The Choice of Environmental Regulatory Enforcement by Lobby Groups

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Abstract:

Across countries and regions, we observe wide variations in the enforcement strategies that are used to reach compliance with environmental regulations. In this paper we study whether the differences in enforcement policies can be justified from an efficiency perspective, and if not, whether they favor the interests of certain lobby groups. We develop a theoretical model to derive the preferred enforcement policy, which is characterized from a global efficiency point of view, and also from the point of view of different interest groups. Also, we explicitly allow for a non-linear deterrence effect of fines. We find that, despite the regulatory costs, green interest groups generally favor more stringent enforcement strategies with high fines and high inspection frequencies, while brown interest groups prefer laxer enforcement strategies. However, we do not find conclusive empirical evidence to support this theoretical result for the European Union.

Keywords: Enforcement policy; Environmental standard; Lobby groups

JEL Classification: D78; H23; K42; Q58

I. Introduction

Across European countries and regions, we observe wide variations in the enforcement strategy that is used to reach compliance with environmental regulation. All states use the same instruments, inspections and sanctions (either monetary or by imprisonment). Previous studies have shown that the main features of monitoring and enforcement policies of OECD countries are rather similar (see for instance Gray and Shimshack (2011) and Nyborg and Telle (2006)). However, both the intensity of inspections and the level of punishment for a same environmental regulation greatly differ among European member states. The objective of this paper is to study the rationale for these variations, as enforcement is an important feature in the fight against climate change. There are several studies showing that enforcement has a considerable impact on an economy's emission level, see for instance Macho-Stadler and Pérez-Castrillo (2006).

We approach enforcement in a political economy context, focusing on the impact of interest groups on enforcement policy. For the political economy of enforcement of environmental standards we can draw upon two sources of literature. On the one hand, there is the (environmental) law enforcement field that studies the most efficient way of enforcing a given regulation (see Cohen, 2000 and Heyes, 2000 for a survey). Looking at previous results on the trade-off between inspections and sanctions, we have to start with Becker (1968). The model developed by Becker (1968) treats inspections and sanctions as perfect substitutes in terms of deterrence of potential violators. However, since setting high inspection frequencies is considerably more costly than setting high fines, the enforcement strategy favored by the regulator includes minimal inspections and maximal fines. Subsequently, more extended models have been developed to explain more realistic enforcement strategies. For instance, Polinsky and Shavell (1979) look at the trade-off between the probability of inspection and the level of the fine when individuals are risk averse rather than risk neutral. The presence of risk aversion allows the regulator to set fines at lower levels and still obtain the same deterrence level. Another paper by Polinsky and Shavell (1992) studies the impact of fixed and variable enforcement costs on the optimal fine and inspection probability. The authors find that if variable enforcement costs are high, the optimal probability will be low because enforcement will be expensive, and that, for sufficiently high variable enforcement costs, the optimal probability will be zero. Further, they find that the effect of fixed enforcement expenditures on the optimal probability depends on their productivity level. Polinsky and Shavell (1991) study how fairness and wealth constraints results in fines that cannot be set arbitrarily.

On the other hand, there is the literature that studies why certain (inefficient) economic policies are selected as a result of the political process of lobbying (see Persson and Tabellini, 2000). Crombez (2002) was the first author to apply interest group lobbying to the legislative process in the European Union. He analyzes lobbying under the consultation and codecision procedures, and distinguishes two different stages: the proposal stage and the voting stage. In the proposal stage, a lobbyist can influence the proposal that is put together, in the voting stage he can lobby for votes. Crombez (2002) finds that at the proposal stage it is optimal for the lobbyist to focus lobbying efforts on a policymaker with similar preferences, while at the vote stage it is optimal for the lobbyist to influence the pivotal policymaker. In our paper, we do not explicitly model the lobbying efforts to influence the decision making process of the European decision makers. We thereby closely follow the common agency model used by Dixit et al. (1997) and Aidt (1998), who implicitly assume optimal lobbying efforts. Further, we bring in an alternative setting for the interplay of the enforcement variables. We introduce a concave deterrence function for the polluting firms, arguing that marginal deterrence decreases with higher levels of punishment. The term `marginal deterrence' was introduced by Stigler (1970), and refers to an individual being deterred from committing a more harmful act owing to the difference, or margin, between the expected sanction for it and for a less harmful act.[1]

There exists a considerable amount of research on marginal deterrence. Shavell (1992), Wilde (1992) and Friedman and Sjostrom (1993) study the conditions under which marginal deterrence requires penalties to be graduated, with respect to the level of harm. Mookherjee and Png (1994) focus on the optimal pattern of marginal deterrence as a function of enforcement costs. They argue for the legalization of very minor acts where marginal expected penalties fall short of marginal harm caused. These studies all deal with the size of punishment related to the level of harm. We put forward a specific non-linear pattern for the deterrence effect of the punishment level, independent from harm. At smaller punishment levels an increase in the punishment has a larger effect than at larger punishment levels: marginal deterrence decreases with the punishment level. The intuition is that there is a social cost attached to punishment, and this social cost decreases with the level of the punishment. For both firms and individuals there is a blame on receiving a punishment, but this blame is no longer very large with severe offenders. Therefore it gets more and more difficult to deter with an increase in the punishment (this goes both for monetary sanctions and imprisonment).[2] For more information on the nature of reputational penalties for corporate (environmental) crime, see Alexander (1999).

With our model we study the variations in enforcement of a given environmental standard, and we look whether these differences can be justified from an efficiency perspective, and if not, whether they favor the interests of certain lobby groups. We derive the preferred enforcement policy. The environmental standard will be fixed ex ante since this allows us to concentrate on the choice of enforcement policy. The observation in practice is indeed that environmental standards are often set on a supranational level (in the EU by the European Parliament as suggested by the European Commission), where the opportunity to lobby is smaller than at member state level. In our model there will be polluting firms and households that are interested in environmental quality, in the profits of the polluting firms and in the regulatory costs of the environmental enforcement policy. The households do not all have the same interests as not all households share in the profits of the polluting firms. In this respect our model resembles the model by Aidt (1998) who analyzed the impact of different environmental taxes and subsidies. The main difference is that we focus on the enforcement choices for a given policy. We characterize the preferred enforcement strategy from a global efficiency point of view, but also from the point of view of different types of interest groups. In a recent paper, Cheng and Lai (2012) also study the impact of lobby groups on environmental regulation. The authors argue that a stricter enforcement policy does not necessarily reduce pollution emissions if the stringency of environmental regulation is subject to the influence of interest groups. Pollution can increase as a result of stricter enforcement, because the latter induces polluters to exert more political pressure reducing the stringency again. Whereas Cheng and Lai (2012) work with a

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[1] Assuming firms are led by individuals and are in hands of shareholders, we can state that marginal deterrence also applies to firms, more generally.

[2] Furthermore, wealth could also provide a decrease in deterrence of punishment, though only for monetary sanctions. When an individual or firm knows it cannot pay the fine, deterrence has no effect and the deterrence function becomes flat.

variable pollution level, we consider a given environmental standard. Our focus is on modeling how lobbying affects the choice between the inspection rate and the fine level.

We find that green and brown interest groups have indeed an interest to influence the enforcement behavior of the government in different ways, which might (partly) explain the divergence between countries. Despite the regulatory costs, green interest groups generally favor more stringent enforcement strategies with high fines and high inspection frequencies. Brown interest groups, on the other hand, prefer laxer enforcement strategies, at the expense of a lower environmental quality. To study the choice between both enforcement instruments, we introduce a fixed enforcement level in the model. By assuming non-linear deterrence effects of punishment on firms, we find that enforcement results are different than in previous theories (such as Becker, 1968). Setting a maximal fine and a low inspection rate is no longer efficient. In addition, the presence of the brown lobby group strengthens this result, whereas the presence of the green lobby group weakens it.

The paper is structured as follows. In section 2 we present some stylized facts on lobbying and its impact on the enforcement of environmental regulation in European Union member states. In section 3 we develop our model. In section 4 the model results are discussed. In section 5 we conclude.

II. Stylized facts

There is a considerable amount of empirical literature on lobbying at the European level, in the field of environmental policies (e.g. Mazey and Richardson, 2002), climate policy (e.g. Michaelowa, 1998, 2000), and the EU Emissions Trading System (e.g. Markussen and Svensen, 2005). All these studies measure European lobbyism, for instance as the difference between Green Papers, designed before lobbying takes place, and the final Directives, published after lobbying has taken place (e.g. Svendsen, 2005); or as the strength of European business and environmental lobbying initiatives (e.g. Gullberg, 2008). Cross-country empirical designs for the European Union are less common. Binder and Neumayer (2005) perform a cross-country time-series regression analysis on the strength of Environmental NGOs (ENGOs) on air pollution levels. Their indicator for the lobby strength of the ENGOs is the number of ENGOs per capita. As actual data on lobbying at national level in the EU member states (not considering proxies like the number of environmental NGOs per country) is very limited, we confine the empirical validation of our research question to some stylized facts. In table 1 we present information on the fine level and inspection rates for water pollution in some EU member states, as well as indicators of the lobby strength of both environmental and industry oriented interest groups. [3]

[3] The data is somewhat outdated, however as there is so little information available on inspections, fine levels and lobbying in Europe, it gives the most adequate indication possible.

Country	Fine	Probability	Green Lobby	Brown Lobby
Germany	275,000	1.41	7.45	29.8
Italy	1,000	17.38	5.2	27
Portugal	125,125	0.03	5.7	23.9
UK	14,375	0.3	2.5	23.6

Table 1: Enforcement levels and indicators of lobby strength

We have indicators for the level of the fine, the inspection rate, and the strength of brown and green lobby groups for 4 member states of the European Union[4], focusing on regulation on water pollution.[5] As a proxy for the inspection rate in water regulation infringements, we define the number of inspectors (full time equivalents) assigned with the inspection of installations, enterprises and facilities[6], corrected for the amount of inspectors for the number of enterprises in the manufacturing and construction sector in each member state (Eurostat, 2007). The figures demonstrate noticeable variations between inspection rates in the member states.[7] The level of the fine is an aggregate per member state of the fine levels for different water regulation infringements, as reported by METRO (Faure and Heine, 2002). The table clearly shows the large difference in enforcement instrument levels between the member states. As an indicator for the strength of industry lobbying on a national level we use the share of gross value added of the industry in each member state (Eurostat, 2007). The indicator for the strength of green lobbying in the 4 EU member states, is the number of green party members in each member state, corrected for population size.[8] The strength of lobbying, as presented by the proxies, is also noticeably different for the member states.

III. Model set-up

In this section we develop the basic model and study the decision making process of three types of economic agents: households, firms, and a government. The firms are owned by the households. At the same time, the firms also generate pollution, from which the households suffer. The government limits the environmental degradation by setting a standard for pollution, which is exogenously determined. If a firm does not comply with this standard and this offense is detected, a fine[9] is imposed. We assume that no judgment errors occur during inspections: when a violating firm is inspected, the fine is levied with certainty.

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[4] For those member states only all the 4 indicators could be defined.

[5] The divergence in the level of the fine and the inspection rate between the EU member states is present in many environmental regulations, but as water pollution fits our theoretical model best (cf. infra), we focus on that type of pollution.

[6] In a working paper of 2007, the European Commission reports on the implementation of a Recommendation (2001/331/EC) providing for minimum criteria for environmental inspections (EC, 2007).

[7] Part of these variations are actual differences in monitoring practices, but part can also be attributed to differences in definitions. For the full time equivalents of inspectors, only the time spent on inspection activities should be counted. It is however not clear from all country reports whether the numbers given represented the full time equivalent or whether instead the total staff of inspecting authorities was counted (including the staff working on other issues).

[8] The indicator for the green lobby strength should be multiplied by 0.0001 in order to get to the actual number, for all 4 member states.

[9] The fine represents the monetary equivalent of all imposed sanctions, including non-monetary sanctions such as prison sentences or license withdrawal.

We are interested in the optimal enforcement policy in different scenarios. As a benchmark, we define the most efficient enforcement strategy. This is the strategy that would be preferred by a welfare maximizing government. To this end we solve the model using backward induction, starting with firm and household behavior, and moving on to the government's enforcement strategy, taking the optimal responses of the other agents into account.

3.1 Firms

We have n firms in the economy, all active in the same competitive sector – each firm produces the same good. This good is sold on the world market at a fixed price – firms are price takers. We do not model the profit maximizing production decision of the firms, as this is not required to get to the projected results of this paper. The production process causes pollution, which harms the households in our economy. For our model, water pollution would fit best as an example. We assume that firms are heterogeneous with respect to initial emissions and abatement costs. Each firm minimizes the costs associated with the environmental policy by choosing the pollution level per unit of output (e^*).[10] We assume firms are risk neutral.[11]

As the government sets a standard $\bar{e}$ on the amount of pollution per unit of output, and fines the non-complying firms, it is costly for a firm to pollute more than this standard. However, compliance is also costly since the firm then faces abatement costs. We further assume that the compliance decision is discrete and that a firm will either invest in an abatement technology or not. The optimal amount of pollution for firm i (e_i^*) equals either the amount allowed by the standard, or the initial amount of pollution ($\mathring{e}_i$, the amount of pollution each firm would emit without facing a standard). We assume that all firms initially emit more than the standard: $\mathring{e}_i > \bar{e}\,; \forall i$. If a firm chooses to comply, its compliance cost equals $AC_i = \theta_i AC$, implying that firms differ in their abatement cost function by a parameter θ_i ($\theta_i \in [\theta_L, \theta_H]$). These cost differences result from differences in the availability of the technologies to abate pollution and from differences in size, age, initial pollution level, or firm location. In analogy with Delhaye et al. (2007), we assume that this cost factor θ is continuously and uniformly distributed with probability density $\frac{1}{\theta_H - \theta_L}$ and cumulative distribution function $\frac{\theta - \theta_L}{\theta_H - \theta_L}$.

The penalty f for not complying with the standard is imposed as soon as monitoring authorities detect an offense. We have $f > 0$ if $e_i > \bar{e}$ and $f = 0$ otherwise. The level of the fine lies between zero and an upper bound $\bar{f}$ (cf. infra). We assume that the deterrence resulting from an imposed fine is a non-linear function of the level of that fine. Increasing the punishment has not the same effect for all fine levels: the higher the initial level of punishment, the lower the marginal increase in deterrence associated with an increase of the level of punishment. To this end, we introduce the deterrence function $D(f)$, consisting of two parts: the actual punishment level (f) and the – more subjective – deterrent effect of the fine on firm behavior, which we will denote as the deterrence premium. The deterrence premium is a quadratic function of the fine level with

[10] As we do not model output explicitly, we define the pollution level of the firms and the standard level of pollution per unit of output.

[11] Risk aversion in this context has already been studied intensively (see for instance Polinsky and Shavell, 1979). Furthermore, we want to introduce non-linear deterrence, and focus on the effects of this type of deterrence on enforcement. Adding risk aversion would only unnecessarily complicate the analysis.

only positive values – if we define the upper bound on the punishment level ($\bar{f}$) accurately. The deterrence function is defined as follows:

$$D(f) = (1 + \mu)f + \delta f^2 \qquad (1)$$

We introduce the following assumptions:

$$\mu > 1 \qquad (2)$$

$$\delta < 0$$

The deterrence function is concave: $D'(f) > 0, D''(f) < 0$. The accurate definition of the upper bound on the fine level is then:

$$\bar{f} < -\frac{(1 + \mu)}{2\delta} \qquad (3)$$

The deterrence function looks as follows:

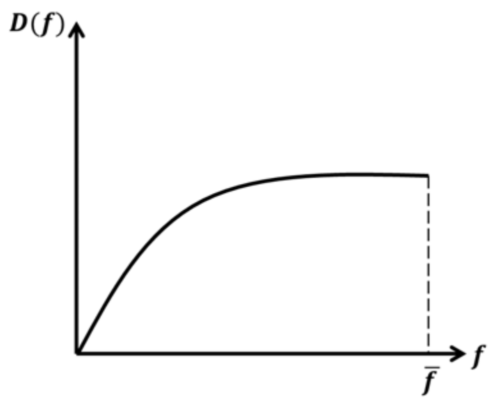

Figure 1: Deterrence function

Firms are monitored with a constant[12] inspection rate ($p \in [0,1]$). As a result, the cost of being fined, from the firms' point of view, looks as follows:

$$pD(f) \qquad (4)$$

The firms maximize their value[13] by choosing the optimal pollution level (a discrete decision) or, equivalently, firms minimize environmental costs. The firms' objective function equals:

$$min_{e_i}\, \theta_i AC + pD(f) \qquad (5)$$

[12] In reality, the inspection rate for environmental violations typically depends on the compliance behavior of a firm (cf. Harrington, 1988 or Rousseau, 2007).

[13] We define the firms' value instead of profit, as the deterrence effect introduced in the firms' objective function is a subjective concept, not reconcilable with the objective concept of profits. As individuals both lead and own the firms, we can rely on this more subjective concept instead of pure monetary profit maximization.

The firms only have one decision to make: to comply with the standard or not, based on the comparison of the compliance cost and the expected penalty for non-compliance. Thus we have the following corner solution for the optimal level of pollution per unit of output for a firm:

$$e_i^* = \overset{\circ}{e_i} \ \ if\ \theta_i AC \geq pD(f) \qquad (6)$$

$$e_i^* = \bar{e} \ \ if\ \theta_i AC < pD(f)$$

We define the value of a firm complying with the standard as π_C and that of a firm violating it as π_V. A firm will then violate the standard if $\pi_V > \pi_C$, while a firm is indifferent between compliance and non-compliance if $\pi_V = \pi_C$. Analogously as in Polinsky and Shavell (2000), we can define a threshold level:

$$\tilde{\theta} = \frac{pD(f)}{AC} \qquad (7)$$

This critical value defines the cost parameter that makes firms indifferent between violating the emission standard and complying. Firms with a cost parameter $\theta_i \geq \tilde{\theta}$ violate the standard, firms with a parameter $\theta_i < \tilde{\theta}$ comply. As θ_i is uniformly distributed, a proportion $\frac{\tilde{\theta}-\theta_L}{\theta_H-\theta_L}$ of the polluting firms complies with the standard and a proportion $\frac{\theta_H-\tilde{\theta}}{\theta_H-\theta_L}$ violates it. Also, we have that a larger critical value entails a decrease in the number of firms that do not comply, i.e. $\tilde{n}'(\tilde{\theta}) < 0$. The number of violating firms, $\tilde{n}(\tilde{\theta})$, equals $\frac{\theta_H-\tilde{\theta}}{\theta_H-\theta_L} n$.

3.2 Households

There are N households in the economy, who all suffer from pollution generated by the firms. Harm from pollution is modeled as:

$$\tilde{n}(\tilde{\theta})h_h + [n - \tilde{n}(\tilde{\theta})]h_o \qquad (8)$$

The first term is the product of $\tilde{n}(\tilde{\theta})$, the number of violating firms ($\tilde{n}(\tilde{\theta}) \leq n$), and a household specific constant h_h (with index $h = 1...N$). The household specific constant is distributed continuously and uniformly on the interval $\left[h_o, \bar{h}\right]$. The second term equals the number of compliant firms multiplied with the harm h_o associated with the emission standard. Defining $H_h \equiv h_h - h_o$, we can redefine harm as:

$$\tilde{n}(\tilde{\theta})H_h + nh_o \qquad (9)$$

The utility of a risk neutral household is assumed to be quasi-linear, and determined by the utility of consuming a vector of goods and the disutility of pollution:

$$U_h = y_h - \tilde{n}(\tilde{\theta})H_h - nh_o \qquad (10)$$

For the consumption vector of goods, y_h, we normalize the price vector to 1. Each household receives an income, consisting of three parts. It obtains a wage from supplying labor on the labor market (income I, exogenously given), it owns a share of the value of the firms (with $\sigma_{h,i}$ the share of household h in value π of firm i) and it receives a positive or negative lump sum transfer t from the government. The households thus differ in the level of harm they incur and their shares in the value of the firms. Knowing that $y_h \leq I + t + \sum_i \sigma_{h,i}\, \pi_i$ we can derive the following indirect utility function:

$$V_h = I + t + \sum_i \sigma_{h,i}\, \pi_i - \tilde{n}(\tilde{\theta}) H_h - n h_o \qquad (11)$$

3.3 Government

The role of the government is to enforce the environmental standard, using two instruments: the fine and the inspection rate.[14] Based on the Dixit et al. (1997) common agency model, the government decisions are assumed to be the result of two types of influences: the political process and the lobby process. The lobby groups influence the government decisions by menus of campaign contributions where the closer the government approaches the policy preferred by the lobby group, the higher the reward for the government. At a political equilibrium, the enforcement policy and the campaign contributions of the different lobby groups are determined by Dixit et al. (1997) as a subgame perfect Nash equilibrium of a two stage game. In the first stage, the lobby groups determine their donation levels. Each lobby group takes the contributions of other lobby groups and the anticipated political optimization of the government in stage two as given. The result is a set of choices of optimal political contributions depending on the enforcement variables. In the second stage the government decides upon the optimal enforcement policy, taking the contribution schedules as given. In this stage the government also collects the contributions. Assuming that lobby groups only make monetary contributions, abstraction can be made of the fact that lobbying requires time and effort, which are non-recoverable assets of the lobby process. One of the interesting features of this model is that the equilibrium of the lobbying and political game can be found as the maximum of a weighted sum of the objective functions of the politicians and the lobby groups. The higher the relative weight attributed to a lobby group, the better the outcome will be for the lobby group. We assume that the political process respects the preferences of the households and results in an unweighted sum of utilities. This is the traditional efficiency objective that will serve as a benchmark in our model.

Thus, in analogy with Dixit et al. (1997), both social welfare and the preferences of the lobby groups are incorporated in the governmental objective function. The first part of the government objective function, social welfare (SW) – that corresponds to the efficiency objective – is defined, assuming an additive utilitarian social welfare function, as:

[14] The standard is set at a level that balances the average of marginal abatement costs of all firms in the considered countries, and the marginal damage for households. We assume that the supranational government perfectly knows the (marginal) harm function, and can make an estimation (an average) of the abatement costs of the firms.

$$SW = N(I + t - nh_o) - \sum_h [\tilde{n}(\tilde{\theta})H_h] + \frac{n}{\theta_H - \theta_L}\left[\int_{\theta_L}^{\tilde{\theta}} (\bar{\pi} - \theta AC)d\theta + \int_{\tilde{\theta}}^{\theta_H} (\bar{\pi} - pD(f))d\theta\right] \qquad (12)$$

The first three terms in this function express the (dis)utility the households receive from their income, from transfers and from pollution. The last term articulates the utility from having a share in the value of the firms, summing the value of compliant and non-compliant firms. As we assume that firms only differ in their abatement decision (cf. supra), we have a constant $\bar{\pi}$ (same for all firms) representing all profits and costs except the ones associated with the compliance decision. The third term thus equals the sum of the shares in firms' values (π_i) of all households in the economy:

$$\frac{n}{\theta_H - \theta_L}\left[\int_{\theta_L}^{\tilde{\theta}} (\bar{\pi} - \theta AC)d\theta + \int_{\tilde{\theta}}^{\theta_H} (\bar{\pi} - pD(f))d\theta\right] = \sum_h \sum_i \sigma_{h,i}\,\pi_i = \sum_i \pi_i \quad (13)$$

This expression stipulates that all value created by the firms goes to their shareholders. In the second part of the general objective function of the government, the outcome of the lobbying game is represented. We thus have the following general objective function:

$$W(p, f) = \omega SW + \sum_l \gamma_l V_l \qquad (14)$$

The objective functions of the lobby groups, V_l, indicate the preferences of the different lobby groups. The weights γ_l define the relative influence lobby groups have on the government with l representing the index for each of the lobby groups. They represent the result of the competition between the lobby groups, and expresses the relative impact of each individual lobby group on the decision process. We assume $\gamma_l \epsilon \{0,1\}$ and $\sum_l \gamma_l \leq 1$. The weights are exogenous in our model, since they depend on the efficiency of the lobbying process itself, which we do not model. The parameter λ represents the government's benevolence. If ω (weight for efficiency) equals 0, the government only considers the relative interests of the lobby groups in the economy. If ω equals 1 and all the γ_l are zero, we are in the situation without lobbying, our benchmark scenario where only efficiency matters.

We discuss two specific lobby groups in the context of this paper: a green (G) lobby group and a brown (B) lobby group ($l \in \{G, B\}$). Further, we define γ_G and γ_B as the weights attached by the government to the interests of the green (V_G) and those of the brown (V_B) lobby group, respectively. We consider functionally specialized lobby groups in our analysis – their motivation for lobbying is solely ideologically inspired.[15] The existence of lobby groups originates by the assumption that some agents overcome the free riding problem, while others do not (cf. Aidt, 1998). More specifically, a subset of the firms organizes an industry lobby that only

[15] This model assumption is based on Aidt (1998) who makes a distinction between lobby groups with multiple goals and functionally specialized lobby groups.

cares about firms' value. At the same time, a part of the households arranges an environmental lobby that only considers the harm incurred by the households. The interest groups offer campaign contributions in order to get a – for them – beneficial environmental enforcement policy in return. Because the Nash equilibrium of our model induces truthful[16] revelation, the contribution schedule of the lobby groups (a function of the enforcement instruments of the government) equals their objective function, minus a constant – this constant distributes the rent between the government and the lobby group (cf. Dixit et al., 1997). Normalizing this constant to zero, the objective function of a green lobby group looks as follows (cf. Aidt, 1998):

$$V_G = -\sum_h \left[\tilde{n}(\tilde{\theta})H_h\right] - Nnh_o \qquad (15)$$

The members of the green lobby group only care about the environmental harm caused by the production process of the firms, and their only objective is to minimize the total harm incurred by all households.[17] By definition, this utility function implies that the contribution depends on the number of firms violating the law: the more firms disregard the standard, the lower the contribution. In this respect, the government gains by punishing more severely or increase monitoring on the firms that do not comply.

The brown lobby group has a pure interest in firms' value creation, and does not care about the environment. This group's objective function only contains firm values, and looks as follows:

$$V_B = \frac{n}{\theta_B - \theta_L}\left[\int_{\theta_L}^{\tilde{\theta}} (\bar{\pi} - \theta AC)d\theta + \int_{\tilde{\theta}}^{\theta_B} \big(\bar{\pi} - pD(f)\big)d\theta\right] \qquad (16)$$

θ_B is an exogenously determined cutoff value for the abatement cost parameter, to divide the firms into the categories `large' and `small and medium sized' enterprises. We assume that the brown interest group represents the larger firms in the economy. SMEs are less often represented by an interest group with a large impact on national politics, which would explain their absence in our objective function. SMEs generally face higher abatement costs than larger companies (see, e.g. Becker et al. 2012). Consequently, we assume that firms with a cost parameter exceeding θ_B are not represented by the brown lobby group. The brown lobby contribution increases if the government decreases enforcement.

So while some households overcome the free rider problem and get organized, either in the green lobby or in the brown lobby, others do not (in our case those households with high shares in smaller firms). It is the presence of unorganized households that will render our equilibrium socially inefficient (cf. infra, as in Dixit et al., 1997 and Aidt, 1998).

The government maximizes its objective function under the constraint that it cannot run a deficit or accumulate a surplus. Thus the expenditures on enforcement cannot exceed the taxes levied on the households plus the (expected) fine revenues. If expected fine revenues exceed enforcement

[16] This means that the political contribution schedule of a lobby group always reflects the true preferences of the lobby group.
[17] It would not make any sense to have an environmental interest group only caring about their own harm from pollution.

costs, the surplus is redistributed to the households as a lump sum transfer *t;* otherwise t stands for a lump sum tax. The balancing of income and expenditures is represented as:

$$C_E(p,f) = Nt + \tilde{n}(\tilde{\theta})pf \qquad (17)$$

with $C_E(p,f)$ (or shorter C_E) representing the enforcement costs, which are increasing and convex in the probability of inspection (detecting non-compliance gets more and more difficult), and linearly increasing in the fine level. We assume the following functional form for the enforcement costs: $C_E = \alpha f + \beta p^2$, where $\alpha < \beta$ (inspections are much more expensive to organize than the imposition of fines). We can also determine an explicit expression for the lump sum transfer:

$$t = \frac{\tilde{n}(\tilde{\theta})pf - C_E}{N} \qquad (18)$$

The transfer is a function of the expected fine revenues, the enforcement costs and the number of households in the economy. We note that as the number of households, N, is assumed to be large, they do not consider the effect of their behavior on the lump sum transfer.

IV. Model results

We can now derive the preferred level of the inspection rate and the fine for different scenarios. First we study the benchmark without lobby groups; next we turn to the case where the green or the brown lobby group can influence the enforcement strategy, and where they both have an impact. Finally, we study the special case where the expected fine is kept constant.

4.1 Benchmark case: No lobby groups

As a benchmark, we study a benevolent government, which chooses an optimal enforcement policy in order to maximize social welfare. We have the following objective function for the government:

$$\begin{aligned} max_{p,f} W &= SW \\ &= N(I + t - nh_0) - \sum_h [\tilde{n}(\tilde{\theta})H_h] \\ &\quad + \frac{n}{\theta_H - \theta_L}\left[\int_{\theta_L}^{\tilde{\theta}} (\bar{\pi} - \theta AC)d\theta + \int_{\tilde{\theta}}^{\theta_H} \big(\bar{\pi} - pD(f)\big)d\theta\right] \qquad (19) \end{aligned}$$

The constraints for optimization are:

$$0 \le p \le 1 \qquad (20)$$

$$0 \le f \le \bar{f}$$

Looking at an interior solution, the first order condition with respect to the inspection rate looks as follows:

$$\frac{dSW}{dp} = -\frac{d\tilde{n}(\tilde{\theta})}{dp}\sum_h H_h + \frac{n}{(\theta_H - \theta_L)}\frac{d\left(-\frac{\tilde{\theta}^2 AC}{2} + pD(f)(\tilde{\theta} - \theta_H)\right)}{dp} - \frac{dC_E}{dp} - \frac{d\left(pf\tilde{n}(\tilde{\theta})\right)}{dp} \qquad (21)$$

A marginal increase in the probability of detection results in a decline of total harm caused by the polluting firms since fewer firms violate the standard. Consequently, there is an increase in abatement costs and a decrease in the expected fine the firms face. The latter effect implies that the disadvantage of expected deterrence decreases for the firms. The net effect on firms' value of an increase in the inspection rate is always negative, though. An increase in the inspection rate also raises enforcement costs. Expected fines are a mere transfer between the firms and the households, their net effect on social welfare is zero.[18] The optimal inspection rate is determined by equating marginal benefits of increasing the inspection rate (decreased harm and decreased deterrence impact on firms) and the associated marginal costs (increased abatement and enforcement).[19]

Rearranging the first order condition and writing the functions $D(f)$ and C_E in full, allows us to write the inspection rate as function of the fine level (reaction function):

$$p = \frac{nf\left((\delta f \theta_H + \mu)AC - (\delta f + 1 + \mu)\sum_h H_h\right)}{n\delta^2 f^4 + 2n\delta\mu f^3 + (n\mu^2 - n)f^2 + 2\beta(\theta_L - \theta_H)AC} \qquad (22)$$

This relationship is graphically illustrated in figure 2, for specific values of the different parameters. This allows us to compare and combine high and low levels of the two policy costs: abatement (AC_{high} versus AC_{low}) and harm (H_{high} versus H_{low}), and their effect on optimal enforcement.[20]

[18] What the households gain in lower fines (profit effect via shares in the firms) they lose in lower head transfers (budget constraint becomes more stringent).

[19] As the analytics are too complex to deliver clear-cut insights, we resort to a comparison of scenarios based on the first order conditions, which gives us an idea about the direction of the effects. For the actual size of the effects we could resort to a numerical exercise, but that goes beyond the scope of the paper.

[20] The other parameters values are exogenously set at: $n = 100,000$; $\theta_H = 3$; $\theta_L = 0.1$; $\beta = 2$; $\delta = -0.000025$; $\mu = 2$.

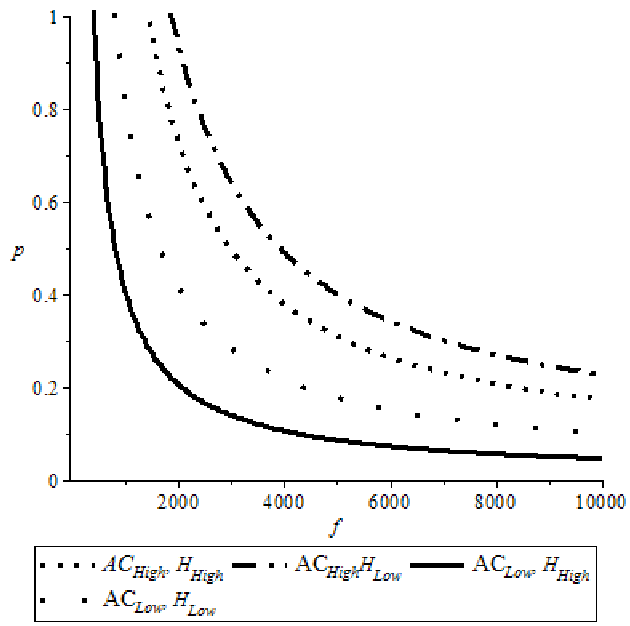

Figure 2: Inspection frequency in function of fine level

For lower levels of the fine, the inspection rate is high (and approaches 1). When the fine level is moving toward its maximum level, the inspection rate is low. The ratio harm over compliance (abatement) costs is an important determinant of the interaction between the inspection rate and the sanction level. When the level of harm is high, enforcement is less strict than for a low level of harm, for a same level of abatement costs. A high level of harm from pollution induces more compliant behavior, as environmental quality is measured against firm value in the social welfare function. As a result, for high levels of harm, a lower inspection rate is needed than for lower levels of harm, for a constant fine level. Enforcement is stricter when abatement costs are high, for a constant level of harm. This is because with high abatement costs, the effect of environmental quality is not as prevailing, such that strict enforcement is necessary to induce firms to abate and not violate the pollution standard.

The first order condition with respect to the fine is:

$$\frac{dSW}{df} = -\frac{d\tilde{n}(\tilde{\theta})}{df}\sum_{h} H_h + \frac{n}{(\theta_H - \theta_L)} \frac{d\left(-\frac{\tilde{\theta}^2 AC}{2} + pD(f)(\tilde{\theta} - \theta_H)\right)}{df} - \frac{dC_E}{df} - \frac{d\left(pf\tilde{n}(\tilde{\theta})\right)}{df} \quad (23)$$

The optimal fine also results from equating the marginal costs (enforcement and abatement) and marginal benefits (decline in harm and deterrence). Rearranging the first order condition would allow us to write the fine level as function of the inspection rate. We only show the graphical illustration of this function in figure 3 (also for specific parameter values[21]), as the analytical expression is very involved and does not add much insight. The relative effect of harm and compliance costs when comparing different levels is equivalent to that of the inspection rate.

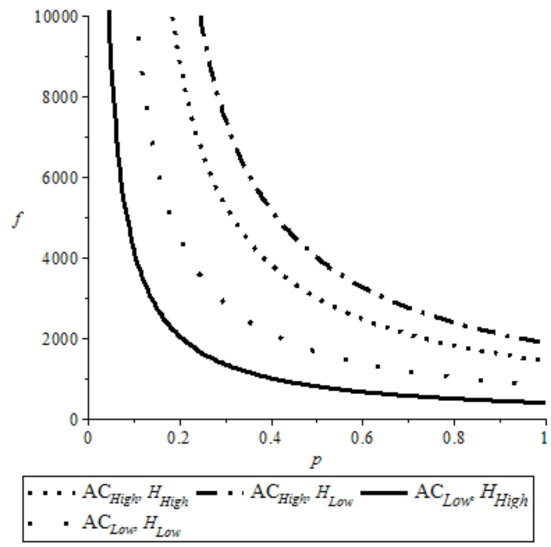

Figure 3: Fine level in function of inspection rate

4.2 Introducing lobby groups

We first consider those scenarios where only one lobby group influences the regulatory objective function. In this setting, the entire surplus from the principal-agent relationship goes to the interest group. This is because the lobby group, by moving first in the game by offering a contribution schedule, creates a take-it-or-leave-it situation for the government, who does not have the alternative to switch to another lobby group for contributions. As a result, the government is equally well off with the financial contribution as without. When competition between lobby groups is created, the government gets full control over the principal-agent relationship, and thus can subtract a surplus, by the credible threat to switch to another lobby group for campaign donations (cf. Dixit et al. 1997). We introduce this as a third scenario.

4.2.1 Scenario 1: Government cares about social welfare and is influenced by the green lobby group

We now assume that the green lobby group can influence the government. We have the following objective function for the government in this scenario:

[21] Same as with inspection rate.

$$max_{p,f} W = N(I + t - 2nh_0) - 2\sum_h [\tilde{n}(\tilde{\theta})H_h] + \frac{n}{\theta_H - \theta_L}\left[\int_{\theta_L}^{\tilde{\theta}} (\bar{\pi} - \theta AC)d\theta + \int_{\tilde{\theta}}^{\theta_H} (\bar{\pi} - pD(f))d\theta\right] \quad (24)$$

First order conditions for the inspection rate and fine level look as follows:

$$\frac{dW}{dp} = -\frac{2d\tilde{n}(\tilde{\theta})}{dp}\sum_h H_h + \frac{n}{(\theta_H - \theta_L)}\frac{d\left(-\frac{\tilde{\theta}^2 AC}{2} + pD(f)(\tilde{\theta} - \theta_H)\right)}{dp} - \frac{dC_E}{dp} - \frac{d\left(pf\tilde{n}(\tilde{\theta})\right)}{dp} \quad (25)$$

$$\frac{dW}{df} = -\frac{2d\tilde{n}(\tilde{\theta})}{df}\sum_h H_h + \frac{n}{(\theta_H - \theta_L)}\frac{d\left(-\frac{\tilde{\theta}^2 AC}{2} + pD(f)(\tilde{\theta} - \theta_H)\right)}{df} - \frac{dC_E}{df} - \frac{d\left(pf\tilde{n}(\tilde{\theta})\right)}{df} \quad (26)$$

For the inspection rate, we observe an increase of $-\frac{d\tilde{n}(\tilde{\theta})}{dp}\sum_h H_h$ in the marginal benefits, compared to the benchmark scenario. For the fine level, the increase equals $-\frac{d\tilde{n}(\tilde{\theta})}{df}\sum_h H_h$.

The green interest group values a reduction in environmental harm more than what is socially optimal. The government thus maximizes contributions from the greens by applying a stringent enforcement strategy. So even without analytically solving for the exact expressions, we can see that the optimal level for both enforcement variables will be higher than in the benchmark scenario. The government enforces more stringently when the green interest group is present. This social inefficiency results from the fact that not all households are fully represented in the green lobby group, such that their impact pulls the government away from the socially desirable outcome, which is an average of all households' viewpoints.

4.2.2 Scenario 2: Government cares about social welfare and is influenced by the brown lobby group

Next we assume that only the brown lobby group can influence the government. In this scenario we get the following objective function for the government:

$$max_{p,f} W = N(I + t - nh_0) - \sum_h [\tilde{n}(\tilde{\theta}) H_h] + \frac{n}{\theta_H - \theta_L}\left[\int_{\theta_L}^{\tilde{\theta}} (\bar{\pi} - \theta AC) d\theta + \int_{\tilde{\theta}}^{\theta_H} \big(\bar{\pi} - pD(f)\big) d\theta\right] + \frac{n}{\theta_B - \theta_L}\left[\int_{\theta_L}^{\tilde{\theta}} (\bar{\pi} - \theta AC) d\theta + \int_{\tilde{\theta}}^{\theta_B} \big(\bar{\pi} - pD(f)\big) d\theta\right] \quad (27)$$

The first order conditions for the inspection rate and fine level are:

$$\frac{dW}{dp} = -\frac{d\tilde{n}(\tilde{\theta})}{dp}\sum_h H_h + \frac{n}{(\theta_H - \theta_L)} \frac{d\left(-\frac{\tilde{\theta}^2 AC}{2} + pD(f)\big(\tilde{\theta} - \theta_H\big)\right)}{dp} + \frac{n}{(\theta_B - \theta_L)} \frac{d\left(-\frac{\tilde{\theta}^2 AC}{2} + pD(f)\big(\tilde{\theta} - \theta_B\big)\right)}{dp} - \frac{dC_E}{dp} - \frac{d\left(pf\tilde{n}(\tilde{\theta})\right)}{dp} \quad (28)$$

$$\frac{dW}{df} = -\frac{d\tilde{n}(\tilde{\theta})}{df}\sum_h H_h + \frac{n}{(\theta_H - \theta_L)} \frac{d\left(-\frac{\tilde{\theta}^2 AC}{2} + pD(f)\big(\tilde{\theta} - \theta_H\big)\right)}{df} + \frac{n}{(\theta_B - \theta_L)} \frac{d\left(-\frac{\tilde{\theta}^2 AC}{2} + pD(f)\big(\tilde{\theta} - \theta_B\big)\right)}{df} - \frac{dC_E}{df} - \frac{d\left(pf\tilde{n}(\tilde{\theta})\right)}{df} \quad (29)$$

Compared to the benchmark scenario, the impact of an increase in the enforcement instruments on private costs has a larger weight than in the benchmark scenario. Since private costs increase due to a raise in the inspection rate or the fine level, both the optimal inspection rate and fine (found by equating marginal costs and benefits) will be smaller than in the benchmark scenario. If the government wants to maximize brown lobby contributions, enforcement is weaker than in the benchmark case. Enforcement is less stringent in the presence of the brown lobby group: both the inspection rate and the fine level are lower than in the benchmark scenario. Again, the inefficiency results from the fact that not all households are represented in the brown lobby group, the only group that has an impact in this scenario.

4.2.3 Scenario 3: Government cares about social welfare and is influenced by both lobby groups

In this scenario, the objective function of the government looks as follows:

$$max_{p,f} W = \omega \left[N(I + t - nh_0) - \sum_h [\tilde{n}(\tilde{\theta}) H_h] \right] - \gamma_G \left[\sum_h [\tilde{n}(\tilde{\theta}) H_h] - Nnh_0 \right] + \omega \left[\frac{n}{\theta_H - \theta_L} \left[\int_{\theta_L}^{\tilde{\theta}} (\bar{\pi} - \theta AC) d\theta + \int_{\tilde{\theta}}^{\theta_H} (\bar{\pi} - pD(f)) d\theta \right] \right] + \gamma_B \left[\frac{n}{\theta_B - \theta_L} \left[\int_{\theta_L}^{\tilde{\theta}} (\bar{\pi} - \theta AC) d\theta + \int_{\tilde{\theta}}^{\theta_B} (\bar{\pi} - pD(f)) d\theta \right] \right] \quad (30)$$

As the analytical elaboration of this scenario does not add any additional insights, we will only discuss the most important findings in words. The choice of the government in terms of enforcement will depend on the relative size of the contributions of lobby groups, and on the benevolence of the government (expressed by ω). If contributions of the green lobby exceed those of the brown, we end up in the outcome of scenario 1 (though with a more moderate effect). If the contribution level of the brown lobby exceeds that of the green lobby, we are again in scenario 2 (though in a more moderate way). The competition between the lobby groups in this paper can be modeled by altering their respective weights (γ_G, γ_B).

4.3 Fixed enforcement level

In our analysis so far, we have considered the level of the fine and the inspection rate without any limitations. We did not consider the choice between the inspection rate and the fine level yet. As a same enforcement level can be achieved by several combinations of the inspection rate and fine level, it is interesting to have a look at the welfare effects of different combinations within our model. Becker (1968) states that because of the perfect substitutability of both enforcement variables, and because it is cheaper to increase the fine level than the inspection rate (cf. $C_E = \alpha f + \beta p^2$, with $\alpha < \beta$), the combination of a higher fine and a lower inspection rate is socially preferred to the opposite combination. So when the expected fine is constrained to a certain level, it is efficient to choose the highest possible fine, and the lowest possible inspection rate.

In our model, marginally increasing the fine level has not the same impact on firm behavior for all fine levels, as we introduced the deterrence function $D(f)$ (cf. supra). Accordingly, we do not get to the same results as Becker. The constrained optimization problem for our model looks as follows:

$$max_{p,f}W = N(I + t - nh_0) - \sum_h [\tilde{n}(\tilde{\theta})H_h]$$
$$+ \frac{n}{\theta_H - \theta_L}\left[\int_{\theta_L}^{\tilde{\theta}} (\bar{\pi} - \theta AC)d\theta\right.$$
$$\left. + \int_{\tilde{\theta}}^{\theta_H} \big(\bar{\pi} - pD(f)\big)d\theta\right] \quad (31)$$

subject to:

$$pf = \bar{E}$$

where $\bar{E}$ is the (exogenously) fixed level for the expected fine. There is no unique solution for the constrained optimization problem. However, we can investigate how the deterrence function influences the choice between the inspection rate and the fine as instruments to enforce, when the enforcement level is given. If we assume a fine level that is slightly below the maximum, we could increase it, which requires a lower inspection rate, and thus lower enforcement costs. But, a marginal increase of an already high fine does not deter firms as much as with linear deterrence (for a corresponding decrease in the inspection probability). The deterrence effect results in the fine being a socially costly enforcement instrument, rather than a mere transfer of money. This cost is expressed by a reduction in firm value (and thus a reduction in utility for the households). Additionally, the impact of deterrence on firm behavior also indirectly affects the disutility households experience from pollution. Total harm from pollution depends on the amount of firms that violate the standard. Compared to a linear deterrence function, the number of firms violating the standard, for a same fine level, is higher, because firms are not as easily deterred by an increase in the fine level (at high levels of the fine). Thus the total amount of harm from pollution in society, depending on the number of firms that violates the standard, is higher in this situation than with linear deterrence. So setting the fine at its maximal level both has a negative behavioral effect (lower firm value), and a positive effect (decreasing pollution). Enforcement costs still increase more with a higher fine than with a higher inspection rate. So we can state that if the positive effect of the maximal fine on the environment is outweighed by the negative effect of the maximal fine on firm behavior, and this net effect is larger than the decrease in enforcement costs of a higher fine (combined with a lower inspection rate), it is more efficient to set the fine lower than its maximum. The effect of a non-linear deterrence function is that it can be more efficient to impose a higher inspection rate and a lower than maximal fine, despite increasing enforcement costs. The presence of the brown lobby group will intensify the direct behavior effect, as it only considers firm value in the objective function. As a result, the optimal fine level, under fixed enforcement, is lower than in the benchmark case, and the inspection rate higher. The green lobby group prefers a higher fine combined with a lower inspection rate, under fixed enforcement, because they only consider the indirect effect on the amount of harm in their objective function. Thus, the green lobby group moves the optimal solution to the conventional interaction between the enforcement instruments (as introduced by Becker, 1968), whereas the brown lobby group moves enforcement away from the traditional relation.

V. Conclusion

Enforcement strategies for environmental legislation strongly vary among countries and regions. In this paper, we study how lobbying could alter the level of enforcement instruments selected by a government. In this sense, our paper serves as an extension to Becker (1968), who treats inspection rates and sanctions as perfect substitutes in deterring potential violators. We introduce a non-linear deterrence function of the punishment for firms that do not comply with an environmental standard. We study the effect of the presence of contributions from interest groups on the optimal values of both the inspection rate and the level of the fine, independently. We find that lobbies push the government to choose inefficient combinations of the enforcement instruments. Using the common agency model developed by Dixit et al. (1997), we find that the presence of a green lobby group results in a higher inspection rate and fine level than is optimal in the case where only efficiency matters. If a brown lobby group has an impact on the government's enforcement approach, the opposite occurs: both the inspection rate and the sanction level are lower than socially optimal. A green lobby group goes for maximal deterrence, and a brown lobby group steers the government to minimize enforcement. In addition, we observe that the efficient enforcement level depends on the relative size of harm versus compliance costs, and is influenced by the shape of the deterrence function for the firms.

We also discuss the choice between both enforcement variables, by studying optimization under the constraint of fixed enforcement. We find that the deterrence effect of the fine on firms influences this optimal choice: the more important the deterrence effect, the lower the optimal fine, and the higher the inspection rate. When we consider interest groups in this setting, we find that the presence of the brown lobby group intensifies this deterrence effect, such that the optimal fine is even lower than in the benchmark (and the inspection rate correspondingly higher), whereas the presence of the green lobby group counterbalances this deterrence effect, and thus results in a lower inspection rate, and a higher fine level than in the benchmark.

References

Aidt, T. S. (1998). Political internalization of economic externalities and environmental policy. *Journal of Public Economics*, Vol. 69, pp. 1-16.

Becker, G.S. (1968). Crime and punishment: An economic approach. *Journal of Political Economy*, Vol. 76:2, pp. 169-217.

Becker, R., Pasurka, C. and Shadbegian, R. (2012). Do environmental regulations disproportionately affect small businesses? Evidence from the pollution abatement costs and expenditures survey. *CES working paper 12-25*.

Binder, S. and Neumayer, E. (2005). Environmental pressure group strength and air pollution: An empirical analysis. *Ecological Economics*, Vol. 55, pp. 527– 538.

Cheng, C.C. and Lai, Y.B. (2012). Does a stricter enforcement policy protect the environment? A political economy perspective. *Resource and Energy Economics*, Vol. 34, pp. 431 – 441.

Cohen, M.A. (2000). Empirical research on the deterrent effect of environmental monitoring and enforcement. *Environmental Law Institute. News & Analysis*, Vol. 30, pp. 10245-10252.

Crombez, C. Information, Lobbying and the Legislative Process in the European Union (2002). *European Union Politics*, Vol. 3:7.

Delhaye, E., Proost S. and Rousseau, S. (2007). Catching or fining speeders: A political economy approach. *Working paper series Centre for Economic Studies, Catholic University of Leuven*, Vol. 2007:2.

Dixit, A., Grossman, G.M. and Helpman, E. (1997). Common agency and coordination: General theory and application to government policy making. *Journal of Political Economy*, Vol. 105:4.

European Commission (2007). Report on the implementation of Recommendation 2001/331/EC providing for minimum criteria for environmental inspections. *Commission Staff working paper SEC(2007) 1493.*

European Commission (2007). Accompanying document to the Proposal for a directive of the European Parliament and of the Council on the protection of the environment through criminal law. *Commission Staff working document SEC(2007) 160.*

European Parliament (2010). Members of the European Parliament. Accessed at http://www.europarl.europa.eu.

Eurostat (2007). Share of industry gross value added in European Member States. Accessed at http://epp.eurostat.ec.europa.eu/portal/page/portal/statistics/themes.

Faure, M. and Heine, G. (2002). Criminal Penalties in EU Member States' Environmental Law. *Maastricht European Institute for Transnational Legal Research (METRO)*.

Friedman, D. and Sjostrom, W. (1993). Hanged for a sheep: The economics of marginal deterrence. *The Journal of Legal Studies*, Vol. 22, pp. 345-366.

Goldberg, P.K. and Maggi, G. (1999). Protection for sale: An empirical investigation. *The American Economic Review*, Vol. 89:5, pp. 1135-1155.

Gray, W. and Shimshack, J. (2011). The effectiveness of environmental monitoring and enforcement: a review of the empirical evidence. *Review of Environmental Economics and Policy*, Vol. 5:1, pp. 3–24.

Grossman, M. and Helpman, E. (1994). Protection for sale. *The American Economic Review,* Vol. 84:4, pp. 833-850.

Gullberg AT. 2008. Rational lobbying and EU climate policy. *International Environmental Agreements: Politics, Law and Economics*, Vol. 8, pp. 161–178.

Harrington, W. (1988). Enforcement leverage when penalties are restricted. *Journal of public economics*, Vol. 37:1, pp. 29-53.

Heyes, A. (2000). Implementing environmental regulation: Enforcement and compliance. *Journal of Regulatory Economics*, Vol. 17:2, pp. 107-129.

Lee, D.S., McCrary, J. (2009). The deterrence effect of prison: Dynamic theory and evidence. *Unpublished manuscript, Department of Economics, Princeton University, Princeton, NJ.*

Macho-Stadler, I. and Perez-Castrillo, D. (2006). Optimal enforcement policy and firms' emissions and compliance with environmental taxes. *Journal of Environmental Economics and Management*, Vol. 51, pp. 110 – 131.

Markussen, P. and Svendsen, G.T. (2005). Industry lobbying and the political economy of GHG trade in the EU. *Energy policy*, Vol. 33:2, pp. 245-255.

Mazey, S. and Richardson, J. (2002). Environmental groups and the EC: Challenges and opportunities. In A. Jordan (Ed.), *Environmental Policy in the European Union. Actors, Institutions and Processes.* London: Earthscan.

Michaelowa, A. (1998). Impact of interest groups on EU climate policy. *European Environment,* Vol. 8:5, pp. 152-160.

Michaelowa, A. (2000). The strength of different economic interests in shaping EU climate policy. *Energy and Environment*, Vol. 11:3, pp. 277-292.

Mookherjee, D. and Png, I.P.L. (1994). Marginal deterrence in enforcement of law. *Journal of Political Economy*, Vol. 102, pp. 1039-1066.

Nyborg, K. and Telle, K. (2006). Firms' Compliance to Environmental Regulation: Is There Really a Paradox? *Environmental and Resource Economics*, Vol. 35, pp. 1-18.

Persson, T. and Tabellini, G. (2000). Political economics: Explaining economic policy. MIT Press.

Polinsky, A.M. and Shavell, S. (1979). The optimal tradeoff between the probability and magnitude of fines. *The American Economic Review*, Vol. 69:5, pp. 880-891.

Polinsky, A.M. and Shavell, S. (1991). A note on optimal fines when wealth varies among individuals. *NBER Working Paper No. 3232*.

Polinsky, A.M. and Shavell, S. (1992). Enforcement costs and the optimal magnitude and probability of fines. *Journal of Law and Economics*, Vol. 35:1, pp. 133-148.

Polinsky, A.M. and Shavell, S. (2000). The economic theory of public enforcement of law. *Journal of Economic Literature*, Vol. 38, pp. 45-76.

Rousseau, S. (2007). Timing of environmental inspections: Survival of the compliant. *Journal of Regulatory economics*, Vol. 32, pp. 17-36.

Shavell, S. (1992). A note on marginal deterrence. *International Review of Law and Economics*, Vol. 12, pp.345-355.

Svendsen, G. T. (2005). Lobbying and CO2 trade in the EU. In B. Hansjürens (Ed.), *Emissions trading for climate policy: US and European perspectives*, pp. 150–161, Cambridge: Cambridge University Press.

Stigler, G. (1970). The optimum enforcement of laws. *Journal of Political Economy*, Vol. 78, pp. 526-536.

Wilde, L. (1992). Criminal choice, nonmonetary sanctions, and marginal deterrence: A Normative Analysis. *International Review of Law and Economics*, Vol. 12, pp. 333-344.