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« Deterrence vs. Efficiency To Regulate Nonpoint Source Pollution »

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Deterrence vs. Efficiency To Regulate Nonpoint Source Pollution

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Abstract

In the context of nonpoint source pollution the regulator can not attribute individually the responsibility of pollution because of informational asymmetry which makes the costs of monitoring of individual emission very high. This grounds a moral hazard problem. We analyse group performance based instruments to regulate this kind of informational problem. In particular, we assess random and collective fining schemes with respect to their deterrence and efficiency. We show that a collective fine scheme is more deterrent than a random fine scheme. However, the analysis of efficiency is less categorical between these two schemes. The efficiency depends on the number of non-compliant agents. If the number of non-compliant agents is high it is better to implement a collective fine scheme. If the number of non-compliant agents is small it is better to implement a random fine scheme.

Keywords : Nonpoint Source Pollution, Group Performance Based Instruments, Deterrence, Efficiency.

JEL codes : H2, H3, L5, Q5

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1 Introduction

Agricultural nonpoint source pollution which appears in the form of surface pollution (rivers, lakes) as well as underground pollution (watertable) is characterized by the fact that the regulator cannot observe individual emissions because it is very costly and/or technically impossible to undertake. This prevents the regulator from using usual instruments such as taxes, standards and tradable permits markets to regulate this kind of pollution. This is why other types of instruments have been designed that circumvent issues associated to the control and monitoring of individual emissions. Indeed, the literature addressed the use of observable variables such as inputs and outputs ([5] and [16]) but also the ambient pollution ([10] and [14]) measured at a well defined hotspot. In this article we address economic instruments based on collective performance which is the level of ambient pollution. Instead of seeking to manage individual emissions (individual performance) the regulator controls aggregated pollution (collective performance) at a hotspot, having defined beforehand an ambient standard not to be exceeded.

Collective performance based instruments have been designed to solve the team moral hazard issue [7], [4] and [13] and have then been extended to nonpoint source pollution issues. The first authors which have mobilized collective performance based instruments to manage nonpoint source pollution are Meran and Schwalbe [10] and Segerson [14]. These authors have independently proposed an incentive tax/subsidy scheme based on the difference between an ambient pollution level observed and a predetermined ambient pollution target. The originality of the scheme is that it applies in both cases of an excess or a lack of pollution compared to the target.

One of the main criticism raised against these schemes is that they are not budget balancing [4], [13], [6]. Indeed, when the number of agents subject to the scheme is high, the amount of collected tax (or subsidy)[1] is very high compared to the social costs of environmental damage. Indeed, the schemes proposed by Meran and Schwalbe [10] and Segerson [14] imply either an excess of collected tax compared to the social damage, or an excess of granted subsidies compared to the social benefit. Hence the non-budget balancing issue.

In order to overcome this problem, Xepapadeas [18] proposed two mechanisms. The first one is based on a collective tax/subsidy and the second one is based on random tax to solve both monitoring and control issues and the problem of budget-balance. The collective tax/subsidy scheme proposed by Xepapadeas [18] is based on the fact that if the ambient pollution standard is exceeded, each agent is taxed but also receives a subsidy for each abatement unit. The random tax is based on the fact that if the pollution standard is exceeded, an agent will be randomly chosen and taxed, independently from his responsibility for the ambient pollution excess. Then the tax is redistributed among the other agents. Although Holmström [7] demonstrated that there is no budget-balanced mechanism that induces the agents to implement the efficient abatement, Xepapadeas [18], by allowing the redistribution of the tax/subsidy, shows that this mechanism is budget-balanced.

Numerous authors have analysed collective tax/subsidy schemes and random taxes to manage nonpoint source pollution ([3] ; [2] ; [8] ; [17]). However these papers were targeted at assessing the economic efficiency of these instruments. Alpizar *et al.* [1] follow these authors by assessing the efficiency of random versus collective fining schemes to achieve an ambient pollution target in a laboratory framework.

However, this literature does not treat the problem of punishing the compliant agents among the non-compliant and its impact on deterrence and

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[1] According to the difference between the ambient pollution standard and the ambient pollution level observed.

efficiency. Indeed, the main characteristic of random mechanisms is that at least one agent will be randomly fined if the ambient standard is exceeded. However, the regulator is not sure to fine the agent who has contributed to the excess of pollution according to the standard. This raises the issue of punishing the compliant agents.

In the case of a collective scheme, all the agents will be fined if the ambient standard is exceeded. So the regulator knows for sure that free-riders will be fined. However, even the agents who have provided an abatement effort will be fined, raising also the issue of punishing the compliant agents. This in turn raises the issue of the social efficiency of such schemes that do not discriminate the compliant from the non-compliant agents.

In this article we analyse random and collective schemes from the deterrence point of view, *i.e.*, we are interested in the capacity that a mechanism has to compel the agents to conform to a given policy. Then we analyse these two schemes from the point of view of efficiency in the vein of Miceli and Segerson [11]. We extend their analysis to the case of several non-compliant agents and fine randomly applied to more than one agent.

We show that a collective fine scheme is more deterrent than a random fine scheme. However, the analysis of efficiency is less categorical between collective and random fine schemes. It depends on the number of non-compliant agents. If the number of non-compliant agents is high it is better to implement a collective fine scheme. If the number of non-compliant agents is small it is better to implement a random fine scheme.

This article is organized as follows. In section 2, we assess the deterrence of both random and collective schemes. Then in section 3 the efficiency analysis is performed for these two schemes. Section 4 discusses and concludes.

2 Random vs. Collective Fining Schemes: A Deterrence Analysis

Consider an agent i among n heterogeneous agents, identified on a well defined zone. Each agent is characterized by an individual abatement level a_i and an abatement cost function, increasing and convex, $c_i(a_i)$. The profit function of agent i is then:

$$\pi_i = \pi_i^0 - c_i(a_i) \tag{1}$$

where π_i^0 is agent i's profit before the pollution abatement policy is applied. We assume that the abatement level does not affect the output function [14].

The regulator does not know individual abatement levels a_i but she can easily observe the aggregated collective abatement level $A = \sum_{j=1}^{n} a_j$ through the equality:

$$A = Z^0 - Z \tag{2}$$

Z^0 being the ambient pollution level before the implementation of the abatement policy, and Z the observed ambient pollution level.

The regulator imposes an ambient pollution standard $\bar{Z}$ she wants to prevent the agents from exceeding collectively. The aggregated abatement objective A^* is determined by the difference between the pre-policy aggregated pollution level and the ambient standard:

$$A^* = Z^0 - \bar{Z} \tag{3}$$

Individually, agent i has to solve the following program :

$$\max_{a_i} \pi_i(a_i) = \pi_i^0 - c_i(a_i) \tag{4}$$

subject to :

$$\sum_{j=1}^{n} a_j \geqslant A^* \tag{5}$$

which implies :

$$a_i + \sum_{k=1}^{n-1} a_k \geqslant A^* \qquad with\ k \neq i \tag{6}$$

However as the agent can only control a_i, this program can not be solved without added information or some coordination of the agents.

Agent i's choices are restricted by the others' decisions as described in the equation 6. This constraint is said coupling [9] because it links the programs of all agents.

Let a_i^* be the abatement level that solves the equation 4 subject to the coupling constraint 5 in a socially optimal way. The optimal equilibrium in $A^* = (a_1^*, ..., a_n^*)$ is such that $c_1^{'}(a_1^*) = ... = c_n^{'}(a_n^*)$. To reach this equilibrium, it is necessary that each agent, including i, knows the others' marginal abatement costs, or, when this condition is not met, that there is an exchange of information that guides the agents towards this equilibrium.

The literature on collective performance based instruments to manage nonpoint source pollution avoids this point by assuming that the agents are homogeneous ([18] and [1]) or by assuming that the agents cooperate, because they have an interest to do so, to determine a_i^* [12], or that the cost function is common knowledge [14]. In the case of nonpoint source pollution, these conditions seem quite demanding. We maintain the assumption that a_i^* is not observable. Then it only matters that the abatement vector meets the collective constraint $\sum_{j=1}^{n} a_j \geqslant A^*$. Therefore, there exists a lot of vectors $\tilde{A} = (\tilde{a}_1, ..., \tilde{a}_n)$ such that $\sum_{j=1}^{n} \tilde{a}_j \geqslant A^*, j = [1, ..., n]$.

In the case where neither the regulator nor the agents know the (other) agents' marginal cost functions, the regulator cannot implement an efficient policy that ensures that all the agents responsible for pollution conform to the abatement target. Failing to implement such a policy, and in charge of ensuring depolluting activities, the regulator needs to develop deterrent mechanisms. The only information exchanged between the regulator and the agents is a fine applied if the pollution standard is exceeded. More precisely, in what follows we analyse two schemes that enforce to reach the collective abatement objective through deterrence.

2.1 Random Fine

Here we consider that the agents have to produce a collective abatement effort to satisfy an environmental standard so that $\sum_{j=1}^{n} a_j \geqslant A^*$. If the abatement level is not met, m agents among the n agents concerned by the policy instrument will be randomly chosen. With a probability $\frac{m}{n}$, m agents have to pay a fine f_r whatever their individual abatement. The individual profit function becomes:

- if the collective abatement A is below A^* such that ambient pollution standard $\bar{Z}$ is exceeded:

$$\pi_i(a_i) = \begin{cases} \pi_i^0 - c_i(a_i) - f_r & \text{with a probability } \dfrac{m}{n} \\ \pi_i^0 - c_i(a_i) & \text{with a probability } \dfrac{n-m}{n} \end{cases} \tag{7}$$

- if the collective abatement A is above or equal to A^*:

$$\pi_i(a_i) = \pi_i^0 - c_i(a_i) \tag{8}$$

This implies the following expected profit function:

$$E\pi_i = p_r[\frac{m}{n}(\pi_i^0 - c_i(a_i) - f_r) + \frac{n-m}{n}(\pi_i^0 - c_i(a_i))] + (1-p_r)(\pi_i^0 - c_i(a_i)) \quad (9)$$

with p_r the probability that the abatement level is not reached and $\frac{m}{n}$ the probability for agent i to be randomly chosen to be fined.
Equation (9) can be compactly read:

$$E\pi_i = \pi_i^0 - c_i(a_i) - p_r\frac{m}{n}f_r \quad (10)$$

For a risk-neutral agent, compliance to the optimal abatement level is a dominant strategy if:

$$c_i(\tilde{a}_i) < c_i(a_i) + p_r\frac{m}{n}f_r \quad (11)$$

which implies :

$$p_r\frac{m}{n}f_r > c_i(\tilde{a}_i) - c_i(a_i) \ \ \forall a_i \in A_i \quad (12)$$

with, A_i the abatement decision space of the agent i.

Agent i compares the gain from abating less than what is required by the ambient standard, $l_i = c_i(\tilde{a}_i) - c_i(a_i)$, with the expected cost from being fined $p_r\frac{m}{n}f_r$.

To ensure that inequality (12) holds, the regulator can act on two variables : the level of the random fine f_r and the number of agents to fine. Indeed, by increasing any of these variables, the regulator ensures a higher level of compliance, thus a high level of deterrence.

However, in contrast with Xepapadeas' scheme [18], any polluting unit reduced above the standard $\bar{Z}$ does not guarantee that a subsidy will be granted. Hence, an agent can not know his socially optimal abatement level, thus agent i faces a dilemma:

- if his individual abatement level a_i is above $\tilde{a}_i$ he incurs an additional cost $c_i(a_i) - c_i(\tilde{a}_i)$ and faces a random fine with a probability $\dfrac{m}{n}$ if $A < A^*$.

- if his individual abatement level a_i is below $\tilde{a}_i$ he saves an abatement cost $c_i(\tilde{a}_i) - c_i(a_i)$ and also faces a random fine with a probability $\dfrac{m}{n}$ if $A < A^*$.

However, the higher the individual abatement level a_i, the lower the probability that the ambient standard is exceeded p_r. On the other hand, the lower the individual abatement level a_i, the higher p_r.

2.2 Collective Fine

Under the collective fine scheme, agents are collectively fined if the regulator observes that the aggregated abatement objective is not reached. Then she imposes a fine f_c to each agent. The difference with the random fine scheme is that potential polluters are sure to be fined if the abatement objective is not reached. If it is, no one will be fined. Hence the following profit function:

- if the collective abatement A is below A^* such that ambient pollution standard $\bar{Z}$ is exceeded:

$$\pi_i(a_i) = \pi_i^0 - c_i(a_i) - f_c \tag{13}$$

- if the collective abatement A is above or equal to A^*:

$$\pi_i(a_i) = \pi_i^0 - c_i(a_i) \tag{14}$$

In terms of expected profit:

$$E\pi_i = p_c(\pi_i^0 - c_i(a_i) - f_c) + (1 - p_c)(\pi_i^0 - c_i(a_i)) \tag{15}$$

With p_c the probability, in the collective fine case, that $A < A^*$.

Equation (15) leads to:

$$E\pi_i = \pi_i^0 - c_i(a_i) - p_c f_c \tag{16}$$

For a risk-neutral agent, compliance with the optimal abatement level is an equilibrium if:

$$c_i(\tilde{a}_i) < c_i(a_i) + p_c f_c \tag{17}$$

which implies :

$$p_c f_c > c_i(\tilde{a}_i) - c_i(a_i) \, \forall a_i \in A_i \tag{18}$$

with, A_i the abatement decision space of the agent i.

Agent i compares the gain from abating less than what is required by the ambient standard, $l_i = c_i(\tilde{a}_i) - c_i(a_i)$, with the expected cost from being fined $p_c f_c$.

In order to guarantee that inequality (18) holds, the regulator can impact on the collective fine level f_c, depending on the level of deterrence she will choose.

Contrary to the random fine case, if agent i modifies his individual abatement level below $\tilde{a}_i$ he faces a collective fine f_c with certainty. However, his individual abatement level has an impact on the probability that the pollution standard is exceeded p_c.

2.3 Discussion On Deterrence

The above-analysis addressed the deterrence capacity of random and collective fine schemes. We have shown that in order for the random fine to reach the abatement objective, the following inequality must hold : $p_r \frac{m}{n} f_r > c_i(\tilde{a}_i) - c_i(a_i)$; and for the collective fine to do so: $p_c f_c > c_i(\tilde{a}_i) - c_i(a_i)$. However, in both cases, the fine does not depend on the agents' actions while the agents' actions depend on the fine: $a_i(f)$.

In this case, the costs incurred by agent i when a random fine is applied are:

$$c_i(a_i(f_r)) + p_r \frac{m}{n} f_r \tag{19}$$

The optimal actions that the agent i must choose can be read from the FOC of equation (19):

$$\frac{\partial c_i}{\partial a_i} \frac{\partial a_i}{\partial f_r} + p_r \frac{m}{n} = 0 \tag{20}$$

$$p_r \frac{m}{n} = -\frac{\partial c_i}{\partial a_i} \frac{\partial a_i}{\partial f_r} \tag{21}$$

Let Pi_r be the probability for agent i to be fined under a random fine scheme. Then $Pi_r = p_r \frac{m}{n}$.

The costs incurred by agent i when a collective fine is applied are:

$$c_i(a_i(f_c)) + p_c f_c \tag{22}$$

The optimal action that the agent i must choose can be read from the FOC of equation (22):

$$\frac{\partial c_i}{\partial a_i} \frac{\partial a_i}{\partial f_c} + p_c = 0 \tag{23}$$

$$p_c = -\frac{\partial c_i}{\partial a_i} \frac{\partial a_i}{\partial f_c} \tag{24}$$

Let Pi_c be the probability for agent i to be fined under a collective fine scheme. Then $Pi_c = p_c$.

As a risk neutral agent is indifferent between the fining schemes such that $\frac{\partial a_i}{\partial f_r} = \frac{\partial a_i}{\partial f_c}$ consequently $Pi_r = Pi_c$, then $p_r \frac{m}{n} = p_c$ which leads to $p_c < p_r$. Facing the same risk of being fined at a given fine amount, the agents assess higher probability to exceed the standard under the random scheme p_r. As it has been defined above, a highly deterrent mechanism leads the probability to exceed the standard toward zero. Then we can conclude from that the collective fine is more deterrent than the random fine.

3 Random vs. Collective Fining Schemes: An Efficiency Analysis

We analysed above the random and collective fine from the point of view of deterrence. In this section we analyse these two types of fine from the point of view of efficiency in the vein of Miceli and Segerson [11] who consider the case of only one non-compliant agent. However, as in the case of nonpoint source pollution, the number of non-compliant agents is unknown, we assume that is equal to m, with $m \in [1, n]$.

The rationale Micelli and Segerson (2007) are using consists to assess the behavior of the pivotal agent. However, it seems relevent to adjust the control policy to some expectation the regulator has about the number of non-compliant agents. This number up to some extend depends on the instrument she implements. So, we extend the analysis of Miceli and Segerson [11] to m agents which are both non-compliant and non-identified. Therefore we are able to study the impact of m on the efficiency of both schemes. In this section we measure the efficiency through the comparison between the Social Welfare of both random and collective schemes. The Social Welfare is given by the difference between the social benefit and the social cost of the applied scheme and whose Social Welfare is above the other is the most efficient.

A social benefit appears when an incentive is applied to the proper agent. In our case, this corresponds to a fine applied to an agent who does not enough reduce its emissions. A social cost appears when an incentive is applied to the wrong agent. In our case, this corresponds to a fine applied to an agent who does enough reduce its emissions.

Let $B(f)$ be the social benefit function to implement a fine f to the non-compliant agents, and f^* the fine that maximizes this function $B(f)$. The characteristics of this social benefit function are such that: If $f < f^*$ then $\frac{\partial B}{\partial f} > 0$ and, if $f > f^*$ then $\frac{\partial B}{\partial f} < 0$. With $\frac{\partial B}{\partial f^*} = 0$, $\frac{\partial^2 B}{\partial f^2} < 0$ and $B(0) = 0$.

Let $\hat{m}$ the number of non-compliant agents. We assume that the regulator makes an assumption about $\hat{m}$ and chooses m such that the number of randomly fined agents equals the number of non-compliant agents. We also note r the probability to fine an agent among the n agents. As the number of agents randomly fined is m then $r = \frac{m}{n}$. Thus, $r = 1$ means that all agents are fined, this is the case of collective fine, such that $m = n$.

Along the lines of Miceli and Segerson [11], we compare the fining schemes with respect to the *ex post* Social Welfare they induce.

The Social Welfare under random fine is:

$$SW_r = rmB(f_r) - r(n-m)\gamma f_r \tag{25}$$

The social welfare SW_r under random fine is equal to the social benefit $B(f_r)$ to fine the m non-compliant agents with probability r minus the cost γf_r to fine the $(n-m)$ compliant agents with probability r.

	m	$(n-m)$
r	non-compliant agents fined $rmB(f_r)$	compliant agents fined $r(n-m)\gamma f_r$
$(1-r)$	non-compliant agents not fined 0	compliant agents not fined 0

As shown in the table above, the social benefit of imposing a fine on the m

non-compliant agents is zero, and the social cost of not imposing a fine on the $(n-m)$ compliant agents is also zero.

The social welfare under collective fine is achieved from the random fine expression (**??**) when r is set to 1:

$$SW_c = \hat{m}B(f_c) - (n-\hat{m})\gamma f_c \tag{26}$$

In the collective fine scheme the assumption $\hat{m} = m$ is not needed and at every time non-compliant agents will be fined. Thus the social welfare SW_c under collective fine is equal to the social benefit $B(f_c)$ to fine the $\hat{m}$ non-compliant agents with probability $r = 1$, because it is sure that they will be fined, minus the costs γf_r to fine the $(n-\hat{m})$ compliant agents with probability $r = 1$, because it is sure that they will also be fined.

In the random fine scheme the regulator can act both on r by choosing $r \neq \frac{m}{n}$, and the amount of f_r. So, the regulator seeks to maximize the social welfare SW_r under these two variables. The FOC of equation (25) is:

$$\frac{dSW_r}{df_r} = rm\frac{dB(f_r)}{df_r} - r(n-m)\gamma = 0 \tag{27}$$

$$\frac{dSW_r}{dr} = mB(f_r) - (n-m)\gamma f_r = 0 \tag{28}$$

Which implies:

$$\frac{dB(f_r)}{df_r} = \frac{(n-m)}{m}\gamma \text{ , with } m \neq 0 \tag{29}$$

As $m < n$, so $\frac{dB}{df_r} > 0$. This implies that $f_r < f^*$ and $B(f_r) < B(f^*)$.

However the regulator can act on m such that $\frac{dB}{df_r}$ becomes close to zero. In this case the regulator chooses $m > \hat{m}$, *i.e.*, the number of fined agents is higher than the number of non-compliant agents. Such a change has a negative impact on social welfare SW_r and increase the social costs because the number of compliant agents fined will increase.

In the random fine scheme the higher SW_r is obtained if all non-compliant agents $\hat{m}$ are choose randomly. In this case the social cost is equal to zero and the social welfare is at the maximum.

In the collective scheme the regulator can act only on f_c. So, the regulator seeks to maximize the social welfare SW_c under this variable. The FOC of equation (26) is:

$$\frac{SW_c}{df_c} = \hat{m}\frac{dB(f_c)}{df_c} - (n - \hat{m})\gamma = 0 \tag{30}$$

Which implies:

$$\frac{dB(f_c)}{df_c} = \frac{(n - \hat{m})}{\hat{m}}\gamma \text{ , with } \hat{m} \neq 0 \tag{31}$$

As $\hat{m} < n$, B is increasing with f_c, and following the definition of B, then $f_c^* < f^*$. However, the social welfare SW_c, is negative when $\frac{\hat{m}}{n - \hat{m}}B(f_c) < \gamma f_c$, a situation which can happen where $\hat{m}$ is small compared to $(n - \hat{m})$ and/or $B(f_c)$ is small compared to γf_c.

In the collective fine scheme the higher $\hat{m}$ the higher SW_c is. As we are in nonpoint source pollution framework the rugulator does not know $\hat{m}$. For this reason, some money has to be diverted to make more accurate the selection of the non-compliant agents. If $\hat{m}$ is close to n the regulator has to choose the collective fine scheme to obtain the higher social welfare SW_c. If $\hat{m}$ is small compared to n the regulator has to choose the random fine scheme to obtain the higher social welfare SW_r.

4 Conclusion

In this article we analysed the collective and random fines from the point of view of deterrence and efficiency. In the first step, we show that the collective fine scheme is more dissuasive than the random fine scheme. However, the analysis of efficiency is less categorical between collective and random fine schemes. It depends on the number of non-compliant agents. If the number of non-compliant agents is high it is better to implement a collective fine scheme. If the number of non-compliant agents is small it is better to implement a random fine scheme.

However, economic policies whose goal is deterrence and those whose goal is efficiency, do not apply to the same circumstances. Indeed, deterrence-based instruments are applied in the case where the regulator can not achieve the efficiency, because of the informational asymmetry between her and the agents covered by the instrument, and the non-cooperation between these agents. The efficiency-based instruments, are applied when the regulator is to accompany her economic policy with a mechanism of identification of non-compliant agents.

So, these two goal-based instruments are substitutable and applicable in different situations. However, it is possible that both could be used complementarily. In this case deterrence is seen as a threat, that the regulator can put forward, if the goal of efficiency is not reached [15].

References

[1] Alpizar, F. and Requate, T. and Schram, A., 2004 Collective versus random Fining: An Experimental Study on Controlling Ambient Pollution. *Environmental and Resource Economics*, 29:231-252.

[2] Byström, O. and Bromley, D. W., 1998. Contracting for non-point-source pollution abatement. *Journal of Agricultural and Resource Economics*, 23:39-54.

[3] Cabe, R., Herriges, J. A., 1992. The Regulation of Non-Point Sources of Pollution Under Imperfect and Asymmetric Information. *Journal of Environmental Economics and Management*, 22:134-146.

[4] Eswaran, M. and Kotwal, A., 1984. The moral hazard of budget-breaking. *Rand Journal of Economics*, 15:578-581.

[5] Griffin, R.C. and Bromley, D.W., 1982. Agricultural runoff as a non-point externality: a theoretical development. *American Journal of Agricultural Economics*, 64:547-552.

[6] Herriges, J. R. and Govindasamy, R. and Shogren, J., 1994. Budget-balancing incentive mechanisms. *Journal of Environmental Economics and Management*, 27:275-285.

[7] Holmström, B., 1982. Moral Hazard in Teams. *Bell Journal of Economics*, 13:324-340.

[8] Horan, R. D. and Shortle, J. S. and Abler, D. G., 1998. Ambient Taxes when Polluters Have Multiple Choices. *Journal of Environmental Economics and Management*, 36:186-199.

[9] Krawczyk, J.B. and Uryasev, S., 2000. Relaxation algorithms to find Nash equilibria with economic applications. *Environmental Modeling and Assessment*, 5:63-73.

[10] Meran, G., Schwalbe, U., 1987. Pollution Control and Collective Penalties. *Journal of Institutional and Theoretical Economics*, 143:616-629.

[11] Miceli, T.J. and Segerson, K., 2007 Punishing the Innocent Along with the Guilty: The Economics of Individual versus Group Punishment. *The Journal of Legal Studies*, 36:81-10.

[12] Pushkarskaya, H. N., 2003 Nonpoint Source Water Pollution Control: Incentives Theory Approach. *The Ohio State University*,

[13] Rasmusen, E., 1987. Moral hazard in risk-averse teams. *Rand Journal of Economics*, 18:428-435.

[14] Segerson, K., 1988. Uncertainty and Incentives for Nonpoint Pollution Control. *Journal of Environmental Economics and Management*, 15:87-98.

[15] Segerson, K. and Wu, J. J., 2006. Voluntary Approaches to Nonpoint Pollution Control: Inducing First-Best Outcomes through the Use of Threats. *Journal of Environmental Economics and Management*, 51:165-184.

[16] Shortle, J. S. and Dunn, J. W., 1986. The Relative Efficiency of Agricultural Source Water Pollution Control Policies. *American Journal of Agricultural Economics*, 68:668-677.

[17] Shortle, J. S. and Horan, R.D., 2001. The economics of nonpoint pollution control. *Journal of economic survey*,15:255-289.

[18] Xepapadeas, A. P., 1991. Environmental policy under imperfect information: incentives and moral hazard. *Journal of Environmental Economics and Management*, 20:113-126.

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[1] La liste intégrale des Documents de Travail du LAMETA parus depuis 1997 est disponible sur le site internet : http://www.lameta.univ-montp1.fr

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