

# **The effects of recommended play on compliance with ambient pollution instruments**

Robert J. Oxoby<sup>◇</sup> and John Spraggon<sup>▽</sup>

## **INTRODUCTION**

Segerson (1988) has shown that ambient pollution instruments are theoretically able to induce individual non-point source polluters to reduce their emissions to the optimal level. However, recent empirical evidence (e.g., Cochard et al., 2005; Alpízar et al., 2004; Poe et al., 2004; Spraggon, 2004b, 2002) casts doubt on the ability of these instruments to induce polluters to comply with a standard. In each of these studies, while the instruments are able to induce the group to the target outcome, the choices of participants are not individually optimal. As a result, there is significant inefficiency and inequality under these instruments.

One potential explanation for the inability of these instruments to induce individuals to the socially optimal outcome is that subjects do not understand the decision making environment. For example, Oxoby and Spraggon (2005) have shown that, among participants who understand the concept of Nash equilibrium, these instruments induce individually and socially optimal decision making. With this in mind, we investigate making the decision environment and the corresponding incentives clearer to decision makers (i.e., recommended play): we explain the environment and the concept of “marginal decision making” carefully to participants. In explaining the environment, we hope participants will not only be able to identify their dominant strategies, but also realize the reward and punishment properties of the instrument.

Other studies (e.g., Andreoni et al., 2003; Fehr and Gächter, 2000; Dickinson, 2001) have

shown that providing subjects with the ability to punish or reward others results in more efficient outcomes. This ability to punish or reward other members of the group is implicit in the ambient pollution instrument. Individuals who choose to reduce their decision numbers below the individually optimal level are rewarding the behavior of others in their group while those who choose numbers which exceed this level are punishing group members. To the extent that subjects realize this nature of the instrument we may observe more subjects choosing to punish the other members of their group. This would lead to less efficient and more inequitable outcomes.

The environment investigated in this paper is of particular interest because it differs from the standard public good environments so often investigated experimentally (see Zelmer, 2003). In these standard public good environments, authors typically appeal to alternate preferences (e.g., preferences embodying payoff inequities, fairness, or reciprocity; see Charness and Rabin, 2002 and Fehr and Schmidt, 1999) and decision error (Anderson et al., 1998; Ledyard, 1995) to explain non-Nash decision making. Indeed, ambient pollution instruments can be designed so that preferences incorporating altruism and reciprocity lead to Nash play. However, preferences embodying, say, relative payoff maximization may lead subjects to make choices which differ from Nash. As a result, the question posed here is “Does explaining the environment more carefully reduce errors in decision making and lead to more Nash play or do these other preference explanations dominate when subjects better understand the decision environment?”

While others have investigated the effects of recommended play on behavior, the work of Croson and Marks (2001) is most germane to our interests.<sup>1</sup> In a threshold public good environment, Croson and Marks (2001) show that recommended play increases Nash play

when agents are heterogeneous. Given our interest in non-point source pollution, our focus is somewhat different. It does not seem reasonable to expect that an environmental regulator would know the socially optimal level of emission for any given firm. However, what does seem reasonable is that the regulator could explain the instrument in detail to representatives from each polluting source. That is, the regulator could explain the form of the instrument: everyone is fined if the ambient level of pollution exceeds the target and therefore everyone should reduce their emissions to the point where their marginal benefit of emitting one more unit is equal to the tax rate. The purpose of this paper is to determine if this type of recommendation increases compliance with ambient pollution instruments.

We proceed as follows; section two presents the experimental environment and relates it to the non-point source pollution problem. Section three presents our results. We delineate these results by analyzing the effects of enhanced instructions (i.e., recommended play) at the aggregate level, by participant type, and at the individual level. With enhanced explanations, the results are mixed: enhanced instructions improve compliance under the tax instrument but not under the tax/subsidy instrument. Moreover, although there is more compliance, efficiency is not improved by much. Section four concludes by discussing the policy implications of this result and suggests that these results may be due to seemingly minor weaknesses in the instruments from the point of view of standard theory.

## **EXPERIMENTAL DESIGN**

The underlying structure of the experiment is based on the non-point source pollution problem (e.g., Segerson, 1988). Non-point sources emit pollution into the air or water in a diffuse manner, making it prohibitively costly to determine how much an individual source is

emitting. In this environment, we assume that the regulator can measure the ambient level of pollution and knows the potential sources of the pollution. Under an ambient pollution instrument, polluters are fined if the observed ambient level of emission exceeds a target level and are (potentially) subsidized if the ambient level of emissions is below the target. The tax and subsidy rates are chosen so that individual polluters choose the optimal level of emission where the marginal benefit of one more unit of emission is equal to the marginal cost (the tax) they pay on that unit. Thus, the ambient pollution instrument implements the socially optimal outcome as a dominant strategy Nash equilibrium (Segerson, 1988).

To investigate ambient pollution instruments in an experimental environment, subjects choose decision numbers which are analogous to emission levels.<sup>2</sup> The higher a participant's decision number the higher is her private payoff. There is also a group component to participants' payoffs such that the higher the aggregate decision number (the sum of decision numbers within a group) the lower the group payoff. Subjects' private payoffs are presented in a table and the ambient pollution instrument is presented as a function. Subjects also have access to a calculator allowing them to determine their payoff from any feasible combination of their decision number and the aggregate decision number of those in their group.

The private payoff function  $B_n$  is given by

$$B_n(x_n) = 25 - 0.002(x_n^{\max} - x_n)^2 \quad (1)$$

where  $x_n$  is subject  $n$ 's decision number and  $x_n^{\max}$  is the subject  $n$ 's maximum decision number. Notice that private payoff is maximized when  $x_n = x_n^{\max}$ . The maximum decision number can be thought of as the unconstrained emission level in the non-point source pollution context. The quadratic payoff function was chosen for consistency with Nalbantian and Schotter (1997) and for mathematical simplicity.

We investigate two ambient pollution instruments. Both instruments involve a tax if the aggregate decision number (analogous to the ambient level of pollution) exceeds the target. The instrument which we refer to as the tax/subsidy instrument also involves a subsidy when the aggregate decision number is below the target. The tax instrument is presented as

$$T_n(X) = \begin{cases} 0.3(X - 150) & \text{if } X > 150, \\ 0 & \text{if } X \leq 150. \end{cases} \quad (2)$$

The tax/subsidy instrument is presented as

$$T_n(X) = \begin{cases} 0.3(X - 150) & \text{if } X > 150, \\ 0.3(X - 150) & \text{if } X \leq 150, \end{cases} \quad (3)$$

where  $X \equiv \sum_{n=1}^N x_n$  is the aggregate decision number (referred to as the group total).<sup>3</sup> The tax/subsidy rate (0.3) was chosen as the emission damage rate for simplicity. This choice, coupled with the number of subjects per group ( $N = 4$ ) and the form of the private payoff function (equation 1), determines the exogenous target (150).

Thus, under the tax instrument, each individual maximizes

$$\pi_n = 25.00 - 0.002(x_n^{\max} - x_n)^2 - \begin{cases} 0.3(X - 150) & \text{if } X > 150, \\ 0 & \text{if } X \leq 150. \end{cases} \quad (4)$$

Under the tax/subsidy instrument, each individual maximizes

$$\pi_n = 25.00 - 0.002(x_n^{\max} - x_n)^2 - 0.3(X - 150). \quad (5)$$

for the tax/subsidy instrument. Therefore, for the tax/subsidy instrument each individual's best response for any given  $X$  is

$$x_n^* = x_n^{\max} - 75. \quad (6)$$

We utilize four subject groups, each with two subjects having a maximum decision number of 100 and two subjects with a maximum decision number of 125. We refer to these different types as medium and large capacity subjects, respectively. Thus, under the tax/subsidy instrument medium capacity subjects should choose  $x_n^* = 25$  while large capacity subjects should choose  $x_n^* = 50$ . Note that there is also a group optimal outcome under this instrument where all subjects choose  $x_n^* = 0$  and the total payoff to everyone in the group is maximized.<sup>4</sup>

For the tax instrument, a subject's best response function is the same as for the tax/subsidy instrument if the sum of everyone else's decision numbers is greater than or equal to the target minus the subject's optimal decision ( $x_n^{\max} - 75$ ). However, if the aggregate decision of the other group members is below this level, the subject should choose a decision number just large enough to insure that the aggregate decision is equal to the target. Since all subjects face this same incentive, the Nash equilibrium (where everyone chooses  $x_n^* = x_n^{\max} - 75$ ) is unique.

We refer to the outcome where subjects reduce their decision number from the maximum by 75 as socially optimal as this is the solution to the social planner's problem (the difference between the individual benefits from emission minus the cost to society of the emission):

$$SP = \max_{(x_1, \dots, x_4)} \left[ \sum_{n=1}^4 B_n - 0.3 \sum_{n=1}^4 x_n \right]. \quad (7)$$

Previous experiments in this environment (Spraggon, 2002, 2004b; Oxoby and Spraggon, 2005) suggest that subjects do not choose the dominant strategy Nash equilibrium. Spraggon (2004a) suggests that both decision error and alternate preferences are important explanations

for this non-Nash behavior. In the same environment, Oxoby and Spraggon (2005) find much more Nash play among subjects who have had a course in game theory, suggesting that decision error may be more important in explaining non-Nash behavior than alternate preferences. If this is the case then providing subjects with a better explanation of the environment should result in more Nash decision making.

In our experiments we conduct two treatments: a standard instruction treatment, and a treatment with enhanced instructions.<sup>5</sup> Primarily, the differences between the instructions lies in the description of the payoff function, which was expanded to include the marginal benefit from increasing the subject's decision number by one for each decision number and an explanation of "marginal decision making." The following is the relevant part of the enhanced instructions:

The purpose of the Group Payoff is to insure that everyone chooses a certain Decision Number. Notice that by increasing your Decision Number by one you increase your Private Payoff by the number given in the third column of Table 1. However, by increasing your Decision Number by one you reduce the Group Payoff by 0.3. As a result you maximize your Total Payoff by increasing your decision number to the point where increasing your decision number by one more will increase your Private Payoff by less than 0.3.

Subjects were also provided with hypothetical numerical examples and a question to test their understanding.

# RESULTS

The results from the experimental sessions are striking. When subjects are given instructions which include a description of marginal analysis they are much more likely to choose the dominant strategy Nash decision. Moreover, they are also much more likely to choose numbers which are below their Nash decision, presumably in an attempt to achieve the group optimal outcome.

## Data and Method of Analysis

The data was collected from eight sessions conducted at the University of Calgary in the winter and fall of 2003 and two sessions conducted in the winter of 2005. Participants were recruited from the general university population. Each experiment consisted of twenty-five periods. Sessions took approximately an hour and a half and average earnings varied between ten and twenty-five dollars (Canadian).

Efficiency is measured as the difference between the optimal and actual value of the Social Planner's problem (equation 7) as a percentage of the difference between the optimal and minimum possible value of the Social Planner's problem. This definition of efficiency accounts for not only differences between the group total and the target, but also for reductions in total payoff due to subjects reducing their decision numbers by more or less than is individually optimal. For example, if two large capacity subjects each chose 75 and two medium capacity subjects each chose 0, the group total would be 150 but the efficiency of this outcome would be only 89 percent.

We begin by discussing the results at the aggregate level. Means are calculated for each group of four subjects and the mean of these means is calculated for each treatment cell.

These statistics are independent for the analysis at the aggregate level and we have five observations in each cell. We also compare the data by participant type (medium and large capacity) across the different treatments. This data is also independent.<sup>6</sup> Finally we look at the distributions of individual decisions. While this data is not independent, we follow Anderson et al. (1998) in assuming that errors in decision making result in a distribution of decisions. As it turns out, these distributions are reasonably normal (subject to the constraints of the decision space).

### **Analysis at the Aggregate Level**

Table 1 shows the aggregate decision numbers and efficiency calculated at the means of session means. Notice that the mean aggregate decision number is closer to the target with the enhanced instructions for the tax instrument but further for the tax/subsidy. The group totals are not significantly different from each other using either analysis of variance ( $p=0.3205$  for the tax/subsidy and  $p=0.1356$  for the tax) or the Mann-Whitney U test ( $p=0.3472$  for the tax/subsidy and  $p=0.1172$  for the tax).

Table 1 about here

The efficiency results are consistent with the group total results (although the enhanced instructions improve efficiency for both treatments). Again the differences are not significant using standard parametric tests ( $p=0.4577$  for the tax/subsidy and  $p=0.4700$ ) or the Mann-Whitney U test ( $p=0.3472$  for the tax/subsidy and  $p=0.3472$ ).

Figures 1 and 3 show the differences in the aggregate decision number and efficiency through time for the tax/subsidy instrument. Notice that the mean group total is typically closer to the

target under the enhanced instructions with the standard instructions but efficiencies are higher during the early period with the enhanced instructions.

Figure 1 about here

Figure 2 about here

Figure 3 about here

Figure 4 about here

Figures 2 and 4 show that group total and efficiency under the tax instrument are better in the treatment with the enhanced instructions during the early periods but are very similar in the later periods.

These results suggest that, at the aggregate level, providing more information to subjects does not significantly effect the efficiency of either instruments.

### **Analysis by Participant Type**

Recall that  $x_n^* = 50$  and  $x_n^* = 25$  are dominant strategies for large and medium capacity subjects facing the tax/subsidy instrument. Tables 2 shows that these predictions are not as consistent with the Nash prediction as the results regarding aggregate decision making might

suggest. For large capacity subjects under the tax/subsidy instrument (Table 2) decisions in the enhanced instruction treatment are significantly below the Nash prediction. Further, notice that the median decisions in both the enhanced and standard instruction treatments are below this prediction. Similar results are observed for medium capacity subjects although decisions are somewhat above  $x_n^*$  under the standard instructions.

Table 2 about here

Under the tax instrument decisions are much higher than the prediction for both the large and medium capacity subjects under the standard instructions and medium capacity subject under the enhanced instructions. However, the results are more consistent with the enhanced instructions.

Figure 5 depicts the time series of average decision number by treatment and subject type for both the tax/subsidy (T/S) and tax instruments. Notice, that for the tax/subsidy under both the standard and enhanced instruction treatments, decisions are very similar between the large and medium capacity types. Under the tax instrument the decisions of large and medium capacity subjects are different, although they are above the Nash predictions.

Figure 5 about here

Summarizing, explaining the marginal nature of the decision making environment results in participants recognizing the collusive outcome under the tax/subsidy and choosing lower decision numbers as a result. Under the tax instrument subjects seem to choose slightly larger decision numbers, but this effect is somewhat mitigated by the enhanced instructions.

## Analysis by Participant

Figures 6 and 7 present the distributions of individual decisions by subject type and instrument. Figure 6 provides the distributions for the tax/subsidy instrument. Notice that subjects seem to focus on the group optimal decision (zero) in all cases except the large capacity subjects under the enhanced instructions. These distributions are significantly different using standard non-parametric tests ( $p < 0.01$ ,  $< 0.01$  for the Mann-Whitney test,  $p < 0.0$ ,  $< 0.011$  for the Median test and  $p < 0.01$ ,  $< 0.01$  for the Kolmogorov-Smirnov test for large and medium capacity subjects respectively).<sup>7</sup> Figure 7 shows that the story is different for the tax instrument. The enhanced instructions focus both the large and medium capacity subjects on the optimal decision. Again, the distributions are significantly different using standard non-parametric tests ( $p = 0.0909$ ,  $< 0.01$  for the Mann-Whitney test,  $p < 0.01$ ,  $< 0.01$  for the Median test and  $p < 0.01$ ,  $< 0.01$ ) for the Kolmogorov-Smirnov test for large and medium capacity subjects respectively). These distributions are unchanged when only the data from periods 10 to 20 are considered. Standard non-parametric tests for these periods are also consistent with this contention except for large capacity subjects under the tax instrument for which the Mann-Whitney and Median tests do not suggest a significant difference.<sup>8</sup>

Figure 6 about here

Figure 7 about here

## CONCLUSION

The policy implications of these results are clear. Providing a better explanation of the instrument to the participants does not necessarily result in more compliance at the aggregate level at least under the instrument without the group optimal outcome. This suggests that the reductions in efficiencies observed in previous empirical studies of these instruments (Cochard et al., 2005; Poe et al., 2004; Spraggon, 2004b) are likely due to a combination of decision errors and strategic play in which participants attempt to take advantage of the group nature of these instruments.

In terms of implementation, two issues regarding these instruments should be considered. First, the instruments' information requirements (on the part of firms and policy makers) are extreme as optimal tax/subsidy rates depend on both firms' costs and the environmental damages they impose. However, following Segerson (1988), one could consider firm-specific tax rates based on firms' differing costs or damage functions. This may be appropriate for non-point source pollution problems as a firm's damage (for a fixed level of emissions) depends on distance from the resource in question (e.g., the watershed).<sup>9</sup> Secondly, if firms are competitors in product markets, an ambient pollution instrument may provide an additional tool for competition: increasing emissions reduces a firm's abatement costs and increases its fine, but also increases the fines paid by competitors without reducing a corresponding reduction in their abatement costs.

Despite this, the empirical evidence (Cochard et al., 2005; Poe et al., 2004; Spraggon, 2002, 2004b) suggests that these instruments are remarkably efficient at reducing the aggregate emission level to the target.<sup>10</sup> These reductions in efficiency are primarily due to differences from optimal behavior at the individual (rather than aggregate) level. This, combined with

our results on the efficiency and compliance gains of recommended play in conjunction with these instruments, provides reason to be optimistic about the ability of these instruments to mitigate not only the non-point source pollution but also other group moral hazard problems (Spraggon, 2002). This may be critically important for pollution problems where there are a large number of polluters and it is financially infeasible to effectively monitor.

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## INSTRUCTIONS

*These are the enhanced instructions. Italicized notes indicate the parts not appearing in the standard instructions.*

This is a session in an experiment in the economics of decision making. During this session you will make a number of decisions. Each of these decisions will result in a payoff which will be reported in lab dollars. At the end of the session your cumulative payoff will be converted to Canadian and you will be paid in cash. Your payment for today's session is both compensation for your time as well as for the effort you put into making your decisions. If you pay attention to the instructions and make your decisions carefully you may earn a considerable amount of money. This research is being funded by the Social Sciences and Humanities Research Council of Canada.

### Overview

Today's session will be conducted using the computer network located in our laboratory. The session will consist of 25 periods. We will begin after everyone has finished reading the instructions and completed 5 practice periods. Please refrain from talking during the session. Each period will proceed as follows.

<b>What the Computer does</b>	<b>What you do</b>
Start period.	
	Choose a "decision number" and enter it in the appropriate box on your computer screen.
Collect decision numbers, calculates individual payoffs, and returns results.	
	Check your payoff and cumulative payoff.
Start next period or end session.	

Now here are the details.

### Detailed Instructions

You have been assigned to a group of four (yourself and three other) participants. This will be your group for the entire session. In each period you (and the others in your group) will be asked to choose a number and enter it into the computer. This is your **Decision Number**.

Your **Total Payoff** for each period is the sum of your **Private Payoff** and your **Group Payoff**:

$$\text{Total Payoff} = \text{Private Payoff} + \text{Group Payoff}$$

Your Private Payoff depends only on your own Decision Number. You have been randomly assigned to a player type. Half (2) of the people in your group must choose their Decision Numbers between 0 and 125. The other half of the people in your group must choose their Decision Numbers between 0 and 100. The payoff are also different for both types of people so that the Private Payoff for choosing 10 for people whose decision numbers can range between 0 and 125 is different that the payoff for choosing 10 for people whose decision numbers can range between 0 and 100.

Table 1 in your folder shows the Private Payoff for each of your possible Decision Numbers. For example if you were to choose 30 Table 1 shows your Private Payoff for choosing that Decision Number.

If your Decision Numbers must be less than 125, Table 1 shows you that your Private Payoff for choosing 30 would be 6.95 lab dollars.

If your Decision Numbers must be less than 100, Table 1 shows you that your Private Payoff for choosing 30 would be 15.20 lab dollars.

Notice that the higher your Decision Number the higher your Private Payoff.

Table 2 in your folder shows the Private Payoffs for each of the possible Decision Numbers for someone of the other type. For example, Table 2 shows the Private Payoff to a participant of the other type who chose 30.

If the participant of the other type's Decision Numbers are always less than 100, Table 2 shows that their Private Payoff for choosing 30 is 15.20 lab dollars.

If the participant of the other type's Decision Numbers are always less than 125, Table 2 shows that their Private Payoff for choosing 30 is 6.95 lab dollars.

Notice that the higher their Decision Number the higher their Private Payoff.

*The following paragraph is specific to the Enhanced Instruction.*

The third column of Table 1 tells you how much your payoff increases if you increase your decision number by 1. Thus if you were to choose 30, the number right beside 30 in Table 1 is your payoff from choosing 30 and the number beside that is how much your Private Payoff would *increase* if you choose 31. The third column of Table 2 provides this information for someone of the other type.

Your Group Payoff depends on the **Group Total**. The Group Total is the sum of your decision number and the decision numbers of the three other people in your group. Since two of the people in your group must choose their decision numbers between 0 and 125 and two

must choose between 0 and 100 the group total must be between 0 and 450.

The Group Payoff depends only on the Group Total and is the same for everyone in your group. If the Group Total is less than or equal to 150 then the Group Payoff will be a positive value equal to 30 percent of the difference between 150 and the Group Total. If the Group Total is greater than 150 then the Group Payoff will be a negative value equal to 30 percent of the difference between 150 and the Group Total. The Group Payoff can be written as the following function of the Group Total:

$$\text{Group Payoff} = \begin{cases} 0.3(150 - \text{Group Total}) & \text{if Group Total} > 150 \\ 0.3(\text{Group Total} - 150) & \text{if Group Total} \leq 150 \end{cases}$$

For example, if the Group Total were 170 then the Group Payoff for every member of the group would be  $0.3(150 - 170) = -6.00$  lab dollars. Similarly if the Group Total were 140 then the Group Payoff for every member of the group would be  $0.3(150 - 140) = 3.00$  lab dollars. Notice that the higher the Group Total the lower the Group Payoff.<sup>11</sup>

*The following paragraph is specific to the Enhanced Instruction.*

The purpose of the Group Payoff is to insure that everyone chooses a certain Decision Number. Notice that by increasing your Decision Number by one you increase your Private Payoff by the number given in the third column of Table 1. However, by increasing your Decision Number by one you reduce the Group Payoff by 0.3. As a result you maximize your Total Payoff by increasing your decision number to the point where increasing your decision number by one more will increase your Private Payoff by less than 0.3.

Consider the following Sample Table 1. Sample Table 1 is different from the actual Table 1's that you and everyone in your group received and is just provided for illustrative purposes.

Sample Table 1

Decision Number	Private Payoff	Increase In Private Payoff from Increasing your Decision Number by 1
8	9.00	0.50
9	9.50	0.40
10	9.90	0.30
11	10.20	0.20
12	10.40	0.10
13	10.50	0.05

Given the numbers in Sample Table 1 and that increasing your decision by 1 reduces your Group Payoff by 0.3 you should choose 10 or 11 to maximize your payoff no matter what everyone else does. Assume that the Group Total is 100 plus your decision number. Sample Table 2 shows your payoff for each of the choices in Sample Table 1.

Sample Table 2

Decision Number	Private Payoff	Group Total	Group Payoff	Total Payoff
8	9.00	108	12.60	21.60
9	9.50	109	12.30	21.80
10	9.90	110	12.00	21.90
11	10.20	111	11.70	21.90
12	10.40	112	11.40	21.80
13	10.50	113	11.10	21.60

Notice that if the other people in your group choose high Decision Numbers your Total Payoff may be negative. If in the above example we had assumed that all of the other people in your group choose 100, the group total would have been 300 plus your decision number. Sample Table 3 shows your payoff for each of the choices in Sample Table 1 given this assumption.

Sample Table 3

Decision Number	Private Payoff	Group Total	Group Payoff	Total Payoff
8	9.00	308	-47.40	-38.40
9	9.50	309	-47.70	-38.20
10	9.90	310	-48.00	-38.10
11	10.20	311	-48.30	-38.10
12	10.40	312	-48.60	-38.20
13	10.50	313	-48.90	-38.40

Notice that despite the fact that everyone else is choosing larger numbers it is still in

your best interest to choose 10 or 11.

**Please answer the following question:**

Use TABLE 1 to fill in the portion of the record sheet below assuming that you chose 65, the Group Total was 400 and the group payoff is 30 percent of the difference between 150 and the Group Total.

Period	Decision Number	Private Payoff	Group Total	Group Payoff	Total Payoff	Cumulative Payoff
Practice						

**Please raise your hand when you are done so that the monitor can check your answer.**

Before we begin we will conduct five practice periods. These practice periods are intended to help you understand today's experiment. Any earnings you make during the practice periods will not be included in your payment at the end of the session. During the practice periods you will be in the same group that you are for the twenty-five periods for which you will be paid at the end of today's session.

Once the first practice period starts you will notice that the game window on the computer screen has three sections. The first section (on the left side of the screen) keeps track of the outcome of all of the previous periods in which you have participated. The second section (on the top right of the screen) is a calculator. Using this calculator, you will be able to determine your payoff from different combinations of values for your Decision Number and the Group Total. The third section (bottom right) tells you your maximum decision number, has a box for you to enter your decision number and a button for you to 'click' to submit your decision. Please feel free to raise your hand and ask any questions you may have.

To help you understand the Calculator please pick any valid decision number and type it into the box beside Your Decision Number on the calculator. Now pick a bigger number

and type it into the box beside Group Total. Notice that the Group Total will always be bigger than your Decision Number as it is the sum of the Decision Numbers of everyone in your group. Now use the arrow buttons beside the box where you typed Your Decision Number to increase or decrease Your Decision Number. Notice the effect of these changes on your Total Payoff.

Your payment for this session will be the sum of your earnings in each of the 25 periods. Your earnings will be converted from lab dollars to Canadian at the rate of 1 lab dollar is equal to 3.4 cents Canadian. You have been given an opening balance of 250 lab dollars (\$5.00 Canadian). In the event that your Cumulative Payoff does fall below zero you will be informed by the computer that you are Bankrupt. At this point the rest of the people in your group will be informed that someone has gone bankrupt and the experiment will end.

Once everyone has had an opportunity to ask any final questions we will begin the 25 periods for which you will be paid at the end of today's session.

## TABLES

**Table 1. Mean Aggregate Decision Numbers by Treatment.**

Treatment	Mean Group	Confidence Interval		Mean Group Efficiency
	Total	Lower Bound	Upper Bound	
Tax/Subsidy Enhanced Instructions	96.94 (11.07) [5]	66.20	127.68	90.18 (0.017) [5]
Tax/Subsidy Standard Instructions	133.50 (32.69) [5]	42.00	222.26	87.09 (0.036) [5]
Tax Enhanced Instructions	183.18 (10.19) [5]	154.89	211.48	91.77 (0.026) [5]
Tax Standard Instructions	205.30 (8.59) [5]	181.45	229.15	89.59 (0.013) [5]

Standard errors are provided in parenthesis and number of observations are provided in square brackets.

**Table 2. Mean Aggregate Decision Numbers, under the Tax/Subsidy by Treatment.**

Treatment	Mean	Confidence Interval		Median
	Decision	Lower Bound	Upper Bound	Decision
Enhanced Instructions, Large Capacity	28.59 (4.88) [5]	15.05	42.12	25.5
Standard Instructions, Large Capacity	35.03 (9.69) [5]	8.13	61.93	36.5
Enhanced Instructions, Medium Capacity	19.88 (4.65) [5]	6.98	32.79	20.5
Standard Instructions, Medium Capacity	31.72 (7.10) [5]	11.99	51.44	26

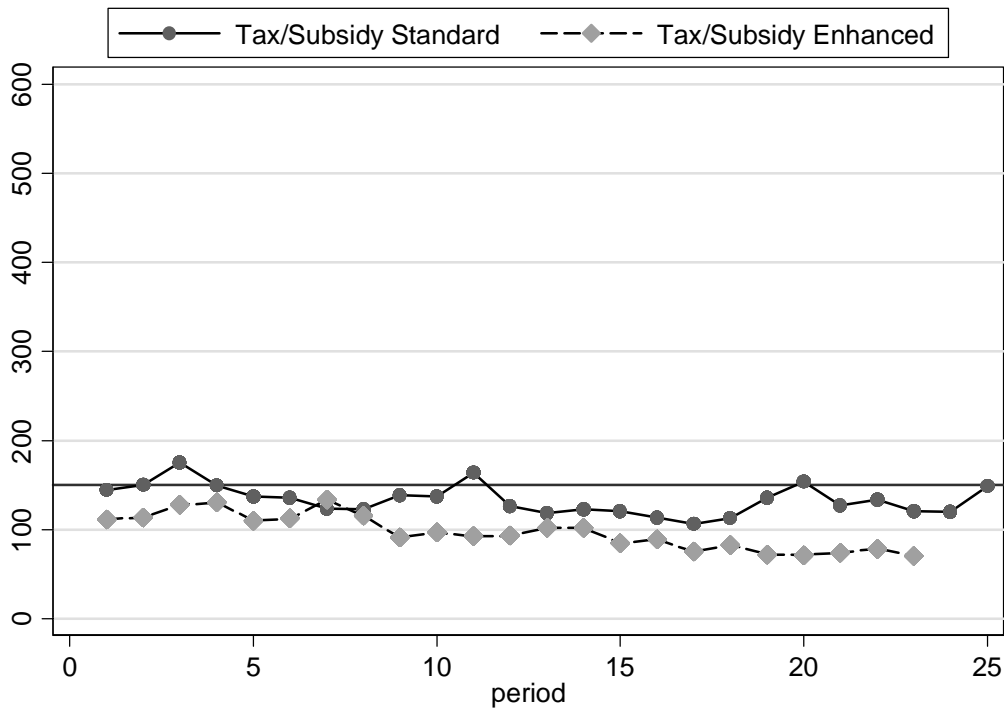
Standard errors are provided in parenthesis and number of observations are provided in square brackets. Median is the Median of Medians by Group.

**Table 3. Mean Aggregate Decision Numbers, under the Tax by Treatment.**

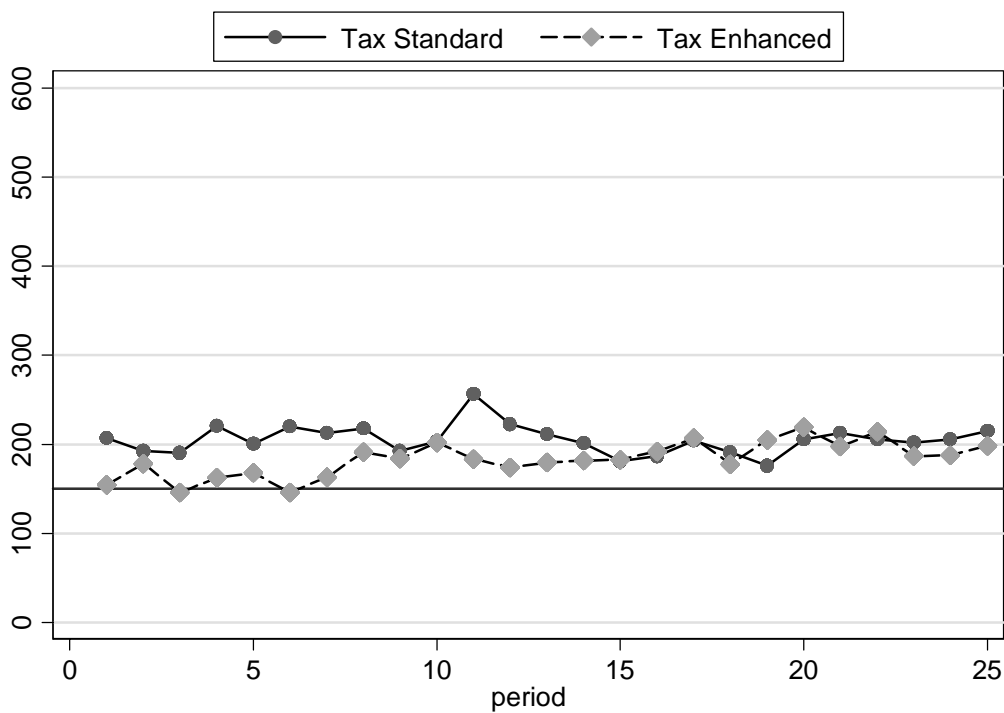
Treatment	Mean Decision	Confidence Interval		Median Decision
		Lower Bound	Upper Bound	
Enhanced Instructions, Large Capacity	56.09 (1.75) [5]	51.24	60.93	50
Standard Instructions, Large Capacity	59.12 (2.46) [5]	52.39	65.95	60
Enhanced Instructions, Medium Capacity	35.50 (5.46) [5]	20.33	50.68	27.5
Standard Instructions, Medium Capacity	43.53 (5.04) [5]	29.55	57.51	49.5

Standard errors are provided in parenthesis and number of observations are provided in square brackets. Median is the Median of Medians by Group.

## FIGURES



**Figure 1:** Mean Group Totals by Treatment and Period, Tax/Subsidy Instrument.



**Figure 2:** Mean Group Totals by Treatment and Period, Tax Instrument.

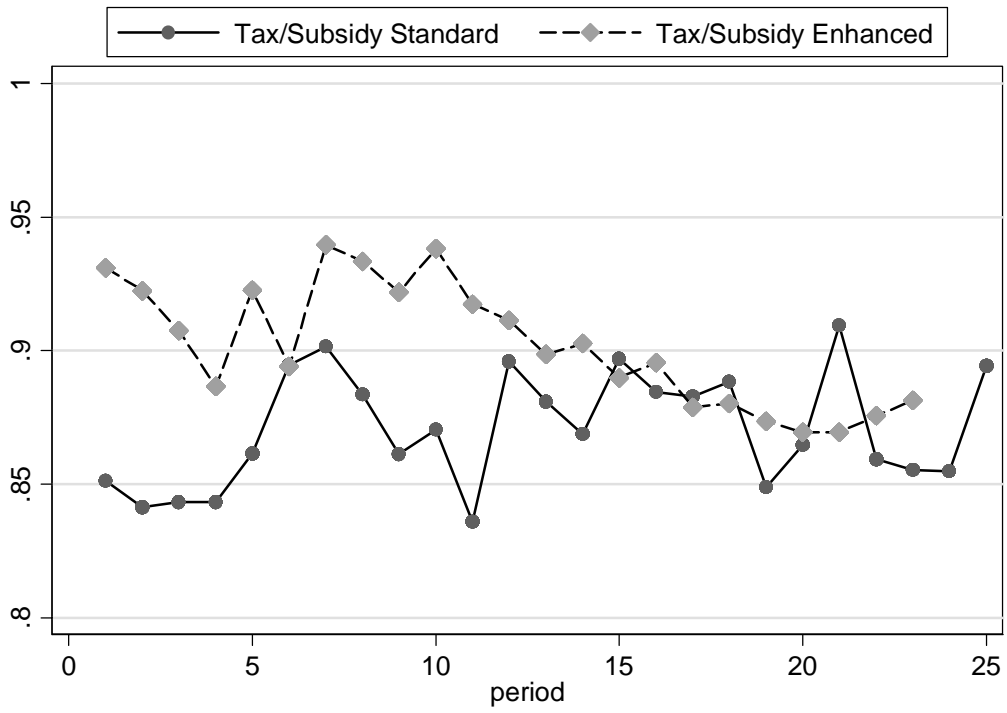


Figure 3: Mean Efficiency by Treatment and Period, Tax/Subsidy Instrument.

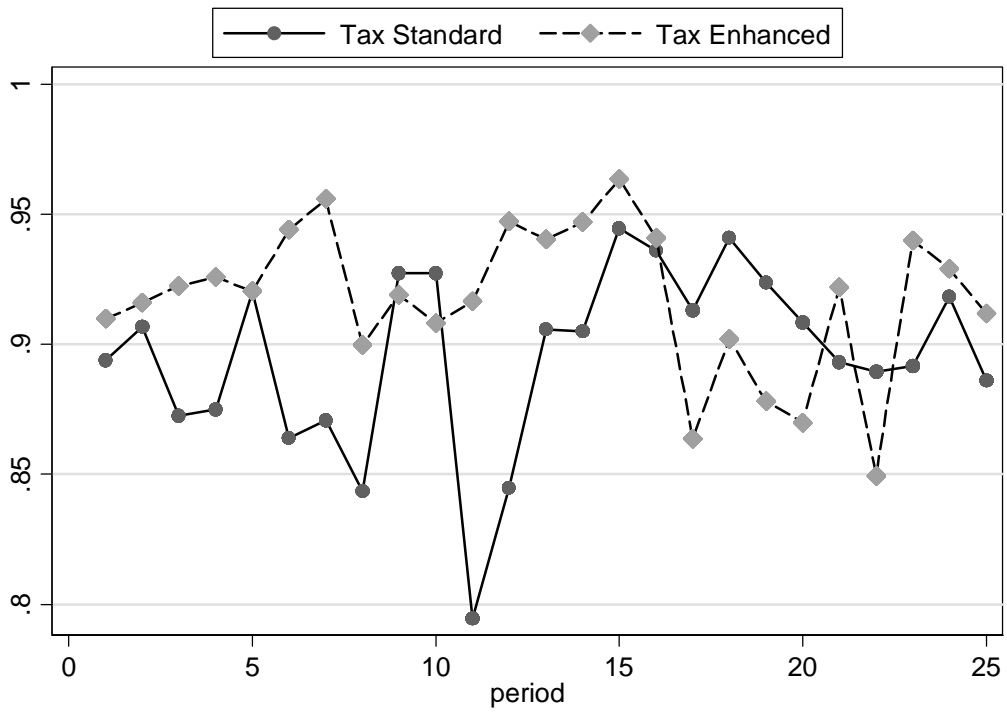
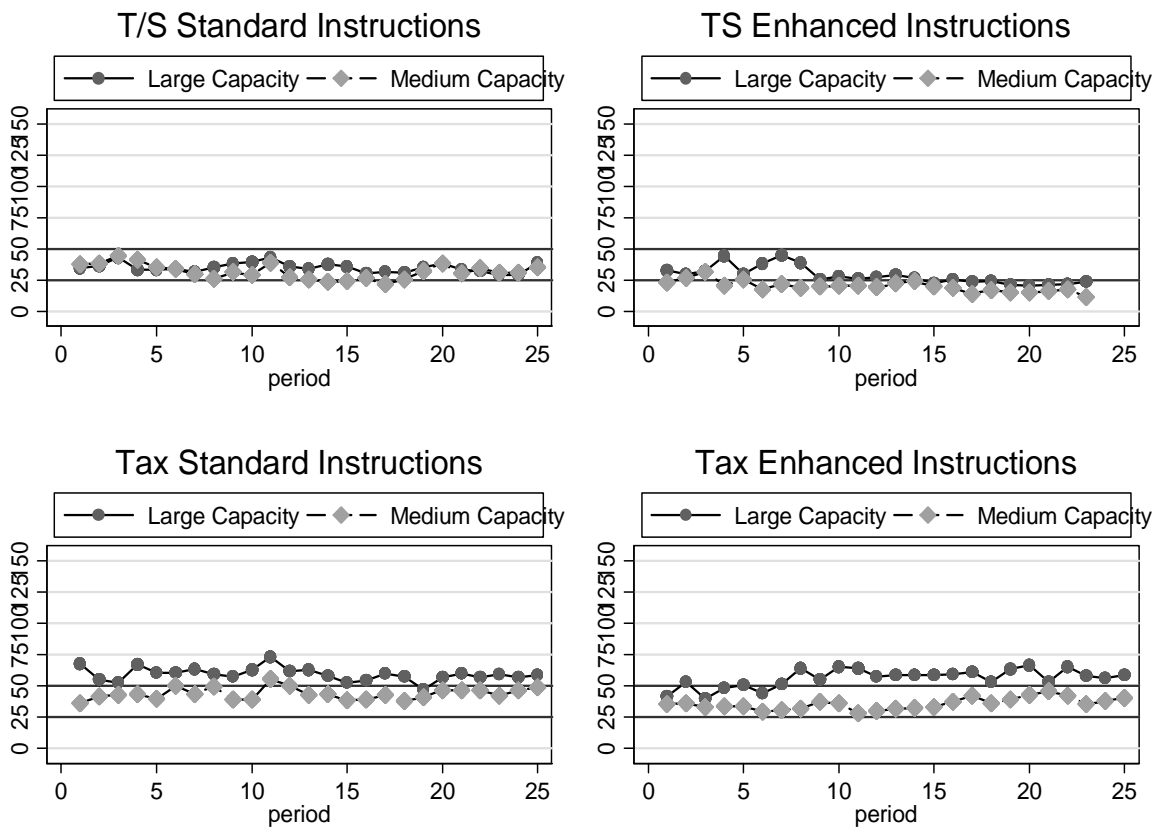
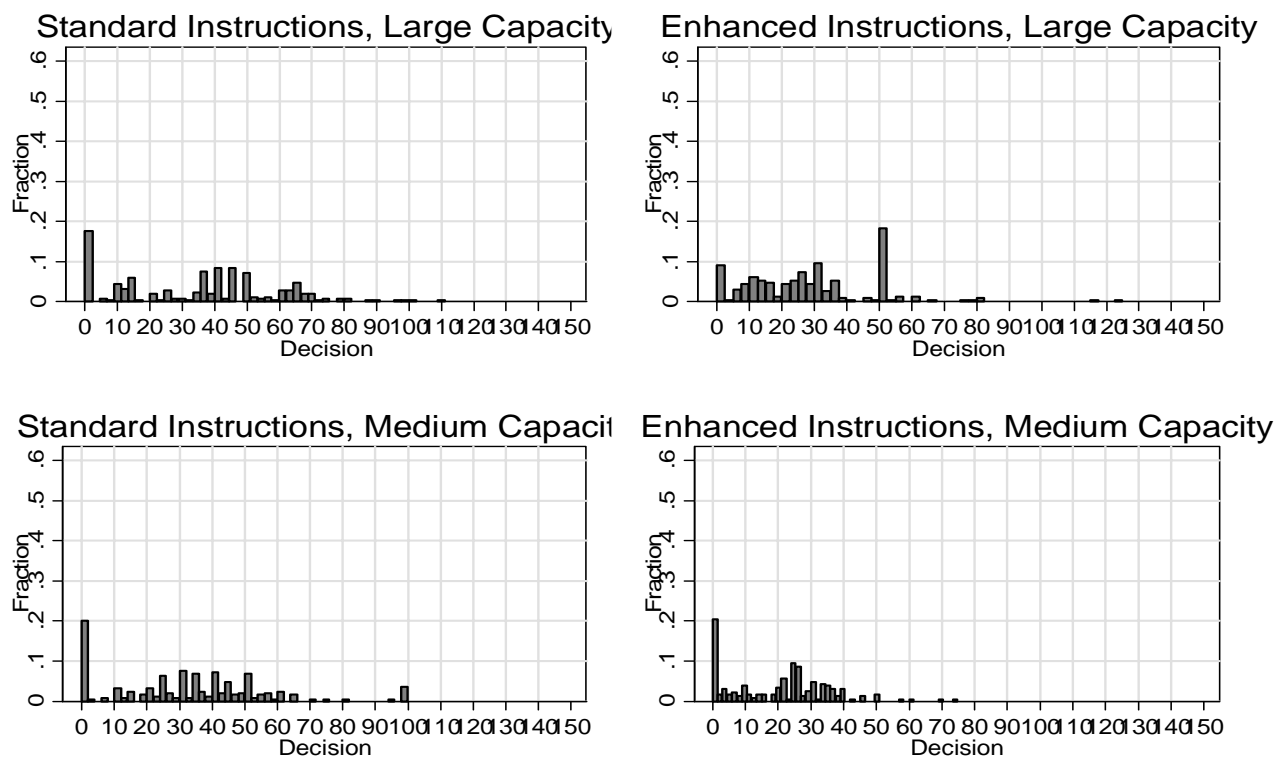


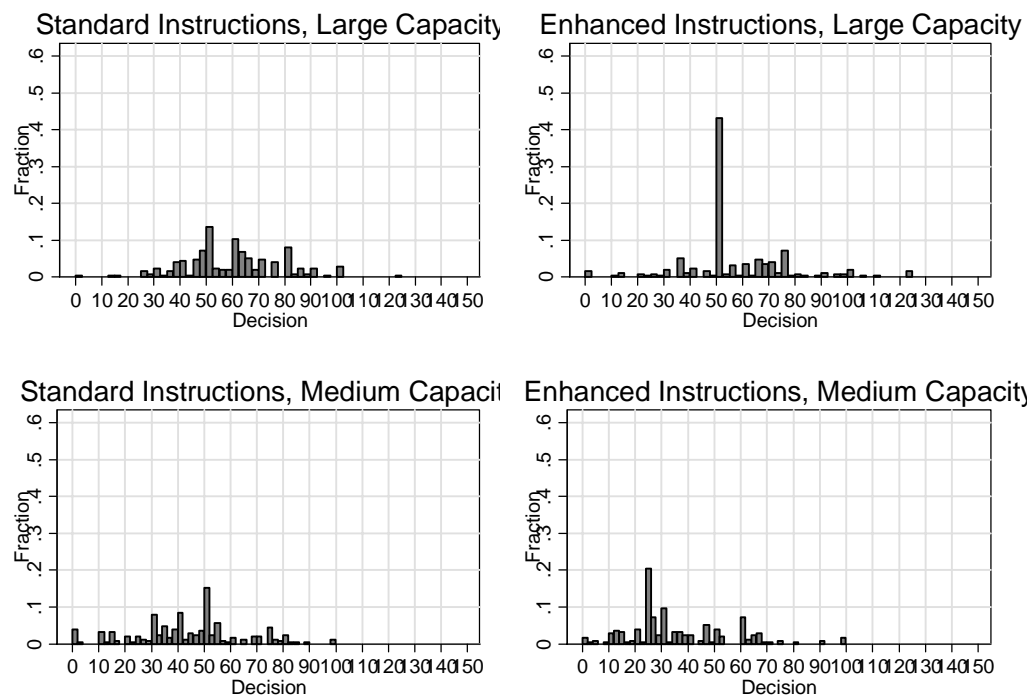
Figure 4: Mean Efficiency by Treatment and Period, Tax Instrument.



**Figure 5:** Mean Decision by Subject Type and Period, Tax/Subsidy Instrument.



**Figure 6:** Distributions of Individual Decisions, by Treatment, Tax/Subsidy.



**Figure 7:** Distributions of Individual Decisions, by Treatment, Tax.

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<sup>◇</sup> Department of Economics, University of Calgary, email:oxoby@ucalgary.ca

<sup>▽</sup> Corresponding Author: Department of Economics, Lakehead University, 955 Oliver Road, Thunder Bay, ON P7B 5E1 Canada; tel: (807) 343-8378; fax: (807) 346-7936; email: john.spraggon@lakeheadu.ca

<sup>1</sup> Other experiments using recommended play include Brandts and Holt (1992), Brandts and MacLeod (1995), and Oxoby and McLeish (2004).

<sup>2</sup> The instructions are presented in neutral language to abstract from the subjects' feelings about pollution.

<sup>3</sup> The instrument is presented to subjects in this way to be clear about the instruments' dichotomous nature.

<sup>4</sup> This outcome was achieved in the experiments of Cochard et al. (2005). These experiments involved a simpler environment where subjects choose between 0 and 20. This outcome was only observed among one group of inexperienced subjects with the standard instructions.

<sup>5</sup> The enhanced instructions, and the standard instructions are included in the appendix.

<sup>6</sup> Means calculated for a subject type (or a subject) are independent from the means calculated for the same subject type (or different subjects) across treatments, but not independent for different subject types (or different subjects) within the same treatment.

<sup>7</sup> A Tobit regression also suggests that the enhanced instruction treatment matters ( $p=0.004$  on the dummy variable for the standard instructions in the regression with dummy variables for tax versus tax/subsidy, capacity, instructions and the four interactions), but we feel that the non-parametric tests are more appropriate due to the non-normality of the data.

<sup>8</sup>  $p$ -values for the Mann-Whitney, Median and Kolmogorov-Smirnov tests for large and medium capacity subjects respectively are  $0.0022, 0.0084; 0.000, 0.002; 0.000, 0.000$  for the tax/subsidy and  $0.4618, 0.0001; 0.138, 0.000; 0.056, 0.000$  for the tax instrument.

<sup>9</sup> Indeed, Weersink et al. (1998) argues (although not theoretically) that these instruments are only appropriate for homogeneous firms.

<sup>10</sup> Poe et al. (2004) finds a much lower level of efficiency (56.2 percent) when a simple market is combined with the ambient pollution instrument.

<sup>11</sup> There was a slightly different function and description for the tax treatment.