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May 2016

Working paper No. 2016 –5

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Nonpoint source pollution: An experimental investigation of the Average Pigouvian Tax

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Abstract

The "Average Pigouvian Tax" (APT) was proposed by Suter et al. (2008) to reduce the financial burden of the standard ambient tax. This instrument consists in a standard ambient tax divided by the number of firms, which requires polluters to cooperate in order to achieve the social optimum. To enable polluters to cooperate, communication is allowed. We introduce different types of communication: cheap talk, exogenous costly communication (communication is imposed), and endogenous costly communication (conducted on a voluntary basis after a vote). Our experiment confirms that the instrument induces polluters to reduce their emissions under cheap talk. However, we find that group emissions are less reduced when communication is costly. This result still holds even when we endogenize communication by introducing a voting phase.

Keywords: nonpoint source pollution, ambient tax, social dilemma, cooperation, cheap talk, costly communication, vote.

JEL classifications: C92, H23, Q53.

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Introduction

The efficiency of ambient taxes (Segerson, 1988) has been experimentally demonstrated (Example: Poe et al., 2004; Spraggon, 2002, 2004; Cochard et al. 2005; Vossler et al., 2006; Suter et al., 2008; Suter et al., 2009; Cochard and Rozan, 2010; Spraggon and Oxoby, 2010; Suter et al., 2010; Vossler et al., 2013; Suter and Vossler, 2014). However, dependence on collective pollution levels and potentially very large penalties have justified criticism against ambient taxes (Shortle et al., 1998; Shortle and Horan, 2001). As a consequence, the implementation of the instrument outside of the laboratory is likely to raise social acceptability concerns. To reduce the financial burdens imposed through taxation, Suter et al. (2008) proposed the "Average Pigouvian Tax" (APT) which is equal to the standard ambient tax divided by the number of firms. Unlike the standard ambient taxes, the specificity of the APT implies that the social optimum is not implemented as a Nash equilibrium of the static game. To achieve the social optimum, firms are required to behave cooperatively by maximizing the joint profit of the group. Suter et al. (2008) found promising results in their lab experiment. They tested the APT combined with nonbinding costless communication (referred to in the experimental economics literature as "cheap talk") and showed that the instrument successfully achieves high levels of efficiency.

Unfortunately, as promising as these findings may be, other factors may affect the enhancement of cooperation thanks to communication. For example, Ostrom et al. (1992) show that in the presence of high stake levels of wealth, repeated communication is no longer effective in comparison with low levels of wealth. This lack of commitment in communication (cheap talk) led other researchers to show that the absence of sanctioning can also be detrimental to the effect of communication on cooperation (Ostrom et al., 1992, Bochet et al. 2006). In the specific context of ambient pollution, two reasons make us believe that another factor is relevant to examine in order to assess the robustness of the APT instrument with communication: the cost of communication.

First, communication is likely to be costly in the field because it requires a minimum amount of resources, time, and attention. Real life examples where individuals bear the costs of organizing meetings and communication mechanisms are numerous. The existence of this costly communication is true in general, but even more in the context of farmers who are regularly involved in collective actions. For example, in the "coordinated crop rotation", farmers are encouraged to work together to deal with environmental issues, whose resolution requires the commitment of all stakeholders. Another example can be observed in the irrigation systems where farmers depend on each other to access water; they need to implement coordinated actions to avoid the overuse of water in drought periods. In addition, such meetings are not only difficult to organize but also suppose a regular basis of interaction (monthly, weekly or daily). Indeed, if one aims to carry on long term projects, these communication costs have to be borne repeatedly. In the case of the APT, all these issues of organizing the collective action to enhance cooperation will be particularly raised.

A second set of reasons can be found in previous laboratory findings. Prior investigations agree to say that implementing a costly communication mechanism significantly decreases the number of discussion sessions in comparison to a free communication setting (Ostrom and Walker (1989), Isaac and Walker (1991) and Kriss et al. (2011)[1]). Put differently, subjects discuss less when there is a costly communication mechanism. In addition, and more importantly, there is mixed evidence of the effect of costly communication on cooperation in a social dilemma. On the one hand, Ostrom and Walker (1989) showed that whenever we introduce costly communication, we observe a decrease in the efficiency of appropriation of a Common-Pool Resource (CPR) in comparison to a free communication setting. In their experiment, subjects had to provide a provision point collective good with an all-or-nothing contribution. Communication is here assimilated to a public good: they can all enjoy discussing with other members of the group whenever the public good is provided or not. The experiment reveals that costly communication (even with subjects who already experienced communication) creates a barrier, and reduces the speed with "which an agreement could be reached, and the efficacy of dealing with players who broke an agreement" (Ostrom and Walker, 1989). On the other hand, Isaac and Walker (1991) found that costly communication is not detrimental to achieve high level of cooperation. In a similar setting, Isaac and Walker (1991) examined the provision of a linear public good game after a costly communication session. They observed a sustaining of contributions over time and did not observe the traditional decay to the zero Nash equilibrium. Particularly, the authors found, in contrast to their working hypothesis, that it was possible to fulfill high level of cooperation even when subjects frequently fail to provide the communication mechanism. Subjects seemed to become more efficient in using the communication mechanism when it was costly than when it was free. This same finding was also observed in a coordination game by Kriss et al. (2011).

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[1] Costly communication reduces the number of individual messages in a coordination game with costly communication.

Furthermore, Villamoyr-Tomas et al. (2011) experimentally implemented another mechanism of costly communication in a CPR context. In their experiment, only subjects who paid a fee could enjoy discussing with each other. The authors introduced the idea of private communication. They showed that the setting where communication was provided as a collective public good was more effective in lowering extraction than the private provision setting of communication. Their experiment revealed that the underlying mechanism of costly communication can prove to be relevant in the study of the impact of communication on cooperation.

Hence, with respect to all these prior findings, examining costly communication is of interest in the case of the ambient pollution and the APT instrument. It is also an open question whether costly communication would entail a positive effect (or not) on cooperation for the APT instrument. Furthermore, we would like also to point out that the existent experimental literature insufficiently addressed the costly dimension of communication and its relation with cooperation. Despite the relevance of the issue in real life, we are only aware of these few experiments: Ostrom and Walker (1989), Isaac and Walker (1991), and Villamoyr-Tomas et al. (2011). Hereafter, we contribute to this literature.

More precisely, the aim of this study is to test the robustness of the improvement of cooperation due to communication. This will allow us to examine the robustness of the efficiency of the instrument. For that purpose, we answer two questions. The first one addresses whether, under costly communication, we observe (or not) a similar convergence to the social optimum in the APT instrument as under free communication (Suter et al. 2008). The second question is to examine whether the performance of cooperation in the APT instrument is dependent on the underlying mechanism that implements the cost in the communication. Two forms of costly communication are tested: the case where communication phases are imposed, hereafter denoted as exogenous costly communication, and the case where communication phases are conducted on a voluntary basis through a vote, hereafter denoted as endogenous costly communication.

The endogenous form of costly communication is of particular interest for us. Several studies have already shown that endogenous institutional settings (free or costly) yield substantial benefits to cooperation (Ostrom et al., 1992; Tyran and Feld, 2006; Kroll et al., 2007; Sutter et al. 2010, Putterman et al., 2011). For example, Sutter et al. (2010) found that giving the opportunity to vote in order to determine whether a group would like to provide a public good or not, has a significantly positive effect on cooperation. By conferring a feeling of self-determination, we believe that the endogenous mechanism may balance the costly dimension of communication. We therefore test in our experiment a costly mechanism of vote. Two rates of costs are implemented: a high cost and a symbolic one.

Our experiment shows that costly communication limits the reduction of polluters' emissions in comparison to a free cheap talk treatment. This result is still verified when we endogenize communication by introducing a voting phase in contrast to our expectation. In line with previous experimental findings, we verify that introducing a costly dimension significantly deteriorates significantly the likelihood of voting for communication phases especially for high level of cost. However, we observe that when communication is actually voted, emissions are reduced in similar amounts to those in the cheap talk treatment. Finally, our experiment reveals that in case of low cost voting phase, the vote prompts the polluter into revealing his polluter type: a positive (negative) vote for communication is associated with lower (higher) emissions.

The remainder of this paper is organised as follows: the first section presents the theoretical model for the experimental study. Section 2 describes the experiment. The experimental results are presented in Section 3. The last section concludes.

1. Theoretical model

n risk-neutral firms whose production activities generate environmental damages are considered. Firm i's ($i = 1, ..., n$) emission of pollution is denoted as x_i. For simplicity, firm i's profit function $\pi(x_i)$ is defined with respect to its emissions, and is assumed to be twice differentiable, strictly increasing, at a strictly decreasing rate. Ambient pollution is equal to total polluters' emissions $X = \sum_{i=1}^{n} x_i$. We assume that ambient pollution is not affected by random natural factors[2] and that the total damage D is a linear function of the ambient pollution level X: $D(X)=\delta X$ with $\delta > 0$.

Without any regulatory policy (i.e. under “laissez-faire”), the firms ignore the damages caused by their activities and emit until their marginal net benefits equal zero. That level of emission is denoted as x^0. To remedy to this situation, the regulator intervenes with the objective to maximize the social welfare $W(x_1,...,x_n)$, defined as the sum of firms’ profits minus the damage. It is given by the following relation:

$$W(x_1,...,x_n)=\sum_{i=1}^{n}\pi(x_i)-\delta\sum_{i=1}^{n}x_i\,. \qquad (1)$$

The level of emission of each firm x_i^* that maximizes social welfare is determined by solving the following first order condition (FOC):

$$\pi'(x_i^*)=\delta\,. \quad (2)$$

As the model is entirely symmetric, we get for all i, $x_i^*=x^*$. Moreover, $x^*<x^0$ due to the strict concavity of the profit function.

Achieving the social optimum requires that each firm equalizes its marginal profit to the marginal social damage. To realize this goal, the regulator can implement the standard ambient tax that was found to be efficient in various experimental studies (e.g. Spraggon, 2002; Cochard et al. 2005; Suter et al., 2008):[3]

$$T_{pt}(X)=\begin{cases}0 & if \;\; X\le nx^* \\ t(X-nx^*) & if \;\; X>nx^*\end{cases}. \qquad (3)$$

The taxation occurs whenever ambient pollution is greater than the socially optimal pollution level. Therefore, the profit function of a firm i which is supposed to follow a Cournot-Nash behaviour when choosing its emission level, becomes:

$$\pi_{pt}(x_i,X)=\begin{cases}\pi(x_i) & if \qquad X\le nx^* \\ \pi(x_i)-t(X-nx^*) & if \qquad X>nx^*\end{cases}. \qquad (4)$$

If $X\le nx^*$, a firm maximizes its profit by emitting x_i as close as possible to x^0. Thus in any case, ambient pollution will be driven as high as possible, i.e. $X=nx^*$. If $X>nx^*$, the

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[2] While the introduction of “natural uncertainty” would be more realistic, it would complicate subjects’ behavior in the experiment, and could therefore lead to more errors. Experimental studies should start with a simple environment and incrementally introduce realistic assumptions whose specific effects can be separated.

[3] This version may be referred to as the standard ambient tax in comparison with the ambient “tax/subsidy”, which is simply equal to $T_{ts}(X)=t(X-nx^*)$, so that polluters get a subsidy if ambient pollution is below the target (i.e. when $X<nx^*$).

dominant strategy for each firm is to emit until its marginal net benefits equal the marginal tax rate.

$$\pi'_{pt}\left(x^*\right)=t\,. \quad (5)$$

To implement the social optimum (2) as a dominant Nash equilibrium, the following relation must be verified:

$$t=\delta\,. \quad (6)$$

At the social optimum, the marginal tax rate should be equal to the marginal environmental damage.

There is no asymmetric equilibrium satisfying the condition $X=nx^*$. At any vector of asymmetric emissions such as $\sum x_i = nx^*$, there is at least one firm *j* which has interest to emit more (on the condition that $x_j < x^*$ due to $\pi'\left(x_j\right) > \pi'\left(x^*\right)=\delta$), even at the cost of triggering the tax. Thus, any strategy such as $x_i \neq x^*$ is strictly dominated. The game admits a unique Nash equilibrium, so that there is no coordination problem. This is probably one of the reasons why the instrument was found to be very efficient, both in settings allowing communication between participants (e.g. Suter et al. 2008) as well as in settings not allowing communication (e.g. Spraggon, 2002; Suter et al. 2008). However, it seems unlikely that such an instrument would be feasible in practice because all firms bear the full marginal cost of an increase in emission of one of them.

The charges incurred by each polluter can however be limited by relaxing the hypothesis according to which polluters follow a Cournot-Nash behaviour when choosing their emission level. This hypothesis fails to internalize cross-effects among agents. By considering a situation in which a group of polluters might cooperate by coordinating their individual emissions choices in order to maximize joint profits, Millock and Salanié (2005) showed that the optimal policy is to choose a much lower ambient tax than that required in a non-cooperative group. The regulator needs only to consider the regulation of one agent: the polluter group. A tax that is equivalent to the level of the standard tax divided by the number of polluters is imposed on each polluter when the socially optimal target is exceeded. Suter et al. (2008) refer to this tax as the "Average Pigouvian Tax" (APT). It is given by the following relation:

$$T_{apt}(X)=\begin{cases}0 & if \quad X \leq nx^* \\ \dfrac{\delta}{n}\left(X-nx^*\right) & if \quad X > nx^*\end{cases}. \quad (7)$$

Thus, in equilibrium,

$$\pi'_{apt}(x_i) = \frac{\delta}{n}. \quad (8)$$

The comparison between conditions (2) and (8) shows that social optimum is not implemented as a Nash equilibrium of the static game. However, we can verify that the cooperative strategy (or fully collusive outcome), which we define as the level of emissions that maximizes joint profits, corresponds to the social optimum. Consider the profit sum:

$$\sum_{i=1}^{n} \pi_{apt}(x_i, X) = \begin{cases} \sum_{i=1}^{n} \pi(x_i) & \text{if} \quad X \leq nx^*, \\ \sum_{i=1}^{n} \pi(x_i) - \sum_{i=1}^{n} \frac{\delta}{n}\left(X - nx^*\right) = \sum_{i=1}^{n} \pi(x_i) - \delta\left(X - nx^*\right) & \text{if} \quad X > nx^*. \end{cases} \quad (9)$$

Clearly, maximizing this joint-profit function with respect to vector (x_1, x_2, …, x_n) results in n first-order conditions such that $\pi'(x_i) = \delta$. Thus, if the firms manage to maximize joint profit, then they will comply with the social optimum and the instrument will be efficient.

2. The experiment

We present hereafter the parametrization of the experiment, the different treatments and the practical procedure of the design.

2.1. Theoretical benchmarks

In the experiment, the profit and damage functions are respectively given by:

$$\pi(x) = -2x^2 + 84x + 500, \qquad (10)$$

$$D(X) = 52X. \qquad (11)$$

Hence, with respect to our group size of 8 players, the tax rate is equal to 6.5. Each subject has a dominant strategy to invest 19 tokens under the static game. The maximum profit of the entire group (or cooperative strategy) which corresponds to the social optimum is achieved if all subjects invest 8 tokens. Using backward induction, the unique sub-game perfect Nash equilibrium of the finitely repeated game is to play the non-cooperative strategy in each period for each subject. We consider therefore two main theoretical benchmarks (Table 1): the static Nash equilibrium (or "non-cooperative" strategy) and the social optimum (fully cooperative strategy). It must be noticed that the benchmarks remain identical with or without communication.

Table 1: Theoretical benchmarks

	Non-cooperative benchmark (static Nash equilibrium)	Cooperative benchmark (social optimum)
Individual investment	19	8
Group investments	152	64
Individual payoff	756	1044

The gain at the cooperative outcome for each player is equal to 1044 points. If everyone plays the non-cooperative emission level, the gain will be equal to 756. Therefore, the net gain of cooperation over one period is equal to 288 points.

2.2. Experimental treatments

The five treatments of this experiment are shown in Table 2. Each participant takes part in only one of them (between-subjects design).

Table 2: Experimental design

Treatments	Description	Number of groups	Number of sessions
NC (No Communication)	No cheap talk throughout the experiment.	4	2
CT (Cheap Talk)	Cheap talk at the end of each four periods (before the 5th, 9th, 13th, 17th and 21st periods).	8	4
ECC (Exogenous Costly Communication)	Same as treatment CT except that communication is costly. The communication cost (200 points) is deducted from the gain of the period that immediately follows the communication phase.	4	2
HCV (High Cost Vote)	A communication phase is held after a vote when the majority approves it. The cost (of communication) to each voter is high (200 points). Those voting against the communication do not bear this cost but the discussion is open to them.	4	2
LCV (Low Cost Vote)	Same as treatment HCV except that the cost of voting is low (10 points).	4	2

In the NC treatment, considered as the baseline treatment, there is no communication throughout the game.

In all other treatments, we introduce the opportunity of communication. Hereafter we refer to a “communication phase” as a phase in which subjects can communicate with written messages that transit through the computer network. All messages are public (no bilateral communication).[4] Subjects can discuss abatement strategies in response to the ambient mechanism imposed on them. The communication phases are limited to three minutes. These communication phases take place before the 5th, 9th, 13th, 17th and 21st periods.

In the CT treatment**,** the communication phase is free. All subjects are involved in the communication phase.

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[4] Bochet et al. (2006), by comparing three forms of communication as incentives to increase contributions in public goods games, found that verbal communication through a chat room was almost as efficient as face-to-face communication to induce cooperation.

In the ECC treatment, the communication phase is subject to a fee of 200. All subjects are involved in the communication phase and are obliged to pay the fee. This is why we denote this treatment as “Exogenous Costly Communication”.

In the LCV and HCV treatments, the communication phase is subject to a vote. Hereafter we refer to “voting phase” as the phase in which subjects are invited to vote for or against holding a communication phase. The following question is asked to each member of the group in the voting phase: “would you like to discuss with other members of your group?” When the majority (at least five subjects) of the group responds “yes”, a communication phase begins. Otherwise, no communication takes place. When the discussion is approved by the majority, only those who voted for communication by answering “yes” bear the cost of the discussion but all group members can participate in the communication phase. When the majority for a discussion is not reached, no one is charged.

In addition, we consider a high and a low cost level. The cost is low in the LCV treatment (cost of 10, i.e. about 3% of the net gain of full cooperation) and high in the HCV treatment (cost of 200, i.e. about 70% of the net gain of full cooperation). The communication cost is deducted from the gain of the period that directly follows the communication phases.

2.3. Practical procedures

The experiment was carried out at the BETA laboratory of experimental economics at the University of Strasbourg (FRANCE) in 2011. 192 students of different majors were randomly selected from a pool of about 1000 subjects. Each session involved 16 subjects. At the beginning of the experiment, subjects were randomly assigned to groups in a partner design (the composition of the groups remains the same throughout the experiment). The program of this experiment has been designed by Kene Boun My with the web platform EconPlay (www.econplay.fr). All interactions were fully anonymous. Upon arriving in the laboratory, subjects were given a copy of the instructions (Appendix 1). A monitor read aloud the instructions to make them common knowledge and informed the participants that before starting the experiment, they would be asked to answer a questionnaire to verify their understanding of the instructions. Once the questionnaire was filled out and corrected if necessary, one trial period was played before the start of the real game.

Subjects played the role of polluting firms but the framing of the experiment was as neutral as possible in order to limit uncontrolled psychological effects. Thus there was no use of words such as “pollution”. Emissions were represented by the amount of invested tokens. In each

period, subjects could invest any integer number of tokens between 0 and 20. A "Decision Sheet" showing the earnings from investment for each of the 20 available choices was indicated in the instructions. Subjects knew that they faced the same investment function, and that their payoff depended on "their own investment" and on the "investment of the group".
After each period, subjects were informed of the sum of the invested tokens by the other members of their group. The game was repeated over a sequence of 24 periods. Earned points were accumulated and converted into euros at the end of the experiment using an announced exchange rate. Each session lasted about 1 hour and 15 minutes and subjects earned on average 23 euros.

3. Results

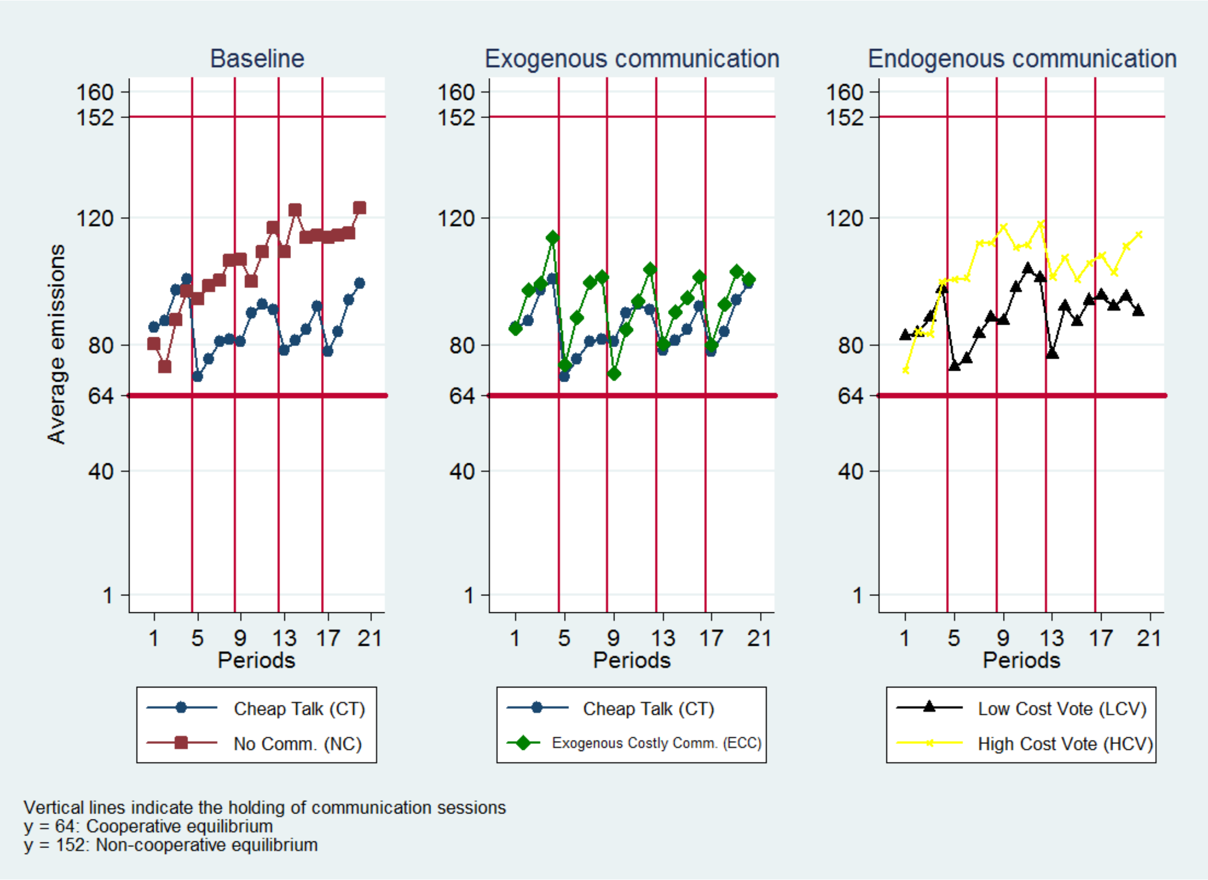
Hereafter, Results 1 and 2 analyse the level of group emissions with respect to the cost (high or low) and the procedure of implementation (exogenous or endogenous). Results 3 and 4 focus on endogenous communication, and address the relation between the vote and the subjects' emission decisions.

Table 3: Average group emissions per treatment

Treatments	Social optimum	Static Nash Equilibrium	Average emissions (S.D)
NC	64	152	110.10 (23.83)
CT	64	152	84.67 (20.33)
ECC	64	152	91.31 (25.90)
LCV	64	152	89.65 (25.49)
HCV	64	152	108.62 (20.44)

Notes: Standard Deviations are in parentheses. Periods 1 to 4 are excluded from all the analyses since the first communication phase takes place between periods 4 and 5. Periods 21 to 24 are not taken into consideration in order to rule out end game effects.

Figure 1: Average group emissions per treatment



3.1 Performance of the APT under costly communication

In this first part, we address the two main concern of this paper. In Result 1 we tackle whether costly communication impacts cooperation under the APT in comparison to free communication. In Result 2, we address whether implementing an endogenous form of costly communication modifies the cooperation level of subjects with respect to the instrument.

Result 1: Communication reduces emissions. This reduction is statistically significant when communication is free, but is no longer significant when communication becomes costly.

Table 3 reports average group emissions per treatment. It shows that in all treatments average emissions lie between the social optimum and the static Nash equilibrium. Table 3 reports that emissions are closer to the social optimum in CT (84.67) than in the baseline treatment, NC (110.10). When applying two-tailed Mann–Whitney tests on average emissions per group, we reject the null hypothesis of no difference between NC and CT treatments at the 10% level (p-value = 0.08, n = 8, m = 4). Table 3 also shows that group emissions under costly communication are reduced in comparison to the NC. However, this reduction is lower than when communication is free. Two-sided Mann Whitney tests conclude that average emissions per group in HCV, LCV and ECC are not significantly different from those noted in NC.

Figure 1 displays for each treatment the average group emissions per period. It provides the graphical evidence of the positive impact of cheap talk on cooperation and the limited effect of costly communication on cooperation. Figure 1 also reveals that the impact of communication tends to be more pronounced in the periods that immediately follow communication phases. The emissions decline just after communication but then tend to increase again over time.

A linear panel data regression with random effects explaining the group average confirms our previous observations. The framework for this analysis is the following model:

$$E_{it} = \alpha_0 + \alpha_1 CT_{it} + \alpha_2 ECC_{it} + \alpha_3 LCV_{it} + \alpha_4 HCV_{it} + \alpha_5 t + \mu_i + \varepsilon_{it}, \qquad (12)$$

where the dependent variable, E_{it}, is the emissions of group $i = 1,...., 24$ at period $t = 5,..., 20$; CT_{it}, ECC_{it}, LCV_{it} and HCV_{it} are dummy treatment-specific indicators and the baseline treatment NC is the reference treatment. $\mu_i \rightarrow N(0, \sigma^2_{\mu_i})$ is an individual-specific random effect and $\varepsilon_{it} \rightarrow N(0, \sigma^2_{\varepsilon})$ is a mean zero error term. The model estimation results are reported in Table 4.

Table 4: Linear panel data regression with random effects explaining group emissions by all treatment variables

Variables	Coefficients (p-value) (1)	(2)	(3)	(4)
CT	-25.43**	-25.43**	-25.43**	-25.43**
	(-2.19)	(-2.25)	(-2.16)	(-2.24)
ECC	-18.80		-18.80	
	(-1.40)		(-1.38)	
LCV	-20.45	-20.45		
	(-1.53)	(-1.57)		
HCV	-1.484	-1.484		
	(-0.11)	(-0.11)		
t	0.887***	0.902***	1.090***	1.183***
	(5.21)	(5.05)	(5.65)	(6.01)
Intercept	99.02***	98.83***	96.48***	95.32***
	(10.21)	(10.43)	(9.72)	(9.92)
N	384	320	256	192
Overall R^2	0.20	0.23	0.21	0.28

Notes: *** Denotes that parameter estimate is statistically significant at the 1% level, ** at the 5% level. p-values are in parentheses. Various robustness tests were carried out and confirmed these results.[5]

CT is the only treatment in which emissions significantly differ from those observed in the baseline treatment (NC). On average, a group reduces its emissions by 25.43 units when the ability to communicate freely is granted in comparison to a situation where this possibility does not exist. In a “meta-analysis” of experiments conducted on social dilemma games from 1958 to 1992, Sally (1995) found that communication increases cooperation by approximately 30% compared to a situation in which it is not implemented.

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[5] The model is estimated by using the Generalized Least Squares (GLS). The robustness of the results is tested by: first, running estimations based on robust standard errors in order to take into account possible heteroscedasticity and autocorrelation problems (estimating the variance-covariance matrix estimator with the Huber/White/sandwich, Bootstrap methods); second, by running the regression on individual data clustered by groups.

The regression also reveals that ECC is not effective in reducing emission while CT significantly impacts pollution. This difference is surprising because the CT treatment can also be viewed as an externally imposed communication that is free. Put differently, the only difference between the CT treatment and the ECC lies in the variation of the cost. This observation confirms that the motivation of our paper, examining costly communication on cooperation, is a relevant issue.

Finally, we observe that emissions in all treatments are significantly increasing, indicating that the performance of the instrument decreases over time. This is in line with the deterioration of cooperation in social dilemma games.

Result 2: Endogenizing communication has no significant impact on group emissions. However, endogenizing communication can be effective in reducing emissions when a communication phase is actually voted in the group.

For the same level of cost (200 tokens), we test in our design two different forms of communications: an exogenous (ECC) and endogenous one (HCV). The comparison between these two treatments shows that endogenous costly communication has no significant impact on group emissions. This observation could already indirectly be inferred from Result 1. Hereafter we provide more direct evidence. However, it is important to note that this comparison does not take into account the success of the group in achieving a communication session. Isaac and Walker (1991) and Kriss et al. (2011) already showed that in costly communication settings, groups communicate less but the impact on cooperation is more effective. We conduct therefore an additional analysis and confirm that whenever communication actually takes place, endogenous costly communication significantly reduces group emissions.

We run a regression in order to compare the exogenous communication (ECC) and the endogenous communication treatments which has the same cost (HCV). The framework for this analysis is the following model:

$$E_{it} = \alpha_0 + \alpha_1 HCV_{it} + \alpha_2 t + \mu_i + \varepsilon_{it}, \qquad (13)$$

where the dependent variable, E_{it}, is the emissions of group $i = 1,\ldots, 8$ at period $t = 5,\ldots, 20$; HCV_{it} is treatment-specific indicators equal to 0 in the exogenous communication treatment (ECC) and 1 in the endogenous communication treatment (HCV). $\mu_i \rightarrow N(0, \sigma^2_{\mu_i})$ is an individual-specific random effect and $\varepsilon_{it} \to N(0,\sigma_{\varepsilon}^{2})$ is a mean zero error term. The model is estimated by using the Generalized Least Squares (GLS), and we conduct the same robustness tests carried out in Result 1.. The results are reported in Table 5. They show no significant difference between ECC and HCV, indicating that for a given cost, endogenizing communication has no impact on group emissions.

Table 5: Regression explaining group emissions by same cost communication treatments (ECC and HCV)

Variables	Coefficients (p-value)
Intercept	85.78*** (0.00)
HCV	17.31 (0.16)
t	0.442 (0.63)
N obs.	128
Overall R²	0.12

Notes: *** denotes that parameter estimate is statistically significant at the 1% level, ** at the 5% level. p-values are in parentheses. Various robustness tests were carried out and confirmed these results.

We then run an additional analysis. We consider model (12), in which we add two interaction terms between treatment variables, LCV_{it} and HCV_{it}, and variable Com_{it}, which is equal to 1 when the group actually communicates and 0 otherwise:

$$\begin{aligned} E_{it} = \alpha_0 + \alpha_1 CT_{it} + \alpha_2 ECC_{it} + \alpha_3 LCV_{it} + \alpha_4 HCV_{it} + \alpha_5 HCV_{it} * Com_{it} \\ + \alpha_6 LCV_{it} * Com_{it} + \alpha_7 t + \mu_i + \varepsilon_{it}. \end{aligned} \tag{14}$$

The model is estimated by using the Generalized Least Squares (GLS) and the same robustness tests as in Result 1 are carried out. The results are presented in Table 6. It reveals that LCV and HCV are not significant. This shows that group emissions are not significantly reduced with respect to treatment NC when communication is not favored by vote in the group. In contrast, the interaction terms are significant, showing that whenever communication is actually favored by vote, group emissions do decrease with respect to the case where communication is not favored by vote. The global effects on group emissions in groups that communicate compared to the NC treatment are given by LCV+LCV*Com and HCV+HCV*Com, which are respectively -27.78 (p = 0.03) and -35.37 (p = 0.00), which should be compared to the effect of CT, -25.43 (p = 0.03). This proves that in groups that actually communicate, group emissions are at least as reduced as in the Cheap Talk treatment, despite the cost of communication. Although the effect of HCV*Com appears to be very large, one should note that in this treatment, communication is favored by vote in one group and only one time (see Table 7). This result should therefore be taken with precaution.

Table 6: Regression explaining group emissions by treatment and communication phase variables

Variables	Coefficients (p-value)
Intercept	100.4*** (0.00)
CT	-25.43** (0.03)
ECC	-18.80 (0.19)
LCV	-13.12 (0.39)
LCV * Com	-14.67*** (0.01)
HCV	0.775 (0.95)
HCV * Com	-36.15*** (0.00)
t	0.779* (0.05)
N obs.	384
Overall R²	0.24

Notes: *** denotes that parameter estimate is statistically significant at the 1% level. p-values are in parentheses. Various robustness tests were carried out and confirmed these results.

3.2 Endogenous Costly Communication

To summarize, endogenous costly communication has no significant impact on group emissions when communication is not favoured by vote. However, whenever communication actually takes place, endogenous costly communication significantly reduces group emissions. We now examine the impact of the cost on the probability of voting for a communication phase. In all this section, we focus our analysis on the two endogenous communication treatments: LCV and HCV.

Result 3: A higher cost of communication deteriorates the individual probability to vote for a communication phase.

Tables 7 and 8 indicate respectively the number of subjects who voted for communication in HCV and LCV. Subjects communicate more in LCV than in HCV. 8 communication phases took place in LCV against only 1 in HCV (over 16 opportunities to communicate, *i.e.* 4 groups * 4 voting phases). The low number of communication phases observed in LCV and HCV is consistent with the studies on costly endogenous communication. Indeed, Isaac and Walker (1991) showed that subjects rarely vote for communication. They suggest that the refusal to communicate could be due to a relatively high cost.[6] Similarly, Kriss et al. (2011) investigated the impact of costly communication in a coordination game, and found that subjects choose not to communicate due to the free-riding on the communication cost even for low costs. Substantial efforts are undertaken in order to avoid incurring the communication costs.

Table 7: Number of subjects who voted for a communication phase in the HCV treatment

Vote before period Groups	5th	9th	13th	17th
Group 1	2	4	5*	0
Group 2	2	1	1	1
Group 3	2	1	1	2
Group 4	4	2	3	4

Table 8: Number of subjects who voted for a communication phase in the LCV treatment

Vote before period Groups	5th	9th	13th	17th
Group 1	5*	5*	1	3
Group 2	5*	4	5*	2
Group 3	5*	4	5*	0
Group 4	5*	3	6*	2

(*): The vote led to a communication phase.

In order to substantiate the previous descriptive analysis, we estimate the determinants of subjects' vote for the communication phase. As previously, the observations can be treated as cross-sectional time series (or panel) data. However, this time, we work at the subject level

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[6] In their study, another explanation could be due to the fact that the cost of communication is not refunded if communication is not favored by vote.

and consider only the 4 voting phases (that is, just before periods 5, 9, 13, 17). There are 64 subjects (2 treatments (LCV and HCV) * 4 groups * 8 subjects). Assume that subject i's (i = 1, …, 64) probability of voting for the communication phase in periods t (= 5, 9, 13, 17) is given by:

$$y_{it}^{*} = \alpha' x_{it} + \mu_i + \varepsilon_{it}\,, \qquad (15)$$

where y_{it}^{*} is a latent variable representing subject i's utility level at period t, x_{it} is a (k × 1) vector of k explanatory variables, α is the (k × 1) regression vector to be estimated, μ_{it} and ε_{it} have the same role as in the previous models. We assume that if $y_{it}^{*} \leq 0$, then the subject votes against the communication phase and if $y_{it}^{*} > 0$, then the subject votes for it. We define the binary observed variable y_{it}, which is equal to 0 when $y_{it}^{*} \leq 0$ and to 1 if $y_{it}^{*} > 0$. The model assumes that $\text{prob}(y_{it}=0 / x_{it}) = \text{prob}(y_{it}^{*} \leq 0 / x_{it}) = F(-\alpha' x_{it})$ and $p(y_{it}=1 / x_{it}) = p(y_{it}^{*} > 0 / x_{it}) = 1 - F(-\alpha' x_{it})$, where F(.) is the cumulative normal distribution. We consider the following panel probit model with random effects:

$$y_{it}^{*} = \alpha_0 + \alpha_1 HCV_{it} + \alpha_2 E_{i-1,t-1} + \alpha_3 t + \mu_i + \varepsilon_{it}\,, \qquad (16)$$

where $E_{i-1,t-1}$ is the sum of the emissions of the other group members in the period just before the voting phase, which is likely to have an impact on voting behavior. We carried out robustness tests (Bootstrap, Jackknife), and also checked that a logit and a hierarchical model specifications yield similar results. The results of the maximum likelihood estimation of are displayed in Table 9.

Table 9: Probit regression on panel data with random effects explaining the individual probability of voting for a communication phase

Variables	Coefficients (p-value)
Intercept	-1.380** (0.02)
HCV	-1.081*** (0.00)
Emissions of others in t-1	0.0252*** (0.00)
t	-0.06*** (0.02)
Log likelihood	-141.05
N.obs	256

Notes: LCV is the reference treatment. *** denotes that parameter estimate is statistically significant at the 1% level. p-values are in parentheses. Various robustness tests were carried out and confirmed these results.

We observe that HCV is significantly negative, indicating that the cost of communication deteriorates subjects' willingness to vote for it. This provides an explanation for the poor performance of endogenous costly communication with respect to cheap talk. Because of the cost, communication phases are rare. As a result, subjects' ability to cooperate is reduced. A reason might be that subjects have fewer opportunities to coordinate. Alternatively, unwillingness to communicate of other group members may be interpreted as unwillingness to cooperate. It should be noticed that the probability of voting for a communication phase is also positively related to the sum of other subjects' emissions in the period before. So, subjects are all the more ready to provide efforts to communicate as group emissions become larger. Nevertheless, we note that the probability of voting for communication decreases over time. Thus, all other things being equal, subjects would be decreasingly willing to vote for communication.

Result 4: The vote reveals the type of the polluter when the cost of communication is low. A positive (negative) vote for communication is associated with lower (higher) individual emissions level.

We restrict our analysis to treatment LCV because the communication phase was adopted only once in one group in treatment HCV. So, there are 32 subjects (4 groups * 8 subjects). Consider the following model:

$$e_{it} = \alpha_0 + \alpha_1 Vote_{it} + \alpha_2 Com_{it} + \alpha_3 E_{i-1,t-1} + \alpha_4 t + \mu_i + \varepsilon_{it}\,, \qquad (17)$$

where e_{it} subject i's $i = 1, ..., 32$ emissions at period $t = 5, ..., 20$; $Vote_{it}$ equals 1 if the subject voted for the communication phase in the last voting phase (that is, just before periods 5, 9, 13, and 17); Com_{it} is equal to 1 when a communication phase actually took place in the group in the last voting phase, and 0 otherwise; $E_{i-1,t-1}$ is the other group members' sum of emissions in the period before (one should keep in mind that variables $Vote_{it}$ and Com_{it} vary every 4 periods whereas variables $E_{i-1,t-1}$ and t vary at every period). The model is estimated by using the Generalized Least Squares (GLS) and the same robustness tests as before are carried out. We first consider the model without variable Com_{it}, and then with this variable. The results are presented in Table 10.

Table 10: Regression explaining individual emissions in the LCV treatment

Variables	Without Com	With Com
	Coefficients (p-value)	Coefficients (p-value)
Intercept	5.785*** (0.000)	8.136*** (4.38)
Vote	-1.283*** (0.000)	-0.691** (-2.22)
Emissions of others in t-1	0.0713*** (0.000)	0.0606*** (7.20)
t	0.0324 (0.720)	-0.0433 (-0.37)
Com	--	-1.678* (-1.79)
N obs.	512	512
Overall R²	0.22	0.24

Notes: LCV is the reference treatment. *** denotes that parameter estimate is statistically significant at the 1% level; ** at the 5% level. p-values are in parentheses. Various robustness tests were carried out and confirmed these results.

Considering first the results of model without the variable Com, we observe that the subject's vote is negatively related to his emission. Thus, a subject voting for communication emits less in the following periods while a subject voting against communication emits more on average. Therefore, voting for communication can be interpreted as an expression of the willingness to cooperate. This result was not self-evident. Indeed, a subject voting for communication might update his plan once he observes the result of the voting phase. To test the robustness of this result, we run the model with Com, which includes the result of the voting phase. We find that the individual vote remains significantly negative. Hence, the fact that the individual vote reveals behavior remains true even after controlling for the output of the voting phase. Finally, it can be noticed that individual emissions are increasing with the sum of others' emissions at the period before, which is a form of reciprocity.

5. Conclusion

We tested the efficiency of the Average Pigovian Tax (APT) first proposed by Suter et al. (2008) to regulate the phenomena of nonpoint source pollution. The choice of this instrument from the set of ambient-based tax mechanisms is justified by the fact that it is less severe and therefore more politically feasible. Contrary to the standard ambient tax, the efficiency of the APT requires cooperation. To facilitate cooperation, Suter et al. (2008) have suggested costless non-binding communication or cheap talk. However, in considering the experimental circumstances in which communication solves cooperation problems, one must remember that the costless communication used in the experiment of Suter et al. (2008) to obtain high rates of efficiency is very unlikely to exist outside the laboratory setting. Thus, in order to mimic that real-world communication often imposes costs on those who are involved in it, we consider in this experiment costly communication.

We confirmed that with cheap talk the APT instrument induces polluters to reduce their emissions. However, we found that the reduction of group emissions is less important when communication is costly even when we endogenize communication by introducing a voting phase. In addition, a variation of the cost when communication is endogenous revealed that a drastic drop of the cost does not provoke a significant reduction of group emissions. A more specific analysis of the performance of the APT instrument under endogenous communication reveals that these findings have to be nuanced. First, we observed that in groups where communication is actually voted, emissions are reduced at the same level as under the cheap talk treatment. However, one should keep in mind that communication is in fact rarely voted. Second, we noticed that subjects' voting behavior is very sensitive to the cost. In other words, a larger cost deteriorates the probability of voting for communication. This explains why communication was rarely favored by vote when it was costly. In contrast, a lower cost not only increases the likelihood of voting for communication, but also prompts the polluter into revealing his type, as a positive vote for communication is associated with lower emission, whereas a negative vote is associated with higher emission. This result implies that the vote might be an indicator to differentiate between the cooperative agents and the non-cooperative ones.

To summarize, our study shows that the APT may be an interesting compromise for dealing with the major concerns of nonpoint source pollution. The APT may allow addressing the challenges of pollution reduction and political acceptability raised by the ambient tax mechanisms. We emphasized that the role of communication is crucial in enhancing the performance of the instrument. Our results suggest that when communication imposes any cost, the ambient-based policy will be less effective than in a situation where communication is essentially free. Specifically, the regulator should pay attention to the cost borne by polluters to implement communication. Further investigations are required to identify the other potential factors that are likely to impact the ability of polluters to communicate with one another.

References

Bochet O., Page T. and Putterman L. (2006) Communication and punishment in voluntary contribution experiments, *Journal of Economic Behavior and Organization* 60, 11-26.

Cochard F. and Rozan A. (2010) Taxe ambiante: un outil adapté à la lutte contre les coulées de boue ? Étude expérimentale, *Revue d'Etudes en Agriculture et Environnement* 91, 296-326.

Cochard F., Willinger M. and Xepapadeas A. (2005) Efficiency of nonpoint source pollution instruments: an experimental study, *Environmental and Resource Economics* 30, 393-422.

Isaac M. and Walker J. (1991) Costly communication: an experiment in a nested public goods problem, *Laboratory research in political economy*, 269-286.

Kriss P., Blume A. and Weber R. (2011) Coordination, efficiency and pre-play communication with forgone costly messages, Working Paper Series, Department of Economics, University of Zurich.

Kroll, S., Cherry, T. L. and Shogren, J. F. (2007) Voting, punishment, and public goods. *Economic Inquiry* 45, 557-570.

Millock K. and Salanié F. (2005) Nonpoint source pollution when polluters might cooperate, *The B.E. Journal of Economic Analysis and Policy* 5, article 12.

Ostrom, E. and J. M. Walker (1989) Communication in a Commons: Cooperation Without External Enforcement. American Political Science Association Meetings, Panel on Freedom and Organization, Atlanta, Georgia.

Ostrom, E., Walker, J. and Gardner, R. (1992) Covenants with and without a Sword: Self-governance Is Possible. *American Political Science Review* 86, 404-417.

Poe G., Schulze W., Segerson K., Suter J. and Vossler C. (2004) Exploring the performance of ambient-based policy instruments when nonpoint source polluters can cooperate, *American Journal of Agricultural Economics* 86, 1203-1210.

Putterman, L., Tyran, J. R., & Kamei, K. (2011) Public goods and voting on formal sanction schemes. *Journal of Public Economics* 95, 1213-1222.

Sally D. (1995) Conversation and cooperation in social dilemmas: a meta-analysis of experiments from 1958 to 1992, *Rationality and Society* 7, 58-92.

Segerson K (1988) Uncertainty and the incentives for non-point pollution control, *Journal of Environmental Economics and Management* 15, 87-98.

Shortle, J. S., Abler, D. G., & Horan, R. D. (1998) Research issues in nonpoint pollution control. *Environmental and Resource Economics 11*, 571-585.

Shortle, J. S., & Horan, R. D. (2001) The economics of nonpoint pollution control. *Journal of Economic Surveys 15*, 255-289.

Spraggon J. (2002) Exogeneous targeting instruments as a solution to group moral hazards, *Journal of Public Economics* 84, 427-456.

Spraggon J. (2004) Testing ambient pollution instruments with heterogeneous agents, *Journal of Environmental Economics and Management* 48, 837-856.

Spraggon J. and Oxoby R. (2010) Ambient-based policy instruments: the role of recommendations and presentation, *Agricultural and Resource Economics Review* 39, 262-274.

Suter J., Segerson K., Vossler C. and Poe G. (2010) Voluntary-threat approaches to reduce ambient water pollution, *American Journal of Agricultural Economics* 92, 1195-1213.

Suter J. and Vossler C. (2014) Towards an understanding of the performance of ambient tax mechanisms in the field: evidence from upstate New York dairy farmers, *American Journal of Agricultural Economics* 96, 92-107.

Suter J., Vossler C. and Poe G. (2009) Ambient-based pollution mechanisms: a comparison of homogeneous and heterogeneous groups of emitters, *Ecological Economics* 68, 1883-1892.

Suter J., Vossler C., Poe G. and Segerson K. (2008) Experiments on damage-based ambient taxes for nonpoint source polluters, *American Journal of Agricultural Economics* 90, 86-102.

Sutter M., Haigner S. and Kocher M. (2010) Choosing the carrot or the stick? Endogenous institutional choice in social dilemma situations, *Review of Economic Studies* 77, 1540-1566.

Villamayor-Tomás, S., Lopez, M. C. and Blanco, E. (2011) Costly Communication and Cooperation in a Changing Water Common Pool, Working paper.

Tyran, J. R., & Feld, L. P. (2006) Achieving Compliance when Legal Sanctions are Non-deterrent. *The Scandinavian Journal of Economics* 108, 135-156.

Vossler C., Poe G., Schulze W. and Segerson K. (2006) Communication and incentive mechanisms based on group performance: an experimental study of nonpoint pollution control, *Economic Inquiry* 44, 599-613.

Vossler C., Suter J. and Poe G. (2013) Experimental evidence on dynamic pollution tax policies, *Journal of Economic Behavior & Organization* 93, 101-115.

Appendix 1: Instructions

These are the translated instructions for treatment HCV. The instructions for the other treatments are available upon request.

Welcome

Introduction

You will participate in an experiment whose objective is to study individual and group decision-making.

Before starting the experiment, we will ask you some questions to verify your understanding of the instructions. After we finish reading the instructions, you can ask us any question you may have.

16 people, randomly divided into two groups of eight, are involved in this experience. So you are a member of one of these two groups of eight members. During the experience you will interact anonymously with the members of your own group.

The gains you realize depend both on your own decisions and on the decisions taken by the other members of your group. These gains will be recorded in points and converted into euros at the end of the experiment.

This experience consists of at least 22 periods. The following instructions will inform you on how your gain at each period will be calculated. They also will explain the chronology of the experience.

1. Your decision

At the beginning of each period, each member of your group, including yourself, has 20 tokens. Your task consists in investing an integer number of tokens between 0 and 20. Your earnings depend on the number of tokens invested by yourself and the other seven members of the group. It is possible that you will win nothing, and worse even, you can lose points.

The gain (or loss) you realize at each period consists of two parts:

- A gain that depends on your own investment.
- A loss that depends on both your investment and those of the seven other members of your group.

In addition, every 4 periods, you may also bear an extra cost if you vote for having a discussion with the other group members.

1.1. The gain due to your own investment

Each token you invest brings you a certain number of points, as shown in the Table below. It is composed of three columns. They respectively indicate the number of tokens you wish to invest, the additional earnings generated by the investment of your last token and your overall earnings.

- If you invest 0 token, your gain is 500 points
- If you invest 1 point, your gain is 582 points (500 +82)
- If you invest 2 tokens, your gain is 660 points (500 +82 +78)

The same principle is applied up to 20 tokens:

- If you invest 20 tokens, your gain is 1380 points (500 + 78 + 82 ... + 14 +10 +6 = 1380).

Tokens	Earnings (in points)	Additional earnings generated by the last token
0	500	-
1	582	82
2	660	78
3	734	74
4	804	70
5	870	66
6	932	62
7	990	58
8	1044	54
9	1094	50
10	1140	46
11	1182	42
12	1220	38
13	1254	34
14	1284	30
15	1310	26
16	1332	22
17	1350	18
18	1364	14
19	1374	10

20	1380	6

You will notice that the more tokens you invest, the less points each of them generates. The un-invested tokens are lost. You can not reuse them in the following periods.

Example: If you invest 9 tokens in one period, you will not have 31 tokens in the next period but 20.

1.2. The loss due to the group investment (your investment and those of your group-members)

Each member of your group, including yourself, incurs a loss if the total number of invested tokens is greater than 64. If the total number of tokens invested by your group is larger than 64, everyone loses 6.5 times the difference between the total number of tokens invested by your group and 64.

Example: The total number of tokens invested by your group is 100 tokens. This number is greater than 64 so each member of the group, including yourself, loses 234 points ((100-64)*6.5).

In summary, the loss depends on the total number of tokens invested by the group. If it is larger than 64, each member of the group incurs a similar loss. The more the number of tokens invested are further from 64, the greater the loss is.

2. The cost due to your participation in the discussion session

You have the opportunity to communicate with your other group-members before the 5th, 9th, 13th, 17th and 21st periods. At each of these periods, you indicate by a vote whether you want to discuss with them ("yes" or "no"). The question "Would you like to discuss with the other members of your group?" appears on your screen. If the majority of the group (at least 5 "yes") wishes to discuss, a chat room will appear and all members of the group, including those who responded "no" can then engage in a discussion phase. Otherwise no discussion will take place.

- If you voted "yes", 200 points will be deducted from your earnings at the end of this period, but only if there is a discussion.
- If you voted "no", no points will be deducted from your earnings at the end of that period whether or not there is a discussion.

After the vote, you will be informed of the holding or not of a discussion session. However, the voting score (how many "yes"" and "no") will not be indicated.

During the discussion phases, limited to three minutes, agreements to share gains after the experiment are prohibited. Apart from the discussion time allowed, it is forbidden to communicate during the experiment.

3. Chronology of the experience

In each period, the computer asks you to enter the number of tokens you want to invest. You can enter any integer number between 0 and 20. The other members of your group do the same task on their side, but you do not observe their individual decisions. You will just know the total sum of their individual decisions at the end of a period. Once all members of your group have made their decisions, the computer calculates the gain or loss for that period. Then it provides each participant with the total number of tokens invested by the seven other members of the group and its gain for the period. The next period begins when all members of your group are ready. At any time, you can view the history of experience. It reminds you for each historical period, your decision, the total number of tokens made by the other seven members of the group and your gain.

At the end of the experiment, your gain will be converted into Euros. The conversion rate to be applied is 1000 points equal to € 1.

Before starting the experiment, you will participate in a trial period. The aim is to enable you to familiarize yourself with the user interface of the computer. During this trial period the computer will play the role of the other seven people, assuming that they invest 70 tokens. The earnings received during this period will not be converted into euros.