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Paper Prepared for 4th Research Workshop "Permit trading in different applications"

University Halle-Wittenberg, Germany

29th November 2006

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Abstract

Nonpoint source pollution is characterized by the fact that individual emissions are not observable at a reasonable cost. This constitutes a moral hazard problem. Furthermore, we explicitly consider adverse selection, a second type of asymmetric information that arises because of the difficulty to differentiate the polluters with respect to their type (marginal benefit of polluting). In this paper, we design a tradable permits market between non point sources of pollution in the vein of Taylor (2003). In order to involve all the polluters contributing to a measured ambient pollution, we consider a collective performance based mechanism. This sanction mechanism is activated if the collective fails to build itself. The threat remains active along a negotiation process in order to make it converge to the equilibrium solution. Indeed, the agents are induced to reveal their real type (polluter, non polluter) through a negotiation on their initial allocation of permits.

Key words: non point source pollution, tradable permits, collective performance, revelation mechanisms, moral hazard, adverse selection, negotiation.

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Patrick Rio gratefully acknowledges financial support from the ADD-Geduque program. Mourad Ali gratefully acknowledges financial support from CIHEAM-IAMM. The authors wish to thank Sophie Legras, Philippe Le Grusse and participants at the LAMETA workshop for constructive comments.

1. Introduction

Non point source pollution (NPSP) is characterized by the impossibility to measure individual emissions of pollution at a reasonable cost. Indeed, the random nature of pollutants' transport and accumulation renders the identification of the polluting units. This is a moral hazard issue. Furthermore, polluters can have an interest in hiding their type (individual marginal benefit of polluting). This is an adverse selection problem. Thus, the design of efficient policies to manage NPSP should account for both kinds of informational asymmetries. Three ways to overcome these informational issues have been analysed in the literature.

First, one can assume that the regulator has a sufficiently good understanding of the polluters' determinants of practice choice. This amounts to setting the analysis in a perfect information framework as proposed by Griffin and Bromley (1982) in their seminal paper. These authors analyse four types of instruments to manage NPSP in a second best framework, namely incentives and norms on emissions and inputs. Griffin and Bromley (1982) show that these four instruments are efficient under the assumption of perfect information[1]. Highly criticized afterwards for this assumption, this approach has the interest to have opened the way to a research line on the determinants of practice choice[2].

Second, one can assume that the quantity of emitted pollutant is closely linked to some individually observable and controllable entity, characteristic of the farm's activity (inputs or outputs). This forms the basis of Shortle and Dunn's analysis (1986). They show that in the case of a single farmer, only incentives on inputs are efficient. Accounting for informational asymmetries, these incentives can induce a farmer to maximize the regulator's objective function using his private information (marginal benefit of input use). When the incentive scheme is extended to *n* farmers, it becomes inefficient because of agents' heterogeneity. Indeed, it is then necessary to specify the incentive according to each farm's characteristics. This process can become extremely costly, thus difficult to implement.

Third, one can suppose that the collective of agents, located on a well-defined zone, can be approached as a single moral person. Contrary to the previous cases there is no "denial" of the informational problem. The perfect information framework is explicitly reconstituted through the building of a collective of agents. In this perspective, the regulator uses the only piece of information he has, namely the collective contribution to ambient pollution. This idea underlies the analysis of Segerson (1988). The author studies a system of penalties, based on the variation between an aggregate level of pollution, measured at a given site, and a pollution target defined in advance. For this reason, these penalties are coined "ambient taxes". As ambient taxes depend on the global level of pollution, the regulator doesn't need to monitor individual compliance. Thus monitoring costs are lowered. However, as noted by Cabe and Herridges (1992), it is necessary to assume that the agents are aware that their behaviour has an impact on the global level of pollution. Furthermore, this system is fiscally neutral only if the norm is respected. Indeed, if pollution is above the target, the tax revenue exceeds the value of the damage, as each agent pays a tax equal to the marginal damage. However, as the ambient tax induces each agent to choose the equilibrium level of emission, this objection is unfounded *in fine*.

In these various approaches, theoretical instruments to manage NPSP are highly centralized. This is questionable since, even without considering control costs, the efficiency of these instruments depends on random variables that skew the regulator's perception. For this reason, Segerson's analysis has been extended to decentralized solutions to NPSP, taking advantage of the building of a collective.

[1] They also assume zero transaction costs.
[2] See Rio (2000) and Biarnès et al. (2004).

Pushkarskaya (2003) addresses NPSP in a principal-agent framework. She treats the informational problems associated with NPSP through the design of incentive contracts; in practice a subsidy to reduce pollution awarded by the regulator (the principal) to the farmers (the agents). A critical assumption is the perfect information each farmer has about his, and the others', abatement cost functions. The combination of this hypothesis with the economic gains from cooperation incites the polluters to organize themselves as a collective. The moral hazard problem is solved and the regulator is left to observe ambient pollution only. The perfect information hypothesis solves adverse selection within the collective. Its members then optimally share the subsidy awarded by the regulator to the collective.

Taylor (2003) relaxes the hypothesis of perfect information within the group: NPS are assumed to know their own abatement cost functions only. The author analyses an auction mechanism between NPS and point sources of pollution, the latter taking part in a pollution permits market. More precisely, the point sources offer the NPS a contract based on their collective performance. Each NPS bids for a quantity of pollution and an associated price. The point source accepts the lowest-cost bids until his pollution target is reached. At this stage, the point source and the successful bidders agree upon an explicit contract. The contract is honoured only if the target is reached, leading the author to consider this mechanism as a collective building process. We highlight that the main problem with this mechanism is that it doesn't exclude two types of free-riding: (1) within the collective of successful bidders, (2) outside the collective, by the agents whose bid was rejected or who didn't bid. Taylor (2003) makes the assumption that the agents outside the collective will stick to their previous levels of emission. This assumption is reasonable for the agents who didn't bid, as they have no abatement effort to provide to comply with the pollution norm. It is more difficult to sustain for the bidders whose offers were rejected because of their high marginal cost of depollution. Consequently, Taylor's mechanism excludes some agents who participate in the emission of pollution. It doesn't guarantee that these agents will comply with the ambient pollution target. One retains from this analysis the necessity to account for all the agents contributing to the pollution.

In this paper, we use the principle of "collective building" developed by Pushkarskaya (2003) to solve the moral hazard problem. Involving all the potential polluters from a given geographical zone is crucial for the regulator to assign responsibility for a measured ambient pollution[3] to the collective as a unique moral person. For this purpose, we design a penalty system, inspired by the incentive schemes developed by Segerson (1988), if the collective fails to build itself.

However, once constituted, the collective is subject a stability constraint. In other words, if the ambient pollution is above the target, the penalty has to be distributed so that no one feels "injured". We address this aspect through the resolution of adverse selection. We consider the implementation of a tradable permits market between the NPS grouped as a collective. If the market works properly, it has the potential to allocate the pollution permits in an efficient manner in order to attain the ambient pollution target, despite an incomplete information structure (Tietenberg, 1998). This consists in a transfer of strategy from the regulator to the polluters. More precisely, the regulator allocates an initial amount of permits to the collective for free. Through a negotiation process, the members of the collective distribute this initial allocation among themselves. The free allocation creates a wealth effect that we use to design a revelation mechanism of the agents' type (polluter, non polluter). This mechanism takes the form of a tax, associated to the market, and is activated if the ambient target is exceeded. It effectively cancels the wealth effect, under the assumption that any agent prefers telling the truth if it does not pay less that lying.

Thus, through the innovative use of mechanisms inspired from Segerson's ambient tax (1988), to induce the agents to join the collective and associated to the tradable permits market, we solve both moral hazard and adverse selection in a NPSP context.

[3] The only information available to the regulator.

Our paper is organized as follows. In section 2, we introduce collective and revelation mechanisms. Section 3 explains the building of the collective. In section 4, we present the tradable permits market and describe the negotiation process on the initial allocation of permits. This negotiation ensures the stability of the collective by inducing the agents to reveal their real type. Section 5 concludes.

2. Collective procedures and revelation mechanisms in the NPSP case: a review

Economic instruments to manage NPSP are difficult to design and implement, because of informational asymmetries such as moral hazard and adverse selection. Indeed, the regulator doesn't know the units involved in pollution; also he can't infer individual contributions to pollution from the observation of ambient pollution. Consequently, a regulator can only address NPSP in a second best framework. He has to leave the agents an informational rent. However, the regulator's problem is not only to choose ways to intervene when uncertainty prevails on the economic functions characterizing the agents. Indeed, nothing guarantees that they will respect the policy spontaneously.

We use collective mechanisms to solve the moral hazard problem due to the non-observability of emissions. Such mechanisms were designed to address moral hazard in teams (Holmström, 1982) in labour economics. Holmström (1982) recommends an incentive scheme linked to the performance of the group, when the players' types are independent[4]. Within a collective, free-riding is due to the opportunity to hide one's actions to avoid compliance to the collective rule. This opportunity arises from the lack of interaction between individual utility functions and collective performance. Then, implementing collective mechanisms amounts to creating these interactions. Consequently, when an agent doesn't comply with the rule, it has an impact on both his and the collective's utilities.

Collective mechanisms have been analysed in the context of NPSP (Meran et Schwalbe, 1987 ; Segerson, 1988 ; Xepapadeas, 1991 ; Cabe et Herriges, 1992 ; Byström et Bromley, 1998 ; Pushkarskaya, 2003 ; Taylor, 2003). Applying Holmström's analysis of group moral hazard to NPS issues, Segerson (1988) proposes a tax/subsidy mechanism based on the difference between a level of global pollution, measured at a given site, and a pollution target defined *ex ante*. Collective performance based instruments are attractive in reason of their theoretical properties of efficiency. However, they have hardly been implemented. The main explanation for the lack of implementation of collective mechanisms lies in the problem of defining the collective as a unique moral person.

In this paper we use group mechanisms to induce the agents to form a collective rather than to induce them to comply with a pollution target. Consequently, moral hazard is solved through the management of a variable easily observed by the regulator, ambient pollution. Once the collective is constituted, the regulator monitors collective performance, rather than individual performances. This is the first step of our mechanism.

However, we also want to design a policy instrument capable of managing adverse selection. Revelation mechanisms have been designed to mitigate adverse selection problems through incentive schemes that induce the agents to reveal their private information. Clarke (1971) and Groves (1973) developed the first mechanisms of this type following Vickrey's auction mechanism (1961). Among these revelation mechanisms, the Groves mechanisms (1973) have both properties of efficiency and incentive compatibility. Furthermore, they are the only ones that render truthful revelation a dominant strategy (Green and Laffont, 1977). However, these mechanisms have hardly been applied to the NPSP context. Taylor (2003) proposed an auction mechanism between point sources (principal) and NPS (agents) to solve adverse selection. However, as we have already stressed, this mechanism sets aside the agents whose bids were rejected by the principal. The revelation mechanism we develop in this paper benefits from the wealth effect induced by the free

[4] In other words, the types' domains are not interdependant.

initial allocation of permits. In our approach, the free-rider is a non-polluter who has an interest to lie in order to benefit from the sale of the permits he holds in excess. We propose to design a mechanism that cancels this wealth effect so that the agents are induced to tell the truth if it does not pay less than lying.

3. First step: building the collective

Until now, mechanisms to induce agents to participate in agricultural NPSP management programs have consisted in voluntary subsidized approaches. They include agri-environmental measures (1991), integrated to the common agricultural policy through the directive no. 2078/92 (1992), farm contracts such as "Contrat Territorial d'Exploitation (CTE)" (1999) and more recently "Contrat d'Agriculture Durable (CAD)" (2002). Based on voluntary participation, these approaches do not guarantee that all the agents under consideration participate in the program. However, to manage NPS in particular in the context of water quality, it is crucial to ensure that all the potential polluters join the collective.

Technically, we consider situations where only the ambient pollution is measured, at the outfall of a catchment for instance. Constituted by the aggregation of individual contributions to pollution, it is compared to a socially accepted norm. If the ambient pollution norm is exceeded, then the measured pollution is the only legally relevant information that the regulator can use against the agents, considered as a unique moral person. This moral person is identified, owns the property rights to the emission and consequently can be held responsible for the ambient pollution. Hence the moral hazard problem is solved.

Building the collective raises the question of how its members will share the depollution effort, or the penalty resulting from non-compliance to the collective norm. In other words, formulating a sharing rule of the depollution effort is a condition of stability of the collective[5]. Before that, we address how the regulator can substitute a unique moral person to the dispersed agents located in the zone affected by pollution. For this purpose, we use a type of ambient tax, as developed by Segerson (1988), to sanction the agents outside the group differently from those joining it, when the ambient pollution norm is not respected.

The threat is formulated as follows. Let x be the ambient pollution measured at the outfall of a catchment and x_0 the socially accepted ambient pollution. The tax inducing the agents to join the collective is:

$$t_i = t\left(x - x_0\right) = D'\left(x - x_0\right) \quad \text{if } x > x_0$$

$$t_i = 0 \qquad \text{otherwise}$$

with D' the marginal damage function.

An agent will pay this tax if the ambient pollution norm is violated, unless this agent joins the collective. The will to reduce pollution, expressed by the choice to join the collective, justifies the recourse to another sanctioning mechanism $t_i^{collective}$ more favourable to the agents[6]. Without more precisions on this penalty, the resulting program faced by an agent is as follows:

$$\forall i, max\ \pi_i = \begin{cases} B(x_i) - t_i^{collective} & \text{if in the collective} \\ B(x_i) - \gamma D'(x - x_0) & \text{otherwise} \end{cases}$$

[5] This is the aim of section 4.
[6] in case the pollution norm is exceeded

where B is the benefit function, x_i is agent *i*'s pollution and γ is a parameter measuring the environmental policy's credibility[7], $0 \le \gamma \le 1$[8].

Any rational agent will prefer to join the collective rather than face an ambient tax if the regulator's threat is credible. This tax is purely persuasive: it is applied only if the collective fails to build itself. This tax ensures that each agent would be worse off in any other situation than joining the group. The assumption of individual rationality ensures that no one will stay out of the collective[9].

4. Second step: Market for tradable permits and negotiation on the initial allocation

To address moral hazard, we proposed to implement a mechanism to induce all the agents to join a collective entity recognized by the regulator. This moral person endowed with complete rights is responsible and punishable in case of non-compliance with the pollution target. Of course this penalty will be shared out between the members of this entity. Without any mechanism to identify the responsibilities of each member, the collective may not be robust to deviation. At this stage, we have no such mechanism to ensure the stability of the collective. This section is dedicated to the building of such a stability mechanism.

What is at stake? We need a policy instrument to differentiate the members of the collective according to their type. Indeed, in the absence of possibility to give each member a right – unverifiable in this case – it is not possible to allocate his responsibility to each agent *a priori*. The best instrument will be the one that induces each agent to reveal his abatement cost function truthfully. As this information is private, the regulator can only be "information taker" - in the extreme case, he could even abstain from trying to get this information. Adverse selection is directly managed by the agents rather than by the regulator. Nonetheless, the outcome of this exchange of information between the agents is of interest to the regulator – it is a condition of stability of the collective.

If each agent's rights were verifiable, a naturally efficient instrument to reach the stability of the collective would be the tradable permits market, because it is a decentralized policy instrument. Instead of searching for information, the regulator lets the farmers reveal their type through the market. Compared to standard instruments, the interest of this solution appears when the regulator does not have enough information about the potential maximum emissions for each farm. The regulator sets an ambient pollution norm and distributes the corresponding number of permits according to a predetermined criterion.

As the rights are not verifiable, can we use such instrument anyway?

In their initial version, permits are introduced through an auction mechanism. Such a mechanism implies a high initial cost for the farms we can reduce by a free initial allocation. Indeed, the equilibrium is reached whatever the initial allocation (Tietenberg, 1998) if the market is competitive[10]. However, this free allocation places the beneficiaries in different position, depending on their abatement costs. In case of low abatement costs, the beneficiary will turn into a seller of the permits he holds in excess. Thus this process generates a wealth effect in his favour. Our idea is to exploit this wealth effect to incite the agents to reveal their type.

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[7] See Segerson and Wu (2001).
[8] It is possible to add a parameter reflecting individual beliefs about the others' strategies. Then we would compare the possible solutions given the probability formulated by one player that the others choose a depollution strategy.
[9] However, one can admit the existence of agents outside the collective, having turned to another activity, either non-polluting or controllable.
[10] However, this poses the question of the optimal size of the market.

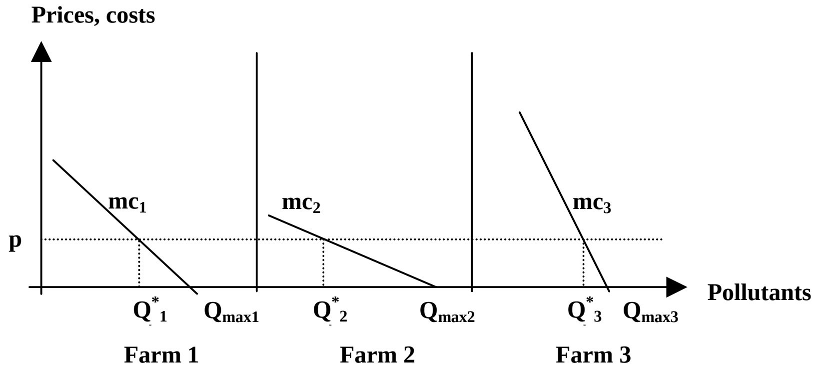
4.1 Market for pollution permits, functioning and wealth effect

To ensure the stability of the collective the agents must be treated according to their type. This necessitates an exchange of information between the members of the collective. With heterogeneous agents with respect to their abatement costs functions, the market for tradable permits is an efficient decentralised instrument to do it. Under the hypothesis that the pollution permits are individually verifiable, the market sets the individual emission levels. Then the agents exchange permits in such a way that the marginal cost of depollution of each agent after exchange equals the price of the permit (see graph 1).

Let ξ_i be the initial allocation of permits, x_0 the socially accepted ambient pollution target and $D(x_0)$ the corresponding damage,

$$\sum_i \xi_i = x_0 \quad \Leftrightarrow \quad D(x_0) = 0$$

Graph 1 : Farms' adjustment to the permits' price.



$Q_{i\,max}$: Pollution level without any reduction policy,

Q_i^* : Pollution level after implementation of the market,

p : Exchange price.

In other words, at the equilibrium, the marginal cost of pollution Cm is equal to the permit price p, for each agent:

$$\forall i \quad mc_1 = mc_2 = \cdots = mc_n = p \qquad (1)$$

Assuming that these permits are individually verifiable, an agent's profit function will be:

$$\pi_i = B_i(x_i) - t_i^{collective} - p(x_i - \xi_i) \qquad (2)$$

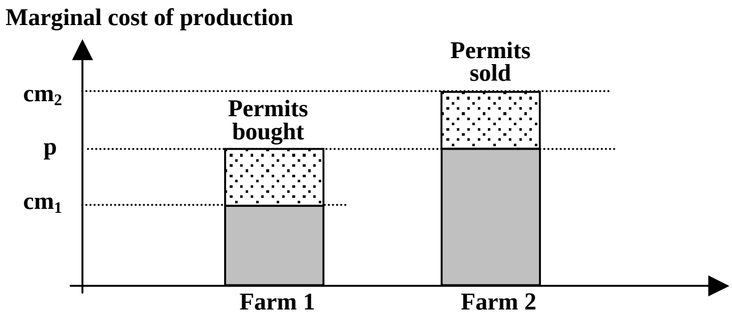
with x_i : permits used,

B_i : private benefit,

$t_i^{collective}$: ambient tax when the pollution target is exceeded.

$x_i - \xi_i$ is then the quantity of permits exchanged at the market price P. The initial allocation creates a wealth effect for the sellers of permits, the less polluting agents. Thus it is rational for them to participate in such a scheme. However, it induces a supplementary cost for the buyers (see graph 2).

Graph 2 : Marginal cost's adjustment to the permit price



In equation (2) we included the term $t_i^{collective}$. It corresponds to the ambient tax activated if the activities of the group's members generate an aggregate pollution above the target. The problem comes from the fact that this mechanism is individually rational if the rights (and their use) are verifiable, but not in the unverifiable case, which focuses our interest.

4.2 Negotiation on the initial allocation

In this section, we use the wealth effect identified in the previous section to induce the agents to reveal their type. As an arbitrary allocation rule doesn't prevent the formation of the market equilibrium (Tietenberg, 1998), we can design this allocation rule as a revelation mechanism. More precisely, we use the wealth effect created by the adoption of a particular allocation rule as a revelation mechanism. Thus, the regulator who doesn't have any particular criterion on the initial distribution of permits engages the members of the collective in a negotiation process to choose the appropriate allocation rule.

We interpret this negotiation mechanism as a bargaining game. A set I of N players have to agree on an allocation ξ_i, $\xi \in \Xi \subset IR^p$ such that $\sum_{i=1}^{n} \xi_i = x_0$. At the even rounds of the game, the players simultaneously propose $\xi^{(i)}$. At the odd rounds, the agent either lets Nature select one of the proposals or rejects the proposals; if one player rejects a proposal, the game continues.

A rationale to reject a proposal is if the agent believes that a proposal $\xi_{k+2}^{(i)}$ exists such that the resulting utility is greater than the utility he would obtain from any of the proposals expressed at the previous even round:

$$\forall\ j \neq i,\ \ U_i\left(\xi_k^{(j)}\right) \ \leq\ U_i\left(\xi_{k+2}^{(i)}\right) \qquad i, j\ \in I$$

and that it is acceptable by the other players. In other words, the payoff from this proposal is at least equal to their expected payoff, deduced from the proposals expressed at the previous even round weighted by the probability w_i of being selected by Nature:

$$\forall\ j,\ \ U_j\left(\xi_{k+2}^{(i)}\right) \ >\ E\left(U_j\right)_{k+1}$$

with $E\left(U_j\right)_{k+1} = \sum_{h=1}^{N} w_h\, U_j\left(\xi_k^{(h)}\right)$ and $\sum_{h=1}^{N} w_h = 1 \qquad h,i,j \in I$

Then each player's program is:

$$\forall i, \quad \max_{\xi \in C} \quad U_i\left(\xi_{k+2}^{(i)}\right) \text{ with } C = \bigcap_j C_j : \left\{\forall j, \quad U_j\left(\xi_{k+2}^{(i)}\right) \geq E\left(U_j\right)_{k+1}\right\}$$

This algorithm converges towards the Pareto-optimal solution (Quérou et al, 2006). Applied to the problem of allocating permits, this process highlights the importance of the choice of the variables under negotiation. Indeed, constraining this choice to the sole quantity of permits will not limit the incentive to cheat. This will not be the case if the price is included in the negotiation.

Negotiation on the quantity of permits only

In a negotiation round, the players simultaneously propose the allocation $\xi^{(i)} = \left\{\xi_j^{(i)}\right\}_{j=1,\dots,n}$ they think preferable for each player contributing to the pollution with $\sum_{j=1}^{N} \xi_j^{(i)} = x_0$. The assumption of individual rationality leads to the following individual program:

$$\forall i \quad \max_{\xi^i, x_i} \pi_i\left(\xi^{(i)}, x_i\right) \text{ s.t. } \sum_{j=1}^{N} x_j \leq x_0$$

Formulating the Lagrangian:

$$\pi_i = B_i(x_i) + \lambda\left(x_0 - \sum_{j=1}^{N} x_j\right)$$

Agent i maximizes his individual profit assuming that all the agents comply with the collective rule. Assuming convergence,

$$\pi_i = B_i(x_i) + \lambda\left(\sum_{j \neq i} \xi_j - \sum_{j \neq i} x_j\right) + \lambda(\xi_i - x_i),$$

and as the decision variables of all the other players are taken as given for agent i,

$$\pi_i = B_i(x_i) + \lambda(\xi_i - x_i)$$

λ satisfying $\lambda \perp \left(\sum \xi_j - \sum x_j\right)_{j=1,\dots,n}$ is interpreted as the permits' price.

To describe the negotiation process, suppose there are two players, each of a type, high or low polluter, to which we will refer in the remainder of this paper as "polluter" and "non polluter". The type is unknown to the regulator, and not completely observable by the other player. The latter can only suspect whether the other has the possibility to modify his technology and become a non-polluter.

Each player has a utility function $U_i(\ )$, $i \in \{np, p\}$ such that $U_i([\xi_i, \xi_{-i}])$. Note $\xi^{(i)}$ the allocation proposed by agent i at the current round of negotiation $[\xi_i, \xi_{-i}]^{(i)}$. This proposal depends on the type and the opportunity to cheat of the agent. If player i, whatever his type, announces himself as a polluter, he asks for "all" $(\xi_i^{(i)} = 1)$, otherwise he asks for "nothing" $(\xi_i^{(i)} = 0)$. Presented in normal form, the game at the first round of negotiation is the following bi-matrix:

Table 1: the players' strategies

Proposals		Polluter	
		Polluter	Non-polluter
Non-polluter	Polluter	$\xi^{np}[1,0];\xi^{p}[0,1]$	$\xi^{np}[1,0];\xi^{p}[1,0]$
	Non-polluter	$\xi^{np}[0,1];\xi^{p}[0,1]$	$\xi^{np}[0,1];\xi^{p}[1,0]$

We consider the following linear utilities:

$$U_{np} = (\xi \geq 0) + p(\xi - 0)$$

$$U_p = \xi \qquad + p(\xi - 1)$$

The first term on the RHS is the satisfaction from owning permits (constant for the non polluter, increasing with the number of permits for the polluter) and the second term on the RHS measures the gain resulting from an exchange of rights, when it is needed. This leads to the following utilities:

Table 2: gains resulting from an exchange of permits

Utilities		Polluter	
		Polluter	Non-polluter
Non-polluter	Polluter	$p+1,1$	$p+1,-p$
	Non-polluter	$1,1$	$1,-p$

Whatever the non-polluter's strategy, the polluter loses from not announcing himself as a polluter, consequently he will never lie. This is not the case for the non-polluter, who benefits from the wealth effect induced by the allocation of tradable permits. Unfortunately, the candidate Nash Equilibrium in dominant strategies where both players announce themselves as polluters is unfeasible.

Thus, as long as the negotiation only concerns the allocation of permits, we cannot design a mechanism that induces both types of agents to tell the truth.

Negotiation on both permits and price

During the bargaining process, Nature selects the player that formulates his allocation proposal. Assuming equal probabilities to be selected by Nature $w_i = \frac{1}{N}$, each player's expected utility can be calculated. For $N = 2$ we have:

$$EU_i = \frac{1}{2}U_i(proposal \ \ i) + \frac{1}{2}U_{-i}(proposal - i)$$

leading to : $EU_{np} = 1 + \frac{p}{2}$

$$EU_p = \frac{1-p}{2}$$

It can be noted that a change of price has an opposite effect on the agents' expected utilities. In particular, a price increase reinforces the wealth effect of the non-polluter.

We make use of this property to induce the non-polluter to declare himself non-polluter, by introducing the permit price in the vector of negotiated arguments, cancelling the wealth effect. Such a mechanism can be of the following form, the regulator announcing to the agents:

"You can negotiate on the quantity of permits and the associated price; if the pollution target is not reached, you will pay the permits you received at the price resulting from the negotiation."

This mechanism can be described as follows. The players simultaneously propose a vector of permits and price $[\xi_i, \xi_{-i}, p]^{(i)}$. If the ambient norm is exceeded, this vector will be interpreted as the penalty imposed on each player. Considering agent *i*'s proposal, his penalty will be $t_i^{collective} = \xi_i^{(i)} \times p^{(i)}$ and the penalty to be imposed on the others $t_{-i}^{collective} = \xi_{-i}^{(i)} \times p^{(i)}$.

Consider the variation of utility resulting from a variation of allocated permits and price (Table 3).

Table 3: Variation of utility with respect to the number of permits and the price

Permits	ξ = 0			ξ = 0.5			ξ = 1		
Price **Agents**	p = 0	p = 0.5	p = 1	p= 0	p = 0.5	p = 1	pP = 0	p = 0.5	p = 1
Non-polluter	1	1	1	1	1.25	1.5	1	1.5	2
Polluter	0	-0.5	-1	0.5	0.25	0	1	1	1

By complementarity, $\sum_i \xi^i = 1$, the allocations $\xi = 0$ for the non-polluter and $\xi = 1$ for the polluter lead to stable utilities whatever the price. Each player has a constant utility $U_i = 1 \quad \forall\, p$. The price effect enhances the non-polluter's wealth effect.

Now let's introduce the price into a penalty mechanism if the pollution target is not reached. The agents' utilities are then $U_i - \delta_{x \rangle x_0}(p\xi_i)$ where $\delta_{x \rangle x_0}(\ ) = 1$ if pollution is above the target, $\delta_{x \rangle x_0}(\ ) = 0$ otherwise.

This situation degrades the utility of the polluter, and neutralises the wealth effect in each case for the non polluter (see Table 4).

Table 4: Utilities accounting for the penalties

Permits	ξ = 0			ξ = 0.5			ξ = 1		
Price **Agents**	p = 0	p = 0.5	p = 1	p = 0	p = 0.5	p = 1	p = 0	p = 0.5	p = 1
Non-polluter	1	1	1	1	1	1	1	1	1
polluter	0	-0.5	-1	0.5	0	-0.5	1	0.5	0

In Table 4, we observe that a polluter has a maximum utility of $U_p = 1$ for $\xi = 1$ and $p = 0$. The non-polluter has a utility of $U_{np} = 1$ for $\xi = 0$ and $p = 0$, knowing that each proposal, even false, will not increase his utility. Assuming that any agent prefers telling the truth if it doesn't pay less than lying, this mechanism induces the polluter to announce himself polluter and cancels the non-polluter's wealth effect by making him reveal his type.

Thus, the success of the revelation mechanism lies on the existence of a sanction announced by the regulator. Under this condition, the most favourable strategies are for each agent to ask for a quantity of permits adapted to his type. The paradox of this mechanism is that a truthful revelation under the threat of a sanction induces each agent to propose a null price for the permit. However, this paradox takes its explanation in the fact that a trade at a null price cancels the wealth effect that a non-polluter could expect.

The players are then confronted to the following alternatives:

In the collective $$\pi_i = \begin{cases} B_i(x_i) - p\xi_i & \text{if } \; x_i > \xi_i \\ B_i(\xi_i) & \text{otherwise} \end{cases}$$

Outside the collective $\pi_i = \quad B_i(x_i) - \gamma\, t_i$

with $t_i = D'(x - x_0)$ and γ is a parameter measuring the credibility of the regulator's policy.

6. Conclusion

In the NPSP literature, there is a growing interest for collective approaches inspired from Segerson (1988). The exploratory nature of these instruments explains that divergent proposals coexist in this research area. Indeed, some authors assume perfect information (Pushkarskaia, 2003) while others design revelation mechanisms (Taylor, 2003). However, the interest of collective approaches is undeniable. It results from the possibility to assign well-defined and verifiable rights to a moral person as a way to overcome moral hazard. This allows setting the analysis in the well understood context of point source pollution. Then the remaining task is to allocate this right between the members of the collective. In particular, this implies distributing the advantages and penalties attached to this allocation. Even limited, this problem is difficult to address because adopting a particular allocation rule impacts on the acceptation of the mechanism by the agents. This will affect the stability of the collective.

The approach we propose is based on an individual assessment, by each member of the collective, of his contribution to the collective compliance to the norm. The assessment consists in a bargaining mechanism that induces each party to account for the others' requirements – expressed in terms of expected utility at each round – to avoid the penalties imposed if the collective fails to build itself. Thus, through the innovative use of mechanisms inspired from Segerson's ambient tax (1988), to induce the agents to join the collective and associated to the tradable permits market, we solve both moral hazard and adverse selection in a NPSP context. Another innovation lies in the role taken by the non-polluter. Indeed, his interest is to keep his informational advantage, translated into a wealth effect because of the free initial allocation of permits. Following the constructive spirit of our approach, we showed that it is possible to design a revelation mechanism that cancels this wealth effect and induces the non-polluter to reveal his preferences. Note that the implementation of our mechanism necessitates the direct involvement of the regulator at both levels of definition of the penalties: within and outside the collective. Thus the mechanism is highly dependant on the credibility of the regulator's policy.

Next, our attention will focus on implementation issues. We will address them by undertaking simulations basing on a database constituted by Carmona (2005). We will use experimental economics in the vein of Spraggon (2002), Cochard et al. (2005) and Poe et al. (2004) associated to approaches in terms of accompanying modelling and role playing games as developed by Le Grusse et al. (2006).

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