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Emission taxes, lobbying and incomplete enforcement

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Abstract

In this paper, I analyze incomplete enforcement in a political economy model. I use a contest framework to explain changes in lobbying behavior when special interest groups anticipate the incomplete enforceability of an emission tax. After the tax is proposed, two lobby groups – representing the interests of producers and environmentalists, respectively – seek to influence the legislator in order to prevent or support the approval and implementation of the regulation. I develop a general framework to demonstrate that the efforts of the interest groups to sway the legislator are motivated not only by the stringency of the proposed policy – as determined by the level of the tax – but, importantly, also by the policy's anticipated enforceability. Using common functional specifications, I then show that incomplete enforcement may not only reduce the industry's opposition to regulation compared to a situation with full enforcement, but it may – despite the possibility of misreporting of emissions – also reduce expected environmental damage.

Keywords: incomplete enforcement, compliance, environmental regulation, emission tax, lobbying, political contest

JEL classification numbers: D72, L51, Q58

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1 Introduction

Determining how best to enforce regulation is an important element of regulatory design and can pose considerable challenges for policy implementation. With limited monitoring capacities, governments cannot fully ensure that citizens adhere to all relevant rules and regulations. As a result, collusion, tax evasion, violation of health or safety standards, and misreporting of effluents or emissions, to name only a few examples, are commonplace. As environmental policies – the focus of this paper – have become stricter over time, the incentives to evade them have increased accordingly, which has been the subject of the extensive literature on monitoring, enforcement, and compliance. At the same time, more restrictive policies have led to special interest groups redoubling their efforts to influence the legislative process as they would like new regulation to reflect their own interests as closely as possible. The analysis of this competition for political influence has a long tradition in economics and, in particular, in environmental economics. In this paper, I seek to complement previous research on this topic by combining these two strands of the literature on regulation in order to analyze the interaction between incomplete enforcement and political competition. I integrate existing models in the respective fields to provide a novel analysis of the lobbying incentives of industrial and environmental interest groups that anticipate the inability of regulatory authorities to fully enforce environmental policies.

The main research question is thus how the lobbies' efforts and the consequent political equilibrium are affected when interest groups know that regulation – once approved by the legislator – cannot be fully enforced. To answer this question, I develop a political economy model in which regulation to limit the emissions of an industrial process is proposed before the legislator – under the influence of both environmental and industry lobby groups – decides whether to accept or reject the policy proposal. This framework reflects the important role interest groups play in parliamentary systems. Whether or not the policy is implemented, thus, crucially hinges on the lobbies: their relative efforts in the political contest, which depend on both the stringency and the enforceability of the proposed regulation, determine their respective prospects of success. If the environmental (industry) lobby succeeds, the proposal is (not) approved and regulation is (not) implemented. Given the prevailing regulation after the political process, the firm then decides how much to produce and whether or not (or to what degree) to comply with the regulation. Emissions and environmental damage ensue. I find that, counterintuitively and due to reduced opposition by the producers of the regulated good, incomplete enforcement may actually reduce expected environmental damage compared to a situation in which an equally stringent policy could be fully enforced.

Unlike traditional political economy models, the framework in this paper accounts for the fact that environmental policies are typically not perfectly enforceable. This has been analyzed for a variety of instruments and contexts (see, e.g., Harford, 1978, 1987; Sandmo, 2002; Macho-Stadler and Perez-Castrillo, 2006; MacKenzie and Ohndorf, 2012). Heyes (2000) provides a comprehensive survey of the earlier literature. This literature, however, takes regulation as given and ignores the political process preceding its approval and implementation. Related to the analysis presented here are studies assuming that, if a violation is detected, fines are contestable. This work was instigated by Kambhu (1989), who – in a general model of a regulatory standard – investigates compliance behavior of firms when they can challenge regulatory outcomes. He finds that relaxing the standard may increase the compliance performance of firms. Several authors have built on this work, including Nowell and Shogren (1994), who find that when enforcement can be challenged, the traditional approach of raising the fine for violations of the law or increasing monitoring efforts (i.e., strengthening enforceability) cannot guarantee a reduction of illegal pollution.

Underlying these analyses, however, is again the assumption that regulation is already in place. I, on the other hand, analyze contestability at an earlier stage, i.e., I allow the industry (and an environmental lobby) to contest the implementation of the policy itself rather than challenging its outcome. The papers by Cheng and Lai (2012) and Ovaere et al. (2013), who – in contrast to this paper – use the common-agency-model of Grossman and Helpman (1994), are closest to my framework. The analysis presented here, however, deviates from those studies in several important aspects. Whereas Ovaere et al. (2013) analyze the influence of lobby groups on enforcement given an environmental standard, Cheng and Lai (2012) focus on lobbies' influence on an emission tax rate given an exogenous enforcement policy. I, on the other hand, analyze the marginal impact of both enforcement and stringency parameters on the political equilibrium. In addition, Ovaere et al. (2013) consider a discrete compliance decision by the firms, i.e., to comply fully or not at all, whereas I allow for partial compliance by the firms as they decide on their optimal level of output, abatement and reported emissions. The framework of Cheng and Lai (2012) accounts for these factors as well, yet they do not make the important distinction between short- and long-term effects, whose differences are highlighted in this paper.

In short, the model presented here accounts for the political competition preceding the implementation of any policy and thereby assists in filling an important gap in the literature on the political economy of regulation. The industry produces a good and – as a by-product – polluting emissions and regulation is proposed to limit this externality. A green lobby supports this proposal in order to reduce the environmental impact, while the industry, represented by the brown lobby, opposes it to avoid having to incur additional (compliance) costs. To model the political competition within the legislative process, I draw from the literature on contests. In particular, I use the lottery contest success function of Tullock (1980), which reflects the idea that interest groups can influence the legislator, but they cannot extort a certain decision or policy from the legislator. Rather, the efforts of the lobbies determine the probability of their preferred policy being passed. Whereas political economy models of regulation typically assume perfect compliance if regulation is enacted, I allow for noncompliant behavior by the firm. To do so, I extend the firm's decision set: the firm now has to decide not only on the profit-maximizing output, but also on the optimal degree of regulatory compliance, which is determined by reported emissions and abatement effort. The compliance decision is driven by the potential fine for violations of the policy as well as by the likelihood of such violations being detected. The model of political competition presented here enables me to determine the probability of policy approval given the lobbies' political efforts when enforcement is incomplete and it allows for the analysis of the factors that increase (or decrease) these efforts and the resulting probability of approval.

The framework I develop in this paper contributes to the political economy literature on regulation as it combines the work on incomplete enforcement with that on political influence and thereby allows for a more realistic description of the regulatory process.

To the best of my knowledge, this is one of the first analyses of the interaction between the firm's effort to influence legislation directly and its compliance decision. In a setting with incomplete enforcement, the possibility of lowering compliance cost by, for example, misreporting its actual emissions, can reduce the opposition of the industry to introduce regulation. I am able to show that, as a result, for the common specifications of the functional forms at hand, when an imperfectly enforceable emission tax is proposed, expected environmental damage is reduced compared to an equivalent, but fully enforceable policy proposal, which attracts stronger opposition. In other words, from an environmental perspective, some leniency in the enforcement of a policy may be desirable as it may signficantly increase its chances of implementation.

The paper is organized as follows: in Section 2, I develop the general framework of political competition with incomplete enforcement. I describe the equilibrium and derive general results. Employing widely used functional forms in Section 3 and focusing on the short-term optimization of the firm, I demonstrate the applicability of the general model. I derive explicit results in order to analyze the different drivers of the political equilibrium in the short term, which is determined not only by the stringency of the proposed regulation but also by its enforceability. Section 4 analyzes the long-term profit maximization by the firm – including its optimal choice of abatement technology – while Section 5 concludes.

2 General model

Consider a representative firm that produces and sells x units of a good on a competitive output market at price p.[1] The price is defined by inverse demand $p(x)$ and is strictly decreasing and quasi-concave in output produced. The production of the good generates emissions e at a rate $e = \frac{\phi}{\gamma} \cdot x$, which cause environmental damage. I refer to $\phi > 0$ as the emission parameter, whereas $\gamma \geq 1$ denotes an abatement technology, which could be prescribed by the regulator or – in the long run – could be chosen by the firm. Here, to limit pollution, an emission tax is proposed, leaving the choice of abatement technology

[1]One could think of many identical firms, whose total number is normalized to one; alternatively, the representative firm could be an association of producers characterized by a similar cost structure. Each individual firm would then not be aware of its impact on the equilibrium price. Accordingly, I assume the market to be competitive and, therefore, the firm treats the price as being exogenous.

up to the firm. The stringency of the environmental policy is captured by parameter $t \in [0, \infty)$ and is increasing in the latter. Initially, $\gamma = 1$, but by adopting an abatement technology $\gamma > 1$, in the long term, the firm is able to modify the production process in a way that reduces the rate of emissions, thereby reducing the firm's tax burden or a possible fine. While the status quo is a situation without regulation, i.e., $t = 0$, assume now that regulation is proposed at some level $\tau > 0$. The legislator can either approve this proposal or reject it, therefore, its policy options are described by $t = \{0, \tau\}$. Even if the policy is approved and implemented, the degree of its enforcement is what ultimately determines the level of compliance and, hence, its environmental benefit. Let F describe the penalty scheme as a function of the degree of noncompliance and let $\mu \in [0, 1]$ denote the likelihood the representative firm assigns to it being caught if it violates the policy, which could, for instance, depend on the announced frequency of inspections. The proposed regulation is thus fully described by $\Psi = (\tau, \mu, F)$, where τ measures the stringency of the proposal and μ and F determine its enforceability.[2]

Having received information about the proposed environmental policy, special interest groups gauge the potential impact of the regulatory scheme on their respective objective and then try to sway the legislator in an attempt to manipulate the probability of approval. I consider a set of lobby groups $I = \{B, G\}$. The interests of the industry are represented by a brown lobby B that opposes the approval and implementation of the policy proposal as that would increase the firm's cost and lower its profit. A green lobby G, which represents environmental interests, supports the proposed bill as it seeks to reduce the negative environmental impact caused by the production of x. The legislative decision to approve or reject the proposed regulation is modeled as a contest, which determines the probability of the proposal being passed. In short, first, a policy scheme is proposed at some level of stringency τ and enforceability μ and F. Next, the interest groups expend lobbying effort to alter the likelihood of this proposal being accepted by the legislator. Following the legislator's decision, the firm observes the prevailing regulatory regime and decides on its output x and level of compliance.

[2]The stringency parameter τ as well as the enforcement parameters μ and F could be proposed at any level. If the objective of the regulator was clearly defined (e.g., to maximize welfare), the stringency and enforceability of the policy proposal could be derived from optimizing the corresponding objective function. The results presented here are more general, however, and hold for any combination of proposed stringency and enforceability, i.e., I do not consider political competition over the exact level of the policy.

The latter is captured by the choice variable z representing reported emissions, where $0 \leq z \leq e$. The payoffs of the two interest groups – determined by profit and environmental damage, respectively – ensue. To derive the equilibrium probability of policy approval, which is a function of the lobbies' efforts, I use backward induction. Hence, I first describe the market equilibrium, in particular, how to derive the equilibrium levels of output, abatement, and compliance, which I then use to calculate the political stake of each lobby.

2.1 Equilibrium production

Once the political contest has led to the implementation or rejection of the proposed regulatory scheme $\Psi = (\tau, \mu, F)$, the firm decides on the profit-maximizing levels of output x, compliance z, and – in the long run – also abatement technology γ:

$$\max_{x,\gamma,z} \Pi = p \cdot x(\Psi) - C\left(x(\Psi), \gamma(\Psi), z(\Psi), \Psi\right). \tag{1}$$

The firm's profit Π is a function of output, abatement, the stringency of the regulation, but also its enforcement and the resulting level of compliance. I assume that output is inversely related to the stringency of regulation measured by τ, i.e., $\frac{\partial x}{\partial \tau} < 0$. Total cost C is given by the sum of production, abatement, and regulatory costs (c_P, c_A, and c_R, respectively):

$$C(\cdot) = c_P\left(x(\Psi)\right) + \lambda \cdot \Big(c_A\left(x(\Psi), \gamma(\Psi)\right) + c_R\left(x(\Psi), \gamma(\Psi), z(\Psi), \Psi\right)\Big),$$

where $\lambda = 1$ if the proposed policy is approved and $\lambda = 0$ otherwise. Total cost is assumed to be increasing in both output and the stringency of the policy, therefore, $\frac{\partial C}{\partial x} > 0$ and $\frac{\partial C}{\partial \tau} > 0$. While output as well as abatement effort increase abatement cost, $\frac{\partial c_A}{\partial x} \geq 0$ and $\frac{\partial c_A}{\partial \gamma} > 0$, the impact of the abatement technology on total cost may be ambiguous, i.e., $\frac{\partial C}{\partial \gamma} \lesseqgtr 0$. Moreover, ensuring positive levels of output requires $\frac{\partial C(0)}{\partial \tau} < p(0) \forall \tau$. Given that the firm may be able to pass on (part of) the regulatory cost, the marginal impact of regulatory stringency on price p is positive, i.e., $\frac{\partial p}{\partial \tau} \geq 0$.

Finally, as more output generates more emissions, which have an increasingly harmful effect on the environment, pollution damage – denoted $D\left(x(\Psi), \gamma(\Psi), \delta\right)$ where δ is a damage parameter – is assumed to be convex in the level of output (and emissions), i.e., $\frac{\partial D}{\partial x} > 0$ and $\frac{\partial^2 D}{\partial x^2} \geq 0$, and decreasing in abatement effort and regulatory stringency: $\frac{\partial D}{\partial \gamma} < 0$ and $\frac{\partial D}{\partial \tau} < 0$.

2.2 The political contest

The main objective of the paper is to analyze the impact of a stricter, yet imperfectly enforced environmental policy on the lobbying behavior of the interest groups and the ensuing political equilibrium. The level of lobbying effort expended by an interest group is driven by its respective political stake. I denote the status quo payoffs of the brown and green lobby groups by Ω_U^B and Ω_U^G, respectively. With subscript "U" denoting the equilibrium without regulation ($\lambda = 0$), they are given by

$$\Omega_U^B = p_U \cdot x_U - c_P(x_U) = \Pi_U \text{ and} \tag{2}$$

$$\Omega_U^G = -D(x_U) = -D_U. \tag{3}$$

The payoff of the brown lobby group is, hence, defined by the profit of the representative firm whereas the (negative) payoff of the green lobby group is equivalent to the environmental damage caused by the production of x_U. If the proposed regulation is approved – indicated by subscript "R" – the new equilibrium and the lobbies' payoffs are characterized by

$$\Omega_R^B = p_R \cdot x_R - C(x_R, \gamma_R, z_R, \Psi) = \Pi_R \text{ and} \tag{4}$$

$$\Omega_R^G = -D(x_R, \gamma_R, \delta) = -D_R, \tag{5}$$

where x_R, γ_R, and z_R are all functions of Ψ.

I can now define the political stake of lobby group i, V_i with $i \in I$, as the difference between its payoffs given group i's preferred outcome and the subjectively worse equilibrium. Given that the green lobby prefers regulation to no regulation and the brown lobby's preference is vice versa, the political stakes are given by

$$V_B = \Omega_U^B - \Omega_R^B > 0 \text{ and} \tag{6}$$

$$V_G = \Omega_R^G - \Omega_U^G > 0. \tag{7}$$

The political stake of the brown lobby is, therefore, simply given by the difference in the firm's earnings with or without regulation. The political stake of the green lobby, on the other hand, is defined by the environmental damage avoided if the proposed emission tax is implemented.

The legislative process, which decides on the approval or rejection, is modeled as a political contest in which lobby group i – depending on its stake in this contest – expends effort, denoted $k_i(V_i)$, to manipulate the likelihood of the legislator's endorsement of the policy. The lobbying effort of interest group i relative to total lobbying expenditures – adjusted for a potential bias of the legislator – determines the probability of it being successful in the political competition. The group's probability of success is given by

$$\rho_i(k_i, k_{-i}) = \begin{cases} \frac{k_i^r}{k_i^r + k_{-i}^r \cdot \omega_{-i}} & \text{if } \max\{k_i, k_{-i}\} > 0, \\ \frac{1}{2} & \text{otherwise,} \end{cases} \tag{8}$$

where $-i = I \setminus \{i\}$, parameter $r > 0$ determines the return on lobbying expenditure, and parameter $\omega_{-i} \geq 0$ represents a potential bias towards one lobby group or the other (if any).[3] To simplify notation, for the remainder of the paper I denote $\rho_G = \rho$ and $\rho_B = 1 - \rho$. The green lobby's probability of success in the contest, $\rho = \frac{k_G^r}{k_G^r + k_B^r \cdot \omega_B}$, is, of course, equivalent to the probability of the proposed policy scheme Ψ being approved by the legislator. Given their respective potential payoffs following the approval or rejection of the policy proposal, the interest groups choose their effort to maximize their net expected payoffs:

$$\max_{k_i} E[\Omega^i] = \rho(k_i, k_{-i}) \cdot \Omega_R^i + (1 - \rho(k_i, k_{-i})) \cdot \Omega_U^i - k_i.$$

[3]Both Konrad (2009) and Epstein and Nitzan (2010) provide an extensive analysis of this mechanism. ω_{-i} could also denote differences between the two groups' efficiencies in lobbying.

I denote the pure strategy Nash equilibrium that solves this game by k_i^*:

$$k_i^* = \frac{r \cdot V_i^{r+1} \cdot V_{-i}^r \cdot \omega_{-i}}{(V_i^r + V_{-i}^r \cdot \omega_{-i})^2}, \tag{9}$$

where V_i and V_{-i} are determined in (6) and (7). Hence, $k_i^* > 0$, which enables me to rewrite the equilibrium probability of policy approval defined in (8) as

$$\rho^* = \frac{V_G^r}{V_G^r + V_B^r \cdot \omega_B}, \tag{10}$$

which is the green lobby group's political stake relative to total political stakes and adjusted for the potential bias of the legislator. It is straightforward to show, however, that even if such bias exists, it does not affect the marginal impact of a more stringent policy proposal – or the impact of its stricter enforcement – on the equilibrium probability of policy approval. The derivative with respect to the policy parameters is given by

$$\frac{\partial \rho^*}{\partial \theta} = \frac{r \cdot V_B^{r-1} \cdot \omega_B \cdot V_G^{r-1} \left(\frac{\partial V_G}{\partial \theta} V_B - \frac{\partial V_B}{\partial \theta} V_G \right)}{\left(V_G^r + V_B^r \cdot \omega_B\right)^2},$$

where $\theta = \{\tau, \mu, F\}$. A more stringent policy proposal would be defined by a larger tax τ whereas stricter enforcement is characterized by either more frequent inspections as represented by larger μ or a larger fine defined by the penalty function F. Proposition 1 follows directly (see also Gerigk et al., 2015):

Proposition 1. *The equilibrium probability of policy approval, ρ^*, increases in the stringency or enforceability of the proposed emission tax if and only if*

$$\frac{\frac{\partial V_G}{\partial \theta}}{V_G} > \frac{\frac{\partial V_B}{\partial \theta}}{V_B}. \tag{11}$$

Intuitively, one might expect a stricter proposal to decrease the probability of its approval, yet this need not be the case. If the relative (positive) marginal environmental impact is greater than the relative (negative) marginal impact on profit, the green lobby increases its support relatively more than the brown lobby increases its opposition. As a result, the equilibrium probability of approval may increase.

Whether or not condition (11) holds is thus crucially driven by the effect of the policy parameters on the political stakes of the two interest groups. The firm's profit and environmental damage after implementation of the proposed emission tax, Π_R and D_R, are functions of Ψ and defined by (4) and (5), respectively. As Π_U and D_U are independent of the policy parameters, the marginal impact of the latter on the lobbies' political stakes is given by $\frac{\partial V_B}{\partial \theta} = -\frac{\partial \Pi_R}{\partial \theta}$ and $\frac{\partial V_G}{\partial \theta} = -\frac{\partial D_R}{\partial \theta}$, respectively, where I again use $\theta = \{\tau, \mu, F\}$. Using the first-order conditions from the firm's optimization problem to simplify notation, the marginal changes in the political stakes can be written as

$$\frac{\partial V_B}{\partial \theta} = \frac{\partial c_R}{\partial \theta} - x_R(\theta) \cdot \frac{\partial p_R}{\partial \theta} > 0 \text{ and} \tag{12}$$

$$\frac{\partial V_G}{\partial \theta} = -\left(\frac{\partial x_R}{\partial \theta} \cdot \frac{\partial D}{\partial x_R} + \frac{\partial \gamma_R}{\partial \theta} \cdot \frac{\partial D}{\partial \gamma_R} \right) \geq 0. \tag{13}$$

Note that the respective political stake of either interest groups is (weakly) increasing in the policy parameters. The impact of a policy change on environmental damage may be transmitted via two channels as it could alter the quantity produced as well as the abatement technology. Both effects increase the stake of the green lobby. The two channels affecting the stake of the brown lobby, on the other hand, are countervailing: the implementation of a stricter environmental policy may raise the equilibrium price, which has a negative marginal impact on the brown lobby's political stake, yet it also induces an increase of the firm's cost, which raises the industry's stake. Notwithstanding the potential price increase, the net effect of a stricter policy on the brown lobby's stake is always positive, because – given the assumption of perfect competition – the firm's cost increase always outweighs the additional marginal revenue. The more of the cost increase is offset by a concurrent price increase, however, the less effort can be expected from the brown lobby to oppose the policy approval. As a result, it is clear that, ceteris paribus, the stronger the price effect, the more likely it is for condition (11) to hold.

3 Compliance in the short term

I now apply common functional forms to the general framework of Section 2, initially assuming that the firm can only choose the levels of output and reported emissions. In the short term, however, it cannot change its production process to reduce actual emissions, i.e., the firm is not able to adopt an abatement technology $\gamma > 1$ to lower its regulatory cost. This assumption is relaxed in Section 4. Moreover, as my objective is to single out the impact of the individual policy parameters on the political competition and equilibrium, I use the simplest plausible specifications for the demand and supply functions. Supply is determined by marginal cost, which I derive from $C^S(x(\Psi), z(\Psi), \Psi) = c_P(x) + \lambda \cdot c_R(x(\Psi), z(\Psi), \Psi)$, where superscript "S" denotes the short term and where production cost is given by

$$c_P(x(\Psi)) = \frac{\sigma \cdot x(\Psi)^2}{2}.$$

Parameter $\sigma > 0$ characterizes the slope of the supply curve. As the firm is not able to modify the abatement technology ($\gamma = 1$), for a given level of production, it can only reduce a potential fine by reporting more truthfully. Regulatory cost is defined by

$$c_R(x, z, \Psi) = \tau \cdot z(\Psi) + \mu \cdot F(e, z) \text{ with } F(e, z) = f \cdot (e(\Psi) - z(\Psi))^2, \tag{14}$$

where f is a monetary unit measuring the severity of the fine, which typically exceeds the cost of compliance, thus, $f > \tau$. Furthermore, the penalty scheme is convex and, therefore, progressive in the degree of noncompliance.[4] I assume inverse demand to be linear and given by

$$p(x(\Psi)) = A - \alpha \cdot x(\Psi). \tag{15}$$

Note, however, that the market is assumed to be competitive, hence, the representative firm does not account for its impact on the equilibrium price. Given above specifications, I can now compute the status quo market equilibrium as well as equilibrium production and price following the approval of the policy proposal. To ease the interpretation of the results and to focus on the effects of the stringency and enforcement parameters, for the remainder of the paper I assume $r = \omega_B = \alpha = \sigma = 1$. Alternative specifications of the parameters are straightforward, but do not change the qualitative results.

[4]This is a common assumption in the literature and used, e.g., in Harford (1978), Sandmo (2002), and Macho-Stadler and Perez-Castrillo (2006). Linear penalty schemes with a constant marginal fine typically lead to an all-or-nothing decision, such that a firm either fully complies or does not comply at all. In that case, the enforcement parameters only affect the equilibrium outcome at the threshold between compliance and noncompliance.

3.1 Equilibrium on the output market without regulation

The preferred outcome of the industry is naturally the rejection of the policy proposal and the perpetuation of the status quo ($\lambda = 0$). In that case, $C(x) = c_P(x)$ and maximization of (1) simply equates output price and marginal production cost. It is straightforward to show that the market equilibrium is then characterized by

$$x_U = \frac{A}{2} \text{ and} \tag{16}$$

$$p_U = \frac{A}{2}. \tag{17}$$

If the output is not regulated, the representative firm, therefore, earns a profit of $\Pi_U = \frac{A^2}{8}$. At the same time, $e_U = \phi \cdot x_U$ emissions are generated, which cause environmental damage

$$D_U = \frac{\delta \cdot e_U^2}{2} = \frac{A^2 \cdot \delta \cdot \phi^2}{8}. \tag{18}$$

D_U and Π_U are the respective payoffs of the interest groups given the status quo, which the green lobby G tries to change and the brown lobby B tries to maintain.

3.2 Equilibrium on the regulated market

Now assume that a policy scheme $\Psi = (\tau, \mu, F)$ has been proposed, where F is defined by (14). To decide on the level of their respective lobbying efforts, the interest groups have to anticipate the impact of the policy on the market equilibrium and the environment if it is approved. In the short term, the firm chooses output and reported emissions to maximize

$$\max_{x,z} \Pi\left(x(\Psi), z(\Psi), \Psi\right) = p \cdot x - \left(\underbrace{\frac{x^2}{2}}_{c_P} + \underbrace{\tau \cdot z + \mu \cdot f \cdot (\phi x - z)^2}_{c_R} \right). \tag{19}$$

The necessary conditions allow me to derive the profit-maximizing levels of compliance and output, z_R^S and x_R^S, and to determine the new equilibrium price, p_R^S:[5]

[5] Note that the Hessian matrix of the optimization problem defined by (19) is negative definite, which proves that x_R^S and z_R^S indeed define a maximum.

$$x_R^S = \frac{A - \phi\tau}{2}, \tag{20}$$

$$z_R^S = \frac{1}{2}\left(\phi(A - \phi\tau) - \frac{\tau}{\mu f}\right), \text{ and} \tag{21}$$

$$p_R^S = \frac{A + \phi\tau}{2}. \tag{22}$$

Note that for an interior solution with positive levels of production, demand has to be sufficiently large, i.e., $A > \phi\tau$. Furthermore, z_R^S can be rewritten as $z_R^S = \phi \cdot x_R^S - \frac{\tau}{2\mu f}$ and for this to be positive, $f \geq \frac{\tau}{\mu\phi(A - \tau\phi)}$ has to hold. Throughout the rest of the paper, I assume these conditions to be fulfilled.

3.3 The political contest

The equilibrium values (20)-(22) enable me to compute the firm's profit after policy approval as well as the environmental damage caused by the production of x_R^S. They are given by

$$\Pi_R^S = \frac{1}{8}\left((A - \phi\tau)^2 + \frac{2\tau^2}{\mu f}\right) \text{ and}$$

$$D_R^S = \frac{\delta\phi^2(A - \phi\tau)^2}{8},$$

respectively. Calculating the political stakes of the two interest groups defined by equations (6) and (7) is then straightforward. The efforts by the lobbies, k_B and k_G, are spurred by the stakes

$$V_B^S = \frac{\tau\left(\mu f \phi(2A - \phi\tau) - 2\tau\right)}{8\mu f} \text{ and} \tag{23}$$

$$V_G^S = \frac{\delta\phi^3\tau(2A - \phi\tau)}{8}. \tag{24}$$

In its general form, the equilibrium probability of the policy scheme being approved is defined by (10) and it is a function of the lobbies' stakes in the political contest. By the use of (23) and (24), in equilibrium, the probability of approval for above specification is then given by

$$\rho^S = \frac{\delta \mu f \phi^3 (2A - \phi\tau)}{\mu f \phi (2A - \phi\tau)(\delta\phi^2 + 1) - 2\tau}. \tag{25}$$

The main aim of the analysis presented here is to investigate how the equilibrium is changed following a (marginal) change in the characteristics of the proposed policy. While the focus of much of the previous political economy literature has been on a stricter emission policy – here, a larger emission tax τ – similar to Ovaere et al. (2013) and the literature on contestable enforcement (e.g., Kambhu, 1989), I also analyze variations in the enforcement parameters, i.e., the frequency of inspections μ as well as larger fines f. The impact of the policy parameters on the brown lobby's political stake follows from the general finding of Equation (12) and is summarized in Lemma 1:

Lemma 1. *A marginal increase in one of the parameters determining the stringency and enforceability of the proposed environmental regulation – τ, μ, and f – has a strictly positive effect on the political stake of the brown interest group:*

$$\frac{\partial V_B^S}{\partial \tau} > 0,$$
$$\frac{\partial V_B^S}{\partial \mu} > 0, \textit{ and}$$
$$\frac{\partial V_B^S}{\partial f} > 0.$$

Proof. The proof follows directly from (23) and is, therefore, omitted. □

Regardless of the policy parameter being reinforced, the expected profit of the industry decreases and, hence, the brown lobby's stake increases. Equation (24) indicates that the situation is different for the green lobby; its reaction to changes in the policy parameters is summarized by the following lemma:

Lemma 2. *A marginal increase in one of the parameters determining the stringency and enforceability of the proposed environmental regulation – τ, μ, and f – has the following effect on the political stake of the green interest group:*

$$\frac{\partial V_G^S}{\partial \tau} > 0 \textit{ and}$$
$$\frac{\partial V_G^S}{\partial \mu} = \frac{\partial V_G^S}{\partial f} = 0.$$

Proof. The proof follows directly from (24) and is, therefore, omitted. □

While τ has the expected positive impact on the green lobby's stake, as production x_R^S is independent of μ and f, neither the probability of detecting noncompliance nor the severity of the fine have an effect on environmental damage and, therefore, they have no effect on the stake of the green lobby. As a result, given their impact on the brown lobby's stake, increases in the enforcement parameters should strictly decrease the equilibrium probability of policy approval. This intuition is confirmed by Corollary 1, which follows directly from the condition formulated in Proposition 1. The effect of an increase in τ on the equilibrium probability, ρ^S, on the other hand, is a priori unclear as both V_B^S and V_G^S are increasing in regulatory stringency. For the above specification, the net effect is summarized as follows:

Corollary 1. *A change in the stringency of the proposed environmental regulation – equivalent to an increase in τ – has a strictly positive effect on the equilibrium probability of policy approval whereas increased enforceability – increases in μ or f – has the opposite effect:*

$$\frac{\partial \rho^S}{\partial \tau} > 0, \tag{26}$$

$$\frac{\partial \rho^S}{\partial \mu} < 0, \textit{ and} \tag{27}$$

$$\frac{\partial \rho^S}{\partial f} < 0. \tag{28}$$

I conclude that if the level of the tax, τ, is the driver of a stricter policy proposal, the likelihood of its implementation is strictly increasing, i.e., the green lobby's reaction to such change is relatively stronger than that of the brown lobby. In other words, the relative marginal environmental benefit of such a stricter proposal is strictly larger than the relative marginal increase of the cost to the producer. If, on the other hand, the driver of stricter regulation is one of the enforcement parameters, μ or f, this decreases the policy's chance of legislative approval. For the policymaker this may then raise the question whether stricter enforcement of the policy could actually improve the environmental outcome or whether a higher, yet less strictly enforced emission tax yields greater environmental benefits.

3.4 Full vs. incomplete enforcement

If stricter enforcement of the proposed policy lowers the probability of its approval, clearly, there is an environmental trade-off to be made. Is it preferable, from an environmental point of view, to have weak enforcement of regulation but a high probability of it being passed? Or should a lot of effort be spent on enforcing the regulation (if implemented) at the cost of lowering its chance of legislative approval in the first place? To answer these questions, I now consider the extreme case of full enforcement, which is regarded here as being equivalent to strict regulatory abidance by the firm. This is in line with the more traditional political economy literature on regulation, which typically assumes full compliance.

If the proposed emission tax, τ, can be fully enforced, the firm maximizes its profit by choosing the optimal level of production:[6]

$$\max_x \Pi\left(x(\tau), \tau\right) = p \cdot x - \frac{x^2}{2} - \tau \cdot \underbrace{\phi \cdot x}_{e}. \tag{29}$$

In equilibrium, this leads to the same level of production as in a situation with incomplete enforcement, i.e., $x_F^S = x_R^S$, where subscript "F" denotes the equilibrium with full enforcement. This is due to the fact that the stringency of enforcement only impacts the level of reported emissions, yet not the equilibrium output. Analogous to the calculations of previous sections, I can compute profit and environmental damage as well as the political stakes in the new equilibrium. The equilibrium probability of policy approval follows directly and is given by

$$\rho_F^S = \frac{\delta\phi^2}{1 + \delta\phi^2}. \tag{30}$$

When comparing equilibrium probabilities of policy approval (30) and (25), it is straightforward to show that $\rho^S > \rho_F^S$, which is in line with the finding of Corollary 1. More important from an environmental perspective, however, is the extent of the expected environmental damage under the two regimes, which are compared in Proposition 2:

[6]Note that due to the convex penalty function, this is not equivalent to $\mu = 1$: even if the firm was sure to be discovered when misreporting its emissions, unless $f \to \infty$, the firm would always deviate from truthful reporting by some (infinitesimally small) amount $e - z$.

Proposition 2. *Given a proposed level of the emission tax, τ, full enforceability of this policy proposal leads to strictly larger expected environmental damage compared to a situation with incomplete enforcement that would allow for the misreporting of emissions, i.e.,*

$$(1-\rho_F^S)\cdot D_U + \rho_F^S \cdot D_F^S > (1-\rho^S)\cdot D_U + \rho^S \cdot D_R^S.$$

Proof. Using the equilibrium values derived above yields the condition $x_U^2 > x_R^2$, which holds for any level of $\phi, \tau > 0$. □

Despite the possibility of (partial) noncompliance by the industry, proposing an incomplete enforcement regime delivers strictly less expected environmental damage than the proposal of a policy regime with full enforcement. The possibility of violating the policy and incorrectly reporting its environmental impact reduces the industry's opposition to the implementation of the regulation. Similar to studies in which the enforceability itself is contestable, I find that starting from a situation with incomplete enforcement, counterintuitively, increasing the enforcement effort for an emission tax cannot deliver on the objective of the policymaker to decrease (expected) environmental damage. The proposal of policies that can be fully enforced always attracts too much opposition by the brown lobby to yield sufficient environmental benefits.

4 Compliance and abatement in the long term

When regulation is introduced that requires the firm to pay a tax on its emissions, a natural response of the firm may be to introduce measures to reduce its emission rate. While the introduction of an abatement technology may not be feasible on short notice, in the medium to long term, the firm can adapt its production process to the new regulatory environment. To reduce the emission tax burden, the firm then has two decisions to make: it can still misreport its actual emissions ($z < e$), but it may now also modify production to lower the emissions per unit of output by adopting a new abatement technology ($\gamma > 1$). While misreporting reduces the amount of the tax paid by the firm, it increases the fine if the firm's noncompliance is exposed. Abatement, on the other hand, reduces both the tax to be paid as well as a potential fine, however, the firm, of course, has to incur the cost of implementing this technology. I assume that this cost depends on an abatement cost parameter η and is increasing in both the efficiency of the technology measured by γ as well as in output x. The profit maximization problem of the firm is then given by

$$\max_{x,\gamma,z} \Pi(x(\Psi), \gamma(\Psi), z(\Psi), \Psi) = px - \left(\underbrace{\frac{x^2}{2}}_{c_P} + \underbrace{\eta x(\gamma - 1)}_{c_A} + \underbrace{\tau z + \mu f \left(\frac{\phi \cdot x}{\gamma} - z \right)^2}_{c_R} \right). \quad (31)$$

Inverse demand (15) and the first-order conditions determine the long-term equilibrium levels – denoted by superscript "L" – of production, abatement, reported emissions, and product price:[7]

$$x_R^L = \frac{A + \eta - 2\sqrt{\eta\phi\tau}}{2}, \quad (32)$$

$$\gamma_R^L = \sqrt{\frac{\phi\tau}{\eta}}, \quad (33)$$

$$z_R^L = \frac{\mu f \sqrt{\eta\phi}\,(A + \eta - 2\sqrt{\eta\phi\tau}) - \tau^{\frac{3}{2}}}{2\mu f \sqrt{\tau}}, \text{ and} \quad (34)$$

$$p_R^L = \frac{A - \eta + 2\sqrt{\eta\phi\tau}}{2}. \quad (35)$$

The ensuing environmental damage, D_R^L, and long-term profit of the firm, Π_R^L, follow directly. The difference between Π_R^L (D_R^L) and Π_U (D_U) determines the stake of the brown (green) lobby group given by

$$V_B^L = \frac{1}{2} \left(\frac{A^2}{4} - \frac{(A + \eta - 2\sqrt{\eta\phi\tau})^2}{4} - \frac{\tau^2}{2\mu f} \right) \text{ and} \quad (36)$$

$$V_G^L = \frac{\delta\phi}{8} \cdot \left(A^2\phi - \frac{\eta\,(A + \eta - 2\sqrt{\eta\phi\tau})^2}{\tau} \right). \quad (37)$$

It is straightforward to show that the conclusions of Lemma 1 and 2 still hold, i.e., (the sign of) the different policy parameters' marginal effect on the political stakes of the interest groups remains unchanged in the long term. As V_G^L is – analogous to the results for the short term – independent of μ and f, of course, the conclusions of Corollary 1

[7]The Hessian matrix of the optimization problem defined by (31) is negative definite, proving that x_R^L, γ_R^L and z_R^L define a profit maximum.

regarding the enforcement parameters' effect on the equilibrium probability of policy approval – now denoted ρ^L and determined by (10), (36), and (37) – still hold, i.e., their marginal effect on the likelihood of legislative approval remains negative in the long term: $\frac{\partial \rho^L}{\partial \mu} < 0$ and $\frac{\partial \rho^L}{\partial f} < 0$. This highlights again the important tradeoff between stricter enforcement and political feasability, which underlies the result of Proposition 2. In fact, assuming that the proposed tax level is fully enforceable in the long term results – again analagous to my findings for the short term – in a strictly lower probability of legislative approval: $\rho^L > \rho^L_F$, where subscript "F" again denotes full enforcement. As a result, the conclusion of Proposition 2 remains valid in the long term as the following corollary summarizes:

Corollary 2. *In the long term, when the representative firm can lower its emissions rate through the adoption of abatement technology, given a proposed level of the emission tax, τ, full enforceability of this proposal results in strictly larger expected environmental damage compared to a situation with incomplete enforcement that would allow for the misreporting of emissions, i.e.,*

$$(1 - \rho^L_F) \cdot D_U + \rho^L_F \cdot D^L_F > (1 - \rho^L) \cdot D_U + \rho^L \cdot D^L_R. \tag{38}$$

Full enforcement of the proposed tax continues to be harmful in the long term if the objective is to reduce expected environmental damage. By allowing the firms some leeway in the reporting of their emissions, the policymaker can increase the chances of policy approval considerably and thereby lower expected environmental damage.

When it comes to changes in the third policy parameter, τ, on the other hand, its marginal impact on the equilibrium probability of policy approval is notably different in the long term and no longer unambiguous. This is summarized in Proposition 3:

Proposition 3. *In the long term, provided a given level of enforceability, a marginal increase of the proposed emission tax, τ, has the following effect on the equilibrium probability of legislative approval ρ^L:*

$$\frac{\partial \rho^L}{\partial \tau} \begin{cases} > 0 & \text{if } \Lambda_1 < \delta < \Lambda_2, \\ \gtreqless 0 & \text{otherwise,} \end{cases}$$

where Λ_1 and Λ_2 are defined in Appendix A.

Proof. $\Lambda_1 < \delta \Leftrightarrow \frac{\partial V_G}{\partial \tau} > \frac{\partial V_B}{\partial \tau}$ and $\Lambda_2 > \delta \Leftrightarrow V_B > V_G$. If both inequalities hold, condition (11) is always satisfied. For more details, see Appendix A. $\square$

In the long term, the level of the emission tax, τ, has an impact on the level of production, the firm's reporting of emissions and, importantly, its abatement effort. These have varying and to some extent opposing effects on the lobbying of the two interest groups such that the marginal effect of a higher emission tax on its probability of legislative approval is typically ambiguous. It is possible, however, to use Proposition 1 to define a sufficient condition for an unambiguously positive effect of τ on ρ^L: if the damage parameter δ is large enough relative to other parameters such that $\frac{\partial V_G}{\partial \tau} > \frac{\partial V_B}{\partial \tau}$, yet not too large to ensure that $V_B > V_G$, the relative marginal reaction of the green lobby to changes in the tax rate always outweighs that of the brown lobby and the probability of policy approval ρ^L is increasing in the policy proposal's stringency. Note the ambiguous impact of the damage parameter, δ, here: whereas it does not affect the brown lobby, it strictly increases both the stake of the green lobby as well as its marginal reaction to a change in the proposed tax level. Ultimately, it is the change in the stakes of the lobby groups, V_B and V_G, relative to their original levels that determines the equilibrium effect of τ. As a result, for sufficiently large levels of δ, $V_G > V_B$ and the sufficient condition is no longer met such that the sign of the marginal effect of τ on ρ^L is uncertain.

In short, while an increase in the enforcement parameters μ and f continue to reduce the probability of policy approval in the long run, the long-term effect of an increase in the stringency parameter τ is ambiguous: different elements of the firm's reaction to such an increase – consisting of lower production, less misreporting of emissions and more abatement effort – may have opposing effects on the interest groups' lobbying efforts, therefore, rendering an unequivocal policy recommendation impossible.

5 Discussion and conclusion

The purpose of this paper is to analyze the strategic behavior of special interest groups and their impact on regulation when the latter is not fully enforced. Whereas the influence of lobbies has been studied extensively in the political economy literature, incomplete enforcement has been widely neglected in these studies. Nevertheless, we often observe that firms or individuals, knowing that violations may not be detected, do not (fully) comply with regulation limiting their legal set of actions. While this may occasionally be due to ignorance, conscious and strategic disregard of regulations seems more often than not to be the underlying driver of these violations. In a model with a representative firm whose emissions may or may not be taxed, I study the political contest between brown and green interest groups when they anticipate the incomplete enforceability of the proposed tax and the consequent level of noncompliance. This study, therefore, contributes to and expands the literature on the political economy of regulation as it is one of the first analyses to account for the incomplete enforcement of the policy in question.

To do so, I first develop a general model of the political competition between the brown and green interest groups, which is based on the policy contest framework of Tullock (1980). An important conclusion from the analysis of the general model is that the relative intensity of the reactions by the lobby groups to changes in the model parameters drives the political equilibrium, namely the probability of policy approval: if the brown (green) lobby is most affected by a marginal increase in one of the parameters, the probability of approval decreases (increases). While I focus on the policy parameters, these results would equally hold for parameters characterizing, for example, environmental damage, demand or supply. Next, I specify the model with common functional forms and find that the policy's stringency parameter τ, i.e., the level of the proposed tax, has a positive marginal effect on the probability of policy approval in the short term. This is due to the fact that the level of the tax has a relatively stronger effect on the green lobby's political stake than on that of the industry, which can pass on part of the regulatory cost to the consumer. On the other hand, pushing for tighter enforcement of the policy – either by conducting more frequent inspections or by increasing the potential fine – may be detrimental to the objective of lowering pollution as it decreases the chance of legislative approval both in the short and long term. In these cases, the brown lobby is more affected and increases its effort in the legislative process accordingly. These results are in line with the findings of Kambhu (1989); Heyes (1994); Garvie and Keeler (1994); Cheng and Lai (2012), who demonstrate that the impact of more frequent inspections may be counterintuitive and ambiguous at best. To conclude, full enforcement of a proposed emission tax may actually lower its expected environmental benefit and the regulator may be better off allowing for some degree of infringement.

As pollution of various kinds is causing severe environmental damage, locally as well as globally, governments around the globe have responded by tightening environmental regulation. This has been accompanied not only by a rising incentive for noncompliance, but also by political pressure from both industry as well as from environmentalists trying to influence the legislative process. An analysis of this political competition without accounting for the need to enforce proposed regulation is just as incomplete as the analysis of imperfect regulatory enforcement without considering the political process preceding the regulation's implementation. In this paper, I have developed a model that enables me to analyze the interaction between the two and that, therefore, provides a more realistic picture of the world than previous models. I illustrate the important difference between the stringency of the policy and the strictness of its enforcement, which both motivate the level of effort by the lobby groups but may have opposing effects on the political equilibrium. Finally, the applicability of the framework developed here is, of course, not limited to an emission tax, but may be equally adequate in the context of other environmental policy instruments, safety regulation, health standards or the like.

A Mathematical Appendix

Proof of Proposition 3 Re-writing equations (36) and (37) yields

$$V_B^L = \frac{1}{2}\left(x_U^2 - (x_R^L)^2 - \frac{\tau^2}{2\mu f}\right) \text{ and} \tag{A.1}$$

$$V_G^L = \frac{1}{2}\delta\phi^2\left(x_U^2 - \left(\frac{x_R^L}{\gamma_R^L}\right)^2\right), \tag{A.2}$$

where x_R^L and γ_R^L are defined by (32) and (33), respectively, and x_U is defined by (16). By use of condition (11), the following holds:

$$\frac{\partial V_G^L}{\partial \tau} > \frac{\partial V_B^L}{\partial \tau} \wedge V_B > V_G \Rightarrow \frac{\partial \rho^L}{\partial \tau} > 0.$$

Differentiation of (A.1) and (A.2) with respect to τ yields

$$\frac{\partial V_B^L}{\partial \tau} = -x_R^L \cdot \frac{\partial x_R^L}{\partial \tau} - \frac{\tau}{2\mu f} \text{ and} \tag{A.3}$$

$$\frac{\partial V_G^L}{\partial \tau} = \frac{\delta\phi^2\left(x_R^L \cdot \frac{\partial \gamma_R^L}{\partial \tau} - \gamma_R^L \cdot \frac{\partial x_R^L}{\partial \tau}\right)}{(\gamma_R^L)^3}. \tag{A.4}$$

By comparison of (A.1) and (A.2) as well as (A.3) and (A.4), the following holds:

$$\delta < \underbrace{\frac{(\gamma_R^L)^2\left(2\mu f((x_R^L)^2 - x_U^2) + \tau^2\right)}{2\mu f \phi^2\left((x_R^L)^2 - (\gamma_R^L)^2 x_U^2\right)}}_{\Lambda_2} \Rightarrow V_B > V_G$$

$$\delta > \underbrace{\frac{-(\gamma_R^L)^3 \cdot \left(2\mu f x_R^L \frac{\partial x_R^L}{\partial \tau} + \tau\right)}{2\mu f \phi^2 x_R^L\left(x_R^L \frac{\partial \gamma_R^L}{\partial \tau} - \gamma_R^L \frac{\partial x_R^L}{\partial \tau}\right)}}_{\Lambda_1} \Rightarrow \frac{\partial V_G^L}{\partial \tau} > \frac{\partial V_B^L}{\partial \tau}$$

Using the equilibrium values (16), (32), and (33), one can show that $\Lambda_2 > \Lambda_1$. This enables me to define the following three intervals:

1. $\delta > \Lambda_2 > \Lambda_1 \Rightarrow V_G > V_B \wedge \frac{\partial V_G^L}{\partial \tau} > \frac{\partial V_B^L}{\partial \tau} \Rightarrow \frac{\partial \rho^L}{\partial \tau} \gtrless 0$,
2. $\Lambda_2 > \delta > \Lambda_1 \Rightarrow V_B > V_G \wedge \frac{\partial V_G^L}{\partial \tau} > \frac{\partial V_B^L}{\partial \tau} \Rightarrow \frac{\partial \rho^L}{\partial \tau} > 0$, and
3. $\Lambda_2 > \Lambda_1 > \delta \Rightarrow V_B > V_G \wedge \frac{\partial V_B^L}{\partial \tau} > \frac{\partial V_G^L}{\partial \tau} \Rightarrow \frac{\partial \rho^L}{\partial \tau} \gtrless 0$.

Proposition 3 directly follows. $\square$

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