Discretionary enforcement and strategic interactions between firms, regulatory agency and justice department: a theoretical and empirical investigation

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Abstract. This paper presents a game theoretic morphological analysis of the U.S. environmental authorities' (i.e., EPA and DOJ) behavioural mechanisms, based on strategic interactions among the players. The models explore the role of discretion that such authorities enjoy, either in deciding how to pursue environmental violations (investigative and prosecutorial discretion) or in judging them (judicial discretion). The purpose is to identify both the optimal firms' behaviour in terms of compliance, and the DOJ's and EPA's optimal strategies in terms of enforcement actions to undertake. Consistent with the setting of the game theory models, the role of EPA and DOJ in deterring firms from polluting is, then, empirically tested, by means of a laboratory experiment. Laboratory evidence on compliance behaviour of firms when faced with enforcement conditions predicted by the theoretical models set up is discussed for the different experimental treatments performed.

JEL classification: 017; 004; 001.

Keywords: environmental enforcement, discretion, game theory, experimental economics.

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1. INTRODUCTION[1]

In this paper the role of the U.S. Environmental Protection Agency (EPA) and of the U.S. Department of Justice (DOJ) is investigated 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 mechanisms available to the U.S. environmental authorities.

This analysis is motivated by the observation that in the enforcement of environmental laws some violators are sentenced at criminal level while 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 and Germani, 2002; Babbit, Cory, *et. al.*, 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 over-deterrence or under-deterrence. 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,[2] 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.

Even though unpredictable and contradictory enforcement can create uncertainty and adverse effects that could potentially limit the effectiveness of environmental policies, 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 actually 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.

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[1] We wish to thank Cesare Imbriani for his continuous encouragement and support in conducting this research and Sam Fankhauser and Antonio Nicita for their valuable comments on a previous version of the work.

[2] 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.

The unpredictability of the enforcement strategy need not be meant as a literal randomization of the strategy of the environmental authorities. Rather, it can be seen as reflecting the heterogeneity of the members of the environmental agencies, and the impossibility by the firm of knowing in advance with which members it will be matched. Thus, even if each individual member of the environmental agency were to follow a pure strategy, their heterogeneity would lead the firm to behave as if the agency as a whole were randomizing its strategies. This interpretation of the results is consistent with Harsanyi's Purification Theorem (Harsanyi, 1973).

These are the core reasons why the U.S. enforcement system has become the object of political, economic and environmental debate with regard to the possibility that environmental regulations are enforced selectively or arbitrarily. This, in turn, raises the issue of potentially inadequate enforcement, partly due to the regulatory competition between EPA and DOJ (e.g., Yeager (1991) on the Clean Water Act enforcement). These considerations constitute the main motivation for developing these specific models of environmental enforcement in which the relationships between EPA and DOJ, that have traditionally been treated as independent of each other, are investigated in a strategic game together with firms. In this paper, thus, we analyse theoretically (by means of a game theory model) and empirically (by means of an experiment) the role of EPA and DOJ in deterring firms from polluting. In this paper, thus, we analyse theoretically (by means of a game theory model) and empirically (by means of an experiment) the role of EPA and DOJ in deterring firms from polluting.

The innovative contribution of this analysis resides in the fact that, contrary to most of the literature, discretion is interpreted as a key element in encouraging firms to adopt compliant environmental behaviour, and thereby constitutes a crucial element in the management of any environmental policy. Overall, a defence of the current U.S. environmental enforcement system is provided, suggesting that, contrary to the prevailing consensus in the literature (Sunstein *et al.,* 2002) that a consistent and predictable enforcement is preferable, a discretionary enforcement may generate higher compliance (Baker *et al.*, 2004). One of the main results of the theoretical analysis is, moreover, that criminal enforcement can enhance deterrence by improving firms' compliance. From a policy perspective, the results obtained may assist regulators and enforcers in environmental policy development and decision-making, by contrasting the impact of alternative enforcement strategies, allowing them to identify the most effective strategies to maximize firms' compliance and, thus, environmental quality. Moreover, this analysis brings new evidence in the realm of enforcement and discretion studies since, to the best of our knowledge, it is the first attempt to offer an empirical validation on the efficacy of a combined use of administrative and civil/criminal enforcement approaches by means of laboratory experiments.

The paper is organized as follows. Section 2 reviews some of the main literature directly related to this issue. Section 3 presents two game theory models on enforcement and discretion. Section 4 presents the experimental design. Section 5 analyses the experimental results and section 6 offers some concluding remarks.

2. Related Literature on Environmental Enforcement

Our analysis is closely related to the literature on selective enforcement (Friesen, 2003; Lando and Shavell, 2004) pioneered by Harrington (1988), who had 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.[3] In revisiting the Harrington paradox, Heyes and Rickman (1999) analyse the role of regulatory dealing by which the enforcement agency can use tolerance in some contexts and for some types of violations, in order to increase compliance in other contexts and for other violations. The authors interpret discretion as an important aspect of the strategic agency's behaviour and as a necessary element of any environmental policy, 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 (see also Polinsky and Shavell, 1984, 2000; Posner, 1985, 2003; Shavell, 1993, 2003; Stigler, 2002; Garoupa, 1997, 2001, 2004), our contribution consists of analysing how the EPA and the DOJ can influence firms' behaviour by randomizing, on purpose, enforcement rules and by modelling their interactions in a strategic game characterized by discretion. We can thus investigate: i) whether the implementation of administrative or civil/criminal actions could help improve environmental compliance, and ii) how both EPA and DOJ choose to handle cases, that is civilly or criminally.

According to Firestone (2003), the EPA does not pursue all enforcement cases administratively. In order to explain why and how EPA makes its decisions, Firestone explored the implications of five main theoretical "alternative" motivations for EPA enforcement decisions: (i) social welfare maximization; (ii) violation minimization; (iii) case maximization; (iv) environmental harm minimization; and (v) political support maximization. Firestone's main results are that when EPA seeks to maximize social welfare, to minimize the number of violations, or to 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

[3] 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.

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.

Related works are also those by Tsebelis (1989) and by Franckx (2001; 2002). In Tsebelis, individuals' offending behaviour is modelled as a one-shot 2x2 game between public and police; the game does not have a pure strategy equilibrium, instead it has a unique mixed strategy equilibrium. Franckx considers inspection games between polluting firms and an inspection agency to identify under which conditions ambient inspections can improve compliance. In another game theoretic framework by Scholz (1991) the EPA's enforcement approach depends on where the agency and firm are in the enforcement process implying that the regulatory enforcement involves the regulator and firm in an on-going series of prisoner's dilemma games. Because the regulatory game is played repeatedly, the regulator chooses its action based on the firm's behaviour in the prior round. If the firm had cooperated, the agency should cooperate, but if the firm defected the agency should punish it until the firm again adopts a co-operative behaviour.

Compared to the extensive theoretical literature on monitoring and enforcement aspects of environmental regulation (Cohen, 2000a; Polinsky and Shavell, 2000), the empirical literature is still lagging behind. In particular, relatively little is known about why firms decide to comply or not with environmental regulations, partly because comprehensive data on compliance and enforcement have been difficult to obtain (Cohen, 2000b), but also because there is a serious lack of empirical data on the motivations influencing firms' compliance behaviour. However, most of the empirical research looks at the factors that can influence the inspection decisions of environmental agencies - some examples are Magat and Viscusi (1990), Laplante and Rilstone (1996), Dion *et al.* (1998), Helland (1998), Dasgupta *et al.* (2000), Stafford (2003), Anderson and Stafford (2003), Rousseau (2007) - where it is extensively shown that increases in the frequency of inspections in regulated facilities increase compliance. Glicksman and Earnhardt in their work (2007) show that the threat of inspections improves firms' compliance. They contrast the effects of administrative and civil fines, finding that civil fine are significantly more effective than administrative fines in terms of their general deterrence. Other studies focusing on the effects of sanctions show that an increase in penalties also results in an increase in compliance rates (Stafford, 2002; Shimshack and Ward, 2005). Related literature also includes, in the macroeconomic field, the literature on rules versus discretion on the conduct of monetary policy (Kydland and Prescott, 1977). Other relevant 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. Game Theoretic Models of Enforcement

The economic structure of the enforcement problem is analysed throughout two game theoretical models. We will study how the violator's behaviour is influenced by the course of actions discretionally implemented by EPA and DOJ actions. In particular, firms' behaviour 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 strategic games in order to determine the payoff maximizing strategies for the players and consequently determine the expected outcomes of the game.

We develop two game theoretical models:

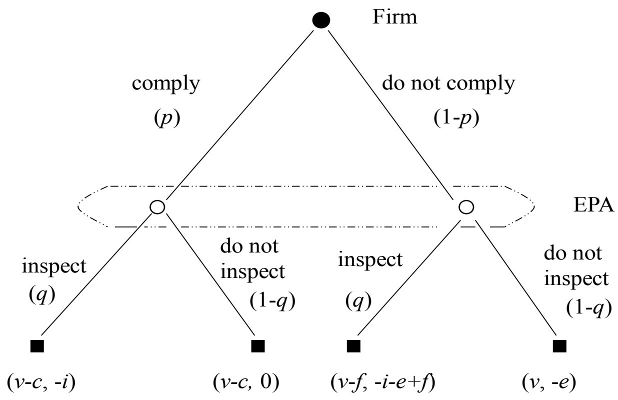
1. *Model 0* is a baseline model where the firm play against the EPA;
2. *Model I* is an heterogeneous model where the firm play against EPA and DOJ, under the assumption that EPA's objective function is different from DOJ's objective function. Note that model 0 is a sub-game of model I.

Regarding the objective functions of regulatory agency, in the literature, there is no consensus on their specification, ranging from minimization noncompliance to maximization of social welfare, from minimization of agency budgets constraints to maximization of agency political support (Viscusi and Zeckhauser, 1979; Jones and Scotchmer, 1990; Niskanen, 1975; Peltzman, 1976). The most common objective function incorporated in theoretical models of enforcement assumes that the enforcer acts to minimize non-compliance, subject to a budget constraint (examples include Harrington, 1988, and Heyes and Rickman, 1999). We assume that EPA and DOJ do not share exactly the same objective function, since the DOJ aims to minimize environmental violations, but it has to take into account also other factors, such as its own prestige/popularity/reputational factors related to prosecutors' concerns (as in Posner, 1993; Glaeser *et al.*, 2000; Rasmussen *et al.*, 2009, etc.).

3.1. The Baseline Model: 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.

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



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 to 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.

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

		EPA: Inspect	EPA: Do not inspect
Firm	Comply	*(v-c, -i)*	*(v-c, 0)*
	Do not comply	*(v-f, -i-e+f)*	*(v, -e)*

For simplicity, all players are assumed to be risk neutral. All the above parameters are strictly positive. We assume that the following additional restrictions on parameter values must hold:

(1) $i < e$

(2) $c < f \leq \bar{f}$

Condition (1) states that the environmental damage must be larger than the cost of inspection and is required to rule out the trivial result that never to inspect is a dominant strategy for EPA. Allowing for a corner solution in which the EPA never inspects (when $i > e$) does not add substantive insight to the analysis. The first part of condition (2) requires that the value of the fine levied by the EPA must be greater than the cost of compliance, and is required to rule out the trivial result that never to comply is a dominant strategy for the firm. Again, to keep the analysis straightforward, it is convenient to rule out the possibility that $c > f$ because, in this case, the costs of compliance would be higher than the fine, and the firm would never comply no matter how great the firm's value is. The upper bound on the fine, $\bar{f}$, rules out the possibility that EPA may set its fine at an infinite value.[4]

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 $v\text{-}f < v\text{-}c$ 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 $v > v\text{-}c$.

Conversely, if the firm complies then the 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 Equilibrium in pure strategies. There does exist, however, a mixed strategy Nash Equilibrium where the firm and the EPA randomize their choice of action (Ordershook, 1986). In a mixed-strategy Nash equilibrium, a player is indifferent between all of the available pure strategies with positive probabilities, but he/she randomizes so as to hide his/her intentions from the other players.[5] In 1973, Harsanyi presented the so-called "purification" interpretation of mixed strategy Nash equilibrium: the idea is that players play pure strategies, but by introducing some kind of heterogeneity (generated, for example, by incomplete information or random matching), a player is no longer sure that his/her opponent is choosing the same action, but has a diffuse belief over his/her opponent's moves. In Harsanyi's interpretation, a mixed strategy represents uncertainty for a player on how the other players will choose their strategies, rather than deliberate randomization (Morris, 2008).

According to the purification theorem of Harsanyi, thus, it could be that the firm and the EPA randomize their behaviours in the following way. Let us denote by p the probability of compliance by the firm and by q the probability of inspection by the EPA. The expected payoff to EPA if it carries out an inspection is given by:

[4] Some of the justifications for assuming an upper bound for the feasible fine are: i) financial constraints on the side of the firm lead to reasonable fines in order to avoid bankruptcy; ii) the "punishment fits the crime" principle (Michael, 1992) requires that the severity of penalty for a wrongdoing should be reasonable and proportionate to the severity of the infraction and is another reason for assuming a restriction on the feasible fine.

[5] This is a standard property of mixed-strategy Nash equilibrium, since the objective function is linear in the probability.

(3) $E(\pi^{I}_{EPA}) = p(-i) + (1-p)(-i-e+f) = -i-e+f+ep-fp$

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

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

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 $E(\pi^{I}_{EPA}) = E(\pi^{NI}_{EPA})$. Solving for *p* yields:

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

Note that *p* is a well-defined probability ($0 < p < 1$) since $0 < i < e$ by condition (1). Hence, $i < f$ for $p > 0$ and $i > f$ for $p = 0$. The expected payoffs to the firm under compliance and non-compliance are respectively:

(6) $E(\pi^{C}_{F}) = q(v-c) + (1-q)(v-c) = v - c$

(7) $E(\pi^{NC}_{F}) = q(v-f) + (1-q)v = v - qf$

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

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

Note that $q < 1$ since $c < f$ by condition (2). 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 $p = 1 - i/f$;

(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 fine. An increasing penalty would have a deterrent effect and the firm would have a greater incentive to comply. 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 and the firm would have greater incentive to violate, the probability of firm's inspection by EPA must accordingly increase. On the other hand, the 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 vice versa. Hence, if the EPA wishes to minimize its enforcement cost, it will set the fine at the largest possible level: $f = \bar{f}$, which would imply that the probability of inspection becomes $q = c / \bar{f}$.

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.

3.2. HETEROGENEOUS ENVIRONMENTAL AGENCIES

In this and the following sections we still consider a strategic model between EPA and DOJ, assuming that they may be characterized by different goals, with possibly conflicting objective functions.[6] The first author to hypothesize some sort of divergence between EPA and DOJ has been probably Niskanen (1975) for whom EPA or DOJ may be driven by self-interest, instead of being driven by a desire to maximize general deterrence. In particular, EPA may choose to maximize the number of enforcement cases. Yeager (1991) with regard to the enforcement of the U.S. Clean Water Act underlines a problem of regulatory competition between EPA and DOJ: "*The Agency refrains from referring some prosecutable cases because the EPA does not wish to share credit for the case with the Department.*" In literature there has been, in fact, a widespread support for introducing a certain degree of differentiation between the regulatory agency and the justice authority. Barker (2002) affirms that coordination between the two agencies can be exacerbated by varying goals,

[6] Blondiau and Rousseau (2010) discuss three objective functions for the enforcing authority: 1) social welfare maximization: it implies that the regulator balances compliance costs with environmental damages; 2) deterrence maximization: it implies that the costs associated with violating the rules should always be larger than the cost of compliance; 3) providing justice. The main objectives for a judge when penalizing violators are to protect society from harm, to show that society disapproves of certain acts and to foster recovery from the harm done; these elements are mainly related to reducing environmental harm and thus with maximizing deterrence and providing justice.

prosecutors giving more importance to conviction rates and being less tolerant of losing cases. Due to the fact that EPA may wish to have independence without coordination with the DOJ, or to the fact that EPA does not wish to share merit for the case with the Department, different motivations can be assumed as the basis for their respective enforcement decisions. This can also open up the problem of prosecutorial behaviour, which is extensively studied in the law and economics literature, especially with regard to career concerns underlying the importance of the incentives facing State and federal prosecutors. Posner (1993) was the first author to maintain that judges behave just like "ordinary people", in a rationality-based framework; since then, a significant body of theoretical research has been developed for understanding judicial behaviour at a trial.[7]

Prosecutors are assumed to be concerned not only with providing justice,[8] but to be also sensitive to their own personal goals: factors such as the possibility of promotion to a higher position or political re-election can affect their decisions (i.e., what penalty to seek, which offenses to prosecute). Dimento (1993) notes that prosecutors may respond to incentive structures that favour pursuing cases other than the most important environmental violations.

Rasmussen *et al*. (2009) focus on the problem of prosecutorial discretion in terms of case selection, i.e., whether to allocate resources broadly over many cases or intensively to a few cases. Forced by limitations of time and resources, prosecutors drop some cases, prosecute others, and prosecute some more intensely than others. A prosecutor's high conviction rate may not be a sign that he/she is tough on crime; instead, he/she might just be taking on easy cases and letting too many criminals go without prosecuting them.

Glaeser *et. al.* (2000) in their model of prosecutors' behaviour find that they tend to select which cases to pursue. Even though they generally aim to reduce crime, different incentives can create a desire among them on one hand to pursue the most dangerous criminals ("crime reduction" incentive) and, on the other hand, to pursue violators who will bring them private returns ("private career" concerns).

So, in formulating the expected payoff of DOJ in this second model, it seemed reasonable to assume that its objective may not be merely to minimize environmental damages but that it might be concerned both with stopping environmental violations and with the success/reputation of prosecutors, who are the most significant representative component of DOJ. Therefore, the firm's

[7] Public choice has developed around the notion that political and bureaucrats' behaviour can be explained, in part, as a result of individual utility maximization.

[8] Justice has been approached in many different ways such as procedural justice, retributive justice and restorative justice. Procedural justice incorporates a theory of procedural fairness for civil dispute resolution (see Solum, 2004). The concept of retributive justice is based on the principle "*Let the punishment fit the crime*" such that the severity of the penalty for a violation should be reasonable and proportional to the severity of the infraction (see Zaibert, 2006). Restorative justice, on the other hand, is concerned with making the victim whole and reintegrating the offender into society (see Braithwaite, 2002).

objective function is to maximize profits at minimum compliance costs, the EPA's objective function consists of minimizing environmental violations at minimum inspection costs. We assume that the DOJ's objective function is to minimize environmental violations taking into account not only social costs of civil and criminal sanctions (as in Blondiau and Rousseau, 2010) but also prestige/popularity/voting/reputational factors related to prosecutors' concerns (Posner, 1993; Glaeser *et al*., 2000; Rasmussen *et al.*, 2009).

This game is subdivided into two sub-games. The first sub-game we consider has the following structure. The firm can decide between complying with environmental regulations and not complying, by assessing the costs and benefits of compliance *versus* pollution. The EPA, not knowing 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 also 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 can levy a fine on the firm. However, if the EPA does not carry out an inspection and the firm does not comply, the EPA will internalize the cost of the environmental damage.

In the second game, the DOJ is introduced in the model. Now, the EPA could serve a notice of violation to the firm and the latter will be referred to DOJ, which exercises its discretion by deciding whether to initiate a civil or a criminal proceeding.

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.[9] If the EPA decides to deal with the case administratively, then it issues 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.[10] At this point, the firm must again decide whether to be compliant or non-compliant. If it does not comply and if the case cannot be resolved at the 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

[9] As noted by Firestone (2003), 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)].

[10] The purpose of a NOV is to initiate corrective action that will stop the violation. To provide an incentive for continuing compliance, NOVs 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.

between the environmental agency and the firm.

3.3. The Strategic Game between Firm, EPA and DOJ

In Model I we study how the introduction of the DOJ affects the interaction between the firm and EPA, under the assumption that EPA and DOJ could have different objective function. The corresponding game tree is illustrated in Figure 2. We assume also a profit-maximizing firm. In this model if the EPA, after the inspections, finds out that a firm is not compliant with some regulatory prescriptions, orders the violator to stop the activity (with a notice of violation). If the firm complies, spontaneously or through informal negotiations, then the case ends (on the game tree, the firm chooses to move on the left). If the case cannot be resolved in the administrative process (the firm chooses the strategy on the right), then the EPA will refer it to the DOJ that may proceed against a violator with either a civil suit or a criminal charge.[11] It retains exclusive authority to prosecute criminally[12] and has the authority to initiate all criminal cases referred by the EPA.[13,14]

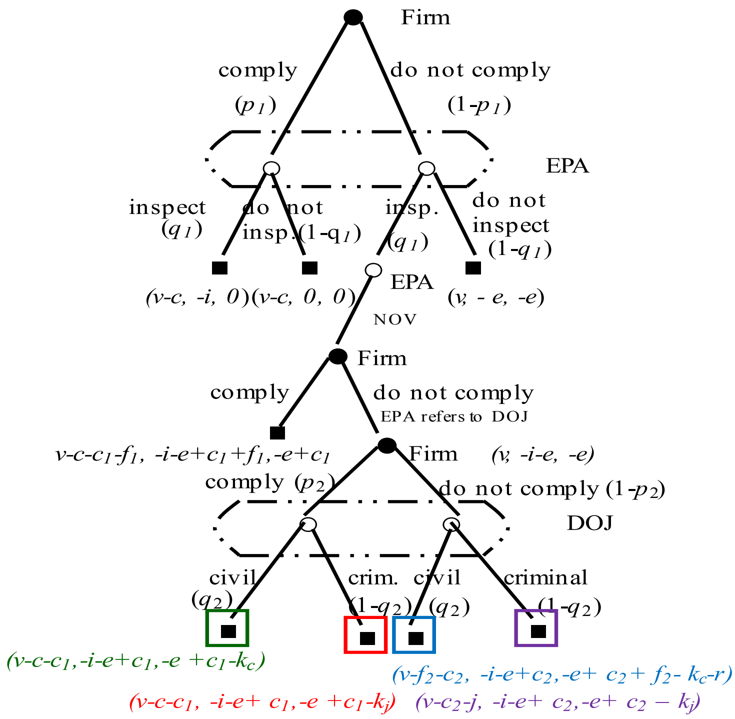
[11] The DOJ's charging decision is subject to administrative guidance. Prosecution should proceed only if there is probable cause to believe such a crime has been committed and the evidence is likely to sustain a conviction (2000 United States Attorneys' Manual, at § 9-27.200). In the decision to proceed 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 (United States Attorneys' Manual 2000, 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.

[12] 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

[13] 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.

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

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



The additional notation relative to the model of section 3.1 is as follows. We denote by c_1 the abatement and clean-up costs to the compliant firm, by c_2 abatement and clean-up costs to the non-compliant firm, by f_1 the fine from EPA if the firm is compliant after being served with a notice of violation, by f_2 the fine from civil prosecution when the firm chooses to remain non-compliant, 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 parameter restrictions must hold:

(9) $f_2 + c_2 < c + c_1$

(10) $c + c_1 < c_2 + j \leq c_2 + \bar{j}$

(11) $c_1 < c_2$

(12) $k_c < k_j$

(13) $k_j - k_c < r$

(14) $f_2 < r$

(15) $f_2 + k_j < r + k_c$

(16) $f_2 < j$

(17) $i < c_1\left(\frac{k_j - k_c}{r - f_2}\right) + c_2\left(\frac{k_j - k_c}{r - f_2}\right)$

Conditions (9)-(17) rule out the possibility of trivial solutions to the strategic game between firm, EPA and DOJ. For instance, (9) rules out compliance as a dominant strategy for the firm in the sub-game with the DOJ. If (9) does not hold, the firm would always trivially find it optimal to comply irrespective of whether the DOJ implements a civil or a criminal prosecution. Similarly, condition (10) rules out that non-compliance may always be a dominant strategy for the firm, irrespective of the DOJ's prosecutorial decision. As for condition (2) for civil prosecution, there must be an upper bound $\bar{j}$ to the largest criminal sentence that can be imposed.

The model can be solved by backward induction in two steps. In the first step, the sub-game between the firm and DOJ is solved; in the second step, the outcome of this sub-game is replaced into the game played between the firm and EPA to find their optimal strategies.

3.4. The Sub-Game between the Firm and DOJ

Following the same methodology as before let us consider first the sub-game between the firm and the DOJ. The payoff matrix for this game is shown in Table 2. 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, since $v - f_2 - c_2 > v - c - c_1$ by condition (9) above. However, if the firm does not comply, the DOJ would be better off by enforcing a criminal rather than a civil prosecution since $-e + c_2 - k_j > -e + c_2 + f_2 - r - k_c$ by condition (15).

Table 2. Payoff matrix for the sub-game between firm and DOJ (model I)

		DOJ: Civil	DOJ: Criminal	
Firm	Comply	$(v - c - c_1, -e + c_1 - k_c)$	$(v - c - c_1, -e + c_1 - k_j)$	p_2
	Do not comply	$(v - f_2 - c_2,$ $-e + c_2 + f_2 - r - k_c)$	$(v - c_2 - j, -e + c_2 - k_j)$	$1 - p_2$
		q_2	$1 - q_2$	

The sub-game between the firm and the DOJ does, however, have 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 expected payoff to DOJ if it enforces a civil prosecution is:

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

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

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

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_2 yields:

(20) $$p_2 = 1 - \frac{k_j - k_c}{r - f_2}$$

Note that $p_2 < 1$ since it is assumed that $k_j > k_c$ and $r > f_2$.

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

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

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

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_2 yields:

(23) $$q_2 = \frac{j-c-c_1+c_2}{j-f_2}$$

where $0 < q_2 < 1$ since by assumption (9a) $c + c_1 - c_2 > f_2$. 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. There is a mixed strategy Nash Equilibrium which is characterised by the following* *randomized strategies:*

(a) The firm complies with probability $p_2 = 1-[(k_j-k_c)/r-f_2]$

(b) The DOJ carries out a civil prosecution with probability $q_2 = (j-c-c_1+c_2)/(j-f_2)$

The probability of compliance by the firm is a decreasing function of the cost of criminal prosecution and of the fine f_2, and is an increasing function of the cost of civil prosecution k_c and of the reputation cost r to DOJ. The probability of civil prosecution by DOJ is an increasing function of the fine f_2, of the criminal sanction j and of the clean-up costs by the firm c_2, and is a decreasing function of the cost of compliance c and of the abatement pollution costs by the firm c_1. Also here, we can assume that the DOJ can minimise the probability of enforcing a costly criminal prosecution $(1-q_2)$ by committing itself to imposing the maximum sentence $\bar{j}$, which would imply that the probability of a civil prosecution becomes $q_2 = (\bar{j}-c-c_1+c_2)/(\bar{j}-f_2)$.

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

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

and the expected payoff to DOJ is:

(25) $$E(\pi_{DOJ}) = c_1 - c_1\left(\frac{k_j - k_c}{r - f_2}\right) + c_2\left(\frac{k_j - k_c}{r - f_2}\right) - k_j - e$$

3.5 THE GAME BETWEEN THE FIRM AND EPA

The payoff matrix for this sub-game is shown in Table 3. Note here that, in equilibrium a firm will never comply when the EPA serves a notice of violation/refers the case to DOJ because for the firm the non-compliance strategy dominates, since $v - c - c_1 < v - c$.

Table 3. Payoff matrix for the game between firm and EPA in the second-stage game (model I)

Firm	EPA: Inspect	EPA: Do not inspect	
Comply	$(v-c, -i-e+c_1)$	$(v-c, 0)$	p_2
Do not comply	$(v-c-c_1, -i-e+c_2)$	$(v, -e)$	$1-p_2$
	q_2	$1-q_2$	

The expected payoff to EPA if it serves a notice of violation and if DOJ implements civil prosecution is:

(26) $$E(\pi^1_{EPA}) = p_2(-i-e+c_1)+(1-p_2)(-i-e+c_2) = -i-e+p_2c_1+(1-p_2)c_2$$

where $p_2 = 1-\dfrac{k_j-k_c}{r-f_2}$, whence:

(27) $$E(\pi^2_{EPA}) = -i-e+\left(1-\frac{k_j-k_c}{r-f_2}\right)c_1+\left(\frac{k_j-k_c}{r-f_2}\right)c_2$$

The expected payoff to EPA if it serves a notice of violation and DOJ prosecutes criminally is:

(28) $$E(\pi^2_{EPA}) = p_2(0)+(1-p_2)(-e) = ep_2-e = (-e)(1-p_2)$$

Since we are solving the game by backward induction, we can replace these expected payoffs at the node that initiates the first game between the firm and EPA. The payoff matrix for this game is shown in Table 4.

Table 4. Payoff matrix for the game between firm and EPA in the first-stage game (model I)

		EPA: Inspect	EPA: Do not inspect	
Firm	Comply	$(v-c,-i)$	$(v-c,0)$	p_1
	Do not comply	$\left(v-c-c_1,-i-e+\left(1-\frac{k_j-k_c}{r-f_2}\right)c_1+\left(\frac{k_j-k_c}{r-f_2}\right)c_2\right)$	$(v,-e)$	$1-p_1$
		q_1	$1-q_1$	

Now, the expected payoff to EPA if it carries out an inspection is:

(29) $$E(\pi^I_{EPA}) = p_1(-i)+(1-p_1)\left[-i-e+\left(1-\frac{k_j-k_c}{r-f_2}\right)c_1+\left(\frac{k_j-k_c}{r-f_2}\right)c_2\right]$$

and the expected payoff if it does not carry out an inspection is:

(30) $$E(\pi^{NI}_{EPA}) = p_1(0)+(1-p_1)(-e) = ep_1-e = (-e)(1-p_1)$$

The firm will choose the probability of compliance, p_1, in such a way that EPA is indifferent between inspecting or not: $E(\pi^I_{EPA}) = E(\pi^{NI}_{EPA})$. Solving for p_1,

(31) $$p_1 = \frac{-i+\left(1-\frac{k_j-k_c}{r-.f_2}\right)c_1+\left(\frac{k_j-k_c}{r-f_2}\right)c_2}{\left(1-\frac{k_j-k_c}{r-f_2}\right)c_1+\left(\frac{k_j-k_c}{r-f_2}\right)c_2}$$

We can rewrite (31) as follows:

(32) $$p_1 = 1 - \frac{i}{\left(1 - \frac{k_j - k_c}{r - f_2}\right)c_1 + \left(\frac{k_j - k_c}{r - f_2}\right)c_2}$$

Note that $0 < p_1 < 1$ because of condition (17).
The expected payoffs to the firm if it complies and if it does not comply are respectively:

(33) $$E(\pi_F^{1,C}) = q_1(v - c) + (1 - q_1)(v - c) = v - c$$

(34) $$E(\pi_F^{1,NC}) = q_1(v - c - c_1) + (1 - q_1)v = v - q_1(c + c_1)$$

The EPA will choose its probability of inspection q_1 so that the firm is indifferent between complying or not: $E(\pi_F^{1,C}) = E(\pi_F^{1,NC})$. Solving for q_1 yields:

(35) $$q_1 = \frac{c}{c + c_1}$$

Note that $0 < q < 1$ since $c > 0$ and $c_1 > 0$.
In equilibrium, then, the expected payoff to the EPA is:

(36) $$E(\pi_{EPA}) = -\frac{ei}{c_1 + \left(\frac{k_j - k_c}{r - f_2}\right)(c_2 - c_1)}$$

The above results can be summarised by the following proposition.

Proposition 3. *The game played by the firm and EPA has no dominant pure strategy Nash Equilibrium. However, there exists a mixed strategy Nash Equilibrium, which is characterized by the following randomized strategies:*

(a) The firm complies with probability $p_1 = 1 - \frac{i}{\left(1 - \frac{k_j - k_c}{r - f_2}\right)c_1 + \left(\frac{k_j - k_c}{r - f_2}\right)c_2}$

(b) The EPA carries out an inspection with probability $q_1 = c/(c + c_1)$

The probability of compliance by the firm is a decreasing function of the cost of inspection, of the reputational costs and of the cost of civil prosecution and is an increasing function of the fine, of the cost of criminal prosecution, and of the clean-up costs if compliant (c_1) and of the clean-up costs when it is not compliant (c_2) and is forced to clean up by DOJ.

In equilibrium, the expected payoff of EPA is a decreasing function of both inspection costs and environmental damages, and is an increasing function of the clean-up cost if compliant (c_1), the clean-up cost when non compliant (c_2) and the incentive that the DOJ might have to prosecute civilly $(k_j - k_c)/(r - f_2)$.

There are some interesting aspects of these results that need to be emphasized. Comparing the EPA's payoffs in the potential different strategies prefigured in the game between the firm, EPA and DOJ, we can observe that the EPA's payoffs, independently of the strategy chosen by DOJ, is $(-i-e+c_1)$ if the firm is compliant, and $(-i-e+c_2)$ if the firm is not compliant.

If $c_1 = c_2$, the EPA is indifferent to the strategy chosen by the firm, but if $c_2 > c_1$, the EPA will be better-off if the firm decides to be non-compliant since the clean-up costs in this case are higher. This implies that, in equilibrium, the EPA will be better-off in expected value of its payoff if the firm decides not to comply. Note also that, if $c_2 > c_1$, the probability of compliance by the firm increases if the incentive the DOJ might have to prosecute civilly $(k_j - k_c)/(r - f_2)$ increases. If $c_2 > c_1$, the incentive for DOJ to prosecute civilly $(k_j - k_c)/(r - f_2)$ increases as the cost of criminal prosecution and the fine increase, and as the cost of civil prosecution and reputational costs decrease. So, if DOJ has a greater incentive to prosecute civilly (because it is less resource intensive), the firm is more likely not to comply, generating higher clean-up costs and making the EPA better-off for this. Since the EPA would have greater incentive to inspect, the firm will try to offset this motivation by increasing its probability of compliance.

Therefore, all these considerations imply that in equilibrium: a) the DOJ, when the cost of criminal prosecution increases, is more likely to initiate a civil action; b) the EPA would have greater incentive to inspect; and 3) the firm will increase its probability of compliance.

In equilibrium, when the EPA is indifferent to the strategy chosen by the DOJ, the firm has a even greater probability of compliance, given that $v\text{-}c > v\text{-}c\text{-}c_1$. So, the involvement of DOJ might improve the firm's probability of compliance, strengthening, as a result, the effectiveness of enforcement policies.

4. THE EXPERIMENTAL DESIGN[15]

We tested in the laboratory the two game theoretical models. Model 0 is our control treatment, Model I is the heterogeneous treatment. The experiment was conducted at the Law School of the University of Rome "Sapienza" (Italy) in December 2010, with subjects being second-year undergraduate students attending Economics classes. The experimental sessions took place in a large classroom and subjects were seated so that they could not observe each other's choices. Each subject was provided with a booklet containing the games to be played as well as printed instructions, which were read aloud to all participants. The experiment lasted about 90 minutes including the initial

[15] Funding for subjects' payments was provided by the University of Rome "Sapienza", Italy.

instruction time and payment of subjects. A total of 32[16] undergraduate students participated in each session. None of them had previously participated in economic experiments. Subjects' choices where elicited under *hot* and *cold* conditions and using pairwise choice gambles. Upon completion of the experiment the subjects were asked one by one to approach the experimenter for payment of show up fees and payoffs from the game. Subjects earned on average €25 including the €5 show up fee.

In the control treatment, we assigned values to the parameters reported in Figure 1 as follows:

- the probability q_1 of EPA starting an inspection was set equal to 2/3;
- the value of non-complying firm v was set equal to €50;
- the cost of compliance c was set equal to €30;
- the fine f_1 was set equal to €20;
- the other two parameters the inspection cost ($-i$) and the environmental damage ($-e$) are not relevant to our experiment as they characterize the EPA pay-off which in the experiment is played out by Nature (see Figure 3).
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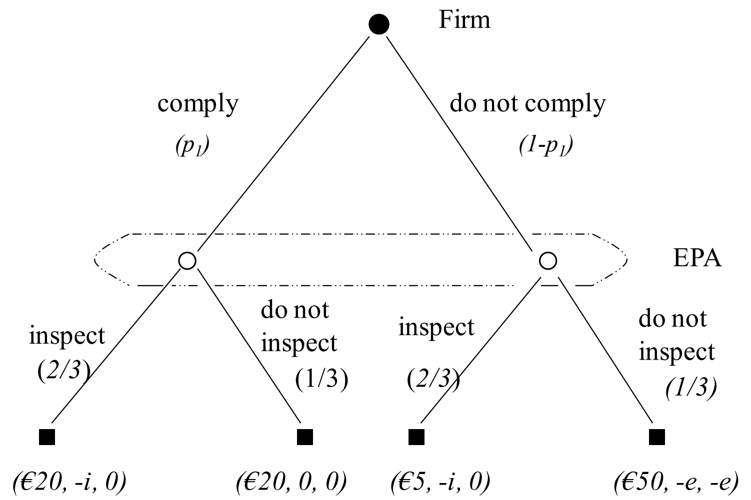
- **Figure 3. Strategic game between firm and EPA in extensive form**



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In the heterogeneous treatment, we assigned values to the parameters reported in Figure 2 as follows:

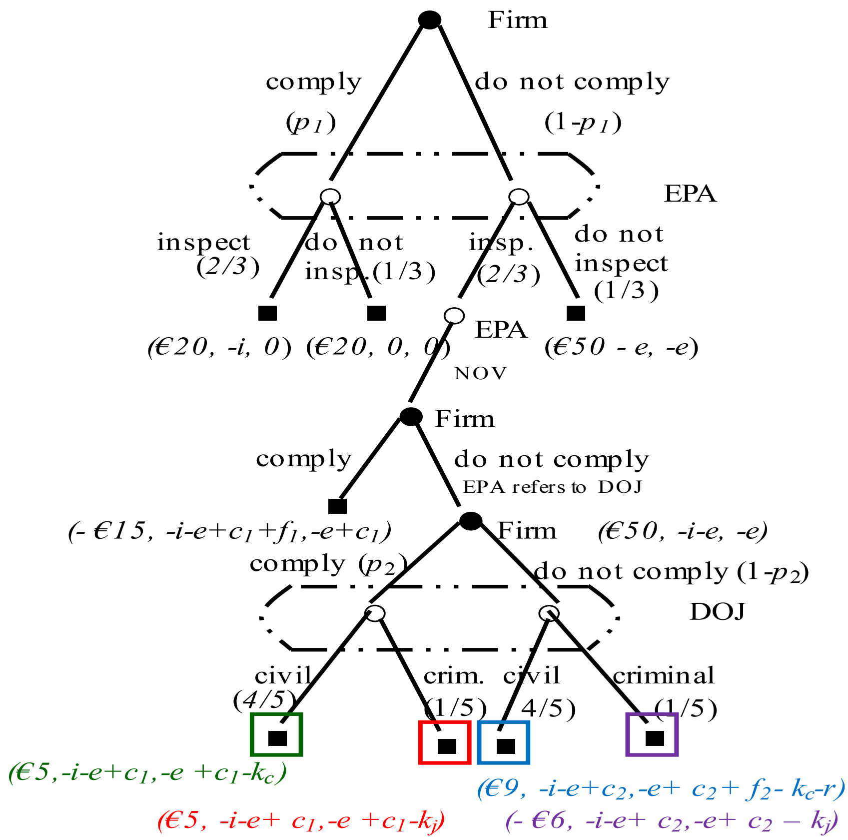
- the probability q_1 of EPA starting an inspection was set equal to 2/3;
- the probability q_2 of DOJ starting a civil action was set equal to 4/5;
- the value v was set equal to €50;
- the cost of compliance c was set equal to €30;
- the additional compliance cost c_1, if the firm did not comply in the first instance, but did

[16] 33 subjects participated when preferences were elicited using pair wise choice lotteries both in the control treatment, and in the heterogeneous treatment.

comply after EPA issuing a notice of violation, was set equal to €15;

- the further abatement and clean up costs to the non-compliant firm, c_2, was set equal to €16;
- the fine f_1, from EPA if the firm is compliant after being served with a notice of violation, was set equal to €20;
- the fine f_2 from civil prosecution when the firm chooses to remain non-compliant was set equal to €25;
- the cost to the firm from criminal prosecution j was set equal to €40.
- Also in this case some parameters where not relevant to our experiment as they characterize the DOJ pay-offs that in the experiment is played out by Nature[17] (see Figure 4).

- **Figure 4. Strategic game between firm, EPA and DOJ in extensive form**



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[17] k_c is the cost to DOJ of enforcing civil prosecution, k_j the cost of enforcing criminal prosecution, and finally r is the reputation cost of letting off an offending firm with only a fine

In the experimental parameterization, we decided to focus only on the case in which $c_2 > c_1$[18] ignoring the other case in which $c_2 = c_1$ (under this circumstance, the EPA is indifferent to the strategy chosen by the firm).

As mentioned above, we elicited subjects' behaviour using *hot* and *cold* methodologies as well as pairwise choice gambles presented as segmented circles. All the presented risky lotteries were composed of the following outcomes: -€15, -€6, €5, €9, €20 and €50. The probabilities of these outcomes are recorded in Table 5.

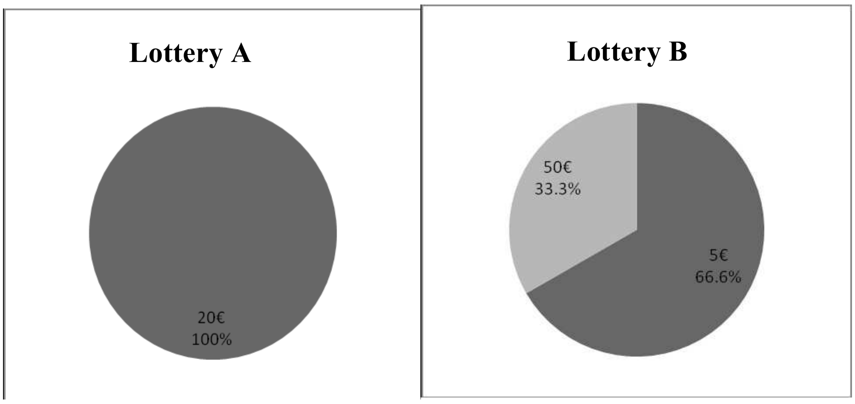
Table 5. Gambles of all games – summary table (second experiment)

Pairwise choice gambles	Left gamble						Right Gamble					
€	*-15*	*-6*	*5*	*9*	*20*	*50*	*-15*	*-6*	*5*	*9*	*20*	*50*
Gamble 1	0	0	0	0	1	0	0	0	0.66	0	0	0.33
Gamble 2	0	0	0	0	1	0	0.66	0	0	0	0	0.33
Gamble 3	0	0	0	0	1	0	0	0.18	0	0.49	0	0.33
Gamble 4	0.66	0	0	0	0	0.33	0	0	0.66	0	0	0.33
Gamble 5	0.66	0	0	0	0	0.33	0	0.18	0	0.49	0	0.33
Gamble 6	0	0	0.66	0	0	0.33	0	0.18	0	0.49	0	0.25

Pairwise choice gamble 1 reported in the first raw of Table 5 (and presented graphically in Figure 5) represents the firm's choice problem in the control treatment (see Figure 3). If the firm decides to comply (see left gamble), whatever the EPA action is, it will receive *v-c* (set in the experiment equal to €20). If, instead, the firm decides to not comply its payoff depends on the EPA action; it will receive v-c-c_1 (equal to €5) with probability q_1 if the EPA decides to inspect, and *v* (equal to €50) otherwise (see right gamble).

[18] the clean-up costs for the firm when it is not compliant and it is forced to clean up by DOJ (c_2) are greater than the clean-up costs if it is compliant (c_1)

Figure 5. Gambles of the game between firm and EPA



Pairwise choice gamble 2 (Table 5) represents one part of the firm's decision problem developed in the heterogeneous treatment presented in Figure 4. If the firm decides to comply (see left gamble 2 in Table 5), it receives v-c = €20 whatever the EPA action. If the firm decides to not comply, its pay-off depends on the EPA's action: if the EPA decides to not inspect it receives v = €50 with probability 1-q_1= 1/3; if the EPA decides to inspect and the firm reacts to the EPA's notice of violation by complying, then its payoff will be v-c-c_1-f_1 = -€15 independently of the DOJ decision (see right gamble 2 in Table 5).

Pairwise choice gamble 3 represents another part of game tree depicted in Figure 2. As always, if the firm decides to comply (see the left gamble 3 in Table 5), whatever the EPA action is, it receives v-c = €20; if the firm decides not to comply and the EPA decides not to inspect, the firm receives v = €50 with probability 1-q_1; if the EPA decides to inspect and the firm does not react to the EPA's notice of violation by complying, then its pay-off is depend on the DOJ's strategy. If the firm decides to remain not compliant its payoff is respectively: v-f_2-c_2 = €9 if the DOJ starts a civil procedure and v-c_2-j = -€6 if the DOJ starts a criminal procedure (see right gamble 3 in Table 5).

Pairwise choice gamble 4 represents another part of the firm's decision problem. If the firm decides to not comply and the EPA decides not to inspect, the firm receives v = €50 with probability 1-q_1; if the EPA decides to inspect and the firm reacts to the EPA's notice of violation by complying, then its payoff will be v-c-c_1-f_1 = -€15 independently of the DOJ decision (see left gamble 4 in Table 5). If, however, the firm decides to comply, after the EPA has referred the case to the DOJ, then its payoff is v-c-c_1 = €5, either if DOJ starts a civil procedure or if the DOJ starts a criminal procedure (see right gamble 4 in Table 5).

Pairwise choice gamble 5 represents almost the same decision problem described in pairwise choice gamble 4, except for the fact that the firm now chooses not to comply even after the EPA has referred the case to DOJ. So, in this case, if the firm decides not to comply and the EPA decides not to inspect, the firm gets v = €50 with probability $1-q_1$; if the EPA decides to inspect and the firm reacts to the EPA's notice of violation by complying, then its payoff will be $v-c-c_1-f_1$ = -€15 independently of the DOJ decision (see left gamble 5 in Table 5). If, however, the firm decides to remain not compliant, after the EPA has referred the case to DOJ, then its two additional payoffs are $v-f_2-c_2$ = €9 if DOJ starts a civil procedure and $v-c_2- j$ = - €6 if DOJ starts criminal procedure (see right gamble 5 in Table 5).

Pairwise choice gamble 6 is the last part of the firm's decision problem to be analysed. If the firm decides to not comply and the EPA decides to not inspect, the firm gets, as before, (with probability $1-q_1$) v = €50; if the EPA decides to inspect and the firm reacts to the EPA's notice of violation by not complying, but decides to comply after the case has been referred to DOJ, then its payoff is $v-c-c_1$ = €5 (see left gamble 6 in Table 5) independently by the enforcement action (civil or criminal) chosen by DOJ. If, however, the firm decides to remain non compliant, after the EPA has referred the case to DOJ, then its payoffs are $v-f_2-c_2$ = €9 if DOJ starts a civil procedure and $v-c_2- j$ = -€6 if DOJ starts a criminal procedure (see right gamble 6 in Table 5).

5. Experimental Findings

In this section we present the results of our experiment using the *hot*, the *cold* and the *pairwise choice gamble* elicitation methods. As discussed in the experimental design section, we first tested the strategic game between the EPA and the firm.

Preliminary we should observe that 20 out of 32 subjects considered in the *hot* elicitation method (see Figure 6), and 18 out of 32 in the *cold* elicitation method decided to comply (see Figure 7); in the *pairwise choice gamble* elicitation methods only 12 out of 33 complied (see Figure 8). Using a Chi-square with two degree of freedom we tested if the compliance rate obtained under the three elicitation methods is the same or not. We cannot reject the null hypothesis at 1% and 5% significance levels (we reject it at a 10% significance level).[19]

[19] Testing hot *vs.* cold we cannot reject the null hypothesis at any significance level; testing hot (cold) *vs.* pairwise choice gamble we reject the null hypothesis at a 5% (11**%**) significance level.

Figure 6. Strategic game between firm and EPA under hot method- results

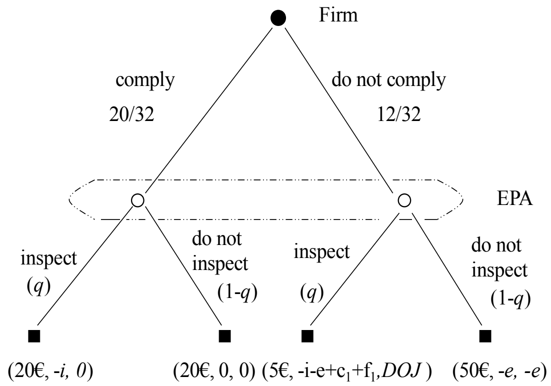


Figure 7. Strategic game between firm and EPA under cold method- results

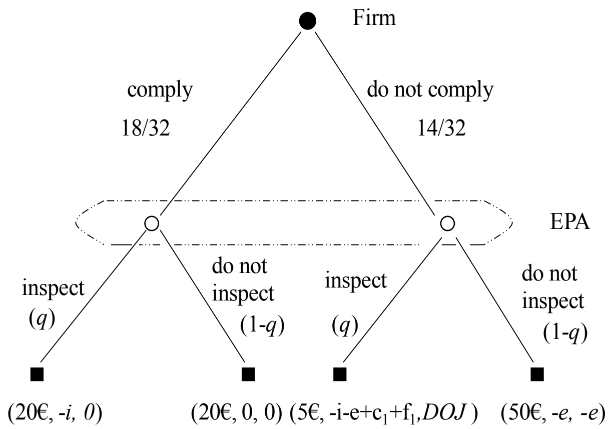
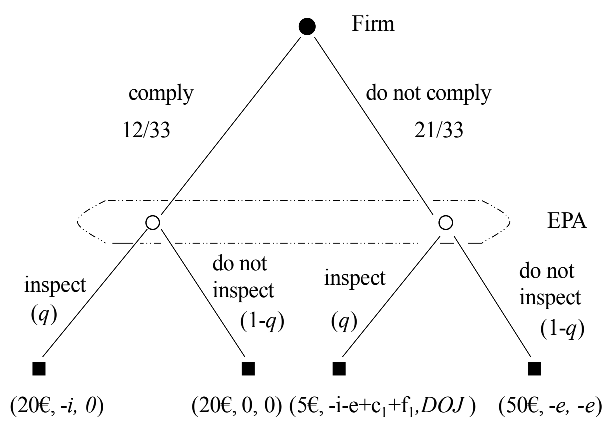


Figure 8. Strategic game between firm and EPA under lotteries method- results



In the heterogeneous treatment we observe that 15 subjects complied with environmental measures in the first move under the *hot* elicitation method (see Figure 9); 18 complied in the *cold* elicitation method (see Figure 10), and 12 in the *pairwise choice gamble* elicitation methods (see Figure 11).

Figure 9. Strategic game between firm, EPA and DOJ under hot method- results

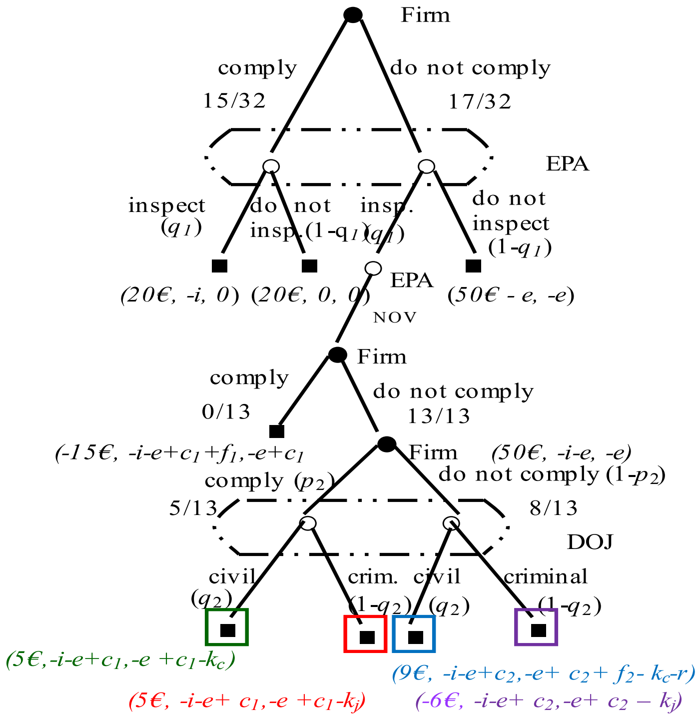


Figure 10. Strategic game between firm, EPA and DOJ under cold method- results

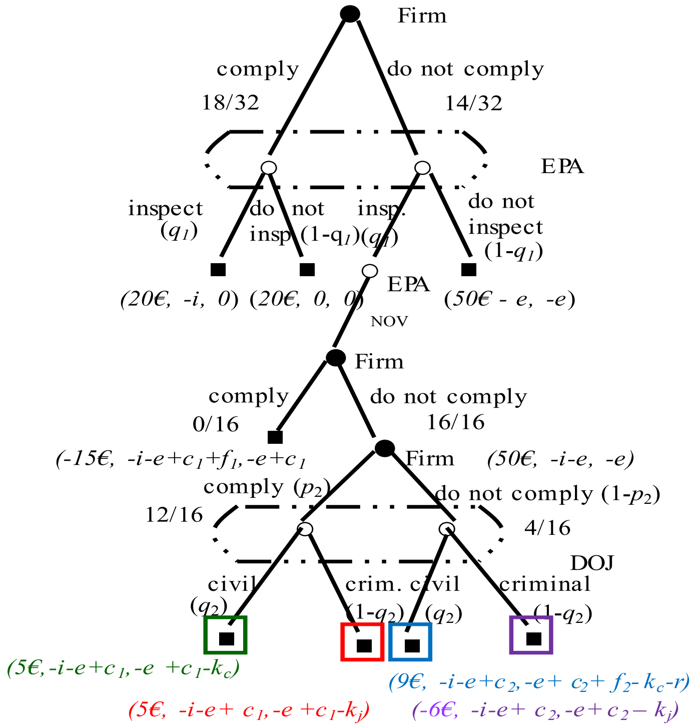
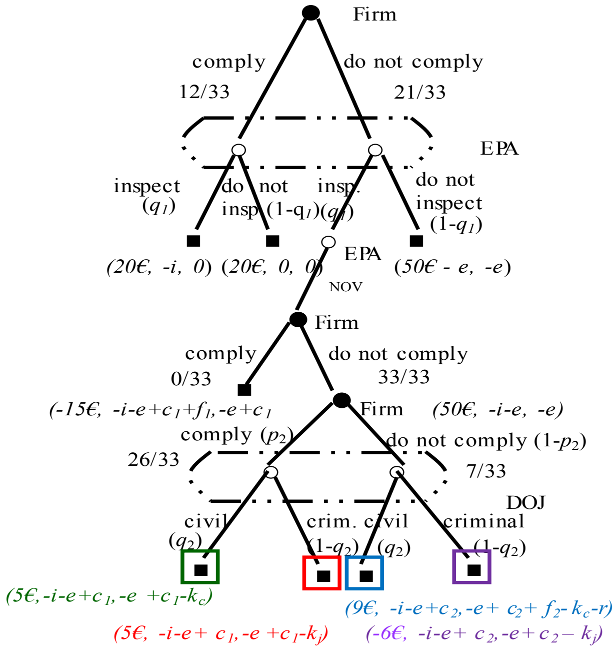


Figure 11. Strategic game between firm, EPA and DOJ under lotteries method- results



Testing if subjects' compliance rate in the first node change across elicitation methods we cannot reject the null hypothesis (at any significance level). In the second decision node all subjects, that received a notice of violation from the EPA, decided to *not compile* irrespectively to the elicitation method. In the third decision node (i.e. once the EPA refers to the DOJ) we can observe that in the *hot* elicitation method, 38% of subjects that initially decided to remain non compliant switched to a compliant behaviour once the EPA notifies the violation; this percentage rise to 75% in the *cold* elicitation method[20] and up to 79% in the *pairwise choice gamble* elicitation methods. Using again a Chi-square with two degree of freedom we tested if the compliance rate obtained under the three elicitation methods is the same or not finding that we cannot reject the null hypothesis at a significance level of 2.5%. This finding is driven by the result obtained when eliciting subject behaviours with *hot* method which differs significantly form the results obtained under the other two elicitation methods. In fact, testing *hot* vs. *cold* we can reject the null hypothesis at a 5% significance level; testing *hot* vs. *pairwise choice gamble* we can reject the null hypothesis at 1% significance level; however, testing *cold* vs. *pairwise choice gamble* we cannot reject the null hypothesis at any significant level. We can now state our first experimental result:

RESULT 1: Subjects' behaviour is largely unaffected by the used elicitation method.

[20] Note that, although in the experiment instructions it was clearly stated that subjects should have made a decision every time they reached a node followed by dotted lines, only 16 subjects (out of 32) expressed their choices on the whole game tree

Now we compare the compliance rate in the control treatment with the first move compliance rate in the heterogeneous treatment. We tested subjects' behaviour for the three elicitation methods pooling all the data together, and separately. We cannot reject the null hypothesis that they are the same in any of the elicitation methods at any significance level. These give us our second result:

RESULT 2: The introduction of the DOJ does not produce, in the first move, a reduction of the compliance rate.

As we already stated in the second movement (irrespectively to the elicitation methods) all the subjects that got a notice of violation from the EPA continue to not compile; they are respectively 13, 16, and 26 in *hot, cold,* and *pairwise choice*. Reached the third decision node (i.e. the EPA refers to the DOJ) 5 subjects out of 13 in the *hot*, 12 subjects out of 16 in the *cold*, and 26 subjects out of 33 in the *pairwise choice*. We can affirm, therefore, that in qualitative terms there are no divergences among the different elicitation methods since, once the EPA has referred the case to the DOJ for civil or criminal prosecution, the firm's probability of compliance might improve; this is consistent with one of the main results of the theoretical model.

As set in the model, we know that the probability of inspection (and hence, for those firms who did not comply, of receiving a notice of violation) is $q_1 = c/(c+c_1)$. So, under our experimental parameterization, this probability will be equal to 2/3. Therefore, we can expect that out of the 17 firms that did not comply, in the first instance, only 11.3 will be inspected by the EPA and then only 4.3 will switch to compliance. All in all, this adds up to 15 + 4.3 = 19.3 complying firms in the *hot* elicitation method. In the *cold* elicitation method we observe 14 firms that did not comply, in the first instance, 9.3 of which will be inspected and so we can expect that out of the inspected firms 7 will comply; this adds up to 18 + 7 = 25 complying firms in the *cold* elicitation method. In the *pairwise choice* elicitation method we observe 21 firms that did not comply in the first move, consequently only 14 will be inspected and out of the inspected firm 11.03 will comply; all in all, in the *pairwise choice gamble* elicitation methods we will end up with 12+11.03 = 23.03 complying firms. On the one hand, comparing the compliance overall rate under the three elicitation methods we cannot reject the null hypothesis that they are equal, this reinforce our Result 1. On the other hand, pooling all the data coming from the three elicitation methods and comparing the overall compliance rates in the two treatments (i.e. control and heterogeneous) we reject the null hypothesis of equality at a 2.5% significance level. We can now state our third results.

*RESULT 3: Introducing criminal enforcement generates a statistically significant increase in the number of compliant subjects***.**

6. CONCLUSIONS

During the last few decades, the enforcement toolbox of U.S. environmental regulators and institutions has been harshly criticized (see, for example, Abbot, 2005) for leaving too large an amount of discretion, administrative and/or investigative, in the hands of the Environmental Protection Agency, and prosecutorial in the hands of the Department of Justice. The U.S. EPA has been promoting enforcement activities on all fronts but especially on criminal actions[21]. Such a trend has come under criticism as it has been argued that the fear of being indicted may, in the long run, undermine environmental compliance thereby worsening both the relations between EPA and firms and environmental conditions (Coffee, 1991; Green, 1997; Gaynor and Lippard, 2002). Moreover, as noted by Firestone (2003), the decision about whether to enforce and what kind of enforcement action to undertake rests entirely in the discretion of the enforcer. This discretion implies that, rightly or wrongly, some cases are handled administratively, whereas very similar cases end up in the courts (Babbit, Cory, *et al.,* 2004). In some circumstances civil injunctions are issued to prevent further harm and to begin clean-up procedures, while in some others, criminal sanctions are applied to further punish the violator.[22]

We do believe that the analysis developed in this paper can offer important insights into the regulator's behaviour. There are some interesting aspects of our results. For example, when the cost of criminal prosecution increases, in equilibrium: a) the DOJ is more likely to initiate a civil action; b) the EPA would have greater incentive to inspect; and 3) the firm will increase its probability of compliance. Overall, our theoretical results may be somewhat surprising since they run counter to the general consensus in the literature that a consistent and predictable enforcement is preferable: we suggest, by contrast, that a discretionary enforcement strategy may generate higher compliance. Another common crucial point of our results is that EPA and DOJ engage in strategic interaction in their environmental enforcement behaviour. We show that not only do they influence each other in their enforcement decisions, but they also impact on decisions by the firms and increase (under certain circumstances) their probability of compliance.

This may suggest that increasing the scope of criminal enforcement programmes would possibly strengthen deterrence since criminal fines might be able to give polluters adequate incentives to prevent environmental crimes by improving the effectiveness of enforcement policies. This result is particularly relevant considering that both in the United States and in the European Union environmental regulators have, in the last decade, been actively reviewing how to extend criminal sanctions in terms of their scale and scope to enhance deterrence (U.S. Senate, 2003; House

[21] U.S. EPA, *Compliance and Enforcement Annual Results* (various years).

[22]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.

of Commons, 2005; European Commission, 2007).

Our experimental results provide, moreover, a strong empirical validation of the theoretical outcomes obtained in the game theory model by supporting the argument that criminal enforcement can enhance deterrence by improving firms' compliance. In terms of environmental policy implications, our result can have notable policy implications concerning the optimal choice of enforcement strategies suggesting that, even though EPA and DOJ have to work together for a better environmental quality, they should not share the same objective functions to maximize the level of compliance by the firms.

While motivated by and intended to analyze the enforcement of environmental regulations, the game theory models developed here are applicable to other contexts that entail relationships between different enforcement institutions. For example, they can be applied to analyze enforcement options and players' behavior in financial crime areas, such as tax law enforcement, money laundering, *etc*. One possible way to extend this study for future research could be to develop dynamic game theory models where players can learn how to play over time and can update their beliefs by learning how to play based on their past experiences and acquired knowledge of the other players' actions and their payoffs. Moreover, the patterns of the different enforcement strategies considered in the game theory models are based on the conventional enforcement system mostly applied in the U.S.; it would be interesting, in future research, to extend this analysis to game theoretical models for Europe, where the environmental enforcement institutional mechanisms are different.

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APPENDIX: EXPERIMENTAL INSTRUCTIONS (ORIGINALLY IN ITALIAN)

In this appendix, we report the instructions that we used for the treatments played.

Instructions for participating to the experiment (these instructions are the same for both experiments).

Welcome and thank you for having accepted to participate at this experiment. You will receive €5 for participating. Please, carefully read the following instructions that are identical for every participant.

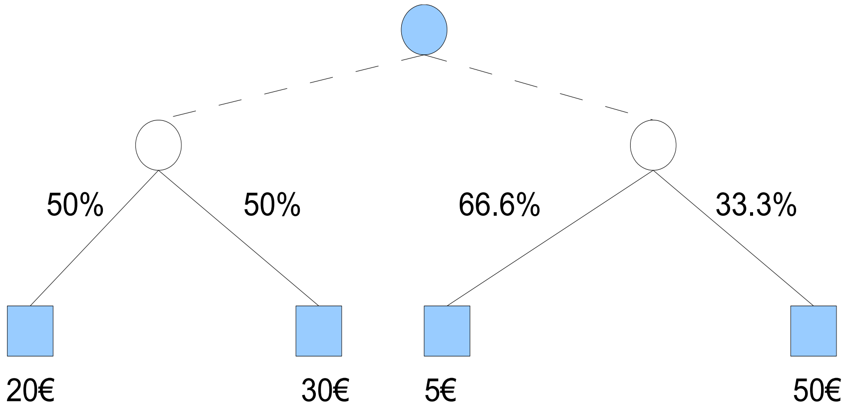
During the experiment you are not allowed to talk with any of the other participants. If you will not respect this rule you will be excluded from the experiment and you will not receive any payment.

If you have any question, please, raise your hand and wait that one of the experimenters will come close to you to respond to your answer.

What you will earn will depend partly by your choices and partly by the case. You will earn €5 for being here plus the half of the overall amount you will gain during the experiment will be paid cash directly at the end of the experiment.

Control treatment - cold

In this experiment you will see two figures (called trees) as the one presented below.



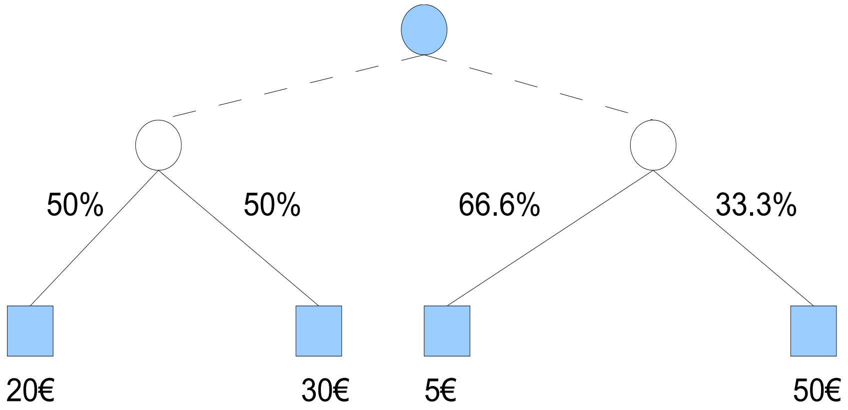
In the above presented tree, as example, starting from the dark circle (called node) you should choose whether to move on the right or on the left side of the tree. To identify your choice, you have to underline with your pen one of the two dotted lines. If you choose left, you will play a lottery where you could win €20 with 50% of probability or €30 with 50% of probability. If you choose right, you will play a lottery where you could €5 with 66.6% of probability or €50 with a probability of 33.3%.

In the trees presented in this experiment, you should make a decision every time you reach a node followed by dotted lines.

Turn page and start your experiment.

Control treatment - hot

In this experiment you will see two figures (called trees) as the one presented below.



In the above presented tree, as example, starting from the dark circle (called node) you should choose whether to move on the right or on the left side of the tree. To identify your choice, you have to underline with your pen one of the two dotted lines. If you choose left, you will play a lottery where you could win €20 with 50% of probability or €30 with 50% of probability. If you choose right, you will play a lottery where you could €5 with 66.6% of probability or €50 with a probability of 33.3%.

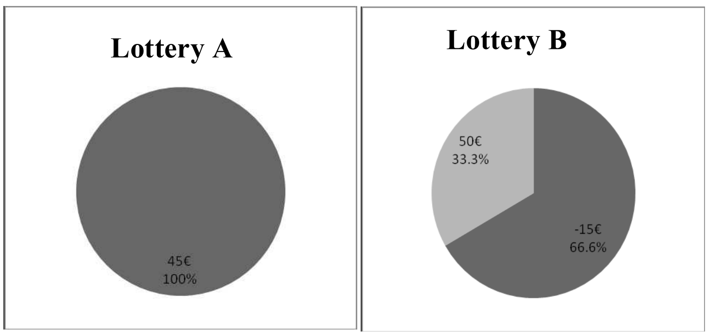
In the trees presented in this experiment, you should make a decision every time you reach a node followed by dotted lines. After you take your decision, underlining a dotted line, please raise your hand to call one of the experimenters that are in the classroom to know how to proceed.

Turn page and start your experiment.

Control treatment – pairwise choice

In this experiment you will see six pairwise choice gamble lotteries, as follows.

For every pairwise lottery you will have to specify if you prefer to play lottery A or lottery B.



If you choose lottery A you will receive €75 with certainty, if you choose lottery B you will receive €50 with 75% of probability and €100 with 25% of probability. You will find ten pairwise choice lotteries: your task is to choose for every pair of lotteries if you prefer lottery A or lottery B.

Turn page and begin the experiment!