

# Modeling Environmental Discretion through Randomized Strategies

Anna Rita Germani\*  
Pasquale Scaramozzino\*\*

December 2007

- \* University of Rome “La Sapienza”, [annarita.germani@uniroma1.it](mailto:annarita.germani@uniroma1.it)  
\*\* DeFiMS, SOAS, University of London and University of Rome “Tor Vergata”,  
[ps6@soas.ac.uk](mailto:ps6@soas.ac.uk)

JEL Classification: K32, K42, Q28, L51, C70

Keywords: environmental enforcement, judicial and prosecutorial discretion, randomized strategies.

## ABSTRACT

This analysis is motivated by the observation that in the enforcement of environmental laws some violators are sentenced at criminal level while some others, who have in substance committed the same crime, are not punished or are sanctioned with a purely administrative or civil fine. We try to understand these apparent inconsistencies in the prosecution of environmental violations by analyzing, in a game-theoretical framework, the possible interactions between environmental authorities and firms. Even though unpredictable and contradictory enforcement can create uncertainty and adverse effects, we provide a possible answer to these incongruities: since there are no dominant strategies for the environmental agencies, their optimal rule of conduct requires that they randomize among their alternative strategies. Overall, we suggest that making environmental enforcement less predictable and creating uncertainty for the firms can help encourage deterrence and, thus, improve compliance.

## ACKNOWLEDGMENTS

We wish to thank particularly Cesare Imbriani for encouraging us in writing this paper and for his many and stimulating discussions on the topic. We would like to thank Piergiuseppe Morone and Pina Testa for their valuable comments and constructive criticisms. We are grateful also to the participants to the 24<sup>th</sup> European Association of Law and Economics (EALE) Conference in Copenhagen (September, 2007) for helpful comments and discussions.

## 1. Introduction

In this work we investigate the role of the U.S. Environmental Protection Agency (EPA) and of the U.S. Department of Justice (DOJ) with regard to their discretion in the enforcement of environmental laws. This can take the form of administrative and investigative discretion for the EPA, and prosecutorial discretion for the DOJ. More specifically, we explore the motivations behind the use of discretion in terms of the effectiveness of the enforcement mechanism available to the environmental authorities.

This analysis is motivated by the observation that in the enforcement of environmental laws some violators are sentenced at criminal level while some others, who have in substance committed the same crime, are not punished or are sanctioned with a purely administrative or civil fine. For instance, it has been demonstrated [Cory & Germani, 2002; Babbitt, Cory & Kruchek, 2004] that for similar violations to the U.S. Clean Water Act, seemingly similar defendants may receive very disparate sentences.

These inconsistencies run the risk of creating serious social and economic policy distortions, either toward an over-criminalization attitude or in favour of a more lenient approach, by creating respectively overdeterrence or underdeterrence. One of the main tasks for the EPA is to determine which violators to prosecute, and whether to pursue violations at the administrative, civil or criminal levels. In fact, the major U.S. environmental statutes, together with the Federal Sentencing Guidelines<sup>1</sup>, afford substantial discretion to the EPA, the Department of Justice, and the courts: they can be more aggressive or more friendly on environmental violations, and can carry out a weaker or a stronger enforcement.

Our contribution consists mainly of trying to better understand why there are these apparent inconsistencies in the prosecution of environmental violations. We consider in a game theoretic framework the possible interactions between

---

<sup>1</sup> In 1984, the U.S. Congress passed the Sentencing Reform Act (SRA) that completely transformed the traditional sentencing process in an attempt to reduce unwarranted disparity in sentencing, to ensure certainty, proportionality and uniformity of punishment, and to establish more serious penalties for specific categories of offenses. In order to achieve these goals, Congress created the United States Sentencing Commission as an independent, permanent agency in the judicial branch with the main purpose to develop an unprecedented body of laws to regulate federal sentencing: the Federal Sentencing Guidelines. The Sentencing Guidelines went into effect in November 1987, and apply to all federal crimes committed on or after that date.

environmental authorities and firms. Even though unpredictable and contradictory enforcement can create uncertainty and adverse effects by making environmental policies not effective, we provide a possible rationale for these apparent incongruities. Since there are no dominant strategies for the environmental agencies, their optimal rule of conduct requires that they randomize among their alternative strategies.

Overall, we suggest that making environmental enforcement less predictable for the firms, and thus creating a degree of uncertainty for the violators, can help encourage deterrence and, thus, improve compliance. In other words, a partly unpredictable enforcement strategy may generate more compliance than an environmental policy that is known with certainty in advance.

This paper is organized as follows. Section 2 focuses on some key aspects of the main theoretical framework on environmental enforcement. Section 3 analyzes the enforcement game between the environmental authorities and the firm. Section 4 explores the strategic interactions between the EPA and the firm, in a simple game theoretic model. Section 5 considers a more complex model to explore the role of the DOJ and its relationship with EPA. Section 5 discusses the main policy implication of the analysis and offers some conclusions.

## **2. Theoretical Background on Environmental Enforcement**

Our analysis is closely related to the literature on selective enforcement [Friesen, 2003; Lando & Shavell, 2004] pioneered by Harrington (1988) who has noted the following paradox: firms' rate of compliance is high even though the EPA's enforcement activity is carried out at low levels and often violators are not punished even if discovered. This paradox shows, therefore, that even though enforcement and monitoring actions are often weak, firms may still be substantially compliant<sup>2</sup>. Revisiting the Harrington paradox, Heyes and Rickman (1999) analyze the role of regulatory dealing by which the enforcement agency can use tolerance in some contexts and for some types of

---

<sup>2</sup> The main result of Harrington's paradox is that firms may have an incentive to comply with the law even though their cost of compliance exceeds the expected penalty for violation or even the maximum penalty that can be applied.

violations, in order to increase compliance in other contexts and for other violations. The authors interpret discretion as an important aspect of their strategic agency's behaviour and as a necessary element of any environmental policies, by showing that the introduction of a regulatory dealing will improve both the rate of compliance and the whole environmental performance of the firms.

While the focus of Harrington and of Heyes and Rickman is on studying the optimal enforcement scheme and the optimal use of sanctions [Polinsky and Shavell, 1984, 2000; Posner, 1985, 2003; Shavell, 1993, 2003; Stigler, 2002; Garoupa, 1997, 2001, 2004], our contribution consists in analysing how the EPA and the DOJ can influence firms' behavior by randomizing, on purpose, enforcement rules and by modeling their interactions in a strategic game characterized by discretion. We can thus investigate: 1) whether the implementation of administrative or civil/criminal actions could help improve environmental compliance, and 2) how both EPA and DOJ choose to handle cases, that is civilly or criminally.

According to the evidence in Firestone [2003] and Cohen [1999-2000], the EPA does not pursue all enforcement cases administratively. In order to explain why and how EPA makes its decisions, Firestone, in his extensive empirical work<sup>3</sup>, explored the implications of the five main theoretical "alternative" motivations for EPA enforcement's decisions: social welfare maximization; violation minimization; case maximization; environmental harm minimization; and political support maximization. Firestone's main results are that when EPA seeks to maximize social welfare, or minimize violations<sup>4</sup>, or minimize the number of violations, or maximize political benefits, it would find judicial remedies less attractive and thus increasingly will choose to handle violations administratively. Only when EPA seeks to minimize environmental harm, as the actual or potential for harm increases, will it invest greater financial resources to punish the conduct criminally. Overall, the objectives of maximizing social welfare and minimizing environmental harm appear to be the main motivations for EPA, while there is little empirical support for the political maximization objective.

---

<sup>3</sup> Available at <http://www.vanderbilt.edu/VCEMS/papers/enforcement.pdf>

<sup>4</sup> This theory is premised on the notion that regulators are motivated primarily by self-interest (Coffee, 1992).

Our findings serve to reinforce, in some respects, Firestone's results, in the sense that we observe a greater probability for violations to be resolved administratively, but we also provide further insights on the possible interactions between the violator and the EPA and especially between the EPA and the DOJ.

Related literature also includes the vast macroeconomic literature on rules versus discretion on the conduct of monetary policy (Kydland and Prescott, 1977). Other remarkable studies are those by Subrahmanyam (1995) in which rules versus discretion in the context of market closure rules are analyzed, and by Kleinig (1996) in which several analyses on the use of discretion by police in law enforcement are provided. Our work relates to these papers, since the utilization of randomized strategies can be interpreted as the exercise of discretion.

### **3. The Enforcement Game**

We model the economic structure of the enforcement problem as a game where the violator's behavior is influenced by the course of actions discretionally implemented by both the EPA and the DOJ. In particular, firms' behavior is likely to change as a consequence of its revised expectations on the exercise of discretion at both the EPA and the DOJ levels. We describe these interactive situations through a strategic game in order to determine the payoff maximizing strategies for the players and consequently determine the expected outcomes of the game.

The game we consider has the following structure. The firm can decide between complying to environmental regulations and not complying, by assessing the costs and benefits of compliance. The EPA, in the absence of information about the strategy chosen by the firm, must decide whether to carry out inspections or not. If the firm complies, it has to sustain a cost. This cost is not incurred if the firm decides not to comply. The EPA has to incur a cost if it decides to carry out an inspection. If EPA carries out an inspection and the firm is not complying, EPA will levy a fine on the firm. Alternatively, the EPA will serve a notice of violation to the firm and the latter

will be referred to DOJ. However, if the EPA does not carry out an inspection and the firm does not comply, the EPA will internalise the cost of the environmental damage.

Therefore, EPA's exercise of discretion comes into play in two instances: first with regard to the decision of whether to investigate or not on the violation, and then, in the case it does decide to investigate, regarding whether to initiate an administrative, civil or criminal enforcement action. Moreover, if EPA decides to pursue a case civilly, it has two options: it may handle the matter internally or seek fines in a federal court<sup>5</sup>. If the EPA decides to deal with the case administratively, then it shall issue a Notice of Violation (NOV) ordering compliance and/or assigning a penalty to the violation. A notice of violation describes the violation and commands the violator to stop the activity<sup>6</sup>. At this point, the firm must decide again whether to be compliant or non-compliant. If it does not comply and if the case cannot be resolved at administrative level, then the EPA will refer it to the Department of Justice for civil or criminal prosecution. At this stage, the DOJ can exercise its discretion on whether to initiate a civil or a criminal proceeding. Solving the game by backward induction allows us to see how the enforcement strategy chosen by the DOJ will affect the game between the environmental agency and the firm.

In order to illustrate the role of randomization even in a very simple setting, we first consider a game between the firm and the EPA, where the firm must decide whether to comply or not and the EPA must choose whether to carry out an inspection or not (Section 4). We then consider a more complex game, where the EPA can serve a notice of violation to the firm if the latter is found non-compliant. The task of environmental control is then taken up by the DOJ, that must choose between a civil and a criminal prosecution (Section 5). Both examples show that, since there are no pure strategy Nash equilibria, the environmental authorities have to resort to randomized strategies consistent with a mixed-strategy Nash equilibrium.

---

<sup>5</sup> As noted by Firestone, administrative and civil judicial enforcement share many elements. The primary distinguishing characteristic is that with administrative enforcement, EPA typically functions as both the enforcer and the adjudicator. A judge or EPA, as appropriate, may impose a civil sanction in an environmental matter whenever a person has violated or is violating a law or a permit condition [see, e.g., 42 U.S.C. § 7413(a)(3) (2000)].

<sup>6</sup> The purpose of a NOV is to initiate corrective action that will stop the violation. To provide an incentive for continuing compliance, NOV's for the Clean Water Act may result in monetary penalties up to \$27,500 per day, per violation, according to 33 U.S.C. 1319.

#### 4. Strategic interactions between the firm and the EPA

The interactions between the firm and the EPA are modelled as a coordination game. The game tree corresponding to the extensive form of the game is illustrated in Figure 1, and the payoff matrix associated with the normal form of the game is given in Table 1. The firm decides whether to comply with the environmental regulations or not. The environmental agency must then decide whether to carry out an inspection or not, without knowing the action of the firm. We denote by  $v$  the value to the firm if it does not comply, by  $c$  the cost of compliance by the firm, by  $e$  the environmental damage that is generated if the firm does not comply and that would be internalised by EPA, by  $i$  the cost of inspection, and finally by  $f$  the fine that would be levied by EPA on the firm if the latter is found to be non-compliant.

All the above parameters are strictly positive. We assume that the following additional restrictions on parameter values must hold:

$$(1) \quad e > i$$

$$(2) \quad f > c$$

Condition (1) states that the environmental damage must be larger than the cost of inspection, whereas condition (2) requires that the value of the fine levied by the EPA must be greater than the cost of compliance.

Figure 1 illustrates the strategic form of the game by showing the moves that the firm and EPA can make. It is immediate to verify that, if the firm knows that the EPA will carry out an inspection, it will be better off by complying, since its expected pay-off is  $v-c$  if it complies and  $v-f$  if it does not comply, with  $v-f > v-c$  by assumption (2). On the other hand, if EPA decided not to carry out the inspection, the firm will be better off by not complying, since its expected pay-off is  $v-c$  if it complies and  $v$  if it does not comply, with  $v > v-c$ . Conversely, if the firm complies then EPA would be better off by

not carrying out the inspection. By contrast, if the firm does not comply, it would be preferable for the EPA to inspect.

Hence, the game has no Nash Equilibria in pure strategies. There is, however a mixed strategy Nash Equilibrium, where the firm and the EPA randomize their choice of action. Let us denote by  $p$  be the probability of compliance by the firm and by  $q$  be the probability of inspection by the EPA. The expected payoff to EPA if it carries out an inspection is given by:

$$(3) \quad E(\pi_{EPA}^I) = p(-i) + (1-p)(-i) = -i$$

The expected payoff to EPA if it does not carry out an inspection is:

$$(4) \quad E(\pi_{EPA}^{NI}) = p(0) + (1-p)(-e) = ep - e$$

The firm will choose the probability of compliance,  $p$ , in such a way that the EPA must be indifferent between inspecting or not: this requires that  $E(\pi_{EPA}^I) = E(\pi_{EPA}^{NI})$ . Solving for  $p$  yields:

$$(5) \quad p = 1 - \frac{i}{e}$$

Note that  $p$  is a well defined probability ( $0 < p < 1$ ) since  $0 < i < e$  by condition (1).

The expected payoffs to the firm under compliance and non-compliance are respectively:

$$(6) \quad E(\pi_F^C) = q(v-c) + (1-q)(v-c) = v-c$$

$$(7) \quad E(\pi_F^{NC}) = q(v-f) + (1-q)v = v- qf$$

The EPA will choose the probability of inspection  $q$  in such a way that the firm is indifferent between complying or not:  $E(\pi_F^C) = E(\pi_F^{NC})$ . Solving for  $q$  yields:

$$(8) \quad q = \frac{c}{f}$$

The above results can be summarised by the following proposition.

**Proposition 1.** *The game played by the firm and EPA has no pure strategy Nash Equilibrium. The mixed strategy Nash Equilibrium is characterised by the following randomized strategies:*

- (a) *The firm complies with probability  $p = 1 - i / e$ ;*
- (b) *The EPA carries out an inspection with probability  $q = c / f$ .*

The probability of compliance by the firm is a decreasing function of the cost of inspection and an increasing function of the environmental damage. This means that if environmental damage increases, the probability of compliance increases. The main intuition for this result is that, if the environmental damage is large, the environmental authority would have a greater incentive to inspect. In order to keep EPA indifferent between inspecting or not, the firm must increase the probability with which it complies with the environmental regulations. On the other hand, if the cost of inspection increases, the probability of compliance decreases: given that inspections may induce firms to improve their environmental performance, if they perceive that inspection and monitoring costs are high for the environmental authority, they will tend to decrease their level of care thus reducing the level of compliance.

The probability of inspection by EPA is an increasing function of the cost of compliance by the firm: this implies that when compliance costs are higher, the firm would have a higher incentive to violate, and the probability of firm inspection by EPA must therefore increase. On the other hand, probability of inspection is a decreasing function of the fine. This implies a trade-off between the fine and the probability of inspection: the greater the fine, the lower the probability of inspection. In other words, a

greater fine, which would increase the costs of violating for the firm, is compensated by a lower probability of inspection. This confirms the classic results by Becker [1968] and by Polinsky and Shavell [2000] that, in any optimal enforcement scheme, it always makes sense to substitute a higher fine for a lower probability of detection and viceversa.

Proposition 1 also provides a possible solution to Harrington's paradox. In equilibrium, the probability of compliance by the firm,  $p$ , can be high even if the probability of inspection by the environmental agency,  $q$ , is low.

## 5. The strategic game between the firm, the EPA and the DOJ

In this second version of the interaction between the firm and EPA we introduce a role for the DOJ by letting EPA serve a notice of violation if the firm is found to be non-compliant. The firm is then referred to the DOJ and has then the opportunity to put right its wrongful action. The DOJ may proceed against a violator with either a civil suit or a criminal charge<sup>7</sup>. It retains exclusive authority to prosecute criminally<sup>8</sup> and has the authority to initiate all criminal cases referred by the EPA<sup>9 10</sup>.

---

<sup>7</sup> The DOJ's charging decision is subject to administrative guidance. Prosecution should proceed only if there is probable cause to believe such a crime has been committed and the evidence is likely to sustain a conviction (2000 United States Attorneys' Manual, at § 9-27.200). In the decision to proceed the following seven factors are considered: 1) federal law enforcement priorities; 2) the nature and the seriousness of the offense; 3) the deterrent effect of prosecution; 4) the offender's culpability; 5) the offender's criminal history; 6) the offender's willingness to cooperate; and 7) the offender's probable sentence or other consequences of conviction (2000 United States Attorneys' Manual, at § 9-27.200). More specifically, with regard to the decision to prosecute environmental crimes, DOJ guidelines consider the following four factors: 1) voluntary disclosure of a violation or other cooperation with the authorities; 2) the entity's level of noncompliance; 3) the existence of preventative measures and compliance programs; and 4) whether the entity pursues its own internal disciplinary actions and produces subsequent compliance.

<sup>8</sup> See generally, U.S. Dept. of Justice in cooperation with the National Association of Attorneys, General Guidelines for Joint State/Federal Civil Environmental Enforcement Litigation (2003), available at [http://www.naag.org/issues/pdf/env-joint\\_enf\\_guidelines-full.pdf](http://www.naag.org/issues/pdf/env-joint_enf_guidelines-full.pdf)

<sup>9</sup> In the memorandum entitled "Factors in Decisions on Criminal Prosecutions for Environmental Violations in the Context of Significant Voluntary Compliance or Disclosure Efforts by the Violator" (1991) are described the factors that the DOJ in order not to create a disincentive to or undermine the goal of encouraging critical self-auditing, self-policing, and voluntary disclosure.

<sup>10</sup> The U.S. DOJ considers all of the following factors in deciding whether to exercise prosecutorial discretion: voluntary, timely, and complete disclosure of the matter under investigation; the degree and timeliness of cooperation; existence and scope of any regularized, intensive, and comprehensive

The DOJ can exercise discretion on whether to initiate civil or criminal proceedings. It is assumed that a criminal prosecution is more expensive than a civil prosecution, but also that jail can be a more effective deterrent than a pecuniary sanction in the form of a fine. A jail term would be more costly to administer than a fine, but the DOJ would suffer a penalty – that could be rationalised as a reputation cost - if an offending firm is punished with a fine rather than with a jail term.

The structure of the game is illustrated in Figure 2. The additional notation relative to the game of section 4 is as follows. We denote by  $c_1$  the additional compliance cost if the firm did not comply in the first instance, by  $f$  the fine from civil prosecution, by  $j$  the cost to the firm from criminal prosecution, by  $k_c$  the cost to DOJ of enforcing civil prosecution, by  $k_j$  the cost to DOJ of enforcing criminal prosecution, and finally by  $r$  the reputation cost to DOJ of letting off an offending firm with a fine.

The previous parameters are all positive. In addition, we assume that the following plausible restrictions hold:

$$(9) \quad f < c_1 < j$$

$$(10) \quad k_c < k_j$$

$$(11) \quad k_j - k_c < r$$

Condition (9) requires that the additional compliance cost must exceed the fine from civil prosecution, but must be less than the cost to the firm if a criminal sentence is imposed. Condition (10) says that the cost to DOJ of enforcing criminal prosecution must be greater than the cost of enforcing civil prosecution. Finally, condition (11) requires that the reputation cost to the DOJ of letting off an offending firm with a fine is larger than the difference between the cost of enforcing criminal prosecution and the cost of administering a fine.

---

environmental compliance program; pervasiveness of non-compliance; effective internal disciplinary action; and efforts to remedy any ongoing non-compliance promptly and completely.

The game tree associated with the model developed in this section is illustrated in Figure 2. The model can be solved by backward induction in two steps. In the first step, we solve the sub-game between the firm and DOJ. In the second step, we replace the outcome of this sub-game into the game played between the firm and EPA to find their optimal strategies.

### 5.1. The sub-game between the firm and DOJ

Let us consider first the sub-game between the firm and the DOJ. It is possible to verify that this sub-game has no pure strategy Nash Equilibrium. For instance, if the DOJ were to resort to civil prosecution, the firm would find it profitable not to comply. However, if the firm does not comply, the DOJ would be better off by enforcing a criminal prosecution.

The sub-game between the firm and the DOJ does, however, admit of a mixed strategy Nash Equilibrium. In this equilibrium, the probabilities of compliance by the firm and of enforcing a civil prosecution by DOJ are obtained by requiring that the other player is indifferent between its actions.

The outcome of the sub-game is then replaced into the game played between the firm and EPA in order to compute the mixed strategy Nash Equilibrium of this game.

The payoff matrix for this game is shown in Table 2. The expected payoff to DOJ if it enforces a civil prosecution is:

$$(12) \quad E(\pi_{DOJ}^{CI}) = p_1(-k_c) + (1 - p_1)(-k_c - r) = -(k_c + r) + p_1 r$$

The expected payoff to DOJ if it carries out a criminal prosecution is:

$$(13) \quad E(\pi_{DOJ}^{CR}) = p_1(-k_j) + (1 - p_1)(-k_j) = -k_j$$

The firm will choose the probability of compliance,  $p_1$ , in such a way that the DOJ is indifferent between a civil and a criminal prosecution:  $E(\pi_{DOJ}^{CI}) = E(\pi_{DOJ}^{CR})$ . Solving for  $p_1$  yields:

$$(14) \quad p_1 = 1 - \frac{k_j - k_c}{r}$$

Note that  $0 < p_1 < 1$  since  $k_j < r + k_c$  by assumption (11).

The expected payoffs to the firm if it complies or does not comply are respectively:

$$(15) \quad E(\pi_F^{2,C}) = q_1(v - c - c_1) + (1 - q_1)(v - c - c_1) = v - c - c_1$$

$$(16) \quad E(\pi_F^{2,NC}) = q_1(v - c - f) + (1 - q_1)(v - c - j) = v - c - j + q_1(j - f)$$

The DOJ will choose the probability of civil prosecution  $q_1$  in such a way that the firm is indifferent between complying or not:  $E(\pi_F^{2,C}) = E(\pi_F^{2,NC})$ . Solving for  $q_1$  yields:

$$(17) \quad q_1 = \frac{j - c_1}{j - f}$$

where  $0 < q_1 < 1$  since  $f < c_1$  by assumption (9).

The above results can be summarised by the following proposition.

**Proposition 2.** *The sub-game played by the firm and DOJ has no pure strategy Nash Equilibrium. The mixed strategy Nash Equilibrium is characterised by the following randomized strategies:*

(a) *The firm complies with probability  $p_1 = 1 - (k_j - k_c)/r$ .*

(b) The DOJ carries out a civil prosecution with probability  $q_1 = (j - c_1)/(j - f)$ .

The probability of compliance by the firm is a decreasing function of the cost of criminal prosecution and an increasing function of the cost of civil prosecution and of the reputation cost to DOJ. The probability of civil prosecution by DOJ is an increasing function of the fine and of the jail term and a decreasing function of the cost of compliance by the firm.

Note that, in equilibrium, the expected payoff to the firm from the second-stage sub-game is:

$$(18) \quad E(\pi_F^2) = v - c - c_1$$

and the expected payoff to DOJ is:

$$(19) \quad E(\pi_{DOJ}) = -k_j$$

## 5.2. The game between the firm and EPA

The payoff matrix for this game is shown in Table 3. For analogous reasons as for Game 1, the game has no pure strategy Nash Equilibria. The game however does have a unique mixed strategy Nash Equilibrium.

The expected payoff to EPA if it carries out an inspection is:

$$(20) \quad E(\pi_{EPA}^I) = p(-i) + (1 - p)(-i) = -i$$

The expected payoff if it does not carry out an inspection is instead:

$$(21) \quad E(\pi_{EPA}^{NI}) = p(0) + (1 - p)(-e) = ep - e$$

The firm will choose the probability of compliance,  $p$ , in such a way that the EPA is indifferent between inspecting or not:  $E(\pi_{EPA}^I) = E(\pi_{EPA}^{NI})$ . Solving for  $p$  gives:

$$(22) \quad p = 1 - \frac{i}{e}$$

Note that  $0 < p < 1$  since  $0 < i < e$  by assumption (1).

The expected payoffs to the firm if it complies and if it does not comply are respectively:

$$(23) \quad E(\pi_F^{1,C}) = q(v - c) + (1 - q)(v - c) = v - c$$

$$(24) \quad E(\pi_F^{1,NC}) = q(v - c - c_1) + (1 - q)v = v - q(c + c_1)$$

The EPA will choose its probability of inspection  $q$  in such a way that the firm is indifferent between complying or not:  $E(\pi_F^{1,C}) = E(\pi_F^{1,NC})$ . Solving for  $q$  yields:

$$(25) \quad q = \frac{c}{c + c_1}$$

Note that  $0 < q < 1$  since  $c > 0$ ,  $c_1 > 0$ . The above results can be summarised by the following proposition.

**Proposition 3.** *The game played by the firm and EPA has a no pure strategy Nash Equilibrium. The mixed strategy Nash Equilibrium is characterised by the following randomized strategies:*

(a) *The firm complies with probability  $p = 1 - i/e$ .*

(b) *The EPA carries out an inspection with probability  $q = c/(c + c_1)$ .*

The probability of compliance by the firm in the first stage of the game is a decreasing function of the cost of inspection and an increasing function of the environmental damage. The probability of inspection by EPA is an increasing function of the cost of compliance by the firm in the first stage of the game and a decreasing function of the cost of compliance in the second stage of the game.

There are some interesting aspects of these results that need to be emphasized. The probability that the firm complies under proposition 3 is the same probability we find under proposition 1, that is  $p = 1 - i/e$ . This implies that, in equilibrium, the threat posed by the application of criminal sanctions does not affect the probability of compliance by the firm. This is important, of course, because indicates that compliance can occur even without the need of recurring to criminal enforcement. Financial and/or interdictive sanctions, such as the revocation of the license or the suspension of the firm's activity, can also be harsh deterrent measures.<sup>11</sup>

The probability of inspection by the EPA under proposition 3 is  $q = c/(c + c_1)$ , while under proposition 1 is  $q = c/f$ . With an unvarying probability of compliance by the firm, the probability of inspection decreases compared to the one obtained in the first stage of the game in which the intervention of the DOJ was not considered. This implies that it would seem more efficient to let the EPA resolve the cases internally (administratively) rather than refer them to the Department of Justice for civil or criminal prosecution.

## 6. Final Remarks

In the U.S. enforcement system, predicting whether an environmental violation will be pursued administratively, civilly or criminally is a difficult task. In some circumstances civil injunctions are issued to prevent further harm and to begin cleanup procedures,

---

<sup>11</sup> Penalties for non-compliance may take various forms, including legal costs, fines, loss of reputation, etc. See, among others, Dewees (1990), Hamilton (1995), Lanoie and Laplante (1994).

while in some others, criminal sanctions are applied to further punish the violator<sup>12</sup>. Moreover, when a violation or a case is raised, the EPA has wide discretion in choosing how to enforce the law; it may choose which cases to decline to pursue, which ones to deal with administratively, which ones to refer to the DOJ for civil action, and which ones to refer for criminal charges [Mandiberg & Smith, 1997].

These are the core reasons why the American enforcement system has become the object of intense political, economic and environmental debate with regard to the possibility that environmental regulations are enforced selectively or arbitrarily. Even though the main goal that motivated the creation of the Federal Sentencing Guidelines was to produce consistency and predictability in the sentencing process, it is a diffuse conviction that they have failed in providing uniform and proportional sentences (Koh, 1992; Barrett, 1992).

But can this attempt to impose uniformity be seen as misguided, and the result of an insufficient understanding of the strategic interactions between the environmental enforcers and firms? It has been argued, in fact, that the exercise of discretion can generate problems of under-enforcement or discriminatory enforcement. We show, in fact, that the actual approach used by both the EPA and the DOJ in which the choice of the enforcement rule is randomized, is more effective in encouraging firms' compliance: instead of being attached to a rigid single approach, it seems more appropriately characterized by a pragmatic setting up that can vary with the particular case at hand.

We do believe that these results offer important insights into the regulator's behaviour. Overall, we suggest that a discretionary enforcement strategy may generate more compliance than an environmental policy that is known in advance with certainty. We are aware that the patterns of the various strategies considered in the model, based on the conventional enforcement system which is mostly applied in the U.S., by allowing for a wide degree of discretion, are able to realize a higher efficiency. It would

---

<sup>12</sup> The application of civil sanctions, generally, includes fines, negative publicity and installation of pollution-control technology; while the application of criminal sanctions includes also fine and imprisonment. The main distinction between sanctions in the criminal and civil systems is the availability of criminal non-monetary sanctions, such as incarceration and probation.

be interesting to extend the analysis to game theoretical models for Europe, where the environmental enforcement mechanisms are different.

**Table 1. Payoff matrix for the strategic game between firm and EPA**

		EPA		
		Inspect	Do not inspect	
Firm	Comply	$(v - c, -i)$	$(v - c, 0)$	$p$
	Do not comply	$(v - f, -i)$	$(v, -e)$	$1 - p$
		$q$	$1 - q$	

**Table 2. Payoff matrix for the sub-game between firm and DOJ.**

		DOJ		
		Civil	Criminal	
Firm	Comply	$(v - c - c_1, -k_c)$	$(v - c - c_1, -k_j)$	$p_1$
	Do not comply	$(v - c - f, -r - k_c)$	$(v - c - j, -k_j)$	$1 - p_1$
		$q_1$	$1 - q_1$	

**Table 3: Payoff matrix for the game between firm and DOJ in the two-stage game**

		EPA		
		Inspect	Do not inspect	
Firm	Comply	$(v - c, -i)$	$(v - c, 0)$	$p$
	Do not comply	$(v - c - c_1, -i)$	$(v, -e)$	$1 - p$
		$q$	$1 - q$	

**Figure 1. Strategic game between firm and EPA in extensive form**

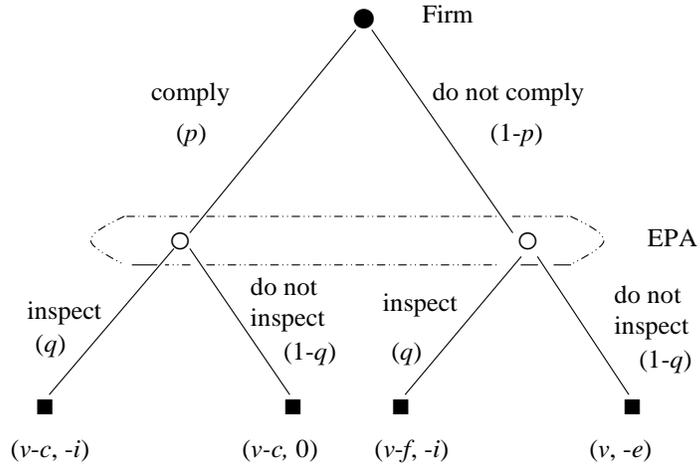
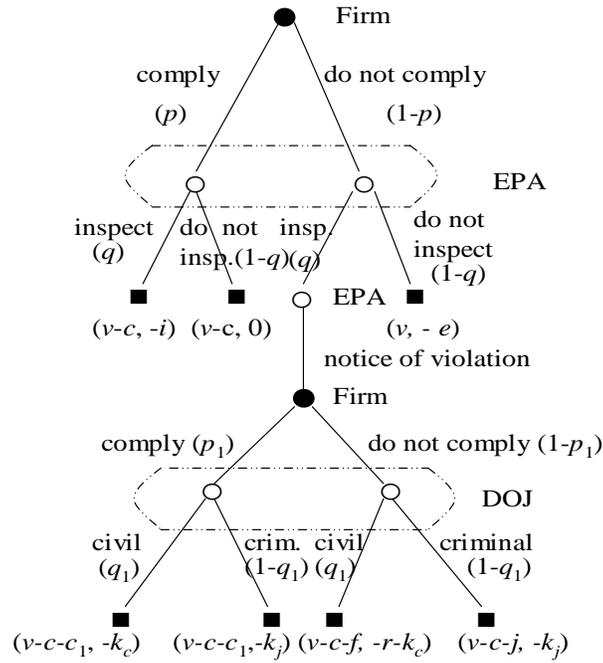


Figure 2: Strategic game between firm, EPA and DOJ in extensive form



## REFERENCES

- Babbitt C.J., D.C. Cory, B.L. Krucke, 2004. Discretion and the Criminalization of Environmental Law, *Duke Environmental Law and Policy Forum*, vol. 15(1)
- Barrett J., 1992. Sentencing Environmental Crimes under the United States Sentencing Guidelines: A Sentencing Lottery, *Environmental Law*, 22
- Becker G.S., 1968. Crime and Punishment: An Economic Approach, *Journal of Political Economy*, 76 (March/April), 169-217
- Cohen M., 1999-2000. Monitoring and Enforcement of Environmental Policy, in the *International Yearbook of Environmental and Resource Economics*
- Cory C.D., A.R. Germani, 2002. Criminal Sanction for Agricultural Violations of the CWA, *Water Policy*, 4(6)
- Deweese D.N. (1990). The Effect of Environmental Regulation: Mercury and Sulphur Dioxide, in M.L. Friedland (eds), *Securing Compliance: Seven Case Studies*, Toronto: University of Toronto Press
- Firestone J., 2003. Enforcement of Pollution Laws and Regulations: an Analysis of Forum Choice, *Harvard Environmental Law Review*, 27, pp. 105-176
- Friesen L., 2003. Targeting Enforcement to Improve Compliance with Environmental Regulations, *Journal of Environmental Economics and Management*, 46:72-85
- Garoupa N., 1997. The Theory of Optimal Law Enforcement, *Journal of Economic Surveys*, 11: 267-295
- Garoupa N., 2001. Optimal Magnitude and Probability of Fines, *European Economic Review*, vol. 45 (9)
- Garoupa N., 2004. *An Economic Analysis of Criminal Law*, in *Economic Analysis of Law: A European Perspective*, Edward Elgar, edited by Aristides Hatzis
- Koh S.Y., 1992. Reestablishing the Federal Judge's Role in Sentencing, 101, *Yale Law Journal*, 1109, 1124
- Hamilton J.T. (1995). Pollution as News: Media and Stock Market Reactions to the Toxics Release Inventory Data, *Journal of Environmental Economics and Management*, 28, 1, 98-113
- Harrington W., 1988. Enforcement Leverage When Penalties Are Restricted, *Journal of Public Economics*, 37:29-53
- Heyes A., Rickman N., 1999. Regulatory Dealing - Revisiting the Harrington Paradox, *Journal of Public Economics*, 72:361-378
- Kydland, F., and E.C. Prescott (1977). Rules Rather than Discretion: the Inconsistency of Optimal Plans, *Journal of Political Economy*, 85: 473-492
- Kleinig, J., 1996. *Handled with Discretion: Ethical Issues in Police Decision Making* (John Kleinig, ed.), Rowman and Littlefield Publishers, Inc., New York
- Lando H.S., Shavell, 2004. The Advantage of Focusing Law Enforcement Effort, *International Review of Law and Economics*, 24:209-218
- Lanoie P. and B. Laplante (1994). The Market Response to Environmental Incidents in Canada: a Theoretical and Empirical Analysis", *Southern Economic Journal*, 60, 3, 657-672
- Mandiberg S.F. and S.L. Smith, 1997. *Crimes against the Environment*, MICHIE Law Publishers

- Polinsky A.M., S. Shavell, 1984. The Optimal use of Fines and Imprisonment, *Journal of Public Economics*, 24:89-99
- Polinsky A. M., Shavell, S., 2000. The Economic Theory of Public Enforcement of Law, *Journal of Economic Literature*, 38:45-74
- Posner R., 1985. An Economic Theory of the Criminal Law, 85 *Columbia Law Review*, 1193
- Posner R. A., 2003. *Economic Analysis of Law*, 6th ed., Aspen Law & Business
- Shavell S., 1993. The Optimal Structure of Law Enforcement, *Journal of Law and Economics* 36: 255-287
- Shavell S., 2003. Economic Analysis of the General Structure of the Law, in *Foundations of Economic Analysis of Law*, Harvard University Press
- Stigler G.J., 2002. The Optimum Enforcement of Laws, *The Journal of Political Economy*, 78(3):526-536
- Subrahmanyam, A., 1995. On Rules versus Discretion in Procedures to Halt Trade, *Journal of Economics and Business* 47: 1-16