AJAE Appendix for 'Experiments on Damage-Based Ambient Taxes for Nonpoint Source Polluters'

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Appendix 1. Instructions (Unformatted)

INTRODUCTION

This experiment is a study of individual and group decision-making. If you follow these instructions carefully and make informed decisions you will earn money. The money you earn will be paid to you, in cash, at the end of the experiment. A research foundation has provided the funding for this study.

You will be in a group consisting of six players. Each player assumes the role of a different firm. Think of your firm and the five other firms as being located near a common water resource.

Your firm yields earnings through its production. Production also generates emissions, which affect the water quality of the common water resource. In general, the higher your production the more you earn from sales, but the greater the emissions your firm generates. Firm earnings are denominated in "tokens", which will be exchanged for cash at the end of the experiment at the rate of 150 tokens to $1.

The experiment is broken up into many decision "rounds". There are two parts to the experiment. Part A of the experiment consists of the first 5 rounds, whereas Part B includes the remaining rounds. You will be given additional instructions after Part A is completed.

In each round your task is to choose among 10 management options, labeled "A" through "J". These options remain constant throughout the experiment. Associated with each management option is: (1) a production level (**Your Production**); (2) the emissions generated (**Your Emissions)**; and (3) the number of tokens you earn from product sales (**Your Earnings From Production)**. You have been provided a sheet titled *Initial Earnings Sheet* that lists the levels of production, emissions and earnings from production that are associated with each management option. Refer to this sheet before making any decisions.

In addition to firm emissions, a variety of factors such as stream flow and the rate of surface runoff affect the water quality or "pollution" level of the water resource. For example, heavy rainfall increases surface runoff, increasing pollution. High stream flow results in relatively less pollution, as the ability of the waterway to assimilate your emissions increases. Unfortunately, these factors are unpredictable due to complex physical, chemical and biological relationships. To take into account the uncertainty surrounding pollution, assume that the **Total Pollution = combined emissions from all firms + random term**. The **random term** ranges from -4.0 to +4.0 and is equal to zero on average. Each number in this range has an equal chance of being selected. This means that, on average, each unit of emissions from any group member amounts to one unit of pollution.

Pollution affects the well-being of water resource users. For example, high pollution levels affect the health of fish, causing losses to fisherman.

A round of the experiment is complete when all six players make their management decision. The computer will then calculate and report the **Total Pollution** along with your overall earnings for the round (**Your Total Earnings**). Pollution does not affect your earnings whatsoever in Part A of the experiment. As such, for Part A **Your Earnings From Production** and **Your Total Earnings** are identical. Below we explain how to make decisions using your computer.

USING THE COMPUTER

In each period, your task is to choose from the 10 management options listed on your *Initial Earnings Sheet*. You make this choice using the scroll down box located in the row of your worksheet labeled **Your Decision**. After you select an option, information on production, emissions, and earnings from production will appear on your worksheet. You can verify that the information in the worksheet is identical to that provided on the *Initial Earnings Sheet*.

In addition to your management decision, we would like you to estimate what the pollution from your group will be. Recall that **Total Pollution** is the sum of the emissions generated by each firm (including your own) plus the random term. It is important to note that your estimate will not affect your earnings or actual group pollution levels in any way. This information is being collected to better understand how individuals make decisions during the experiment. Please enter this information in the **Estimated Total Pollution** box.

Once you have made a management decision and supplied an estimate for expected group pollution, you must then click the <**SUBMIT**> button for the current round. Once you have clicked the <**SUBMIT**> button, it is no longer possible to change your management option.

After all six players have clicked the submit button, the experiment moderator will soon instruct you to click the <**RECEIVE**> button. After clicking the <**RECEIVE**> button, the cells indicating the **Total Pollution** and **Your Total Earnings** will be filled. Recall that pollution does not affect your earnings in Part A of the experiment.

As the experiment progresses, the total number of tokens you have earned will be calculated in the **Total Tokens** box located in the lower right portion of the spreadsheet. The **Take Home Earnings ($)** box displays the amount of money you have earned, in U.S. dollars, after the tokens have been exchanged.

INSTRUCTIONS FOR PART B

TAX CALCULATIONS

Please switch to the Part B worksheet on the computer. In each period, as before, you will enter your management decision. A key difference is that **Total Pollution** now affects your earnings. In particular, in order to protect the water resource, the relevant authorities require you, and everyone else in your group, to pay the following **Tax** on pollution:

If pollution is 30 or less: **Tax** = 0

If pollution is greater than 30: **Tax** = **(Total Pollution** – 30) * 20

In other words, if **Total Pollution** is less than or equal to 30, you pay nothing. If **Total Pollution** is greater than 30, each player pays 20 tokens for each unit of pollution above 30 units. It is important to note that **Total Pollution** is based on the management decisions of everyone in your group, not just your own. The *Tax Calculation Sheet* provided to you displays the tax payment corresponding to different pollution levels. Please refer to this sheet during the experiment.

Notice that there is a field on your Part B worksheet labeled **Tax**. After everyone makes his or her management decision, **Total Pollution** will be calculated as before. **Tax** will be calculated using the formula above. The tax you pay, if any, will be deducted from your **Earnings From Production** and reported in the field **Your Total Earnings**.

Although the computer does all the calculations, it is important to us that you understand how all the calculations work. In the table below, only the pollution level and management decision are filled in. Please refer to the *Initial Earnings Sheet* and *Tax Calculation Sheet* to help you fill in the empty fields of the table.

Your Decision	E
Your Earnings From Production	
Your Emissions	
Total Pollution	35
Tax	
Your Total Earnings	

Someone will come by to look over your calculations shortly and provide any assistance that you may need.

GROUP DISCUSSION

A second key difference in Part B is that you will be allowed to discuss management strategies with other group members prior to Rounds 6, 11, 16, and 21. Group discussions are limited to 5 minutes. The only guidelines for the discussion are that you cannot make any threats to the other participants and no side payments of any kind are allowed. Aside from the designated discussion times, please refrain from talking during the experiment.

Appendix 2. Derivation of Cooperative and Noncooperative Predictions

Let $\tilde{x}$ denote total emissions such that $\tilde{x} = \sum_{i=1}^{6} r_i$ and $x = \tilde{x} + e$. Further, let the expected tax on the individual be denoted by E[T(x)], which is simply the expected tax given that pollution is above the threshold multiplied by the probability of being above the threshold given $\tilde{x}$:

$$\boldsymbol{E}\left[\boldsymbol{T}\left(\boldsymbol{x}\right)\right] = \boldsymbol{P}\left(\tilde{\boldsymbol{x}} + \boldsymbol{e} > \bar{\boldsymbol{x}}\right) * \boldsymbol{E}\left[\boldsymbol{T}_{\boldsymbol{i}}\left(\boldsymbol{x}\right) \mid \tilde{\boldsymbol{x}} + \boldsymbol{e} > \bar{\boldsymbol{x}}\right] \tag{A1}$$

Given that $e \sim U[-4, 4]$, it follows that

$$\boldsymbol{P}\left(\tilde{\boldsymbol{x}} + \boldsymbol{e} > \bar{\boldsymbol{x}}\right) = \begin{cases} 0 & \textbf{\textit{if}}\ \tilde{\boldsymbol{x}} \le \bar{\boldsymbol{x}} - 4 \\ \dfrac{\tilde{\boldsymbol{x}} + 4 - \bar{\boldsymbol{x}}}{8} & \textbf{\textit{if}}\ \bar{\boldsymbol{x}} - 4 < \tilde{\boldsymbol{x}} < \bar{\boldsymbol{x}} + 4 \\ 1 & \textbf{\textit{if}}\ \tilde{\boldsymbol{x}} \ge \bar{\boldsymbol{x}} + 4 \end{cases} \tag{A2}$$

and

$$\boldsymbol{E}\left[\boldsymbol{T}_{\boldsymbol{i}}\left(\boldsymbol{x}\right) \mid \tilde{\boldsymbol{x}} + \boldsymbol{e} > \bar{\boldsymbol{x}}\right] = \begin{cases} 0 & \textbf{\textit{if}}\ \tilde{\boldsymbol{x}} \le \bar{\boldsymbol{x}} - 4 \\ \frac{1}{\tilde{\boldsymbol{x}} + 4 - \bar{\boldsymbol{x}}} \int_{\bar{\boldsymbol{x}}}^{\tilde{\boldsymbol{x}}+4} \boldsymbol{T}\left(\boldsymbol{x}\right)\boldsymbol{dx} - \boldsymbol{T}\left(\bar{\boldsymbol{x}}\right) & \textbf{\textit{if}}\ \bar{\boldsymbol{x}} - 4 < \tilde{\boldsymbol{x}} < \bar{\boldsymbol{x}} + 4 \\ \frac{1}{8} \int_{\tilde{\boldsymbol{x}}-4}^{\tilde{\boldsymbol{x}}+4} \boldsymbol{T}\left(\boldsymbol{x}\right)\boldsymbol{dx} - \boldsymbol{T}\left(\bar{\boldsymbol{x}}\right) & \textbf{\textit{if}}\ \tilde{\boldsymbol{x}} \ge \bar{\boldsymbol{x}} + 4 \end{cases} \tag{A3}$$

With the linear tax and nonlinear tax, $T(x) = 20[x - \bar{x}]$ and $T(x) = (1/3)x^2 - (1/3)\bar{x}^2$, respectively, it follows that

$$E\left[Linear\ Tax\right] = \begin{cases} 0 & \textbf{\textit{if}}\ \tilde{\boldsymbol{x}} \le \bar{\boldsymbol{x}} - 4 \\ \left(\frac{\tilde{\boldsymbol{x}}+4-\bar{\boldsymbol{x}}}{8}\right) * \left(\frac{10}{\tilde{\boldsymbol{x}}+4-\bar{\boldsymbol{x}}}\left(\left(\tilde{\boldsymbol{x}}+4\right)^2 - \bar{\boldsymbol{x}}^2\right) - 20 * \bar{\boldsymbol{x}}\right) & \textbf{\textit{if}}\ \bar{\boldsymbol{x}} - 4 < \tilde{\boldsymbol{x}} < \bar{\boldsymbol{x}} + 4 \\ \frac{10}{8}\left(\left(\tilde{\boldsymbol{x}}+4\right)^2 - \left(\tilde{\boldsymbol{x}}-4\right)^2\right) - 20 * \bar{\boldsymbol{x}} & \textbf{\textit{if}}\ \tilde{\boldsymbol{x}} \ge \bar{\boldsymbol{x}} + 4 \end{cases} \tag{A4}$$

$$E\left[Nonlinear\ Tax\right] = \begin{cases} 0 & if\ \tilde{x} \le \bar{x} - 4 \\ \left(\frac{\tilde{x}+4-\bar{x}}{8}\right) * \left(\frac{1}{9*(\tilde{x}+4-\bar{x})}\left(\left(\tilde{x}+4\right)^3 - \bar{x}^3\right) - \frac{1}{3}\left(\bar{x}^2\right)\right) & if\ \bar{x} - 4 < \tilde{x} < \bar{x} + 4 \\ \frac{1}{72}\left(\left(\tilde{x}+4\right)^3 - \left(\tilde{x}-4\right)^3\right) - \frac{1}{3}\left(\bar{x}^2\right) & if\ \tilde{x} \ge \bar{x} + 4 \end{cases} \tag{A5}$$

The expected tax for the group is determined by multiplying the individual expected tax by the 6 participants. The individual profits associated with each level of emissions can be found in Table 2 of the published article. The group profit, $\Pi(\tilde{x})$, is determined by multiplying each individual emissions level, r, and each individual profit level, $\pi(r)$, by 6. This gives the group profit for group emissions levels, $\tilde{x}$ = 6,12,18,24,30,36,42,48,54, 60,66 and 72 . To find the group profit associated with emissions levels that are not divisible by 6, we apply the following formula:

$$\Pi(\tilde{x}) = \left(6 - \left(x - x^L\right)\right) * \pi\left(r^L\right) + \left(x - x^L\right) * \pi\left(r^H\right) \qquad \text{(A6)}$$

where : x^L = nearest level of group emissions divisible by 6 that is at or below x

x^H = nearest level of group emissions divisible by 6 that is at or above x

$r^L = x^L/6, \; r^H = x^H/6$

Cooperative Predictions

When groups are allowed to communicate, we predict they will choose the level of emissions that maximizes expected after tax group profits, *EP(x)*. The Group Profit and Expected Tax functions are both monotonically increasing, therefore to show that the predicted level of emissions maximizes *EP(x)* it is enough to show that *EP(x)* is lower for levels of emissions that are one unit above or below the predicted level (given that non-integer emission levels are not in the group's choice set). We do this below for each treatment.

Treatment 1, Linear Tax, Threshold = 0, Cooperative Prediction = 6

$$EP(\tilde{x}) = \Pi(\tilde{x}) - 6 * \tfrac{10}{8}\left((\tilde{x} + 4)^2 - (\tilde{x} - 4)^2\right)$$

*EP(*5*)* = N/A (6 is the minimum group emissions amount)

***EP(6)* = 3,544 – 720 = 2,824**
EP(7) = 3,616 – 840 = 2,776

Treatment 2, Linear Tax, Threshold = 18, Cooperative Prediction = 17

$$EP(\tilde{x}) = \Pi(\tilde{x}) - 6 * \left(\frac{\tilde{x}-14}{8}\right) * \left(\frac{10}{\tilde{x}-14}\left((\tilde{x}+4)^2 - 18^2\right) - 20 * 18\right)$$

*EP(*16*)* = 4,159 – 30 = 4,129
***EP(17)* = 4,204 – 68 = 4,139**
*EP(*18*)* = 4,249 – 120 = 4,129

Treatment 3, Linear Tax, Threshold = 30, Cooperative Prediction = 27

$$EP(\tilde{x}) = \Pi(\tilde{x}) - 6 * \left(\frac{\tilde{x}-26}{8}\right) * \left(\frac{10}{\tilde{x}-26}\left((\tilde{x}+4)^2 - 30^2\right) - 20 * 30\right)$$

*EP(*26*)* = 4,481 – 0 = 4,481
***EP(27)* = 4,503 – 7.5 = 4,496**
*EP(*28*)* = 4,525 – 30 = 4,495

Treatment 4, Nonlinear Tax, Threshold= 0, Cooperative Prediction = 12

$$EP(\tilde{x}) = \Pi(\tilde{x}) - 6 * \frac{1}{72}\left((\tilde{x}+4)^3 - (\tilde{x}-4)^3\right)$$

*EP(*11*)* = 3,905 – 253 = 3,653
***EP(12)* = 3,978 – 299 = 3,679**
*EP(*13*)* = 4,023 – 349 = 2,675

Treatment 5, Nonlinear Tax, Threshold = 18, Cooperative Prediction = 18

$$EP(\tilde{x}) = \Pi(\tilde{x}) - 6 * \left(\frac{\tilde{x}-14}{8}\right) * \left(\frac{1}{9*(\tilde{x}-14)}\left((\tilde{x}+4)^3 - 18^3\right) - \frac{1}{3}\left(18^2\right)\right)$$

*EP(*17*)* = 4,204 – 43 = 4,161
***EP(18)* = 4,249 – 77 = 4,172**
*EP(*19*)* = 4,281 – 123 = 4,158

Treatment 6, Nonlinear Tax, Threshold = 30, Cooperative Prediction = 27

$$EP(\tilde{x}) = \Pi(\tilde{x}) - 6 * \left(\frac{\tilde{x}-26}{8}\right) * \left(\frac{1}{9*(\tilde{x}-26)}\left((\tilde{x}+4)^3 - 30^3\right) - \frac{1}{3}\left(30^2\right)\right)$$

*EP(*26*)* = 4,481 – 0 = 4,481
***EP(27)* = 4,503 – 7.6 = 4,495**
*EP(*28*)* = 4,525 – 30.7 = 4,494

Treatment 7, Average Pigouvian linear Tax, Threshold = 30, Cooperative Prediction = 32

$$EP(\tilde{x}) = \Pi(\tilde{x}) - \left(\frac{\tilde{x}-26}{8}\right) * \left(\frac{10}{\tilde{x}-26}\left((\tilde{x}+4)^2 - 30^2\right) - 20*30\right)$$

*EP(*31*)* = 4,585 – 31.25 = 4,553.5
EP(32) = 4,600 – 45.0 = 4,455.5
*EP(*33*)* = 4,616 – 61.25 = 4,454.9

Treatment 8, Average Pigouvian Nonlinear Tax, Threshold = 30, Cooperative Prediction = 32

$$EP(\tilde{x}) = \Pi(\tilde{x}) - \left(\frac{\tilde{x}-26}{8}\right) * \left(\frac{1}{9*(\tilde{x}-26)}\left((\tilde{x}+4)^3 - 30^3\right) - \frac{1}{3}\left(30^2\right)\right)$$

*EP(*31*)* = 4,585 – 33.0 = 4,551.8
EP(32) = 4,600 – 48.0 = 4,552.5
*EP(*33*)* = 4,616 – 66.0 = 4,550.2

Noncooperative Predictions

When individuals cannot communicate, our individual emissions predictions are based on the Nash equilibrium. Since all individuals face the same profit and tax functions, the predicted level of individual emissions is the unique symmetric NE in each treatment. We show that deviating from the predicted strategy is not optimal and therefore the individual prediction for each treatment is a symmetric NE. The noncooperative prediction is the individual prediction multiplied by 6.

Treatment 1, Linear Tax, Threshold = 0, Noncooperative Prediction= 30 (Individual= 5)

Suppose the other 5 individuals choose $r = 5$. The 6th individual faces the expected profit:

$$Ep(\boldsymbol{r}) = \pi(\boldsymbol{r}) - \frac{10}{8}\left((5*5+\boldsymbol{r}+4)^2 - (5*5+\boldsymbol{r}-4)^2\right)$$

*Ep(*4*)* = 739 – 580 = 159
Ep(5) = 762 – 600 = 162
*Ep(*6*)* = 777 – 620 = 157

Treatment 2, Linear Tax, Threshold = 18, Noncooperative Prediction= 30 (Individual= 5)

$$Ep(\boldsymbol{r}) = \pi(\boldsymbol{r}) - \tfrac{10}{8}\left(\left(5\boldsymbol{*}5+\boldsymbol{r}+4\right)^2 - \left(5\boldsymbol{*}5+\boldsymbol{r}-4\right)^2\right) - 20\boldsymbol{*}18$$

*Ep(*4*)* = 739 – 220 = 519
Ep(5) = 762 – 240 = 522
*Ep(*6*)* = 777 – 260 = 517

Treatment 3, Linear Tax, Threshold = 30, Noncooperative Prediction= 32.3 (Individual= 5.38)

$$Ep(\boldsymbol{r}) = \pi(\boldsymbol{r}) - \left(\tfrac{5\boldsymbol{*}5+\boldsymbol{r}-26}{8}\right) * \left(\tfrac{10}{5\boldsymbol{*}5+\boldsymbol{r}-26}\left(\left(5\boldsymbol{*}5+\boldsymbol{r}+4\right)^2 - 30^2\right) - 20\boldsymbol{*}30\right)$$

*Ep(*4*)* = 739 – 11 = 728
*Ep(*5*)* = 762 – 20 = 742
Ep(6) = 777 – 31 = 746

This is not a symmetric NE since given that the other 5 individuals choose to emit 5 units, the 6th individual will not optimally choose 5 units. There is a symmetric mixed strategy NE whereby each individual chooses *r*=5 with probability 0.62 and r=6 with probability 0.48. This leads to an individual prediction of r=5.38.

*Ep(*0.7*(5)+0.3*(6)*)*= 766.2 – 48.03 = 718.170
Ep(0.62*(5)+0.38*(6))= 767.5 – 49.32 = 718.178
*Ep(*0.6*(5)+0.4*(6)*)*= 767.8 – 49.62 = 718.177

Treatment 4, Nonlinear Tax, Threshold = 0, Noncooperative Prediction= 30 (Individual= 5)

$$Ep(\boldsymbol{r}) = \pi(r) - \tfrac{1}{72}\left(\left(5*5+r+4\right)^3 - \left(5*5+r-4\right)^3\right)$$

*Ep(*4*)* = 739 – 282 = 457
Ep(5) = 762 – 302 = 460
*Ep(*6*)* = 777 – 322 = 455

Treatment 5, Nonlinear Tax, Threshold = 18, Noncooperative Prediction= 30 (Individual= 5)

$$Ep(\boldsymbol{r}) = \pi(r) - \tfrac{1}{72}\left(\left(5*5+r+4\right)^3 - \left(5*5+r-4\right)^3\right) - \tfrac{1}{3}\left(18^2\right)$$

Ep(4) = 739 – 174 = 565
***Ep*(5) = 762 – 194 = 568**
Ep(6) = 777 – 214 = 563

Treatment 6, Nonlinear Tax, Threshold = 30, Noncooperative Prediction= 31.7 (Individual= 5.29)

$$Ep(\mathbf{r}) = \pi(r) - \left(\tfrac{x-26}{8}\right) * \left(\tfrac{1}{9*(x-26)}\left((5*5+r+4)^3 - 30^3\right) - \tfrac{1}{3}\left(30^2\right)\right)$$

Ep(4) = 739 – 12 = 728
Ep(5) = 762 – 21 = 741
***Ep*(6) = 777 – 33 = 744**

Here again we do not have a symmetric pure strategy NE. There is a symmetric mixed strategy NE whereby each individual chooses r=5 with probability 0.71 and *r*=6 with probability 0.29. This leads to an individual prediction of *r*=5.29. Below we show that deviating from this strategy is not optimal.

Ep(0.8*(5)+0.2*(6))= 764.7 – 42.46 = 722.24
***Ep*(0.71*(5)+0.29*(6))= 766.1 – 43.84 = 722.25**
Ep(0.6*(5)+0.4*(6))= 767.8 – 44.57 = 722.23

Treatment 7, Average Pigouvian Linear Tax, Threshold = 30, Noncooperative Prediction= 54 (Individual= 9)

$$Ep(\mathbf{r}) = \pi(r) - \tfrac{10}{6*8}\left((9*5+r+4)^2 - (9*5+r-4)^2\right) - \frac{20}{6}*30$$

Ep(8) = 795.01 – 76.66 = 718.34
***Ep*(9) = 798.82 – 80.0 = 718.82**
Ep(10) = 800.0 – 83.33 = 716.67

Treatment 8, Average Pigouvian Nonlinear Tax, Threshold = 30, Noncooperative Prediction= 48 (Individual= 8)

$$Ep(\mathbf{r}) = \pi(r) - \tfrac{1}{6*72}\left((8*5+x+4)^3 - (8*5+x-4)^3\right) - \frac{1}{18}\left(30^2\right)$$

Ep(7) = 788.04 – 73.02 = 715.02
***Ep*(8) = 795.01 – 78.30 = 716.71**
Ep(9) = 798.82 – 83.69 = 715.14

Appendix 3. Complete Treatment Results

Table 3a. Experimental Treatments and Outcomes for all Round Groupings

Treatment	Rounds	Tax Function	Tax Threshold	No Communication		Communication	
				Predicted	Actual	Predicted	Actual
No Mechanism	1-5	-	-	60	59.54 (0.42)	60	59.54 (0.42)
1	6-10	Linear	0	30	27.28 (1.43)	6	16.37* (1.59)
	11-15				29.52 (1.47)		8.65 (1.64)
	16-20				29.15 (1.52)		7.93 (1.69)
2	6-10	Linear	18	30	28.79 (1.17)	17	18.74* (0.36)
	11-15				29.41 (1.20)		18.46* (0.36)
	16-20				29.40 (1.24)		18.43* (0.37)
3	6-10	Linear	30	32.3	35.58* (0.81)	27	29.17 (0.40)
	11-15				35.45* (0.83)		27.00 (0.40)
	16-20				35.58* (0.85)		27.09 (0.41)
4	6-10	Nonlinear	0	30	34.10* (1.37)	12	13.49 (1.01)
	11-15				35.69* (1.40)		12.41 (1.03)
	16-20				33.96* (1.45)		13.95 (1.06)
5	6-10	Nonlinear	18	30	24.59* (1.08)	18	18.69 (0.64)
	11-15				24.68* (1.10)		18.54 (0.65)
	16-20				27.35* (1.14)		19.39* (0.67)
6	6-10	Nonlinear	30	31.7	32.99 (0.72)	27	29.57* (0.78)
	11-15				31.37 (0.73)		28.2 (0.80)
	16-20				30.91 (0.76)		26.56 (0.82)

Note: Asterisk (*) denotes estimated mean is significantly different from the predicted level at the 5% level. Standard errors are in parentheses.

Table 5a. Complete Social Efficiency Table

Treatment and Rounds		No Communication					Communication				
		Social Eff.	Treat-ment Eff	EE	DE	AE	Social Eff.	Treat-ment Eff	EE	DE	AE
1	6-10	82.1	82.1	93.8	99.3	88.0	40.4	-397.5	-574.2	96.0	78.0
		(2.98)	(2.98)	(1.93)	(0.12)	(2.03)	(6.89)	(67.74)	(110.67)	(2.04)	(8.08)
	11-15	83.9	83.9	93.4	99.4	90.5	8.4	-82.6	-172.3	93.3	84.4
		(2.90)	(2.90)	(1.88)	(0.12)	(1.99)	(6.71)	(65.94)	(107.79)	(2.01)	(7.91)
	16-20	79.6	79.6	88.1	99.4	91.1	-0.1	0.5	-71.0	97.6	90.9
		(2.98)	(2.98)	(1.93)	(0.12)	(2.03)	(6.89)	(67.74)	(110.67)	(2.04)	(8.08)
2	6-10	82.4	82.4	97.1	99.7	85.1	82.0	106.5	107.4	99.7	99.5
		(2.00)	(2.00)	(0.99)	(0.11)	(1.59)	(0.80)	(1.04)	(1.2)	(0.11)	(0.25)
	11-15	81.3	81.3	96.1	99.5	85.0	82.0	106.5	107.0	99.7	99.9
		(1.94)	(1.94)	(0.96)	(0.11)	(1.56)	(0.78)	(1.02)	(1.17)	(0.11)	(0.25)
	16-20	86.7	86.7	97.3	99.5	89.4	81.5	105.9	107.1	99.6	99.2
		(2.00)	(2.00)	(0.99)	(0.11)	(1.59)	(0.80)	(1.04)	(1.20)	(0.11)	(0.25)
3	6-10	86.0	87.0	94.7	99.6	92.2	98.6	99.2	100.0	99.5	99.6
		(1.29)	(1.3)	(1.41)	(0.06)	(0.71)	(0.49)	(0.49)	(0.20)	(0.03)	(0.29)
	11-15	87.7	88.7	95.3	99.6	93.4	98.3	98.8	99.7	99.3	99.8
		(1.25)	(1.27)	(1.38)	(0.06)	(0.7)	(0.48)	(0.48)	(0.20)	(0.03)	(0.28)
	16-20	87.5	88.5	95.3	99.6	93.2	98.5	99.0	99.8	99.3	99.9
		(1.29)	(1.30)	(1.41)	(0.06)	(0.71)	(0.49)	(0.49)	(0.20)	(0.03)	(0.29)
4	6-10	76.1	76.1	94.0	99.7	80.9	54.0	109.6	118.6	99.3	95.4
		(2.87)	(2.87)	(2.70)	(0.06)	(2.21)	(1.63)	(3.3)	(6.88)	(0.25)	(2.78)
	11-15	77.9	77.9	93.6	99.6	83.7	49.3	100.0	104.2	99.3	98.1
		(2.79)	(2.79)	(2.63)	(0.05)	(2.17)	(1.58)	(3.21)	(6.71)	(0.25)	(2.72)
	16-20	76.8	76.8	95.0	99.5	81.4	54.6	110.7	119.3	98.9	96.2
		(2.87)	(2.87)	(2.70)	(0.06)	(2.21)	(1.63)	(3.30)	(6.88)	(0.25)	(2.78)
5	6-10	83.6	83.6	93.4	99.3	90.5	76.9	95.0	100.6	99.0	96.0
		(1.97)	(1.97)	(0.98)	(0.13)	(2.11)	(1.16)	(1.43)	(2.28)	(0.14)	(1.42)
	11-15	83.8	83.8	94.4	99.2	89.9	77.7	96.1	99.7	98.6	97.8
		(1.91)	(1.91)	(0.95)	(0.13)	(2.06)	(1.12)	(1.39)	(2.22)	(0.13)	(1.39)
	16-20	86.6	86.6	97.5	99.4	89.4	76.8	94.9	101.8	98.8	94.8
		(1.97)	(1.97)	(0.98)	(0.13)	(2.11)	(1.16)	(1.43)	(2.28)	(0.14)	(1.42)
6	6-10	90.5	91.2	99.1	99.7	92.3	93.8	94.3	99.7	99.5	95.1
		(1.28)	(1.29)	(0.55)	(0.07)	(1.08)	(1.04)	(1.05)	(0.48)	(0.05)	(0.91)
	11-15	90.8	91.4	99.7	99.7	91.9	96.5	97.0	99.7	99.3	98.0
		(1.24)	(1.25)	(0.53)	(0.07)	(1.05)	(1.02)	(1.02)	(0.47)	(0.05)	(0.89)
	16-20	89.0	89.7	100.3	99.6	89.8	96.4	96.9	99.5	99.3	98.1
		(1.28)	(1.29)	(0.55)	(0.07)	(1.08)	(1.04)	(1.05)	(0.48)	(0.05)	(0.91)

Note: Standard errors are in parentheses. EE, DE and AE refer to Emissions, Design and Allocative Efficiencies respectively.

Table 6a. Treatments 7 and 8 Predictions and Outcomes for all Round Groupings

Treatment	Rounds	Tax Function	Tax Threshold	No Communication		Communication	
				Predicted	Actual	Predicted	Actual
7	6-10	Linear	30	54	44.30* (1.04)	32	33.60 (1.30)
	11-15				47.44* (1.06)		32.88 (1.34)
	16-20				50.10* (1.10)		31.23 (1.39)
8	6-10	Nonlinear	30	48	41.16* (0.98)	32	32.14 (1.12)
	11-15				39.61* (1.00)		31.79 (1.15)
	16-20				38.54* (1.04)		31.17 (1.19)

Note: Asterisk (*) denotes estimated mean is significantly different from the predicted level at the 5% level. Standard errors are in parentheses.

Table 6b. Efficiency Results for Treatments 7 and 8

Treatment and Rounds		No Communication					Communication				
		Social Eff.	Treat-ment Eff	EE	DE	AE	Social Eff.	Treat-ment Eff	EE	DE	AE
7	6-10	66.3	200.8	215.5	99.6	93.4	90.2	91.0	94.3	99.7	96.5
		(4.91)	(14.87)	(15.81)	(0.12)	(1.25)	(3.44)	(3.47)	(3.23)	(0.06)	(0.82)
	11-15	54.8	165.9	181.7	99.5	89.9	91.7	92.6	95.6	99.9	95.9
		(4.71)	(14.27)	(15.21)	(0.12)	(1.20)	(3.30)	(3.33)	(3.11)	(0.06)	(0.78)
	16-20	44.8	135.6	150.9	99.3	90.4	97.7	98.6	101.3	99.7	97.6
		(4.91)	(14.87)	(15.81)	(0.12)	(1.25)	(3.44)	(3.47)	(3.23)	(0.06)	(0.82)
8	6-10	72.8	121.2	131.2	99.8	92.9	94.1	94.9	98.6	99.8	96.6
		(3.21)	(5.34)	(6.05)	(0.04)	(2.18)	(2.70)	(2.72)	(1.40)	(0.07)	(1.65)
	11-15	76.5	127.4	138.4	99.6	91.8	96.7	97.5	99.2	99.8	98.3
		(3.08)	(5.12)	(5.82)	(0.04)	(2.09)	(2.59)	(2.61)	(1.35)	(0.07)	(1.59)
	16-20	78.6	130.8	143.8	99.6	90.5	96.8	97.7	99.6	99.6	98.3
		(3.21)	(5.34)	(6.05)	(0.04)	(2.18)	(2.70)	(2.72)	(1.40)	(0.07)	(1.65)

Note: Standard errors are in parentheses. EE, DE and AE refer to Emissions, Design and Allocative Efficiencies respectively.