoffs would increase.

Figure 3 sums up the effect of an increase in the effectiveness of private lobbying  $\theta$  on the equilibrium level of total emissions, with  $\gamma$  fixed at 5. Qualitatively, the same results hold for all other positive values of  $\gamma$ . As long as  $\theta < \gamma = 5$ , an increase of  $\theta$  has no effect on total emissions, as only general lobbying takes place in equilibrium. A marginal increase of  $\theta$  around  $\gamma = 5$  leads to a drop in emissions to half the original level. Thus, a change in parameters with a positive direct effect on firms induces an undesirable strategic effect.<sup>16</sup> Firms face a stronger temptation to engage in private lobbying, even though it is inefficient for the group of firms. A further increase

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<sup>16</sup>Similar arguments have been made in the context of oligopoly games ( Cabral and Villas-Boas 2001).

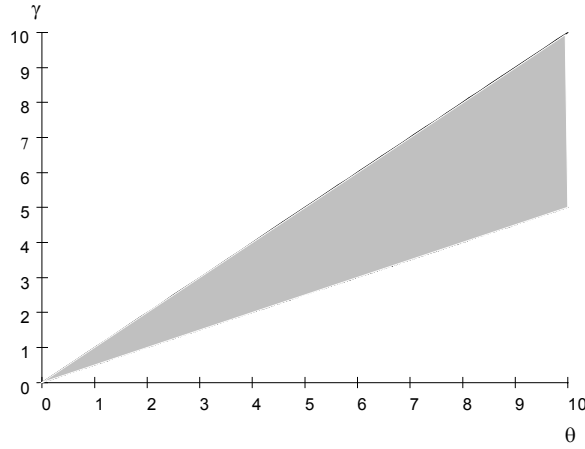


Figure 2: Equilibrium Structure in the Discrete Case with Fixed Budget

of  $\theta$ , however, leaves the equilibrium structure unaffected and the situation for firms improves. When  $\theta > 2\gamma = 10$ , the firms are eventually better off than in the general lobbying equilibrium: Private lobbying is actually more productive in reducing total emissions than general lobbying.

The main conclusion from this example is that, somewhat paradoxically, if politicians react more favorably to private lobbying of firms, the environment may win and firms may lose. Firms are tempted to focus on private lobbying even though it is not efficient for them as a group. In the following, we investigate the robustness of this argument. Specifically, to which extent does our argument rely on the assumption of a fixed budget? Phrased in our  $\{0, 1\}$ -framework: how important is it that firms can only choose between private and general lobbying, whereas "no lobbying" or "private *and* general lobbying" are not feasible options?

### 3.2 Endogenous Budget

In a first step towards endogenizing the amount of lobbying, suppose firms can choose  $p^i \in \{0, 1\}$ ,  $g^i \in \{0, 1\}$  without the restriction that  $g^i = 1 - p^i$ .

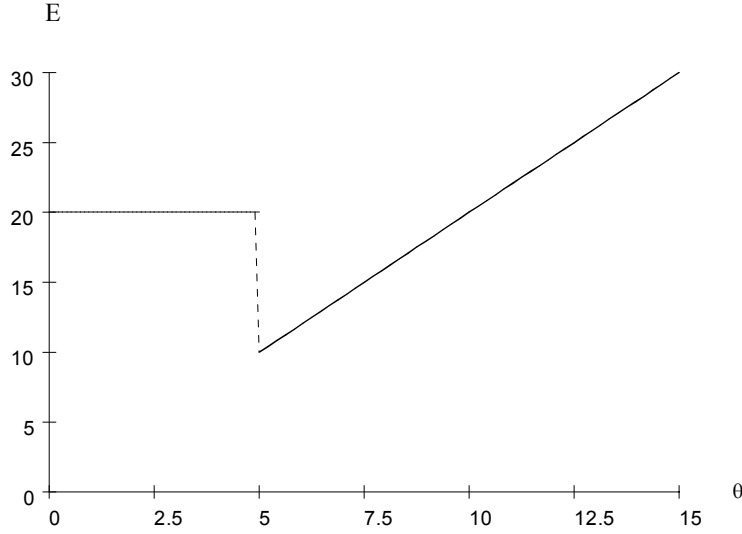


Figure 3: Increasing the Productivity of Private Lobbying in the Discrete Case with Fixed Budget

With payoff functions as in (5) and (6), the payoff matrix is given as in Table 4.<sup>17</sup>

There are four conceivable symmetric pure strategy equilibria: both firms engage in private and general lobbying ( $PG, PG$ ); both firms only engage in private lobbying ( $P, P$ ); both firms only engage in general lobbying ( $G, G$ ); neither firm engages in lobbying ( $0, 0$ ). Up to permutations of firms, there are six candidates for asymmetric pure strategy equilibria ( $G, 0$ ), ( $PG, P$ ), ( $P, 0$ ), ( $GP, 0$ ), ( $P, G$ ), ( $PG, G$ ). However, the last four of these constellations cannot arise in equilibrium, except for knife-edge cases. Such equilibria would require exactly one firm to engage in private lobbying. But if private lobbying is profitable for one firm, it is also profitable for the other one.<sup>18</sup>

<sup>17</sup>In the table,  $P$  corresponds to  $p^i = 1, g^i = 0$ ;  $G$  corresponds to  $p^i = 0, g^i = 1$ ,  $PG$  corresponds to  $p^i = g^i = 1$ .

<sup>18</sup>Given any total level  $g$  of general lobbying, a firm that decides to engage in private lobbying increases its emissions from  $g$  to  $\theta + g$ . Thus, the difference in net payoffs between choosing  $p = 1$  and  $p = 0$  is  $\sqrt{\theta + g} - \sqrt{g} - 1$  for both firms. Thus, if  $\sqrt{\theta + g} - \sqrt{g} - 1 \neq 0$ ,



	0	P	G	PG
0	0,0	0, $\sqrt{\theta} - 1$	$\sqrt{\gamma}, \sqrt{\gamma} - 1,$	$\sqrt{\gamma}, \sqrt{\theta + \gamma} - 2$
P	$\sqrt{\theta} - 1, 0$	$\sqrt{\theta} - 1, \sqrt{\theta} - 1,$	$\sqrt{\theta + \gamma} - 1, \sqrt{\gamma} - 1$	$\sqrt{\theta + \gamma} - 1, \sqrt{\theta + \gamma} - 2$
G	$\sqrt{\gamma} - 1, \sqrt{\gamma}$	$\sqrt{\gamma} - 1, \sqrt{\theta + \gamma} - 1$	$\sqrt{2\gamma} - 1, \sqrt{2\gamma} - 1$	$\sqrt{2\gamma} - 1, \sqrt{\theta + 2\gamma} - 2$
PG	$\sqrt{\gamma} - 2, \sqrt{\gamma}$	$\sqrt{\theta + \gamma} - 2, \sqrt{\theta + \gamma} - 1$	$\sqrt{\theta + 2\gamma} - 2, \sqrt{2\gamma} - 1$	$\sqrt{2\gamma + \theta} - 2, \sqrt{2\gamma + \theta} - 2$

Figure 4: Payoff Matrix for the Discrete Case with Endogenous Budget

Figure 5 shows that the four symmetric constellations and each of the remaining asymmetric constellations actually are equilibria for non-degenerate parameter areas.

The implications of an increase in private lobbying effectiveness  $\theta$  are now more subtle than in the fixed budget case. Intuitively, if the equilibrium switches as a result of an increase in  $\theta$ , this need not result in lower emissions. An increase in  $\theta$  may induce more private lobbying without inducing less general lobbying. Depending on the effectiveness of general lobbying ( $\gamma$ ), four scenarios can arise. Emissions are never decreasing in  $\theta$  for the first two scenarios, but undergo downward jumps in the third and fourth.

#### Non-Decreasing Emissions (for low $\gamma$ )

- (i) For very ineffective general lobbying ( $\gamma < 1$ ), there will be no lobbying at all if  $\theta$  is also small ( $\theta < 1$ ): Neither type of lobbying is sufficiently profitable to justify the lobbying cost. Thus, total emissions are zero. As  $\theta$  increases, both firms will engage in private lobbying ( $PP$ ), so that total emissions are  $2\theta$ . Thus, at  $\theta = 1$ , there is a discontinuous upward jump in emissions as  $\theta$  increases. Higher effectiveness of private lobbying is thus good for firms and bad for the environment for  $\gamma < 1$ .

- (ii) The effect is slightly less pronounced in the region where  $\gamma > 1$ , but  $p_i = 1, p_j = 0$  is impossible in equilibrium.

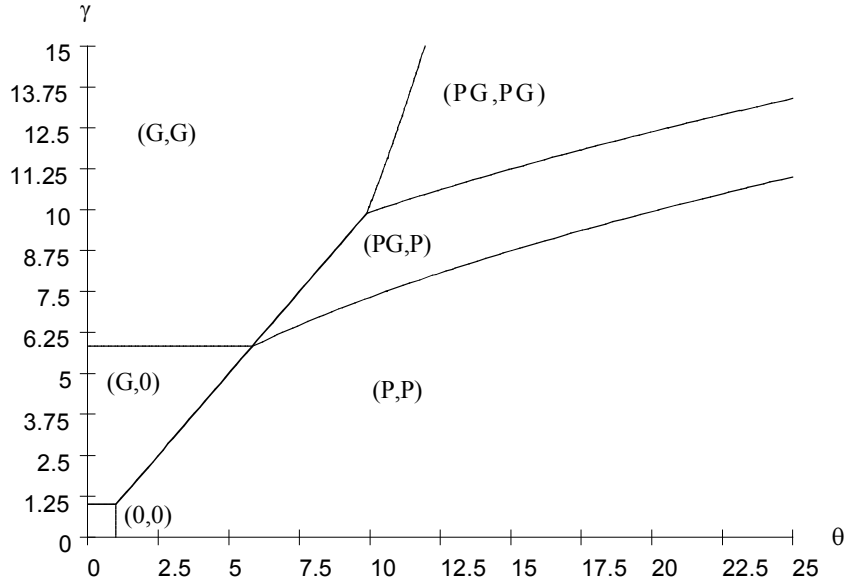


Figure 5: Equilibria in the Discrete Case with Endogenous Budget

$\sqrt{2\gamma} - \sqrt{\gamma} < 1$  ( $1 < \gamma < 5.83$ ): Here, for low values of  $\theta$ , there will be a chicken-type equilibrium  $(G, 0)$ . One firm engages in general lobbying, providing benefits of  $\sqrt{\gamma}$  to the other. Given this amount of general lobbying, additional general lobbying by the second firm would yield  $\sqrt{2\gamma} - \sqrt{\gamma}$  in additional benefits, which is not worth the costs of 1 in this parameter regime. As  $\theta$  increases beyond  $\gamma$ , the only equilibrium has both firms engaging in private lobbying  $(P, P)$ . Emissions are therefore  $2\gamma$  for  $\theta < \gamma$  and  $2\theta > 2\gamma$  for  $\theta > \gamma$ . Thus, higher attention to private lobbying increases total emissions, but there is no discrete jump in emission levels at the regime boundary.

#### Downward jumps of Emissions (for high $\gamma$ )

If  $\sqrt{2\gamma} - \sqrt{\gamma} > 1$ , the chicken equilibrium  $(G, 0)$  breaks down for low values of  $\theta$ . Instead, general lobbying is valuable enough for both firms to engage in it. Thus total emissions are constant at  $E = 4\gamma$ . The outcome as  $\theta$  increases depends on the exact size of  $\gamma$ .

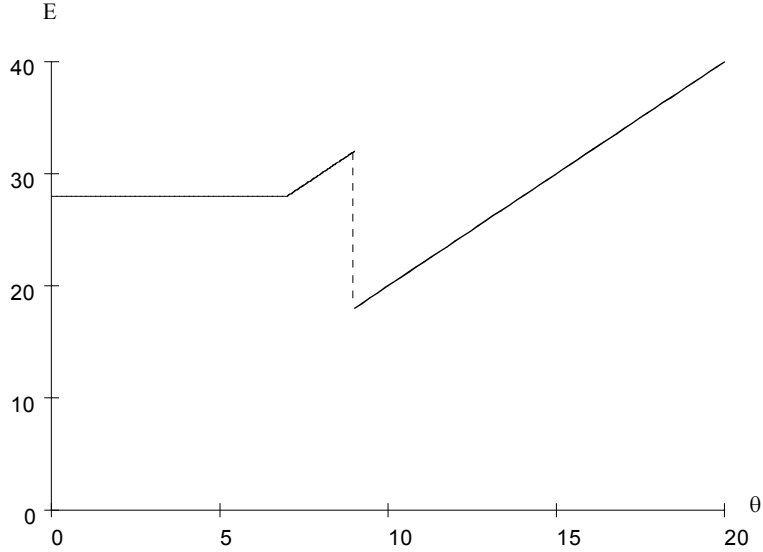


Figure 6: Increasing the Effectiveness of Private Lobbying in the Discrete Case with Endogenous Budget, scenario (iii).

- (iii) If  $\sqrt{3\gamma} - \sqrt{2\gamma} < 1$  ( $\gamma < 9.89$ ), the equilibrium structure switches as  $\theta$  increases beyond  $\gamma$ : It becomes attractive for one firm to free ride on the other, resulting in a chicken equilibrium  $(PG, P)$ . Emissions in this regime are  $E = 2\gamma + 2\theta$ , thus increasing in  $\theta$ . As private lobbying becomes even more attractive ( $\sqrt{\theta} > \sqrt{\theta + \gamma} - 1$ ), both firms engage in private lobbying only. Emissions are then  $E = 2\theta$ , that is, there is a discrete downward jump at the regime boundary, followed by a gradual increase of emissions. The emissions behavior in this regime is summarized in Figure 6, which corresponds to  $\gamma = 7$ . Thus, for a non-degenerate region of  $\gamma$ 's, things are as in the fixed budget case: Starting from sufficiently low values of  $\theta$ , greater effectiveness of private lobbying may lead to a strategic disadvantage of the firms, which results in lower emissions, as long as the increase in  $\theta$  is not so large that positive direct effects overwhelm negative strategic effects.

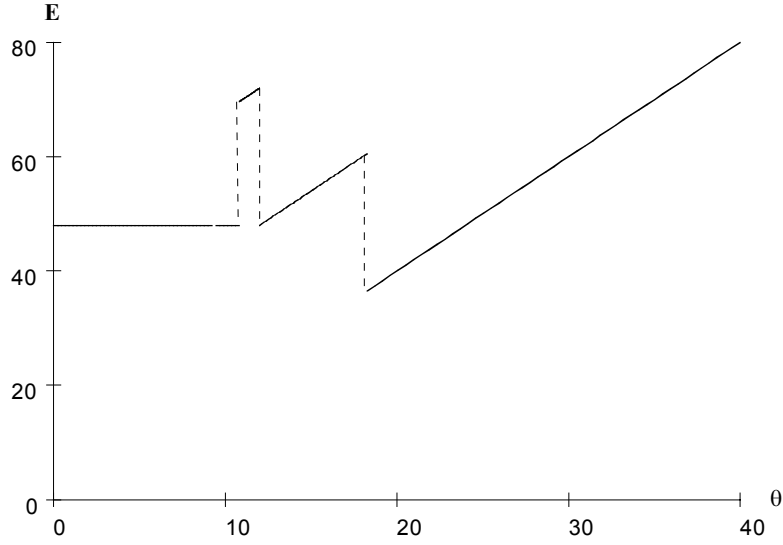


Figure 7: Increasing the Effectiveness of Private Lobbying in the Discrete Case with Endogenous Budget, scenario (iv)

- (iv) For  $\sqrt{3\gamma} - \sqrt{2\gamma} > 1$  ( $\gamma > 9.89$ ), the main conclusion is similar, but the pattern is slightly more complex. The emission pattern as a function of  $\theta$  is described in Figure 7, which corresponds to  $\gamma = 12$ . Here, as  $\theta$  increases, the equilibrium first switches from  $(G, G)$  to  $(GP, GP)$ , obviously resulting in higher emissions. Next, however, the equilibrium switches to the chicken equilibrium  $(GP, P)$  and finally to  $(P, P)$ . At each of the last two regime boundaries, there is a discrete drop in emission, which reflects the same strategic effects as (iii) above.

To sum up, while the emissions behavior is more complex in the flexible budget case, the qualitative insight that higher effectiveness of private lobbying crowds out general lobbying and thereby reduces emissions still holds for suitable changes in  $\theta$ , provided general lobbying is sufficiently effective ( $\sqrt{2\gamma} - \sqrt{\gamma} = 1$ ). The intuition is straightforward. Because profits are concave in emissions, if higher  $\theta$  induces more private lobbying, this reduces the

benefits from general lobbying.

It is interesting to compare the nature of the free-rider-problem with the familiar underinvestment problem in a pure public goods situation with  $\theta = 0$ . In this case, inefficiency for the firms arises only if  $\gamma$  is small (cases (i) and (ii)): As we have seen, for higher  $\gamma$ , firms that decide only about whether or not to engage in general lobbying, would both choose  $g^i = 1$ , as general lobbying is so effective that it is even worthwhile for both firms when they behave non-cooperatively. A chicken or zero-investment equilibrium will only arise for lower  $\gamma$ . Sufficiently effective private lobbying, however, may turn the equilibrium into an inefficient one, even if it is efficient for  $\theta = 0$ . Thus, the possibility of private lobbying creates a public goods problem for such  $\gamma$  where none exists with  $\theta = 0$ .

## 4 Continuous Lobbying with Fixed Budgets

We now give up the assumption that lobbying is a (0,1)-decision. However, as in section 3.1, we assume that the budget of each lobby is fixed and normalized to one. This assumption is slightly more than just a convenient simplification: In some contexts, the budget will be hard to change. An industry lobby finances its campaigns from the contributions of its members which, at least in the short term, cannot be increased arbitrarily. Nevertheless, we shall consider the case of an endogenous budget in the next section.

We restrict ourselves to the separable specification given by (5) and (6). We thus consider the game with  $p^i \in [0, 1]$  and objective functions

$$\begin{aligned} \tilde{\pi}^i(p^i, p^j; \theta) = \\ \pi^i(E^i(p^i, p^j, 1 - p^i - p^j; \theta)) = \pi^i(B(2 - p^i - p^j) + l^i(p^i, p^j, \theta)) \end{aligned}$$

We are interested in comparative statics with respect to the effectiveness parameter  $\theta$ . To carry out these comparative statics and to guarantee local stability, we introduce the next assumption.

**Assumption 3**  $\tilde{\pi}^i(p^i, p^j)$  is twice continuously differentiable with respect to all variables and  $\tilde{\pi}_{ii}^i \tilde{\pi}_{jj}^j - \tilde{\pi}_{ij}^i \tilde{\pi}_{ji}^j > 0$ .<sup>19</sup>

This game has a Nash equilibrium in pure strategies,  $(p_*^1, p_*^2)$ .<sup>20</sup> For any interior equilibrium, straightforward calculations yield:

$$\frac{dp^i}{d\theta} = \frac{-\tilde{\pi}_{i\theta}^i \tilde{\pi}_{jj}^j + \tilde{\pi}_{j\theta}^j \tilde{\pi}_{ij}^i}{\tilde{\pi}_{ii}^i \tilde{\pi}_{jj}^j - \tilde{\pi}_{ij}^i \tilde{\pi}_{ji}^j} \quad (7)$$

$$\frac{dg^i}{d\theta} = -\frac{dp^i}{d\theta} \quad (8)$$

Intuitively, one would expect a higher  $\theta$  to increase private lobbying: By definition,  $\tilde{\pi}_{i\theta}^i = \pi_{E}^i \frac{\partial^2 E^i}{\partial p^i \partial \theta} \geq 0$ .<sup>21</sup> Thus, a higher  $\theta$  increases the marginal returns to increasing  $p^i$ , so that, other things being equal, more private lobbying should result. However, because of strategic effects, an additional assumption is needed to give the result.

**Proposition 1** *If the politician becomes more responsive to private lobbying ( $\theta$  increases), private lobbying efforts of firm  $i$  ( $i \neq j$ ) increase if and only if  $l_{j\theta}^j (B_{gg} + l_{ij}^i) - l_{i\theta}^i (B_{gg} + l_{jj}^j) > 0$ .*

**Proof.** See Appendix. ■

Using (4) and the concavity of  $B$  and  $l^i$ , the following simple implication is immediate.

**Corollary 1** *If private lobbying efforts are strategic complements at the equilibrium ( $\tilde{\pi}_{ij}^i \geq 0$ , or equivalently,  $B_{gg} + l_{ij}^i \geq 0$ ),  $p^i$  is increasing in  $\theta$  for  $i = 1, 2$ .*

---

<sup>19</sup>Here and in the following, subscripts stand for derivatives, i.e.,  $\tilde{\pi}_{ii}^i = \frac{\partial^2 \tilde{\pi}^i}{\partial p^i \partial p^i}$  etc.

<sup>20</sup>The strategy spaces are non-empty, convex and compact subsets of  $\mathbb{R}$ , and the payoff functions are continuous and quasiconcave. The proof thus follows immediately from Mas-Colell et al. (1995, prop. 8.D.3).

<sup>21</sup> $\tilde{\pi}_{i\theta}^i = \pi_{E}^i \cdot l_{i\theta}^i + \pi_{EE}^i l_{\theta}^i (l_i^i - B_g)$ , but  $l_i^i - B_g = 0$  in equilibrium.

Intuitively, with strategic complements, the direct effects of  $\theta$  on  $p^1$  and  $p^2$  are mutually reinforcing: The direct effect of  $\theta$  on  $p^1$  induces a positive effect on  $p^2$  and vice versa. However, strategic complements are not necessarily the most convincing assumption: As  $\tilde{\pi}_{ij}^i = \pi_E^i (l_{ij}^i + B_{gg})$  and  $\pi_E^i > 0$ , the concavity of  $B_{gg}$  yields a force against complementarity. Intuitively, if player  $j$  increases private lobbying, he must reduce general lobbying. Doing so increases the marginal effectiveness of general lobbying for player  $i$ , given the concavity of  $B$ . Strategic complements require  $l_{ij}^i \gg 0$ . Thus, we also need to consider strategic substitutes.

With strategic substitutes, the indirect effects of private lobbying are more complex than with complements: an increase in private lobbying by one firm induces decreasing private lobbying by the other one. Thus, the positive direct effects of  $\theta$  on  $p^1$  and vice versa tend to offset each other to some extent. Potentially, as Figure 8 suggests, even though both reaction curves shift to the right (from  $R_i^o(p_j)$  to  $R_i^n(p_j)$ ), the indirect effect may lead to a reduction in private lobbying by one firm. In Figure 8, the equilibrium changes from  $(p_i^o, p_j^o)$  to  $(p_i^n, p_j^n)$ . Proposition 2 shows that, with strategic substitutes, a reduction of private lobbying for firm  $i$  requires that the own responsiveness to private lobbying ( $l_{i\theta}^i$ ) is small relative to the other firm's  $\left(\frac{l_{i\theta}^i}{l_{j\theta}^j} < \frac{B_{gg} + l_{ij}^i}{B_{gg} + l_{jj}^j}\right)$ . This suggests that at most one firm will reduce private lobbying if  $\theta$  increases. An immediate implication of Proposition 2 is that this is indeed true.

**Corollary 2** *If private lobbying becomes more effective ( $\theta$  increases), at least one firm increases private lobbying.*

**Proof.** See Appendix. ■

Corollary 2 immediately leads to the next result.

**Corollary 3** *Suppose both firms have identical payoff functions. If the equilibrium is symmetric before and after an increase in  $\theta$ , private lobbying must increase with  $\theta$ .*

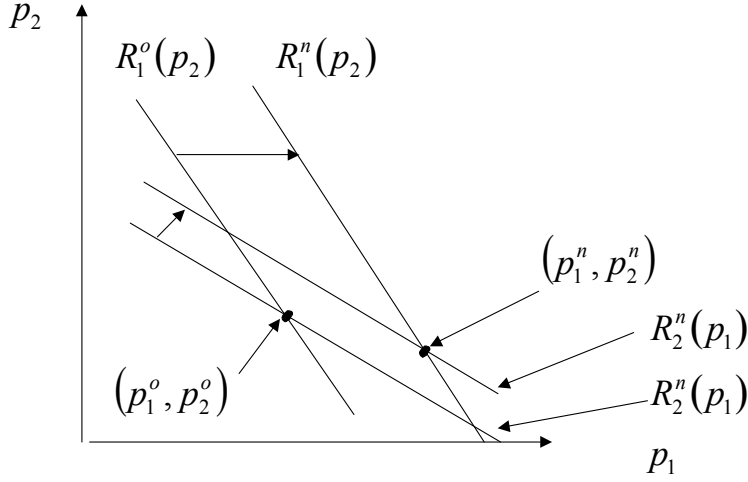


Figure 8: Comparative Statics in the Continuous Case with Fixed Budget

The proof is straightforward. By corollary 2, at least one firm increases private lobbying. By symmetry, therefore, both firms increase private lobbying. In a symmetric equilibrium, the change in the effectiveness of private lobbying affects both firms in the same way. The direct and strategic effects are the same for both firms. An increase of  $\theta$  gives both firms the same direct incentive to increase private lobbying. Strategic effects dampen this incentive, but do not reverse it: direct effects dominate over strategic effects, and private lobbying by both firms increases.

Do firms benefit if the politician gets more responsive to private lobbying? What is the effect on the environment? Total lobbying expenditures do not change, because budgets are fixed by assumption. A firm benefits from a change of  $\theta$  if the induced lobbying responses lead to higher individual pollution standards. The total effect on the environment depends on how both individual pollution standards change. Total emissions are:

$$TE^L = 2B(2 - p^1 - p^2) + l^1(p^1, p^2, \theta) + l^2(p^1, p^2, \theta)$$

The following proposition provides a strong argument that an increase in



the effectiveness of private lobbying benefits the environment:

**Proposition 2** *With fixed budgets, emissions decrease with  $\theta$  if and only if*

(a) *both firms increase private lobbying, or*

(b) *only one firm, say firm 1, decreases private lobbying and*

$$-dp^1(B_g - l_1^2) < -dp^2(-B_g + l_2^1).$$

Intuitively, three effects occur if a firm increases private lobbying: First, the individual loophole increases, which harms the environment. Second, as  $l_j^i \leq 0$ , the opponent's loophole tends to become smaller, which reduces emissions. Third, because of the fixed budget, more private lobbying means less general lobbying. The base levels of emissions decline, which affects both firms. Thus the only effect which might harm the environment is the increase of the individual loophole. Note that firms equate the marginal benefit of private lobbying ( $l_i^i$ ) with its cost ( $-B_g$ ) in equilibrium. Hence, the negative effect through an increase of the individual loophole offsets the positive effect through the decrease of one's own base level. Positive environmental effects through a smaller base level and a smaller loophole of the opponent remain. In a symmetric equilibrium, both firms increase private lobbying. As a result, environmental quality improves.

If one firm ( $i$ ) reduces private lobbying, whereas the other one increases it, emissions might go up if  $|dp^i|$  is large relative to  $|dp^j|$  and firm  $j$ 's strategic reaction to the decrease in  $p^j$  is weak relative to firm  $i$ 's reaction to the increase in  $p^j$  as stated in proposition 2.

Proposition 2, which generalizes the example from section 3.1, is our central result for the fixed budget case. It indicates that, in this setting, an increasing importance of loopholes tends to benefit the environment, at least in a symmetric situation. If lobbying becomes more important, firms focus on lobbying activities which tend to be ineffective.

## 5 Continuous Lobbying with Endogenous Budget

With exogenous budgets, an increase in private lobbying necessarily coincides with a decrease in general lobbying. As we have seen, environmental quality therefore tends to increase with the effectiveness of private lobbying.

Now suppose budgets are endogenous. Thus, in the framework of section 2, suppose  $(p^i, g^i)$  can be chosen from  $[0, \infty) \times [0, \infty)$ .<sup>22</sup> Further, for simplicity, we restrict the analysis to a symmetric setting where  $\pi^1 = \pi^2 \equiv \pi$ ;  $E^1 = E^2 \equiv E$ , and we only consider symmetric equilibria, which we denote as  $(p_*^1, p_*^2, g_*^1, g_*^2)$  such that  $p_*^1 = p_*^2$  and  $g_*^1 = g_*^2$ .

As we saw for the discrete case in section 3.2, with endogenous budgets it is no longer obvious that an increase in private lobbying decreases general lobbying: Firms could increase both types of lobbying following an increase in  $\theta$ . However, for the separable case described by (5) and (6), simple calculations show that  $\Pi_{p^i g^i}^i = \pi_{EE}^i B_g l_i^i < 0$ , i.e., private and general lobbying are substitutes in a firm's objective function. Thus, it is at least true for an individual firm that an increase in  $p^i$  reduces the marginal returns from increasing  $g$ . Intuitively, as  $p^i$  increases, so do allowed emissions. Because of the concavity of the profit function in  $E^i$ , the profit increase resulting from a further increase of allowed emissions by general lobbying therefore falls. Ignoring strategic interactions, this would suggest that greater private lobbying and lower general lobbying go hand in hand. In this section, we explore to which extent such a claim remains true with strategic interactions. We do so by considering various special cases.

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<sup>22</sup>The proof of this claim uses Prop. 8.D.3 in Mas-Colell et al. (1995). Assumption 1 guarantees that strategies with  $p^i + g^i > S$  are strictly dominated, so that, to find a Nash equilibrium, one can assume compact strategy spaces.

## 5.1 Non-Competitive Lobbying in the Separable Case

First, consider the separable specification given by (5) and (6) and suppose further that private lobbying has no effect on the loophole of the other party.

**Condition WLC:**  $l_j^i(p^i, p^j) = 0$  for arbitrary  $(p^i, p^j)$ .

This corresponds to extremely *weak lobbying competition*: private lobbying has no adverse effect on the competitor.

**Proposition 3** *If WLC holds, then an increase in  $\theta$  leads to more private lobbying and less general lobbying.*

**Proof.** See Appendix B. ■

In spite of the reduction in general lobbying, it is not clear what happens to the emissions level when the effectiveness of private lobbying increases. For instance, consider the following specification

$$E_i = \left( \theta (p^i)^{1/2} + g^i + g^j \right), \pi_i(E_i) = (E_i)^{1/2}, \quad (9)$$

with  $\theta > 0$ . Simple numerical calculations show that  $E_i$  is independent of  $\theta$  as long as  $\theta$  is sufficiently small, as reduced general and increased private lobbying cancel out. Thus, from the environmental point of view, the effectiveness of lobbying does not matter. For higher  $\theta$ , there is no more general lobbying, and emissions are increasing in  $\theta$ .

In another example, the effect of increasing private lobbying dominates. Suppose

$$E_i = \left( \theta (p^i)^{1/2} + (g^i + g^j)^{1/2} \right), \pi_i(E_i) = \ln(E_i).$$

Then equilibrium emissions for  $\theta \in [0, 5]$  are given in Figure 9.

## 5.2 Fully competitive lobbying in the Separable Case

As the opposite extreme, we use the following additional condition in the separable specification given by (3) and (4)

**Condition ILC:**  $l_\theta^i = 0$  and  $l_i^i = -l_j^i$  at the equilibrium.

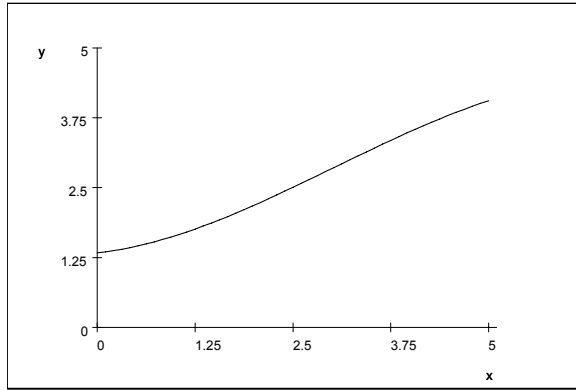


Figure 9: An Example of Weak Lobbying competition

Condition ILC says that, if both firms increase private lobbying by the same amount, individual loopholes do not change. It thus corresponds to a situation of *intense lobbying competition*, and it is a boundary case with respect to the conditions described by (4).

**Proposition 4** *Suppose ILC holds. If the politician becomes more responsive to private lobbying, then private lobbying efforts by both firms increase. General lobbying, however, remains unaffected, as does the emissions level.*

The intuition for the result is as follows: If the politician gets more responsive to private lobbying, both firms have the same direct incentive to increase private lobbying. By condition ILC, the additional private lobbying efforts cancel out. Thus, emissions levels are unaffected by private lobbying, and the incentives to increase general lobbying remain unaffected. In other words, a general increase in the responsiveness to private lobbying only leads to counteractive lobbying effects, but not to a change in regulation. There is no effect on the equilibrium base levels of pollution, the individual loopholes and the overall level of pollution. Firms lose if the politician gets more responsive to private lobbying, because their equilibrium lobbying efforts are higher, without any corresponding gain. Proposition 4 is important because

it clarifies that the statements that a positive effect of  $\theta$  on the firms and a negative effect on the environment are not equivalent.

### 5.3 The Non-Separable Case

In the above examples, the separability assumption implied that increases in one type of lobbying did not reduce the marginal effect of the other type of lobbying on emissions. As discussed in section 2.2, separability is not necessarily the most convincing assumption. Therefore, we also consider a non-separable specification:

$$E_i = \theta (p^i)^{1/2} + \frac{(g^i + g^j)^{1/2}}{K + p^j} - p^i - g^i; \theta > 0, K \geq 0; \pi_i(E_i) = E_i \quad (10)$$

This specification satisfies all the properties laid out in section 2. In particular, an increase in  $\theta$  would increase allowed emission levels for both parties if private lobbying levels remained unchanged. Further, with  $K \geq 0$ , an increase in private lobbying decreases the effects of general lobbying on the competitors allowed emissions, as  $\frac{\partial^2 E_i}{\partial g^i \partial p^j} = -\frac{1}{2\sqrt{(g^i + g^j)(K + p^j)^2}} < 0$ . As long as  $K$  is close to 0, private lobbying has a strong negative influence on the effectiveness of general lobbying, as  $K$  increases, the effect becomes smaller. Numerical calculations show that  $p = \frac{\theta^2}{4}$  for arbitrary  $K$ , so that private lobbying is increasing in  $\theta$ . Further, they show that general lobbying is a decreasing function of  $\theta$  such that the lower  $K$ , the more rapid the decline of general lobbying as a function of  $\theta$ .

Finally, Figure 10 plots the net effect, which depends on  $K$ : For high values ( $K = 1$ ; dotted line), emissions are monotone increasing in  $\theta$ . For low values ( $K = 0.5$ ; dashed line and  $K = 0.1$ ; solid line), emissions are first decreasing and then increasing in  $\theta$ . Broadly, this behavior is similar to the pattern identified in the discrete example (section 3.2). Intuitively, if private lobbying has a strong negative influence on the effectiveness of general lobbying ( $K$  small), starting from low values, higher  $\theta$  first decreases emissions, because the induced increase in private lobbying reduces the effectiveness of

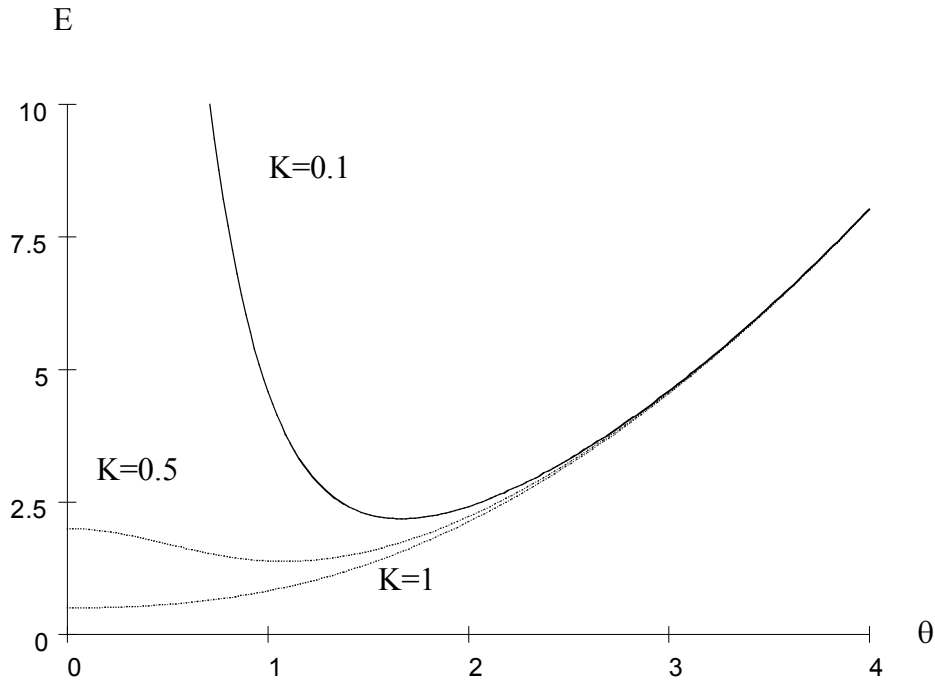


Figure 10: An Example with Non-Separable Emissions

general lobbying. As  $\theta$  grows beyond a certain level, private lobbying is so much higher than general lobbying that the crowding out on general lobbying no longer matters, and emissions grow.

## 6 Conclusions

Our analysis has shown that distributive concerns among anti-environmentalist lobbies may lead to improved environmental quality. Firms put more emphasis on private lobbying the more they expect politicians to supply loopholes. If the lobbying budget is fixed, an increase in private lobbying induces a decrease in general lobbying, the net effect of which is a reduction in emissions. The results are less clear-cut in the flexible budget case, but they continue to hold if private lobbying has a sufficiently strong negative effect on general

lobbying.

It is important to note that the politicians responsiveness to private lobbying does not just reflect his preferences. It depends in an essential manner on the type of regulation considered. In some cases, the very nature of the problem will leave only limited scope for private lobbying. In others, there are so many ways to design a regulation that the politician's discretion is rather high. We can conclude from our analysis that environmental regulation is more likely in the latter case than in the former. However, there is an important caveat to our analysis. We have focussed entirely on distributional concerns among anti-environmental lobbies. Symmetric issues arise with pro-environmental lobbies, however. Environmental lobbies will be in favor of environmental regulations, but may disagree on the right type. For instance, with respect to climate policy, some environmentalists advocate joint implementation, whereas others are strictly against it. More generally, attitudes towards market instruments differ across environmentalists. Similarly, environmentalists disagree on the relative importance of different topics: For instance, for some nuclear energy constitutes the main problem, whereas others are more concerned about climate issues. Thus, some groups concentrate on "private lobbying" against nuclear energy, whereas others focus on private lobbying against carbon dioxide. The "general lobbying" for reduced total energy consumption may therefore suffer, for reasons similar to the ones discussed in the paper. Clearly, there may be cases where the disagreements between environmentalists are less profound than those between anti-environmental lobbies. Casual evidence for energy policy suggests, however, that this is not necessarily so.

Although our model is formulated as a lobbying game against environmental regulation, the general idea is potentially relevant for arbitrary policy games such that interest groups have a common aim, but compete about the distribution of its benefit. For example, consider the lobbying behavior of different import industries fighting for protection. The industries will agree in that they prefer a high general degree of protection. But given that a

certain level of protection is realized, they disagree about how protection should be distributed across industries. Similarly, consider redistribution schemes between the members of federal states. Net recipients of transfers have a common interest in a high level of redistribution, but compete about the distribution of these gains. It will be the subject of further research to understand the implications of our arguments in these settings.



## 7 Appendix

### 7.1 A: Continuous Lobbying with Fixed Budget: Proofs

#### 7.1.1 Proof of Proposition 1

The denominator of  $\frac{dp^i}{d\theta}$  is positive by (7) and assumption 3. Hence

$$\begin{aligned} \text{sign} \left\{ \frac{dp^i}{d\theta} \right\} &= \text{sign} \{ -\tilde{\pi}_{i\theta}^i \tilde{\pi}_{jj}^j + \tilde{\pi}_{j\theta}^j \tilde{\pi}_{ij}^i \} \\ &= \text{sign} \{ -\pi_E^i l_{i\theta}^i \pi_E^j (l_{jj}^j + B_{gg}) + \pi_E^j l_{j\theta}^j \pi_E^i (l_{ij}^i + B_{gg}) \} \\ &= \text{sign} \{ -l_{i\theta}^i (B_{gg} + l_{jj}^j) + l_{j\theta}^j (B_{gg} + l_{ij}^i) \}. \end{aligned}$$

This yields the result.

#### 7.1.2 Proof of Corollary 2

By corollary 1, we can restrict ourselves to the case that  $\tilde{\pi}_{ij}^i = \pi_E^i (l_{ij}^i + B_{gg}) < 0$ . Suppose that both firms decrease  $p^i$ . From proposition 1,  $\frac{(B_{gg} + l_{11}^1)}{(B_{gg} + l_{21}^2)} < \frac{l_{1\theta}^1}{l_{2\theta}^2}$  and  $\frac{(B_{gg} + l_{22}^2)}{(B_{gg} + l_{12}^1)} < \frac{l_{2\theta}^2}{l_{1\theta}^1}$  must hold. These two conditions yield  $\frac{(B_{gg} + l_{11}^1)}{(B_{gg} + l_{21}^2)} < \frac{l_{1\theta}^1}{l_{2\theta}^2} < \frac{(B_{gg} + l_{12}^1)}{(B_{gg} + l_{22}^2)}$  and thus  $(B_{gg} + l_{11}^1)(B_{gg} + l_{22}^2) < (B_{gg} + l_{12}^1)(B_{gg} + l_{21}^2)$ . This contradicts assumption 3, which implies that  $(B_{gg} + l_{11}^1)(B_{gg} + l_{22}^2) > (B_{gg} + l_{12}^1)(B_{gg} + l_{21}^2)$ . Thus at least one firm must increase  $p^i$ .

#### 7.1.3 Proof of Proposition 1

The effect of a change  $(dp^1, dp^2)$  on total emissions is

$$dTE^L = -2B_g(dp^1 + dp^2) + (l_1^1 + l_1^2)dp^1 + (l_2^2 + l_2^1)dp^2.$$

By the first order conditions,  $B_g = l_1^1 = l_2^2$  in equilibrium, so that

$$dTE^L = [-B_g + l_1^2]dp^1 + [-B_g + l_2^1]dp^2.$$

Result (b) immediately follows.

If both firms increase private lobbying,  $dTE^L < 0$  is equivalent to

$$\frac{dp^1}{dp^2} > -\frac{[-l_2^2 + l_2^1]}{[-l_1^1 + l_1^2]}.$$

Note that the right hand side is negative and the left hand side is positive. Emissions thus fall if both firms increase private lobbying.

## 7.2 B: Continuous Lobbying with Endogenous Budget: Proofs

By symmetry, for  $i = 1, 2$ ,

$$\Pi_{p^i p^i}^i = \pi_{EE}^i (l_i^i)^2 + \pi_E^i l_{ii}^i \leq 0 \quad (11)$$

$$\Pi_{g_1 g_1}^1 = \Pi_{g_1 g_2}^1 = \Pi_{g_2 g_1}^2 = \Pi_{g_2 g_2}^2 = \pi_{EE}^i (B_g)^2 + \pi_E^i B_{gg} \leq 0 \quad (12)$$

$$\Pi_{g_1 p^1}^1 = \Pi_{p^1 g_1}^1 = \Pi_{p^1 g_2}^1 = \Pi_{p^2 g_1}^2 = \Pi_{p^2 g_2}^2 = \Pi_{g_2 p^2}^2 = \pi_{EE}^i B_g l_i^i \leq 0 \quad (13)$$

$$\Pi_{p^1 p^2}^1 = \Pi_{p^2 p^1}^2 = \pi_{EE}^i l_i^i l_j^i - l_{ij}^i \pi_E^i \geq 0 \quad (14)$$

$$\Pi_{g_1 p^2}^1 = \Pi_{g_2 p^1}^2 = \pi_{EE}^i B_g l_j^i \geq 0 \quad (15)$$

$$\Pi_{p^1 \theta}^1 = \Pi_{p^2 \theta}^2 = \pi_E^i l_{i\theta}^i + \pi_{EE}^i l_{\theta l_j}^i \geq 0 \quad (16)$$

$$\Pi_{g_1 \theta}^1 = \Pi_{g_2 \theta}^2 = \pi_{EE}^i l_{\theta}^i B_g \leq 0 \quad (17)$$

Using these conditions together with the implicit function theorem, finding  $dp^i/d\theta$  and  $dg^i/d\theta$  reduces to the solution of

$$\begin{aligned} (\pi_{p^i p^i}^i + \pi_{p^i p^j}^i) dp_*^i + 2\pi_{p^i g^i}^i dg_*^i &= -\pi_{p^i \theta}^i d\theta \\ (\pi_{p^i g^i}^i + \pi_{g^i p^i}^i) dp_*^i + 2\pi_{g^i g^i}^i dg_*^i &= -\pi_{g^i \theta}^i d\theta, \end{aligned}$$

which is given by

$$\frac{dp^{i*}}{d\theta} = \frac{\pi_{g^i g^i}^i \pi_{p^i \theta}^i - \pi_{g^i \theta}^i \pi_{p^i g^i}^i}{\left(\pi_{p^i g^i}^i\right)^2 + \pi_{p^i g^i}^i \pi_{g^i p^j}^i - \pi_{g^i g^i}^i \pi_{p^i p^i}^i - \pi_{g^i g^i}^i \pi_{p^i p^j}^i}, \quad (18)$$

$$\frac{dg^{i*}}{d\theta} = \frac{1}{2} \frac{\pi_{p^i p^i}^i \pi_{g^i \theta}^i + \pi_{p^i p^j}^i \pi_{g^i \theta}^i - \pi_{p^i \theta}^i \pi_{p^i g^i}^i - \pi_{p^i \theta}^i \pi_{g^i p^j}^i}{\left(\pi_{p^i g^i}^i\right)^2 + \pi_{p^i g^i}^i \pi_{g^i p^j}^i - \pi_{g^i g^i}^i \pi_{p^i p^i}^i - \pi_{g^i g^i}^i \pi_{p^i p^j}^i} \quad (19)$$

We can now use these conditions to derive propositions 3 and 4.

### 7.2.1 Proof of Proposition 3

WLC, (14) and (15) imply  $\Pi_{p^i p^j}^i = 0$  and  $\Pi_{g^i p^j}^i = 0$ . Therefore, using (19) and (18),

$$\frac{dp_*^i}{d\theta} = \frac{\pi_{g^i g^i}^i \pi_{p^i \theta}^i - \pi_{g^i \theta}^i \pi_{p^i g^i}^i}{\left(\pi_{p^i g^i}^i\right)^2 - \pi_{g^i g^i}^i \pi_{p^i p^i}^i}, \quad \frac{dg_*^i}{d\theta} = \frac{1}{2} \frac{\pi_{p^i p^i}^i \pi_{g^i \theta}^i - \pi_{p^i \theta}^i \pi_{p^i g^i}^i}{\left(\pi_{p^i g^i}^i\right)^2 - \pi_{g^i g^i}^i \pi_{p^i p^i}^i}. \quad (20)$$

(11)-(17) show that the numerator of  $\frac{dp_*^i}{d\theta}$  is negative and the denominator of  $\frac{dg_*^i}{d\theta}$  is positive. The denominators in (20) are negative by concavity of  $\pi$ .

### 7.2.2 Proof of Proposition 4

**Proof.** (16), (17) and  $l_\theta^i = 0$  yield  $\Pi_{p^i \theta}^i = \pi_E^i l_{i\theta}^i > 0$ ,  $\Pi_{g^i \theta}^i = 0$  and  $\Pi_{p^i g^i}^i = \Pi_{g^i p^j}^i$ . Thus, by (7) and (19)

$\frac{dp_*^i}{d\theta} = -\frac{\Pi_{p^i \theta}^i}{\left(\Pi_{p^i p^i}^i - \Pi_{p^i p^j}^i\right)} > 0$  and  $\frac{dg_*^i}{d\theta} = 0$ . By ILC, total emissions are therefore unchanged. ■

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