Experimental study of effectiveness of nonpoint source water pollution control group contract.

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Experimental study of effectiveness of nonpoint source water pollution control group contract.

The goal of this experimental study was to test an effectiveness of a group contract designed to control nonpoint source water pollution from farms' runoff (Pushkarskaya 2003). In particular, the regulator pays for pollution reduction credits earned by the group of the farmers, who voluntary enter the contract, and is concerned only with the total level of the abatement achieved, while the group of farmers undertakes responsibility to distribute the payment so as to induce the farmers to deliver the desired level of abatement.
First round of experiments was conducted using as subjects undergraduate students from the Ohio State University, second round of experiments was conducted using as a subjects Kentucky farmers, who would be an actual subjects to this policy if it is ever implemented. Experiments with farmers can be considered as an intermediate step between traditional experiments with undergraduate students and field experiments. Results of these experiments suggest, in contrast to common believes among environmental economists, that uncertainty, associated with diffusive nature of nonpoint source water pollution, not only does not affect negatively farmers' participation in the program, but also might play a positive role in promoting a cooperation within a group.

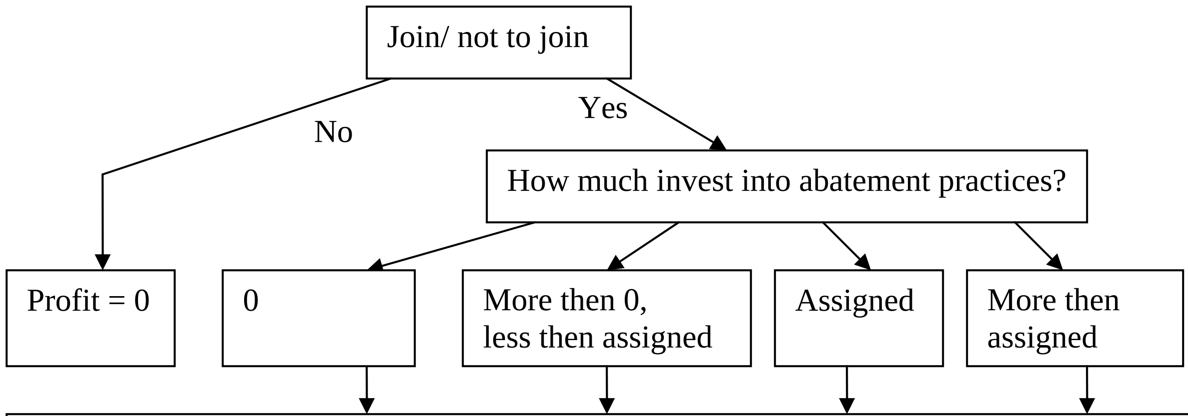
We tested experimentally a coordination game that serves as a basis for a theoretically developed group contact to control nonpoint source (NPS) water pollution from farms' runoff. The farmers make unobservable individual contributions to the level of pollution and receive individual payments depending on the total group performance in pollution abatement (Pushkarskaya, 2003). The game contains two equilibria, one of which is pay-off dominant and another which is risk free. We tested the contract in two different settings that were created by an independent variable: certain versus uncertain relationship between individual pollution abatement efforts and individual pollution output. We used two groups of subjects in experiments: undergraduate students at the Ohio State University and Kentucky farmers.

Overview of the Game

Subjects in the experiment assumed a role of farmers who live in the same watershed, produce a homogeneous product, and create water pollution as a by-product. They were given an opportunity to participate in a special USDA pollution abatement program. Specifically those farmers who agree to invest into abatement practices and form an abatement association in the beginning of the growing season will receive a subsidy from the USDA based on the total reduction of pollution in the watershed. Only members of the association receive the payment, which they distribute among themselves. Individual abatement contributions are unobservable, but the regulator is able to measure the total level of the abatement from the association. The total payment from the regulator depends on the total level of abatement in the watershed.

Since the association knows each farmer's costs exactly (an assumption of the model), the association can calculate what individual assignments will maximize group profit (and satisfy the efficiency condition) given the regulator's offer and the costs of the association members. However members of the association cannot monitor each other's contributions. Therefore they use the following payment rule: If at the end of the period the total pollution abatement in the watershed is equal to the sum of individual abatement assignments (we will call this the group's "target level"), then the payment from the regulator will be distributed among the association members proportional to their assignments. If the group does not meet the target, then each member of the group is penalized; the association holds back a part of the payment made by the regulator and distributes among its members only a portion. *The Association holds back enough money to reduce the profit below what each farmer would have received had they produced their assigned level of abatement--even for those association members who choose to deliver* *less than their assigned abatement level and therefore save on cost*. (See Appendix A for the mathematical description of the contract.)

Therefore, each player has to make one or two decisions during each of the growing periods: (1) join or not to join the association, and (2) if the decision is made to join, how much should be invested into the abatement practices. If the player does not join the association during a specific growing season, then his profit is zero during this season. If player joins the association, then his profit (positive or negative) depends on his own actions and the actions of other members of the association. Each player could invest any nonnegative dollar amount in abatement practices. Therefore the choice variable was continuous. The form of the payoff function depends on whether association delivers at, above, or below the target abatement level. Figure 1 depicts the extensive form of the game that the participants played.



Profit depends on the player i^{th} deviation from the assignment ($\Delta_i = i^{th}\ player\ assignment - i^{th}\ player\ action$) and other members' deviation from their assignments ($\Delta_{-i} = \sum_{j \neq i} (j^{th}\ player\ assignment - j^{th}\ player\ action)$).

Player *i*. / All players	0 $\Delta_i = -a_i^*$	More then 0, less then assigned $a_i^* < \Delta_i < 0$	Assigned $\Delta_i = 0$	More then assigned $\Delta_i > 0$
$\Delta_i + \Delta_{-i} < -\frac{A}{B}$	0	$-C_i + B\lvert\Delta_i\rvert - t_i\Delta_i^2$	$-C_i$	$-C_i - B\lvert\Delta_i\rvert - t_i\Delta_i^2$
$\Delta_i + \Delta_{-i} < 0$	$B\Delta_{-i} - b$	$A_i - b + B\Delta_{-i} - t_i\Delta_i^2$	$A_i - b - B\lvert\Delta_{-i}\rvert$	$A_i - b - B\lvert\Delta_{-i}\rvert - t_i\Delta_i^2$
$\Delta_i + \Delta_{-i} = 0 \Rightarrow \Delta_i = -\Delta_{-i}$	$Ba_i^* - b$	$A_i - b + B\Delta_{-i} - t_i\Delta_i^2$	$A_i - b$	$A_i - b - B\lvert\Delta_{-i}\rvert - t_i\Delta_i^2$
$\Delta_i + \Delta_{-i} > 0$	$B\Delta_{-i} - b$	$A_i - b - \frac{k-2}{k}B\Delta_{-i} + \frac{2(k-1)}{k}B\lvert\Delta_i\rvert - t_i\Delta_i^2$	$A_i - b - \frac{k-2}{k}B\Delta_{-i}$	$A_i - b - \frac{k-2}{k}B(\Delta_{-i} + \Delta_i) - B\Delta_i - t_i$

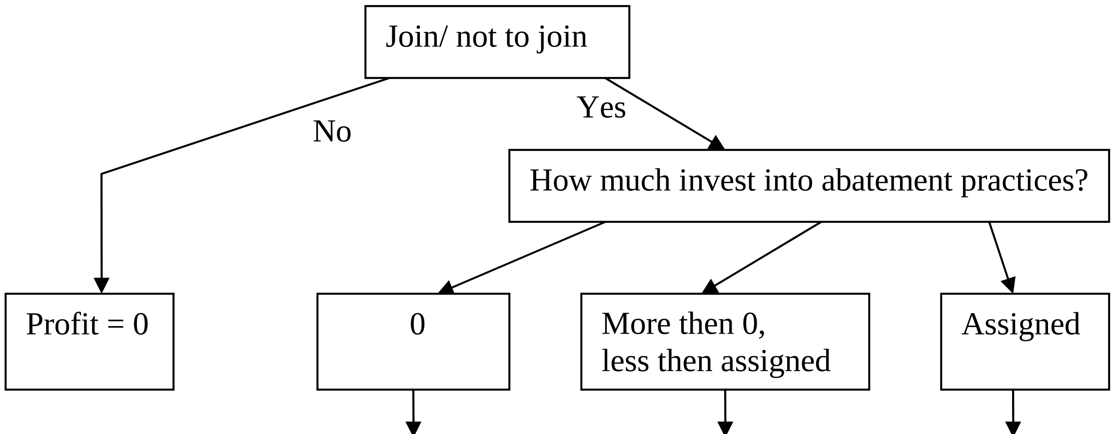
Where *A* and *B* are positive constants, that depend on which players joined the association; t_i is a positive constant that is specific for each player (same for homogeneous payers, different for heterogeneous players); k is a number of people in the association, and C_i is a cost of producing assigned level of abatement for player i.

Figure 1. The game in extensive form.

Game Theoretical Predictions

Standard game theory employs the iterative elimination of dominated strategies approach to predict what strategy would be chosen in the game by risk neutral players.

First, every player recognizes that a strategy “join/ produce more then assigned” is strictly dominated for any player. Therefore, this strategy never is going to be chosen by any player and should be eliminated. That means that deviation from the assignment Δ_j for any player *j* is non-positive. *Figure* 2 depicts the new game.



Profit depends on the player i^{th} deviation from the assignment ($\Delta_i \le 0$) and other members' deviation from their assignments ($\Delta_{-i} \le 0$).

Player *i.* / All other players	0, $\Delta_i = -a_i^*$	More then 0, less then assigned $-a_i^* < \Delta_i < 0$	Assigned $\Delta_i = 0$
$-\sum_{j \neq i} a_j^* = \Delta_{-i}$	0 **	$-C_i + B\lvert\Delta_i\rvert - t_i\Delta_i^2$	$-C_i$
$-\sum_{j \neq i} a_j^* < \Delta_{-i} < 0$	0	$A_i - b - B\lvert\Delta_{-i}\rvert - t_i\Delta_i^2$	$A_i - b - B\lvert\Delta_{-i}\rvert$
$\Delta_{-i} = 0$	0	$A_i - b - t_i\Delta_i^2$	$A_i - b$ **

Figure 2. Game after one time elimination of dominated strategy.

Second, once a strictly dominated strategy is eliminated, the game becomes a coordination game that has two equilibria: (1) "join/produce assignment" (pay-off dominant), and (2) "join/produce 0" (risk-free). Although the first equilibrium is more desirable for all players, either of these two equilibria could be chosen.

The strategy "join/ produce more then zero, less than assignment" is not going to be chosen. A strategy "don't join" is pay-off equivalent to the strategy "join/produce "0", but is not an equilibrium, because if all players except for the player i choose this strategy, player i can benefit by joining the association and producing the assigned level of abatement.

Spiteful Players

Following (*) we call the game spite-sensitive, if players, who are interested in maximizing their relative profit choose different strategy then players who choose to maximize their absolute profit. In the described contract potential for spite exists, since if player i chooses to underabate, his total losses are smaller then losses of other players. Let $\Delta_j = a_j^* - a_j > 0, \forall j = 1,...,n$, and let $\Delta_{-i} = \sum_{j \neq i} a_j^* - a_j$ For simplicity, assume that deviations are small enough so that each player receives nonnegative profit. Then let's consider profit for the player i.

$\pi_i(\Delta_i, \Delta_{-i}) = A_i - b - t_i \Delta_i^2 - B\Delta_{-i}$. Therefore, the average profit

$$\overline{\pi}_i(\Delta_i, \Delta_{-i}) = \frac{1}{n}\sum_j A_j - b - \frac{1}{n}\left(t_i\Delta_i^2 - B(n-1)\Delta_i\right) - \frac{1}{n}\left(\sum_{j \neq i} t_j \Delta_j^2 - B(n-1)\Delta_{-i}\right).$$

The difference between individual profit and average is then

$$\left(\pi_i - \overline{\pi}_i\right)(\Delta_i, \Delta_{-i}) = \left[A_i - \frac{1}{n}\sum_j A_j\right] + \frac{n-1}{n}\left[B\Delta_i - t_i\Delta_i^2\right] - \frac{1}{n}\left[\sum_{j \neq i} t_j\Delta_j^2 - B\Delta_{-i}\right].$$

Spiteful player wants $\pi_i - \overline{\pi}_i$ to be at least positive. For the purpose of this paper we do not model specifically what is the objective of the spiteful player, whether he wants to maximize his relative profit or just wants to keep it positive.

$\frac{\partial\left(\pi_i - \overline{\pi}_i\right)(\Delta_i, \Delta_{-i})}{\partial \Delta_i} = \frac{n-1}{n}(B - 2t_i\Delta_i)$. It can be shown (see appendix), that for $\Delta_i > 0$ such that $\pi_i(\Delta_i) > 0$: $\frac{\partial\left(\pi_i - \overline{\pi}_i\right)(\Delta_i, \Delta_{-i})}{\partial \Delta_i} > 0$. Therefore, a spiteful player will increase his relative profit by choosing positive Δ_i. Consequently, the strategy spiteful players might choose in the game is to "join/ produce more then zero, less than assignment" – the strategy that is strictly dominated under standard game theoretical approach.

Role of Uncertainty

We suggest that traditional economic theory would make no prediction concerning changes in players' behavior if a stochastic component is introduced into the equation relating payment for pollution abatement and actual abatement.

Psychological research might lead one to predict that the stochastic component might lead people to cooperate more compared to the situation in which there was a deterministic relation between the payment for pollution abatement and the actual amount of abatement. Consider the case in which you did not receive maximal payment from the regulator because one of the other players did not comply with the assigned level of pollution abatement on her farm. Now consider the case in which you did not receive maximal payment because the amount of pollution abatement everyone paid for may or may not have been their assigned optimal amount, but due to a lot of rainfall this season, an unusually large amount of chemical fertilizer was washed into the stream. In which situation would you be more likely to cooperate with your neighboring farmers in next year's pollution abatement program? In the first case, your neighbor's intentions were evil, and you suffered from them. In the second instance, no one is at fault. An analogous situation may have occurred in a study by Blount (1995) which utilized the ultimatum game. In this game one person—the Proposer—suggests to a Responder how an amount of money should be divided between the two of them. The Responder can accept the proposed division of the funds, in which case the money is allocated according to the Proposer's suggestion, or the Responder can reject the proposal, in which case both persons get nothing. A prediction of the standard economic model is that the Responder should accept any offer greater than zero. However the most typical offer from Proposers is a 50%-50% split, and Responders typically reject offers in which they would receive less than 30% (Camerer & Thaler, 1995). Blount (1995) made one minor change in the procedure. In some instances the suggested division of the funds came not from the Proposer but from a computer. In these cases rejection rates dropped substantially.

We predict that in the second instance farmers would be more willing to cooperate in subsequent rounds of the game than in the situation in which no stochastic element is introduced.

Independent Variable

Uncertainty. In two of the experimental settings we simultaneously introduced two kinds of uncertainty: one was an uncertain relation between an individual's choice of investment in abatement practices and the reduction in that individual's contribution to the total abatement level (different across the farmers, corresponding to "production uncertainty"); the second type of uncertainty was an uncertain relation between the sum of the individual contributions and the total realized abatement level (corresponding to weather uncertainty). Production uncertainty was modeled as normal distribution with 0 mean and variance specific for each farmer. Weather uncertainty was modeled as a normal distribution with 0 mean and the same variance for all farmers. Both types of uncertainty are simultaneously prevalent in actual farming environments. Hence these are highly realistic types of uncertainty.

Participants

Each game had 5, or 6 players depending on the vicissitudes of subject attendance. Subjects were recruited from two different pools: first, undergraduate students at the Ohio State University who were taking either introductory economics or introductory psychology courses, and second, Kentucky farmers who attended one of the two conferences: Kentucky Farm Bureau annual meeting, and Kentucky Beef Farmers meeting.

We had 2 groups with 5 players, and 9 groups with 6 players recruited from the undergraduate students pool; and 2 groups with 5 players, and 2 groups with 6 players recruited from the Kentucky Farmers pool and tested in the setting with uncertainty .

Method

General Procedure

The experiments were controlled by a computer program, which was written to test the collective subsidy scheme taken from Pushkarskaya (2002). The mathematics of the model were never shown to participants. Instead, the first frame of the program presented a verbal description of the NPS pollution problem. Among the main points were that (1) all the players were farmers in the same watershed, (2) the pollution from any one participant cannot be monitored, (3) the United States Department of Agriculture (USDA) will monitor the total pollution in the entire watershed, and (4) an optimal level of pollution abatement will be assigned to each farmer who joins the Association of farmers, (5) the USDA will pay farmers based on the total pollution abatement in the watershed. In order to maximize one's subsidy from USDA, the farmer should pay for the level of abatement that has been deemed optimal for each member of the Association. Participants were staked to $10, and they were correctly told that they could earn more than this amount. At the beginning of the experiment the individual farmers were randomly assigned either to high or low cost pollution abatement conditions, because the farms differed in how much it would cost to purchase a unit of pollution abatement.

Given the cost of the abatement for their farm and the relation between this cost and the payment they would receive if the Association were to achieve various levels of abatement, each participant was given three minutes to decide whether to join the Association. During the three-minute period, feedback to each participant was provided continuously concerning how many participants had decided to join the Association at that moment and, given that number, the optimal level of abatement the farmer would be assigned, how much that abatement level would cost, and what the expected payment subsidy would be. This information was accurate, timely, and complete. At the end of the three-minute period, each participant had to commit to joining or not joining the Association. Those who did not join were shown a frame that merely told them to wait until the end of the trial. If any of the participants decided not to participate in the program, they were given an opportunity to use Internet Explorer and e-mail programs during any period during which they decided not to join. These programs were made available to decrease one's desire to play "just for the sake of the game."

Those who did join the Association were shown the third frame of the program. In this frame participants were instructed to choose the number of units of pollution abatement they wished to purchase. They were also provided with information concerning (1) the abatement level they should choose which would eventuate in the maximal level of subsidy, and (2) the abatement levels assigned to the other participants. The screen contained “decision tools,” which were comprised of a table that illustrated how the contract works. Through the use of these tools each participant was given “real time” feedback about everyone’s tentative decision about how much pollution abatement they will purchase and the financial consequences of those tentative decisions. Each participant could try out various levels of pollution abatement to ascertain what would be the precise consequences of each potential decision he or she might make. At the end of three minutes, everyone’s choice of how much abatement to purchase was deemed final.

The last frame was shown both to those who had joined the Association and those who had not. This frame showed what the Association’s total NPS abatement level was and the complete array of financial consequences to the player. Of course, for non-participants the information concerning the Association’s financial fate was not relevant, but it was informative with regard to a decision on whether to join on the next trial. Prior to the actual trials there was one “explanatory period,” when the experimenter was one of the farmers and the screen of her computer was projected on the wall. In addition, there were two practice periods, after which subjects had a final opportunity to ask questions. This procedure was to make sure that subjects understood how to interpret the market results as well as ask about the experiment after gaining some experience. Finally there were several experimental periods, each corresponding to one growing season. All information given to participants was accurate and given in a timely fashion. Note that the computer program eliminates any need for calculations on the part of the participant.

Thus the decision to join or not join the Association and the decision on how much pollution abatement to purchase are driven by easily apprehended financial considerations which were displayed in "real time." Post-experiment discussions with participants showed that they fully understood both the underlying contract and how the computer program worked.

The same game was repeated from 10 to 19 times. (The number of periods in each experiment was randomly chosen between 10 and 19 before each game started). In order to eliminate the "end effect," players were not told how many periods they would experience before the experiment terminated. Profit (plus or minus) was added to player's total funds at the end of each round.

Recall that players were randomly assigned either to the high or low cost pollution abatement condition. As a result of this arrangement, low cost players in each round of the game with heterogeneous players made more money than high cost players. Each group thus moved from an equal to a more unequal distribution of "wealth" with each period.

Each player was paid at the end of the experiment proportionally to what he had earned during the experiment. Parameters of the experiment were chosen so that if all players would join the Association and produce their assigned level of pollution abatement, then in each period they could earn between $2.50 (for the lowest cost player) and $1.50 (for the highest cost player). Over 15 rounds funds would accumulate to between $37.50 (for the lowest cost player) and $22.50 (for the highest cost player).

At the end of the experiment each player answered the following questions: What was your individual strategy and why? Did the group perform well and why? What are ways to improve the contract?

Results

In this paper we focus on equilibrium analysis at an aggregate level. Specifically, we are interested whether the groups after several periods were able to achieve either of the theoretically predicted equilibria: (1) “join/produce assignment” (pay-off dominant), and (2) “join/produce 0” (risk-free). Therefore, in all of the following analyses the 5 to 7 participants who comprise a group of players collectively contribute only a single datum on each trial, and we will analyze only the last ten trials of each experimental session. We do not analyze the individual performance of the players within a group nor any dynamics during each experimental session. We will measure an overall performance of the contract, the level of players’ participation in the association and--for those who did join the Association – their compliance with their abatement assignment.

First we describe results of the experiments with students, and then we compare these results with experiments with farmers.

Overall Performance of the Contract

Overall the contract performed well. We can measure the efficiency of the contract by AA/MA, which is a measure of the extent to which participants’ actual abatement approached the total abatement levels the association would be assigned if all players had joined the association. The later was chosen as a reference point, because parameters of the model were set so it was profitable for each player to join the association, and if all players participated in the program and deliver assigned abatement level, then the social welfare would be maximized.

The mean AA/MA across all groups was .76. A 2 (uncertainty: present/absent) x 2 (subjects: farmers/students) analysis of variance (ANOVA) was run on the dependent variable of mean AA/MA over the last 7 trials. No factors approached significance, which reflects the fact that AA/MA varied only between .714 and .83 among the three groups. Thus the relatively strong performance of the contract was general across the groups. However, Levene's test of equality of error variance was violated, which indicated that stability in groups' performance was different across different settings. We will discuss stability of environments later.

We cannot compare our results directly to the relative efficiency measures that are usually employed in experimental tests of NPS abatement mechanisms (Camacho & Requate, 2004; Alpizar, Requate, & Schramm, 2004; Spraggon, 2002; Cochard, Willinger, & Hapapadeas, 2002; Vossler, Poe, Segerson, and Schulze, 2002), because our experimental design differs in the following important ways: (1) We allow voluntary participation in the abatement program; (2) We measure the level of abatement, not pollution, so the reference point is zero; (3) We don't specify any social welfare or social damage functions, making it impossible to compute change in welfare resulting from application of the instrument, and the most important (4) Abatement in our experiment is a continuous variable between 0 and infinity, while in other experiments players have to choose among discrete levels of abatement (0, 1, 2, 3, 4, 5, 6).

Despite these differences, if we use AA/MA as our measure of efficiency and compare our results with those of Camacho and Requate (2004), then the performance of our contract is superior to the performance of their contracts and schemes, with the possible exception of the tax-subsidy scheme. (See results in the table below).

	Mean actual level	Optimal level	Actual/ optimal
collective 60	1.13	2	0.565
collective 90	1.28	2	0.64
Random 300	1.19	2	0.595
Random 450	1.27	2	0.635
Tax Subsidy	2.06	2	1.03

All of the above schemes were tested in no uncertainty/ heterogeneous setting, and therefore should be compared to our mean of AA/MA in this setting, which was .714.

Note, that since players in these experiments had to choose between 0, 1, 2, and other discrete levels, then the efficiency of each contract in each round could be only one out of the following numbers--0, 0.5, 1, l.5, 2, 2.5, 3, while in our experiment it could be any number between 0 and infinity. Therefore any comparison between our contract and the schemes tested by Comacho and Requate (2004) is not conclusive.

Level of Participation

We used the ratio number of players who joined the association over total number of players in the experiment as a measure of participation in the contract.

The mean of participation across all groups was .87, that means that on average not more then 1 player out of 5 or 6 had chosen to not to participate in the contract. A 2 (uncertainty: present/absent) x 2 (subjects: farmers/students) analysis of variance (ANOVA) was run on the dependent variable of mean participation over the last 7 trials. No factors approached significance, and Levene's test of equality of error variance was not violated, which indicated that participation was high and stable across all the settings.

Compliance with Abatement Assignment

The ration actual abatement over target abatement was chosen as a measure of the extent to which participants' actual abatement complied with the total abatement level the association had been assigned on each of the last seven trials. For example, an AA/TA of 1.0 means that on average the participants complied with their assigned abatement level on each of the last 7 trials.

The mean AA/MA across all groups was .86. A 2 (uncertainty: present/absent) x 2 (subjects: farmers/students) analysis of variance (ANOVA) on the dependent variable of mean AA/TA over the last 7 trials demonstrated that no factors approached significance, while Levene's test of equality of error variance was violated. AA/TA varied between .78 and .96 among the three groups, and variance varied from .00097 (for uncertainty, students groups) to .014 (for no uncertainty, students group).

Figures 3 and 4 below depict AA/TA for all three setting for last seven periods.

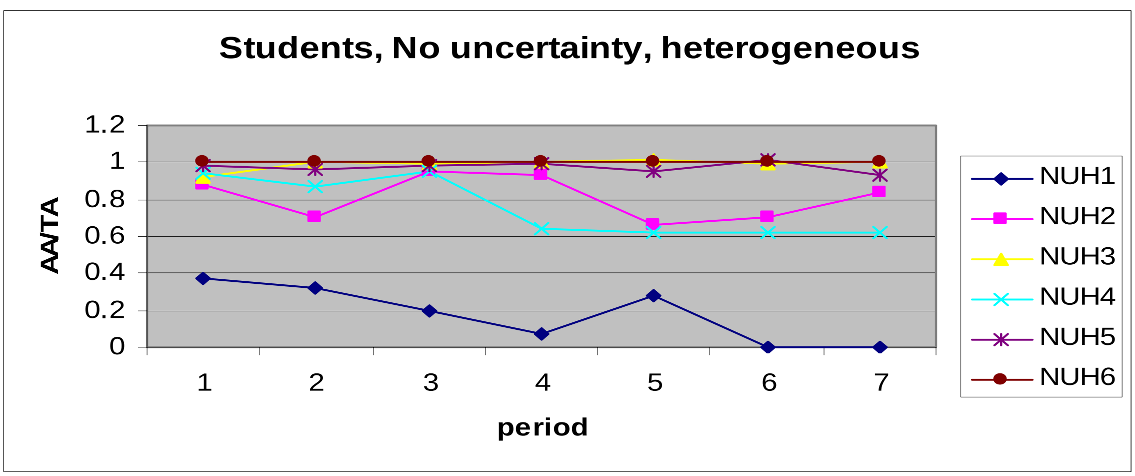


Figure 3. Participants – students, setting – no uncertainty.

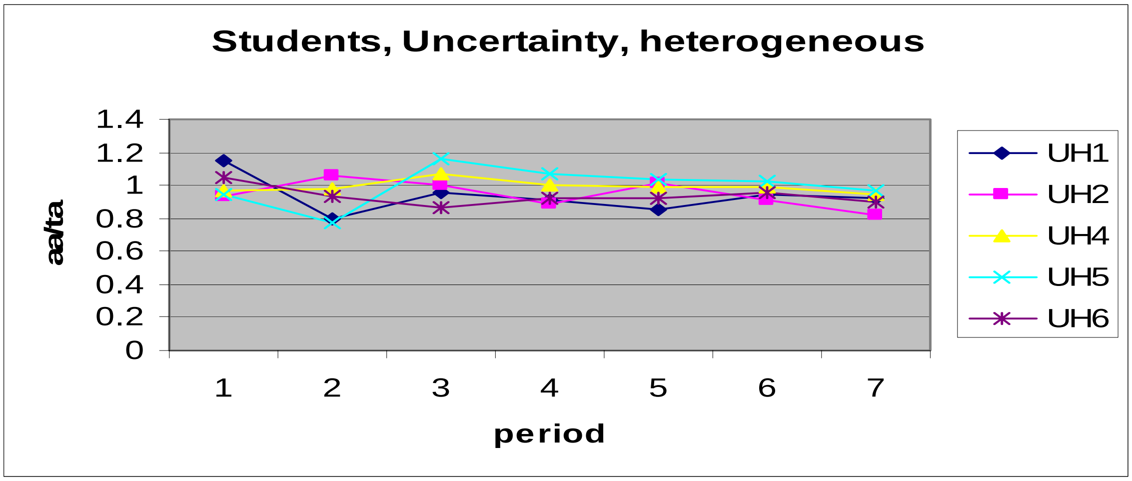


Figure 4. Participants – students, setting – uncertainty.

Uncertainty played a stabilizing role in the experiments with students

In the setting with uncertainty, students groups on average performed better and more homogeneous. Moreover, variance across all groups in the setting with uncertainty was decreasing over time (α_p = -0.00168, p<0.05), while in the setting with no uncertainty variance was increasing over time (α_p = 0.015211, p<<0.05).

Figure 5 below depicts how AA/TA was changing during last 7 period for all groups with participants – farmers.

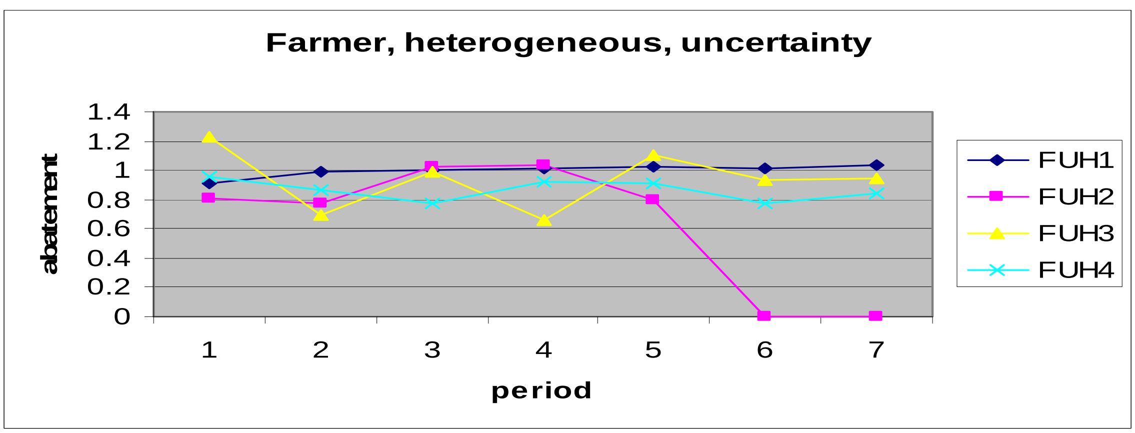


Figure 5 . Participants – farmers, setting – with uncertainty.

The average AA/TA for the farmers' groups in the setting with uncertainty was 0.86 and variance was 0.025, and as for the groups of students in the setting with no uncertainty variance was increasing over time ($\alpha_p = 0.035407$, $p<0.05$).

On average, groups with farmers performed worse then students in the same setting, but better then students in the setting with no uncertainty; variance was higher then in any other group.

The level of compliance with assigned level of abatement affected overall efficiency of the contract. Figures 6-8 below demonstrate how each group performed over last seven periods.

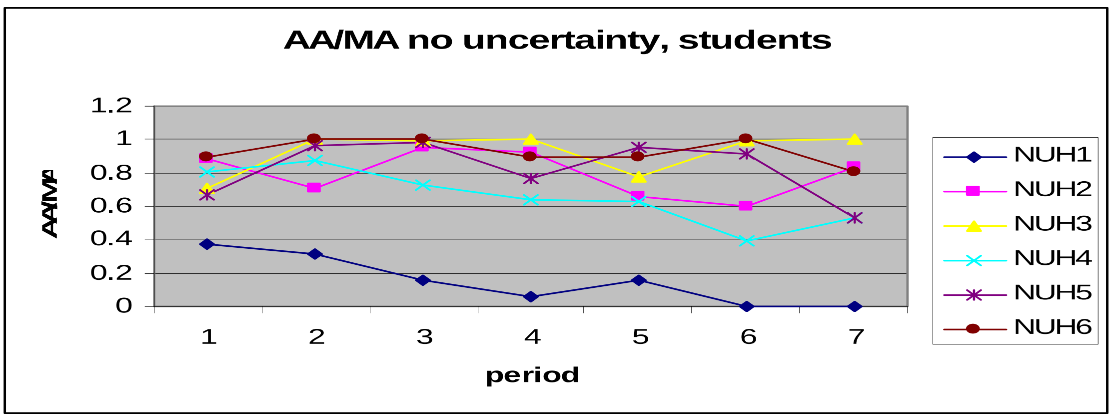


Figure 6. Overall performance of the contract, no uncertainty, students

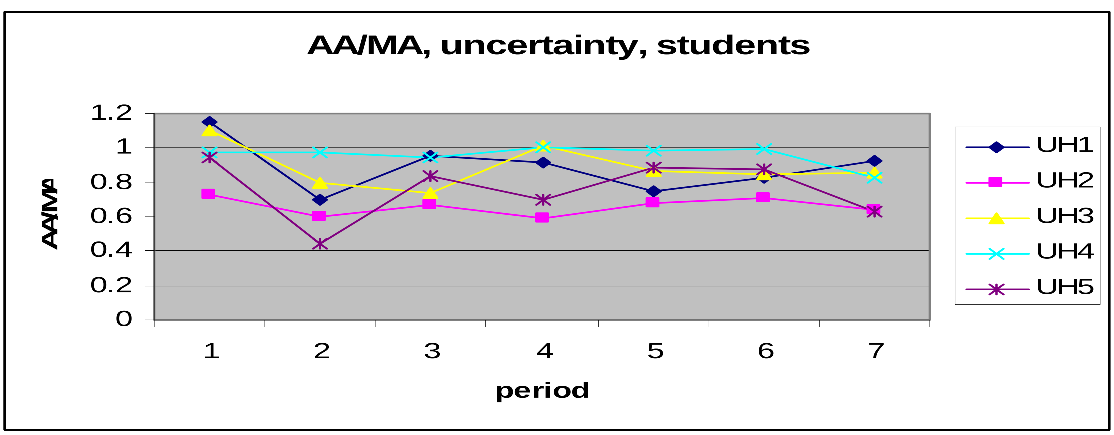


Figure 7. Overall performance of the contract, uncertainty, students

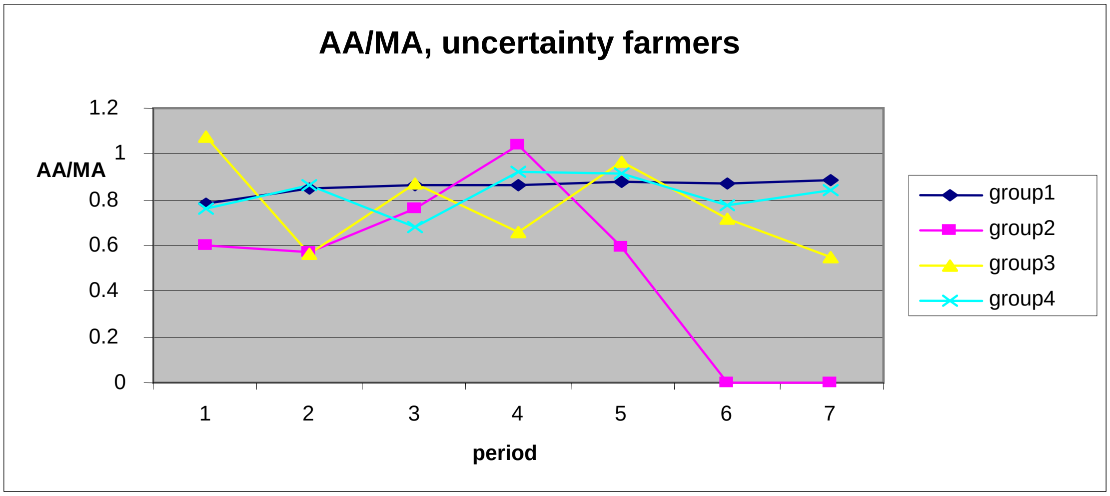


Figure 8. Overall performance of the contract, uncertainty, farmers

Deviation from the Equilibria Predicted by standard game theoretic approach

Players who joined the Association did not choose the theoretically predicted payoff dominant equilibria. To arrive at this conclusion we compared each condition's AA/TA with the payoff dominant 1.00.

For the uncertainty students' groups the mean AA/TA was .962, $t(5) = 1.93$, $p < .06$. For the no uncertainty students groups the overall mean AA/TAs was 825, $t(5) = 1.76$, $p < .07$. For uncertainty farmers' groups the mean AA/TA was .86, $t(3)=-1.78$, $p=.086$.

All of these tests were one-tailed. The extreme heterogeneity of the certainty students group and uncertainty farmers group diminished the statistical significance of their result despite the fact that its mean was the furthest from 1.00.

Conclusion

There are several results in this study.

First result is that spite from some members of the group indeed may compromise a group performance. Since some players are interested in achieving higher relative profit, their own absolute profit decreases as well as an absolute profit of other members in the group. Consequently, some groups ended up in suboptimal equilibria.

Second result was that introduction of uncertainty in the experiments with students stabilized groups' performance in a sense that under uncertainty variance among groups was smaller compared to variance across groups in a certain setting, and average performance is closer to optimal. Therefore, uncertainty can be a positive factor for the group contracts.

Third result was that farmers weren't affected positively by uncertainty. Variance across these groups is closer to the variance across students' groups in no uncertainty setting. One of the groups ended up in risk free equilibria, as it was the case in the no uncertainty setting with participants- students.

Discussion after experiments with farmer revealed that they were more concerned that this contract could affect negatively their relationship with their neighbors, then about uncertainty. To the specific question: "Is it a problem that you do not have full information about effect of you abatement actions?" they usually reply: "What else is new?"

Therefore, we suggest that since farmer used to operate under uncertainty, they are not affected by it neither in negative, nor in positive way; and a group contracts could work effectively in NPS setting if they are not spite sensitive.