WORKING PAPER SERIES

by

DEPARTMENT OF ECONOMICS

McMASTER UNIVERSITY

Hamilton, Ontario, Canada L8S 4M4

Exogenous Targeting Instruments as a Solution to Group Moral Hazards

John Spraggon
Department of Economics
McMaster University
1280 Main Street West
Hamilton, Ontario
Canada
L8S 4M4
phone: (905) 525-9140 x27614
fax: (905) 521-8232

email: spraggjm@mcmaster.ca

September 1998

This research is sponsored through a grant from Environment Canada McMaster University's Eco-research Program for the Hamilton Harbour. Earlier drafts of this paper were presented at the 1997 Annual Meeting of the Economic Science Association, and the 1997 Annual Meetings of the Canadian Economic Association. Thanks are due to Andrew Muller, Stuart Mestelman, Peter Kuhn, and Martin Osborne for guidance and helpful comments. Any comments would be appreciated.

Abstract: Exogenous Targeting Instruments as a Solution to Group Moral Hazards

The ability of four contracts within the general class of exogenous targeting instruments, proposed by Segerson (1988), to induce socially optimal outcomes in a group moral hazard environment is investigated in an experiment based on Nalbantian and Schotter (1987). Both contracts based on the Holmstrom (1982) forcing contract with multiple equilibria, and contracts based on the Segerson study with unique equilibria are tested. My result -- that contracts can be designed that mitigate the moral hazard problem at the aggregate level -- is a significant advance on the result of Nalbantian and Schotter -- that costly monitoring or competitive teams are required to solve the moral hazard problem. It is shown that this result is robust to uncertainty as well as experience. However, none of the contracts insures compliance at the individual level, and as a result hefty fines may be accrued by individuals even when they choose the socially optimal action. (JEL H21, C92)

Inducing workers to choose the optimal level of effort, agents to contribute the optimal amount to a public good or reduce their consumption of a common resource, firms to choose the optimal level to pollute, and even countries to reduce their emissions of green house gases are all examples of the "moral hazard in groups" problem. This common social problem is characterized by a difference between socially and individually optimal actions, in combination with non-observability of the individual agents' actions. As a result, some form of regulation or institution is required to induce agents to make socially optimal choices.

One well-known solution to the group moral hazard problem, in the context of workers' effort, is the introduction of a principal who receives all the workers' output if total output is below the optimal level (Holmstrom 1982). These kinds of contracts are often referred to as "forcing contracts". Perhaps surprisingly, a number of recent attempts to implement forcing contracts in laboratory settings have produced quite poor results. For example, Nalbantian and Schotter (1997) provide a laboratory test of Holmstrom's forcing contract and find that it cannot induce workers to supply the optimal level of effort. The Isaac, Schmidtz and Walker (1989), and Suleiman and Rapoport (1992) studies for threshold public goods, and common property resources have produced similar results. Taken together, these experiments provide little basis for optimism that effective social institutions can be devised that solve this very common problem in human societies.

In this paper, I argue that the pessimism that seems to emerge from the above studies may be misplaced. It is misplaced largely because the class of solutions --discontinuous forcing contracts-- that have received the bulk of theoretical and empirical attention to date, share a multiple-equilibrium problem which is not present in simpler, continuous contracts. In particular, in addition to the socially efficient “cooperative” equilibrium, these discontinuous forcing contracts also have an equilibrium in which all agents choose *individually*, rather than socially optimal actions (Arrow 1985). In contrast, when optimal continuous (indeed linear) contracts are designed, Nash equilibria are efficient and unique (Segerson 1988, McAfee and McMillan 1991). When such contracts are implemented in a controlled laboratory environment, they perform much better than the “forcing” contracts hitherto examined.

In more detail, this paper examines the ability of four contracts within a general class proposed by Segerson (1988) to induce socially optimal outcomes in a group moral hazard context. These contracts use lump sum fines and bonuses, combined with a proportional tax or subsidy on the difference between the actual group outcome and the socially optimal group outcome. Clearly this general class of contracts encompasses both discontinuous and continuous “forcing” contracts. In a laboratory experiment, cast in terms of a non-point source pollution problem, subjects are asked to choose a decision number; penalties and bonuses are then based on the total of these decision numbers (referred to as the group total)[1]. A “Tax-Subsidy” (continuous) contract combines a tax and a subsidy depending upon whether the group total is above or below the optimal level. The “Tax” (continuous) contract involves only a tax if the optimal level is exceeded. The “Subsidy” (discontinuous) contract involves a subsidy and a bonus which is provided if the group total is below the optimal level. The “Group Fine” (discontinuous) contract involves a lump-sum fine if the group total exceeds the optimal level.

I find that under the continuous contracts the group total is not significantly different from the socially optimal level. Further, this result is robust to both uncertainty and experience with the environment. However, the data show that these contracts do not ensure individual compliance. An additional problem with these contracts is that agents may face substantial fines even though they have chosen the socially optimal action. I conclude that exogenous targeting instruments are able to mitigate the moral hazard in groups problem but care must be taken in their implementation.

I. Experimental Design

As mentioned, the experiment is cast in terms of the non-point source pollution problem where individual decisions cannot be observed. The underlying model is standard in the literature on non-point source pollution (Segerson 1988, Malik 1990, and Xepapadeas 1992) and experimental design decisions were made for consistency with Nalbantian and Schotter (1997). Six subjects (indexed by n=1,..,6) choose a decision number which determines a private benefit and a social cost. The higher the decision number, the higher the individual private benefit, and the higher the cost to the group.

In the laboratory environment, an individual's private benefit, B_n, is quadratic in the decision number, x_n:

$$B_n(x_n) = 25 - 0.002(100 - x_n)^2 \quad \text{for n = 1,...6} \tag{1}$$

Notice that an agents's benefit is increasing in x_n up to the "maximum" decision number, x_{max} = 100. Subjects were provided a table listing the values of $B_n(x_n)$ for each (integer) value of x_n between 0 and 100. The values of this benefit function for each decision number are shown in the first frame of Figure 1.

The cost to the group depends on the total of the decision numbers, $X = \sum_{n=1}^{6} x_n$, which will be referred to as the group total. Under the uncertainty treatment the group total includes a random variable ϵ, uniformly distributed from -40 to +40, measured in units of the decision number, $X = \sum_{n=1}^{6} x_n + \epsilon$. For simplicity the social cost from the decision number choices are defined as a scalar multiple of the group total: D(X) = 0.3X.

Assuming that both the agents and the principal are risk-neutral, the socially optimal decision number for each agent is found by maximizing the benefits minus the expected social cost:

$$\max_{x_1,\ldots,x_6} \sum_{n=1}^{6} B_n(x_n) - D(X)$$

$$\max_{x_1,\ldots,x_6} \sum_{n=1}^{6} [25 - 0.002(100 - x_n)^2] - 0.3\sum_{n=1}^{6} x_n \tag{2}$$

It is straight forward to show that the socially optimal decision number for each agent is $x_n^* =$ 25. Thus the optimal group total is $X^* = \sum_{n=1}^{6} x_n^* = 150$. Notice that the "maximum" group total is 600 which is the outcome that will be selected by profit maximizing agents in the absence of any policy intervention. As a result there is a role for a principal to penalize the agents if the observed group total is above 150 or reward the agents if the group total is below 150. Because agent's decisions are unobservable, group incentive contracts are utilized (Holmstrom 1982, Segerson 1988, McAfee and McMillan 1991, Xepapadeas 1991, 1992, Andolfatto and Nosal 1997). Under these contracts each individual faces a profit function which is the benefit from the individual decision minus some function of the measured group total:

$$\Pi_n(x_n) = B_n(x_n) - T_n(X) \qquad \text{for all n = 1,...,6} \tag{3}$$

where $T_n(X)$ is the incentive scheme or contract imposed by the principal. Profit maximizing agents will choose the socially optimal level of emission when $T_n' = D'$ assuming that T_n and D are differentiable.

Group Incentive Contracts

All of the contracts considered in this paper are of the form suggested by Segerson [1988] for the non-point source pollution problem:

$$T_n(X) = \begin{cases} t_n(X-X^*)+\tau_n & \text{if } X > X^* \\ s_n(X-X^*)-\beta_n & \text{if } X \leq X^* \end{cases} \qquad (4)$$

Where s_n and t_n are a subsidy and a tax respectively, β_n is a bonus and τ_n is a fine. Since the subsidy, tax, bonus and fine parameters are symmetric across individuals the subscripts can be dropped.

In general, there are multiple non-cooperative Nash equilibria and a unique cooperative outcome which maximizes the group's payoff under each of these contracts. The non-cooperative equilibria may be further divided into symmetric and asymmetric equilibria. There are two types of outcomes which may be symmetric equilibria: *group compliance* where all individuals choose 25 units and *group non-compliance* where all individuals choose 100 units. Asymmetric equilibria are characterized by any combination of individual decisions that sum to the optimal group total (150 units). I will refer to these types of outcomes as *asymmetric compliance*. I will refer to the cooperative outcome which maximizes the total payoff received by the agents as the *group optimal* outcome. Achieving this outcome assumes that subjects can implicitly collude and as a result I do not expect them to be achieved in this experiment.

The important distinction between the different contracts is whether or not the agent's profit function is continuous. If β_n or τ_n are non-zero the agent's profit function will be discontinuous. This discontinuity results in both group compliance and group non-compliance being Nash equilibria. Similarly if s_n and t_n are both zero then asymmetric compliance outcomes are Nash equilibria.

Tax-Subsidy Contract

The Tax-Subsidy contract provides a subsidy if the group total is below the optimal level and a tax if it is above the optimal level:

$$T(X) = \begin{cases} 0.3*(X - 150) & \text{if } X > 150 \\ 0.3*(X - 150) & \text{if } X \leq 150 \end{cases} \quad (5)$$

Under certainty the individual payoff function is continuous:

$$\pi_n = 25 - 0.002(100 - x_n)^2 - 0.3(\sum_{i=1}^{6} x_i - 150), \ \ n = 1,..,6 \quad (6)$$

The first order conditions for the agent's decision problem are the same as for the social planner's problem (2). Thus, an agent's best response is always to choose $x_n = x_n^* = 25$ no matter what the other agents do. The symmetric group compliance outcome ($x_n = 25 \ \forall n$), is therefore the only Nash equilibrium. However, there is a cooperative equilibrium where everyone chooses zero units. An individual's benefit function, the Tax-Subsidy contract, and the individual's profit function given that all other subjects comply are all depicted in figure 1. Table 1 presents the incentives for compliance simplified down to a normal form game between subject n and the rest of the subjects (the total of whose decisions are denoted X_{-n}). Uncertainty does not effect the predictions of theory for this contract.

Notice that each individual pays the entire damage due to the excess of the group total over the standard. Thus, the taxes paid by the agents could be quite high. Consider the case were everyone chooses 100 units. Table 1 shows that in this case the profits for all of the firms are -110 lab dollars. Notice also from Table 1 that subjects may earn negative profits if they comply and other subjects choose not to comply.

Tax Contract

If agents can coordinate on the cooperative solution under the Tax-Subsidy contract, the group total will be inefficiently low and the principal will be forced to pay a large amount to the agents. In contrast, under a Tax contract agents are taxed if the group total is above the optimal but no subsidy is provided when the group total is below.

$$T(X) = \begin{cases} 0.3*(X - 150) & \text{if } X > 150 \\ 0 & \text{if } X \le 150 \end{cases} \qquad (7)$$

Thus an individual's payoff function is

$$\pi_n = \begin{cases} 25 - 0.002(100 - x_n)^2 & \text{if } X \le X^* \\ 25 - 0.002(100 - x_n)^2 - 0.3(\sum_{i=1}^{6} x_i - 150) & \text{otherwise} \end{cases} \qquad (8)$$

It is clear that this contract leads an agent to the socially optimal decision if $X > X^*$, since the first order conditions are the same as for the social planner's problem. However, if the group total (X) is less than the optimal level (X^*) an agent's best response is to choose $x_n = 100$, which results in the group total exceeding the optimal level and an individual's best choice being to choose $x_n = 25$. Figure 2 depicts an individual's benefit function, the graph of the tax contract and the graph of the agent's payoff for each decision number, assuming that all other agents choose the optimal level of emission ($x^*_n = 25$). Table 2 presents the incentives for compliance; notice that symmetric group compliance is the only Nash equilibrium. The asymmetric outcomes are not Nash equilibria under this contract as the individual profit function is always maximized where $x_n = 25$. If the agents were able to collude they would choose the symmetric group-compliance outcome ($x_n = 25 \ \forall n$) under this contract.

Under uncertainty the Tax contract is weaker because there is some probability that agents will not be fined even if group total exceeds 150. An individual's profit function is the same as before except for the random variable which is added into the ambient level of pollution:

$$\pi_n = \begin{cases} 25 - 0.002(100 - x_n)^2 & \text{if } X \leq X^* \\ 25 - 0.002(100 - x_n)^2 - 0.3(\sum_{i=1}^{6} x_i + \epsilon - 150) & \text{otherwise} \end{cases} \quad (9)$$

The only Nash equilibrium under this contract is a symmetric outcome where everyone chooses 28 units. Asymmetric outcomes are not Nash equilibria and the cooperative equilibrium is the symmetric Nash equilibrium where each agent chooses 28 units. As was the case for the Tax-Subsidy contract it is again possible for individuals to face substantial losses even when they are in compliance with the standard (see table 2).

Subsidy Contract

Both the Tax and Tax-Subsidy contracts assume that agents can be held liable for the damages caused by their decisions. If agents are not liable for their decisions they must be subsidized for any reduction. A pure subsidy contract provides subsidies if the optimal group total is attained. Notice however that a marginal subsidy (s_n) alone cannot induce compliance with the standard because the ambient pollution subsidy (s_n) does not change the slope of the firm's profit function for emission levels above 25 units (assuming all of the other agents comply). To induce compliance the payoff for choosing 25 units must be increased above the payoff for choosing 100 units (given that all other agents comply). As a result, a bonus (β_n>0) is added to the subsidy contract. The Subsidy contract shares the real social benefit due to the reduction among the agents if the standard is attained.

$$T(X) = \begin{cases} 0 & \text{if } X > 150 \\ 0.3*(X - 150) + 22.50 & \text{if } X \leq 150 \end{cases} \quad (10)$$

where 22.50 represents an equal share of the real social benefits from an optimal reduction in the group total. This contract is equivalent to the Holmstrom forcing contract with the output being split among the agents if the optimal level of effort is provided.

Under certainty, an individual's payoff is given by a discontinuous function:

$$\pi_n = \begin{cases} 25 - 0.002(100 - x_n)^2 - [0.3[\sum_{i=1}^{6} x_i - 150] - 22.50] & \text{if } X \le X^* \\ 25 - 0.002(100 - x_n)^2 & \text{otherwise.} \end{cases} \quad (11)$$

In this case the individual's decision problem provides the same incentives as the social planner's problem when the group total is below the optimal level ($X \le X^*$) and as a result each agent choosing $x_n = 25$ is a Nash equilibrium. However, if $X > X^*$ then it is in an agent's best interest to maximize her private benefits (choose $x_n = 100$) as the subsidy is not going to be received. As a result non-compliance (each agent choosing $x_n = 100$) is also a Nash equilibrium under this contract. Figure 3 depicts an individual's benefit function, the graph of the subsidy contract and the graph of the agent's profits for each decision number assuming that all other agents choose the optimal decision ($x_n^* = 25$).

Table 3 presents the incentives for compliance. Notice that it is in agent n's best interest to comply with the standard (choose $x_n = 25$) as long as everyone else chooses to comply. Notice also that agents maximize the payoff to the group if everyone chooses 0 units. Thus, this contract is undesirable as the principal is likely to face capital constraints which would make subsidising agents' decisions infeasible.

Under uncertainty an individual's profit is given by a discontinuous function:

$$\pi_n = \begin{cases} 25 - 0.002(100 - x_n)^2 - [0.3[\sum_{i=1}^{6} x_i + \epsilon - 150] - 22.50] & \text{if } X \le X^* \\ 25 - 0.002(100 - x_n)^2 & \text{otherwise} \end{cases} \quad (12)$$

In this case only group non-compliance is a Nash equilibrium. Group compliance is no longer a Nash equilibrium because even if all agents comply there is some probability that the subsidy will not be provided. As a result, an individual increases her expected profit by increasing her decision number. As with the certainty case there are no asymmetric Nash equilibria, and the group payoff is maximized if everyone chooses 0 units.

Group Fine Contract

The final contract is a forcing contract when the group total is above the optimal level as opposed to the subsidy contract which is forcing when the level is below optimal. Under the Group Fine contract all of the agents are fined if the group total is above the optimal level:

$$T(X) = \begin{cases} -24 & \text{if } X > 150 \\ 0 & \text{if } X \leq 150 \end{cases} \qquad (13)$$

The value of the fine (-24) is chosen so that the marginal expected value of the contract is equal to the marginal damage at the optimum $\partial T(X)/\partial(x_n)|_{X=X^*} = \partial D(X)/\partial(x_n)|_{X=X^*}$ under uncertainty[2]. Under both certainty and uncertainty an individual's profit function is discontinuous:

$$\pi_n = \begin{cases} 25\text{-}0.002(100\text{-}x_n)^2 & \text{if } X \leq X^* \\ 1\text{-}0.002(100\text{-}x_n)^2 & \text{otherwise} \end{cases} \qquad (14)$$

Under certainty, any set of decision numbers which sum to 150 are a Nash equilibrium. An agent's best response to this contract is to choose a decision number which makes the group total just equal to 150 ($x_n = 150 - X_{-n}$) if possible ($50 < X_{-n} \leq 150$), and to choose $x_n = 100$ if not ($X_{-n}<50$ or $X_{-n}>150$). For both the certainty and uncertainty case group compliance, group non-compliance and asymmetric compliance are Nash equilibria. Group compliance is the group optimal outcome for this contract. Figure 5 shows the individual's benefit function, the Group Fine contract and an individual's profit function given that everyone else complies and table 4 presents the incentives for compliance or non-compliance for the individual. Notice that the potential for large losses is not as sever under this contract as it is under the Tax-Subsidy and Tax contracts.

Table 5 summarizes the potential outcomes under certainty (C) and uncertainty (U) for the four different contracts. Notice that the Tax contract has one potential outcome, the Tax-Subsidy and the Group Fine have two, the Subsidy contract has three potential outcomes. Also notice that the Tax-Subsidy and Tax contracts only have one Nash equilibrium while the Subsidy and Group Fine contracts have two. As a result it is more likely that the subjects will choose the socially optimal outcome (group compliance) under the Tax-Subsidy and Tax contracts.

Design

Twenty four sessions were conducted at the McMaster Experimental Economics Lab during the winter term of 1997. Each session involved one group of six subjects who participated in twenty-five periods for each of two different contracts. Subjects were recruited from the university population and earned on average twenty three dollars for a session which lasted between 1 and 2 hours.

In each period the subjects were asked to choose a decision number between 0 and 100[3]. They were told that their total payoff in each period was the sum of a private payoff and a group payoff. The private payoff was found by looking up their decision number on a payoff table. The group payoff depended on the group total. They were informed that the group total was the sum of the decision numbers of all of the subjects, and in the uncertainty condition, a uniform random variable between -40 and +40. The group payoff was described using one of the four contracts (Tax-Subsidy, Tax, Subsidy, or Group Fine).

To control for group effects it would be best to have each subject participate in each contract. Unfortunately, this was not feasible as it would have made the experimental sessions too long. In each session 25 periods of each of two contracts were presented. Each contract was paired with each other contract for twelve pairings under certainty and uncertainty. As a result there are three replications of each contract under certainty and uncertainty in both the first and second positions.

II. Testable Hypotheses

Three theories are used to predict the outcomes from the experimental sessions: non-cooperative game theory, non-cooperative game theory with equilibrium selection, and cooperative game theory. Non-cooperative game theory in this case just appeals to the concept of Nash equilibrium. There are unique Nash equilibria under the Tax-Subsidy and Tax contracts but not under the Subsidy or Group Fine contracts. To predict results for the Subsidy and Group Fine contracts we need an equilibrium selection mechanism. A common choice is payoff dominance, which predicts that the group compliance equilibrium will be chosen for both of these contracts. Cooperative game theory suggests that under the Tax-Subsidy and Subsidy contracts individuals will be able to coordinate on the group optimal outcome where each agent chooses zero units. These predictions are summarized in Table 6.

The effect of uncertainty on each of the contracts can also be tested. The tax-subsidy should perform equally well under certainty as under uncertainty. The tax and subsidy contracts are developed for the certainty case and as a result should perform better under certainty than uncertainty, whereas, the group fine contract should perform better under uncertainty.

As people become more experienced with the environment they should be better able to coordinate on the payoff dominate Nash equilibrium. This implies that the results for the Subsidy and Group fine contracts conducted in the second position should be more similar to the socially optimal outcome than those conducted first.

Results

Result 1: ***The continuous contracts (Tax-Subsidy and Tax) are better able to enforce the standard than the discontinuous contracts (Subsidy and Group Fine)***.

The first question is whether these contracts are able to induce the group to the socially optimal outcome (or enforce the standard). Table 7 presents the mean of the group total over all 25 periods of the three sessions in each cell. The standard errors are large enough that none of these mean group totals are significantly different from the socially optimal target of 150. However, notice that the group totals for the Subsidy and Group Fine contracts are larger and have much higher standard errors in all cases. Table 8 presents the mean of the mean group total over the three sessions in each cell. It could be argued that this is the proper statistic to use to compare the contracts since the twenty five periods in each session are not independent. Using the mean of the group total across the twenty-five periods for each of the three sessions, the mean group totals for the Tax-Subsidy contract under certainty in the second presentation, under uncertainty in the first presentation, the Tax contract under certainty in the first presentation, and the Group Fine contract under uncertainty in the second presentation are all significantly different from 150. Table 9 presents the percentage reduction in the group total from 600 (a reduction to the socially optimal level 150 would be 100 percent). This table shows that the group total is reduced by much more under the Tax-Subsidy and Tax contracts.

Figures 5 through 8 depict the Group Totals (i.e. total of the individual decision numbers) in each of the twenty five periods for each contract, certainty and order condition. These graphs show that while the group totals tend to be around 150 under the Tax-Subsidy and Tax contracts, the group total is often closer to 600 under the Subsidy and Group Fine contracts. The observation that individuals choose non-compliance is consistent with the previous studies of Holmstrom's forcing contract (Isaac, Schmidtz, and Walker 1989, Rapoport and Suileiman 1992, and Nalbantian and Schotter 1997).

It is clear from these results that the Tax-Subsidy and Tax contracts are better able to induce agents to the socially optimal outcome than the Subsidy and Group Fine contracts. The Box Whisker diagram presented in figure 9 shows this result quite clearly[4].

Result 2: Result 1 is robust to uncertainty and experience

Table 8 and figures 5 through 8 show that neither uncertainty nor order of presentation make much difference to the observed results. Anova analysis conducted on the mean group totals in each of the forty-eight sessions confirms that order and uncertainty are not significant ($p>.32$ for order and $p>0.72$ for uncertainty) Table 11 and Tables 12 through 15 show that order is significant for the tax contract but otherwise all of the certainty and order variable are insignificant even when the regressions are run separately by contract. As a result, I claim that not only are the Tax-Subsidy and Tax contracts able to induce a group to the social optimum but that this result is robust to uncertainty and experience with the environment.

Result 3: Individual free-riding is not eliminated

Figures 12 and 13 present the distributions of individual decision numbers by contract and certainty condition. These pictures show that agents free-ride to a greater extent under the discontinuous contracts (Group Fine and Subsidy) contracts than they do under the continuous contracts (Tax and Tax-Subsidy). It is also clear that the variance in the decision numbers is higher under uncertainty than under certainty except under the Group Fine contract where the percentage of decision numbers in the 90 to 100 range is approximately 50 percent.

Result 4: Bankruptcy is important

The exogenous targeting instruments investigated in this paper are in a sense extreme. If one person chooses a non-socially optimal action all of the subjects are punished. As a result agents who choose the socially optimal action may earn significantly negative payoffs [see tables 1 through 4]. Subjects in the experiment were endowed with an opening balance to reduce the likelihood of bankruptcy. Despite this, bankruptcy was observed under all of the contracts where it was possible (Table 10). That agents who are in compliance are penalized for the non-compliance of others may provide an incentive for these agents to find ways to credibly report their actions. This is an important issue in the environmental compliance literature as there are many situations where regulation is based on self-reporting (Malik 1993, Swierzbinski 1994**,** and Livernois and McKenna 1997).

III. Conclusions and Extensions

In a simple environment where moral hazard would result in non-compliance, exogenous targeting instruments are able to induce compliance with a standard. Four contracts: Tax-Subsidy, Tax, Subsidy, and Group Fine have been tested in a controlled laboratory environment. Of these, the two “forcing” contracts, suggested in work by Holmstrom (1981) and Andolfatto and Nosal (1997) are unable to consistently enforce the standard. In contrast, the two continuous contracts, (Tax-Subsidy and Tax) are essentially effective without the need to resort to (costly) monitoring of individual performance or to set up multiple, competing “teams” (Nalbantian and Schotter 1997). I find that these results are robust to uncertainty as well as to experience with the environment.

It seems clear that a key explanation behind the inability of discontinuous, “forcing” contracts to induce compliance with a standard is the coordination problem that arises under these contracts. Under the continuous contracts the marginal incentives induce agents to the socially optimal outcome, whereas under discontinuous contracts the group needs to coordinate on one of many possible Nash outcomes. There is an extensive literature on coordination failures which shows that even groups of two players have trouble coordinating when there as few as two possible equilibria[5]. Further, sessions were conducted in which subjects were allowed to communicate and they were consistently able to coordinate on the group optimal outcome.

While cast in terms of a non-point source pollution problem, it is clear that the results of this experiment --that “continuous” penalties and rewards, based on the difference between the value of the observed statistic and the desired value work well-- have implications for the optimal design of contracts in other situations. For example, an analogous contract to the Tax-subsidy contract in the worker effort case would work as follows: Workers could be paid some proportion of the firm's profits such that the groups reward is below the firm's profit if the workers produce less than the target level and the reward is above the firm’s profit if they produce more. Alternatively, the firm’s profits could be distributed among the workers and a proportional fine could be charged if the target is not met and a proportional bonus provided otherwise). Isaac, Schmidtz, and Walker [1989] and Bagnoli and McKee [1991] address alternate renumeration schemes in their threshold public good papers. They investigate a full money back guarantee as well as a partial (fifty percent) money back guarantee if the public good is not provided. They find that the full money back guarantee does increase compliance with the target but the partial money back guarantee has no affect whatsoever. They conclude that a full money back guarantee must be offered to induce compliance. However, the results from this study suggest that if the guarantee was proportional to the difference between the observed contribution and the target, compliance would be induced.

Finally, it should be noted that even the "continuous" contracts examined in this paper are not without problems. For example, while "group" compliance is well-enforced, individual free-riding is not eliminated by any of these contracts. In future work I intend to appeal to recent work done on bounded rationality (Anderson, Goeree, and Holt 1996) and experience weighted attraction (Camerer and Ho 1997) to determine if better explanations can be provided for the observed results[6]. Another potential concern is that Tax-Subsidy, Tax, and Group Fine contracts may result in agents facing large fines or taxes even when they are in compliance with the standard. Further, the Tax-Subsidy and Subsidy contracts may result in significant costs to the regulator if firms are able to collude. Thus, some of these contracts may not be politically feasible. Still, I believe my results provide a basis for renewed optimism regarding the possibility of designing simple but practically effective social institutions to control problems of moral hazard in groups.

References

Anderson, Simon, Jacob Goeree, and Charles Holt. "Minimum-Effort Coordination Games: An Equilibrium Analysis of Bounded Rationality." University of Virginia Discussion Paper 273, 1996.

Andolfatto, David and Ed Nosal. "Optimal team contracts." *Canadian Journal of Economics*, , May 1997, XXX No. 2 pp. 385-96.

Arrow, Kenneth J. "The Economics of Agency." in J. W. Pratt and R.S. Zeckhauser eds. *Principals and Agents: The Structure of Business* (Boston: Harvard Business School Press), , 1985, pp. 37-35.

Bagnoli, Mark, and Michael McKee. "Voluntary contribution games: efficient private provision of public goods." Economic Inquiry, April 1991, Vol. XXIX, pp. 351-366.

Camerer, Colin and Teck-Hua Ho. "Experience-Weighted Attraction Learning in Games: A Unifying Approach." California Institute of Technology Working Paper 1003 , March 1997.

Cooper R., D. DeJong, R. Forsythe, and T. Ross. "Selection Criteria in coordination games: Some experimental results." *American Economic Review*, 1990, 80, pp. 218-33

Fukuyama, Kei, Marc, D. Kilgour, and Keith, W. Hipel. "Systematic Policy Development to Ensure Compliance to Environmental Regulations.", *IEEE Transactions on Systems, Man, and Cybernetics*, 1994, 24, 9, pp. 1289 - 1305.

Holmstrom, Bengt. "Moral Hazard in Teams." *Bell Journal of Economics*, Autumn 1982, 13, pp. 324-340.

Isaac, Mark R., David Schmidtz, and James M. Walker. "The assurance problem in a laboratory market." *Public Choice*, 1989, 62, pp. 217-236.

Livernois, John and C.J. McKenna. "Truth or Consequences: Enforcing Pollution Standards." University of Guelph Working Paper, May 1997.

Malik, Arun. "Self-Reporting and the Design of Policies for Regulating Stochastic Pollution." *Journal of Environmental Economic Management* , 1993, 24, pp. 241-257.

Malik, Arun. "Markets for Pollution Control when firms are Noncompliant." *Journal of Environmental Economic Management*, 1990, 18, pp. 97-106.

McAfee, Preston R. and John McMillan. "Optimal Contracts for Teams." *International Economic Review*, August 1991, 32, 3, pp. 561 - 576.

Nalbantian, Haig and Andrew Schotter. "Productivity Under Group Incentives: An Experimental Study." *American Economic Review*, June 1997, 87, pp. 314-41.

Russell, Clifford. "Game Models for Structuring Monitoring and Enforcement Systems.", *Natural Resource Modeling*, Spring 1990, 4,2, pp.143-173.

Segerson, Kathleen. "Uncertainty and incentives for nonpoint pollution control.", *Journal of Environmental Economic Management*, 1988, 15, pp. 87-98.

StataCorp. *Stata Reference Manual*, 1997, Release 5, Volume 2, G-O, Stata Press, Texas.

Suleiman, Ramzi and Amnon Rapoport. "Provision of step-level public goods with continuous contribution." *Journal of Behavioral Decision Making*, 1992, 5, pp. 133-143.

Swierzbinski, Joseph. "Guilty until Proven Innocent - Regulation with Costly and Limited Enforcement." *Journal of Environmental Economic Management*, 1994, 27, pp. 127-146.

Xepapadeas, A. P. "Environmental Policy under Imperfect Information: Incentives and Moral Hazard." *Journal of Environmental Economics and Management*, 1991, 20, pp. 113-126.

Xepapadeas, A. P. "Environmental Policy Design and Dynamic Nonpoint-Source Pollution." *Journal of Environmental Economics and Management*, 1992, 22, pp. 22-39.

Endnotes

1. In contrast to the worker effort case, note that lower group totals are socially preferred in the pollution case. It was however never suggested to subjects that their decision variables might be interpreted in an environmental or any other context.

2. Notice that $\partial T(X)/\partial x_n = 0$ under certainty. Thus this contract should be more likely to induce the socially optimal outcome under uncertainty.

3. A copy of the instructions as presented to the subjects is included as an appendix.

4. The box depicts the interquartile range, the line through the box the mean, and the whiskers the upper and lower adjacent values [StataCorp 1997, Reference Volume 2, G-O, page 60].

5. For example the battle of the sexes games studied by Cooper, DeJong, Forsythe, and Ross 1990.

6. The analysis presented in this paper ignores the fact that these are repeated games. In future work I will attempt to take this into account.

TABLE 1
Tax-Subsidy Contract

Agent n	Other Agents Over Comply: $X_{-n} = 0$	Comply: $X_{-n} = 125$	Non-compliance: $X_{-n} = 500$
Over Comply: $x_n = 0$	50.00, 50.00	12.50, 21.25	-100, -80.00
Comply : $x_n = 25$	51.25, 42.50	13.75, 13.75	-98.75, -87.50
Non-compliance: $x_n = 100$	40.00, 20.00	2.50, -8.75	-110, -110

TABLE 2
Tax Contract

Agent n	Other Agents Over Comply: $X_{-n} = 0$	Comply: $X_{-n} = 125$	Non-compliance: $X_{-n} = 500$
Over Comply: $x_n = 0$	5.00, 5.00	5.00, 13.75	-100, -80.00
Comply : $x_n = 25$	13.75, 5.00	13.75, 13.75	-98.75, -87.50
Non-compliance: $x_n = 100$	25.00, 5.00	2.5, -9.25	-110, -110

TABLE 3
Subsidy Contract

Agent n	Other Agents Over Comply: $X_{-n} = 0$	Comply: $X_{-n} = 125$	Non-compliance: $X_{-n} = 500$
Over Comply: $x_n = 0$	72.50, 72.50	35.00, 43.75	5.00, 25.00
Comply : $x_n = 25$	73.75, 65.00	36.25, 36.25	13.75, 25.00
Non-compliance: $x_n = 100$	62.50, 42.50	25.00, 13.75	25.00, 25.00

TABLE 4
Group Fine Contract

Agent n	Other Agents Over Comply: $X_{-n} = 0$	Comply: $X_{-n} = 125$	Cheat: $X_{-n} = 500$
Over Comply: $x_n = 0$	5.00, 5.00	5.00, 13.75	-19.00, 1.00
Comply : $x_n = 25$	13.75, 5.00	13.75, 13.75	-10.25, 1.00
Cheat: $x_n = 100$	25.00, 5.00	1.00, -10.25	1.00, 1.00

TABLE 5
Potential outcomes under the four contracts

Contract		Symmetric	Asymmetric	Cooperative
Tax-Subsidy	C	150*	None	0
	U	150*	None	0
Tax	C	150*	None	150*
	U	168*	None	168*
Subsidy	C	150*, 600*	None	0
	U	600*	None	0
Group Fine	C	150*, 600*	150*	150*
	U	150*, 600*	150*	150*

C - Certainty
U - Uncertainty
* - Nash Equilibrium

TABLE 6
Predicted outcomes under the four contracts

	Contract Tax-Subsidy	Tax	Subsidy	Group Fine
Non-Cooperative Game Theory				
Certainty	SC	SC	None	None
Uncertainty	SC	SC*	None	None
Non-Cooperative Game Theory and Equilibrium Selection				
Certainty	SC	SC	SC	SC
Uncertainty	SC	SC*	SC	SC
Implicit Coordination				
Certainty	GO1	SC	GO1	SC
Uncertainty	GO1	SC*	GO1	SC

SC - Symmetric Compliance (25,25,25,25,25,25)
SC* - Symmetric Compliance for the Tax Contract under uncertainty (28,28,28,28,28,28)
GO1 - Group Optimal (0,0,0,0,0,0)

TABLE 7
Mean Decision Number Totals by Period

Contracts	Certainty		Uncertainty		Totals
	First	Second	First	Second	
Tax-Subsidy	158.44 (34.44) 75	188.97 (60.30) 75	211.19 (50.71) 75	158.92 (51.17) 75	179.38 (54.50) 300
Tax	209.99 (53.76) 75	183.72 (40.80) 75	201.27 (77.93) 75	169.19 (37.96) 75	191.04 (56.89) 300
Subsidy	351.45 (178.42) 75	232.48 (137.23) 75	233.91 (121.42) 75	294.52 (158.60) 75	278.09 (159.61) 300
Group Fine	358.00 (179.29) 75	250.47 (161.55) 75	366.52 (171.52) 75	379.93 (169.22) 75	338.64 (175.70) 300

TABLE 8
Mean Decision Number Totals by Session (n=3/cell)

Contracts	Certainty		Uncertainty		Totals
	First	Second	First	Second	
Tax-Subsidy	158.44 (13.34) 3	188.97 (6.92) 3	211.19 (19.35) 3	158.92 (29.49) 3	179.38 (28.32) 12
Tax	209.99 (10.85) 3	183.72 (26.03) 3	201.27 (18.68) 3	169.19 (21.57) 3	191.04 (23.75) 12
Subsidy	351.45 (188.83) 3	232.48 (118.55) 3	233.91 (52.83) 3	294.52 (157.15) 3	278.09 (128.13) 12
Group Fine	358.00 (183.13) 3	250.47 (177.76) 3	366.52 (176.07) 3	379.93 (98.60) 3	338.64 (148.79) 3

TABLE 9
Percentage Reduction in Group Total

Contracts	Certainty		Uncertainty		Total
	First	Second	First	Second	
Tax-Subsidy	98.12%	91.34%	86.40%	98.02%	93.47%
	(2.96)	(1.54)	(4.30)	(6.55)	(6.29)
	3	3	3	3	12
Tax	86.67%	92.51%	88.61%	95.74	90.88%
	(2.41)	(5.79)	(4.15)	(4.79)	(5.28)
	3	3	3	3	12
Subsidy	55.23%	81.67%	81.35%	67.88%	71.53%
	(41.96)	(26.35)	(11.70)	(34.92)	(28.70)
	3	3	3	3	12
Group Fine	53.78%	77.67%	51.97%	48.90%	58.08%
	(40.70)	(39.50)	(39.13)	(21.91)	33.07%
	3	3	3	3	12

Means, Standard deviations, and number of observations.

TABLE 10
Number of Sessions in which Bankruptcy was observed, by Treatment

Contracts	Certainty		Uncertainty	
	First	Second	First	Second
Tax-Subsidy	0	1	1	0
Tax	0	1	1	0
Subsidy	0	0	0	0
Group Fine	0	1	0	1

TABLE 11
OLS

Full Sample:	Number of obs	R-squared	Root MSE	Adj R-squared	
	48	0.42	107.86	0.15	
Source	Partial SS	df	MS	F	Prob >F
Model	274546.47	15	18303.10	1.57	0.14
Treatment	204797.36	3	68265.79	5.87	0.0026
Uncertainty	1246.03	1	1246.03	0.11	0.75
Order	10105.93	1	10105.93	0.87	0.36
Interactions					
Treatment Uncertainty	16054.06	3	5351.35	0.46	0.71
Treatment Order	1943.58	3	647.86	0.06	0.98
Uncertainty Order	8452.46	1	8452.46	0.73	0.40
Treatment Order Uncertainty	31947.06	3	10649.02	0.92	0.44
Residual	372270.15	32	11633.44		
Total	646816.614	47	13762.06		

Table 11
OLS Cont/.

Variable	Coefficient	Std. Error	t	P > |t|
Constant	163.4	62.41	2.62	0.01
Group Fine	217.8	88.26	2.47	0.02
Subsidy	130.15	88.26	1.48	0.15
Tax	8.23	88.26	0.09	0.93
Certainty	25.57	88.26	0.29	0.77
First	46.95	88.26	0.53	0.6
Group Fine & Certainty	-156.31	124.83	-1.24	0.22
Subsidy & Certainty	-86.64	124.83	-0.69	0.49
Tax & Certainty	-13.48	124.83	-0.11	0.92
Group Fine & First	-61.63	124.83	-0.49	0.63
Subsidy & First	-106.13	124.83	-0.85	0.4
Tax & First	-14.31	124.83	-0.12	0.91
Certainty & First	-77.48	124.83	-0.62	0.54
Group Fine, Certainty & First	199.69	176.53	1.13	0.27
Subsidy, Certainty & First	254.76	176.53	1.44	0.16
Tax, Certainty & First	71.11	176.53	0.4	0.69

TABLE 12
OLS for Tax Subsidy

Variable	Coefficient	Std. Error	t	P > |t|	N=12
Constant	164.64	28.28	5.822	0	F(2,9) = 0.41
Certainty	13.17	17.05	0.772	0.46	Prob>F = 0.673
Order	-8.21	17.05	-0.481	0.64	R^2 = 0.0842

TABLE 13
OLS for Tax

Variable	Coefficient	Std. Error	t	P > |t|	N = 12
Constant	220.49	20.11	10.96	0	F(2,9) = 3.22
Certainty	-8.91	12.13	-0.73	0.48	Prob>F = 0.088
Order	-29.45	12.13	-2.43	0.04	R^2 = 0.42

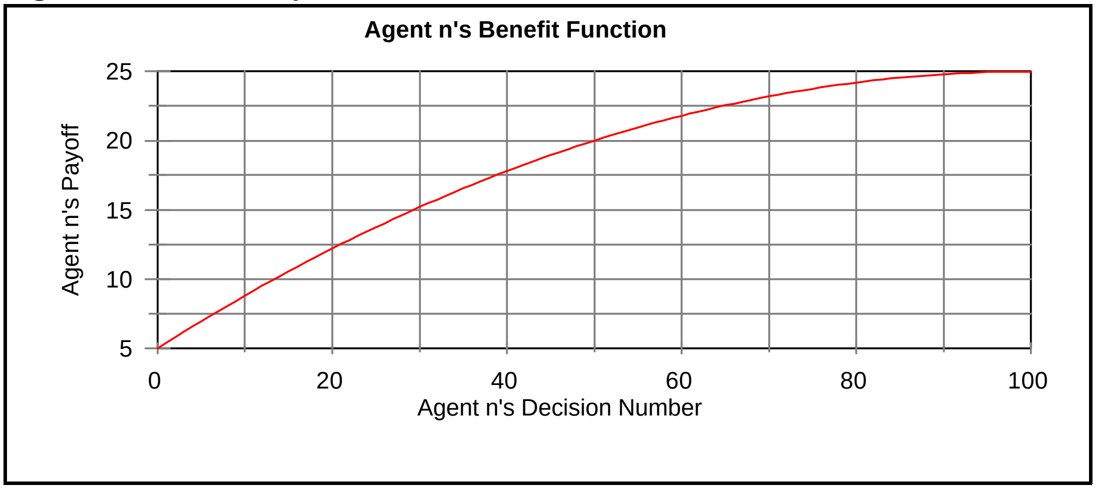
TABLE 14
OLS for Subsidy Contract

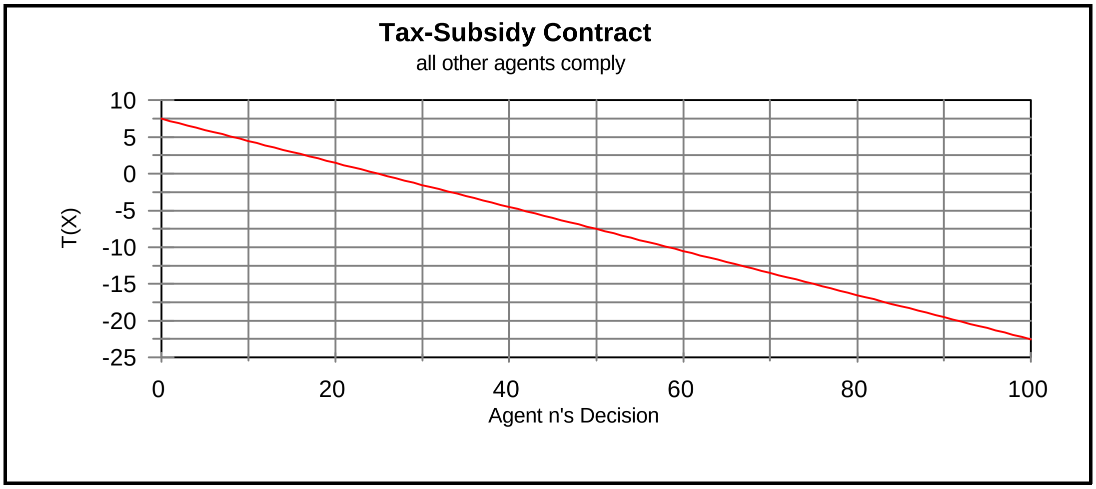
Variable	Coefficient	Std. Error	t	P > |t|	N = 12
Constant	333.83	134.14	2.49	0.04	F(2,9) = 0.12
Certainty	-27.57	80.89	-0.34	0.74	Prob>F = 0.88
Order	-29.45	80.89	-0.36	0.72	R^2 = 0.0269

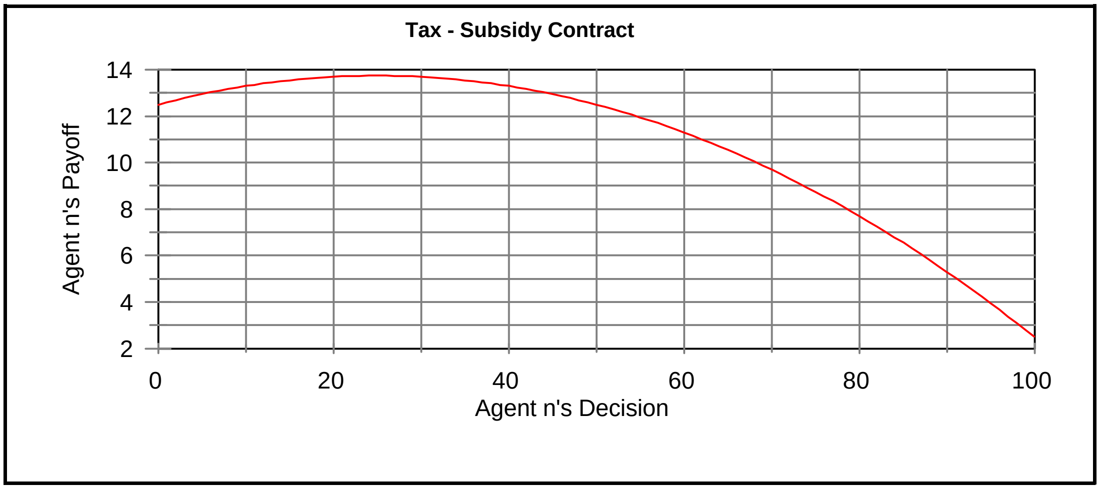
TABLE 15
OLS for Group Fine Contract

Variable	Coefficient	Std. Error	t	P > |t|	N = 12
Constant	257.92	151.3	1.7	0.12	F(2,9) = 0.42
Certainty	69.63	91.24	0.76	0.47	Prob>F = 0.67
Order	-46.43	91.24	-0.5	0.62	R^2 = 0.086

Figure 1: Tax-Subsidy Contract

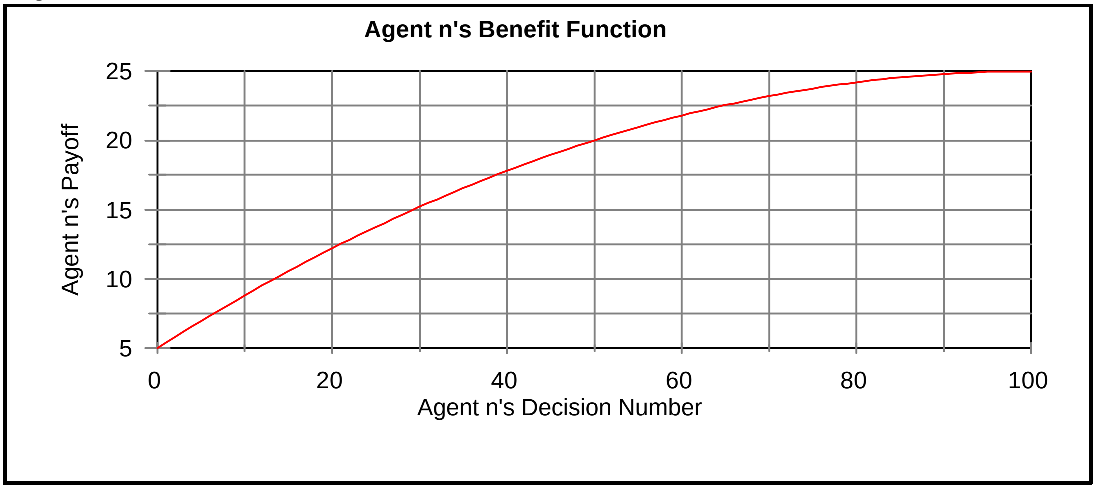


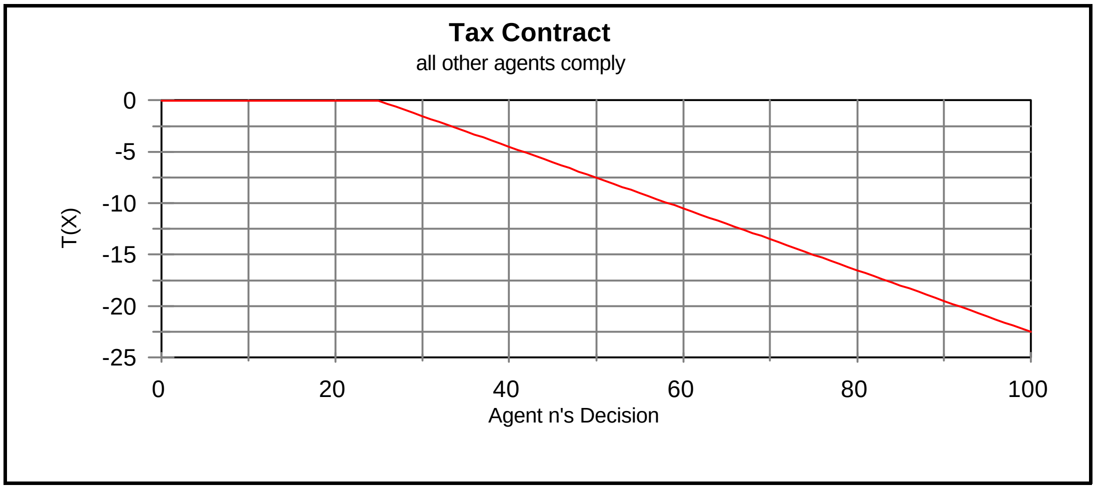


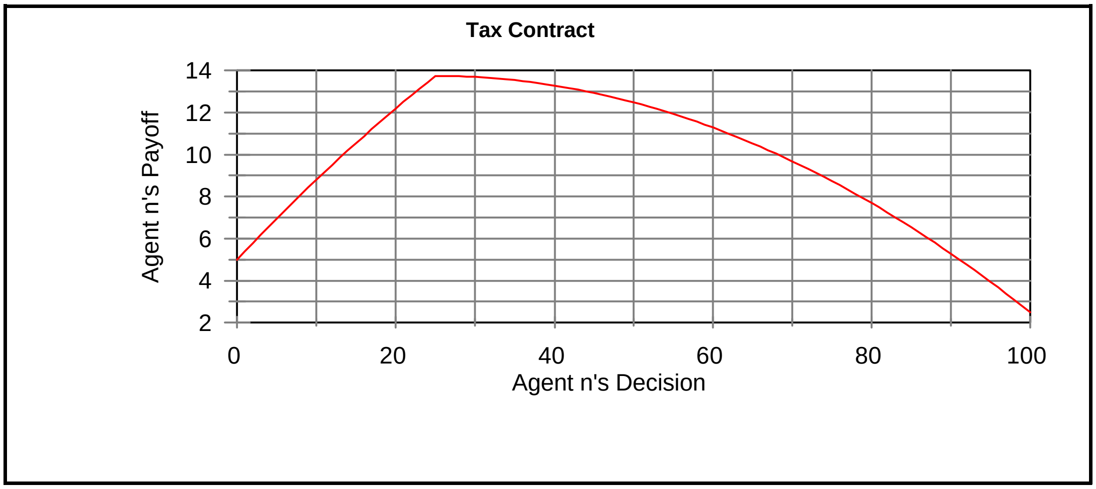


Assumes that all other agents comply

Figure 2: Tax Contract

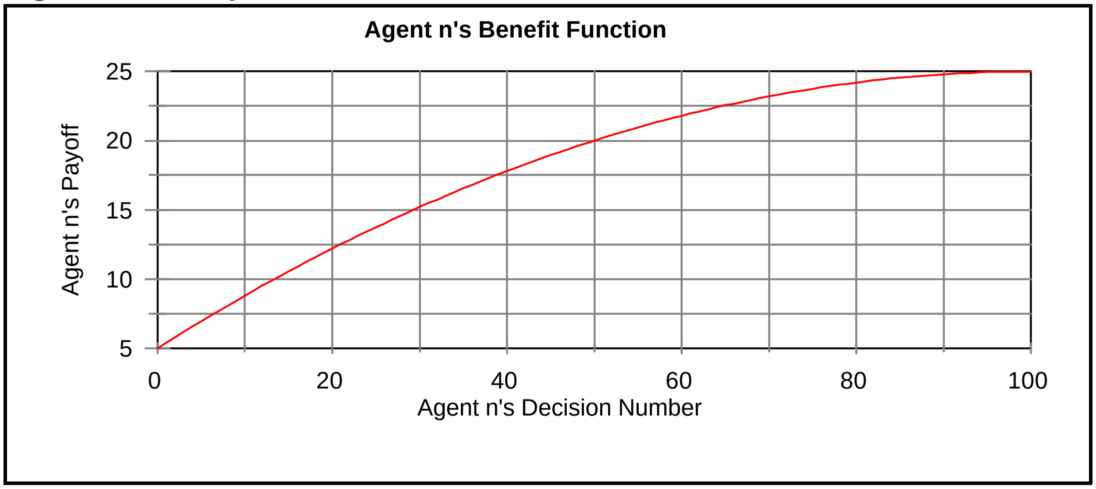


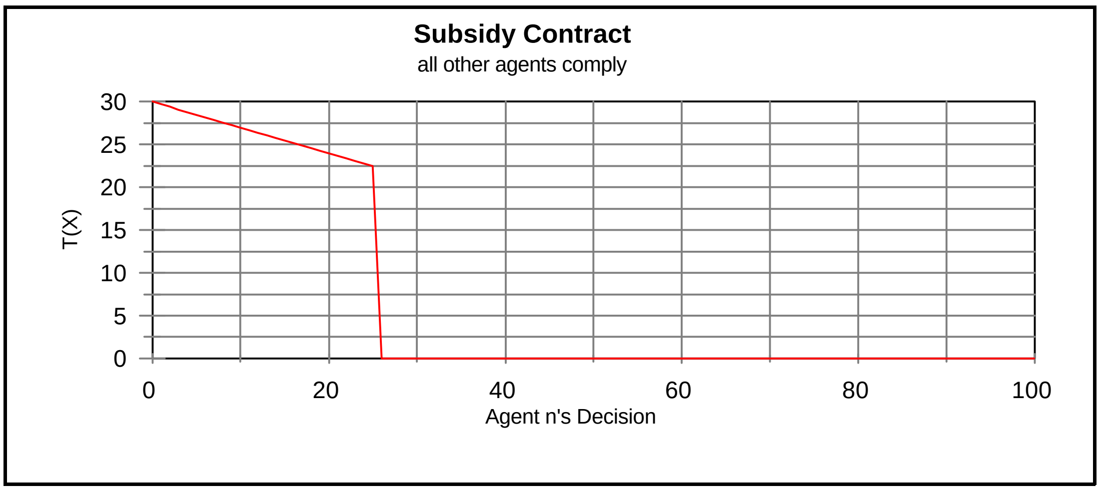


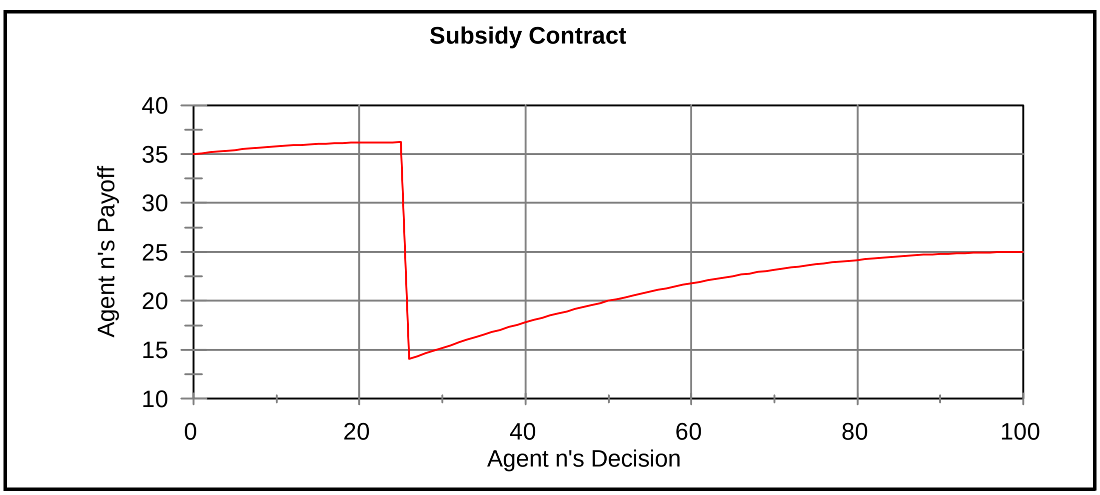


Assumes that all other agents comply

Figure 3: Subsidy Contract

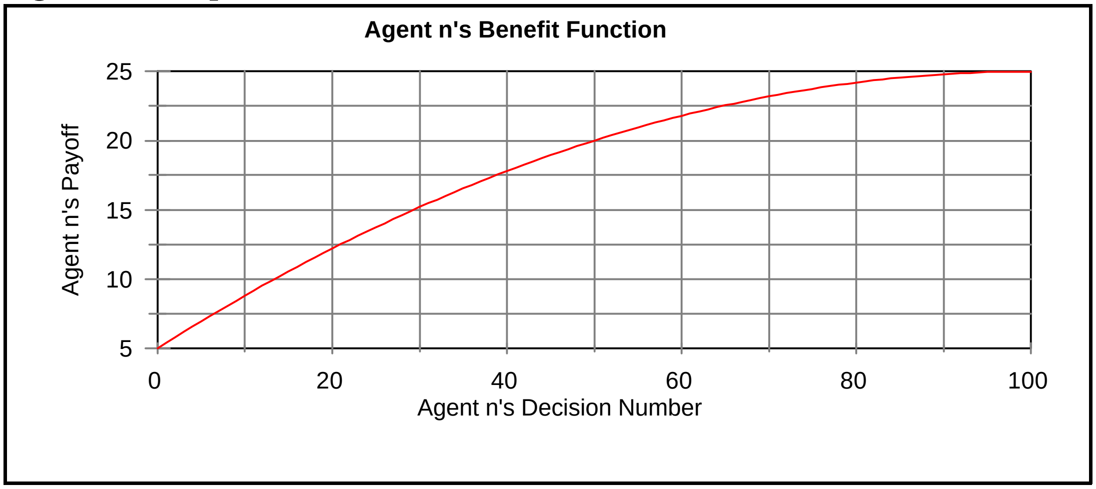


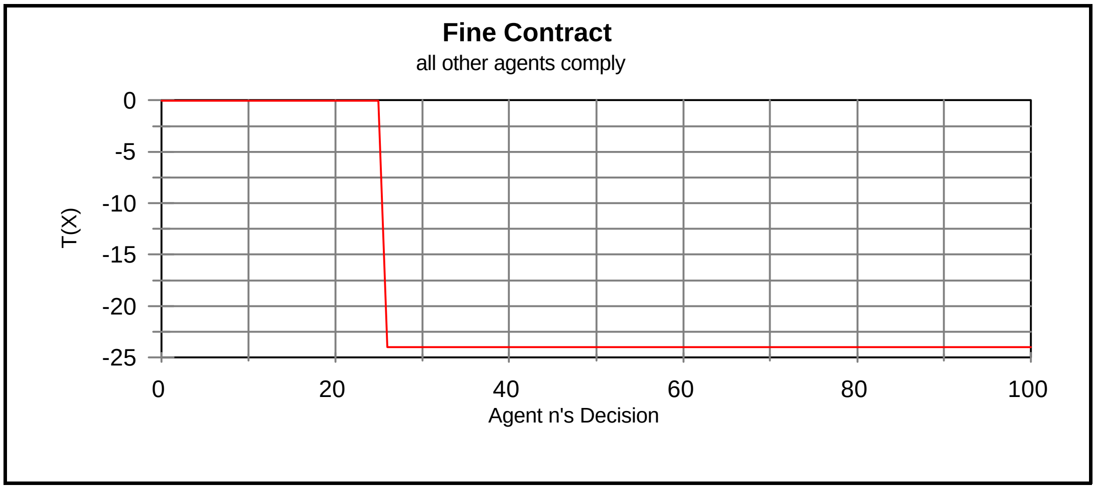


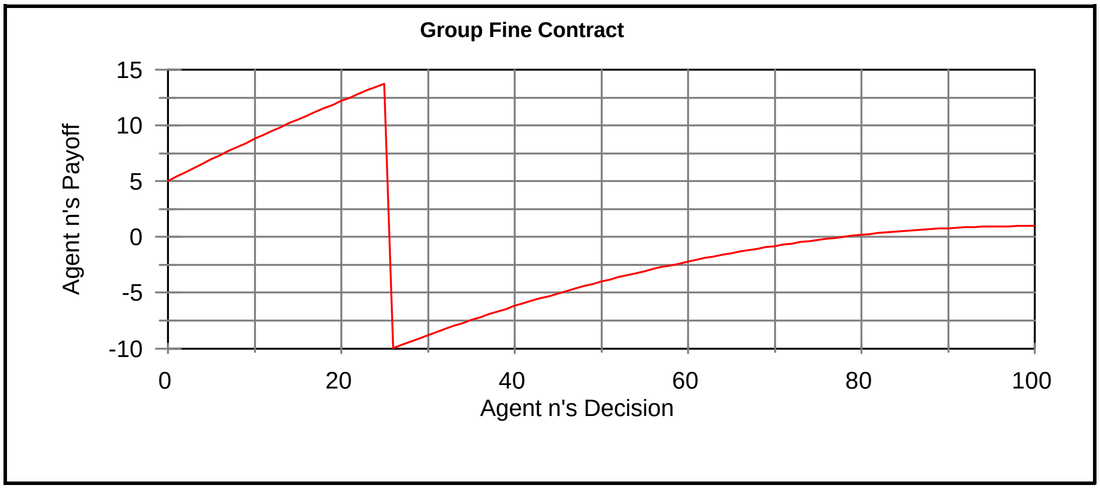


Assumes that all other agents comply

Figure 4: Group Fine Contract







Assumes that all other agents comply

Figure 5 : Tax-Subsidy Sessions

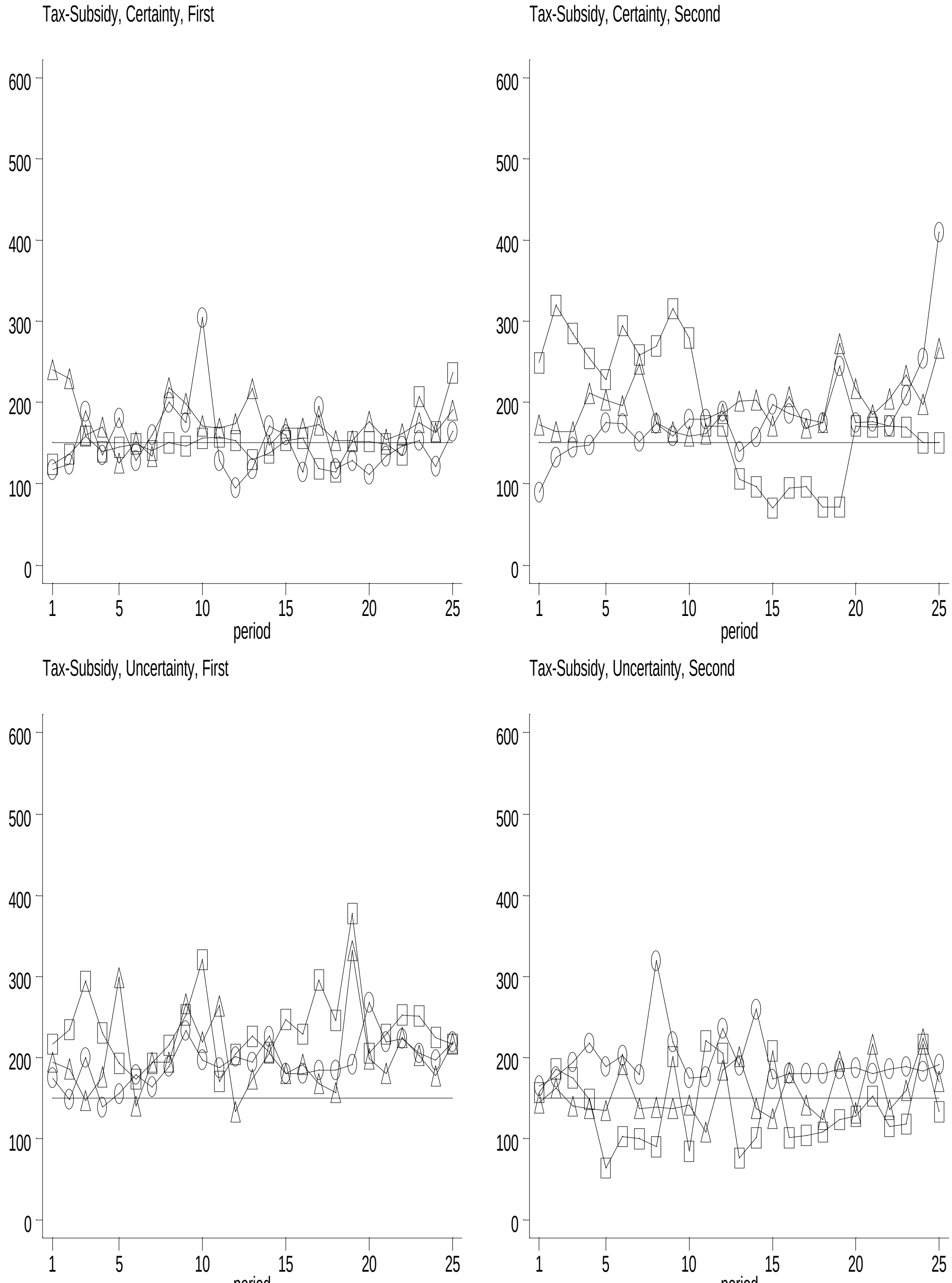


Figure 6: Tax Sessions

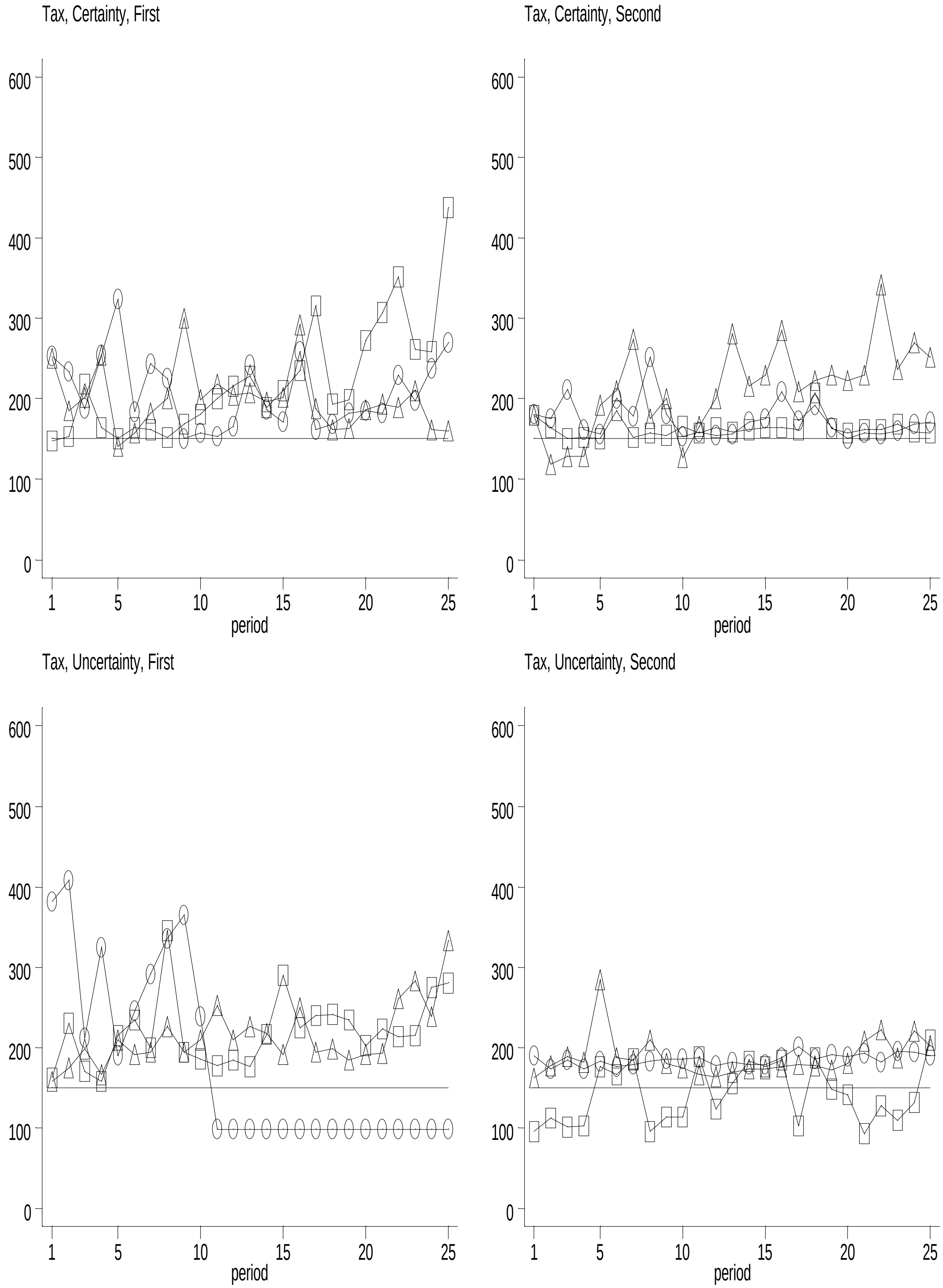


Figure 7: Subsidy Sessions

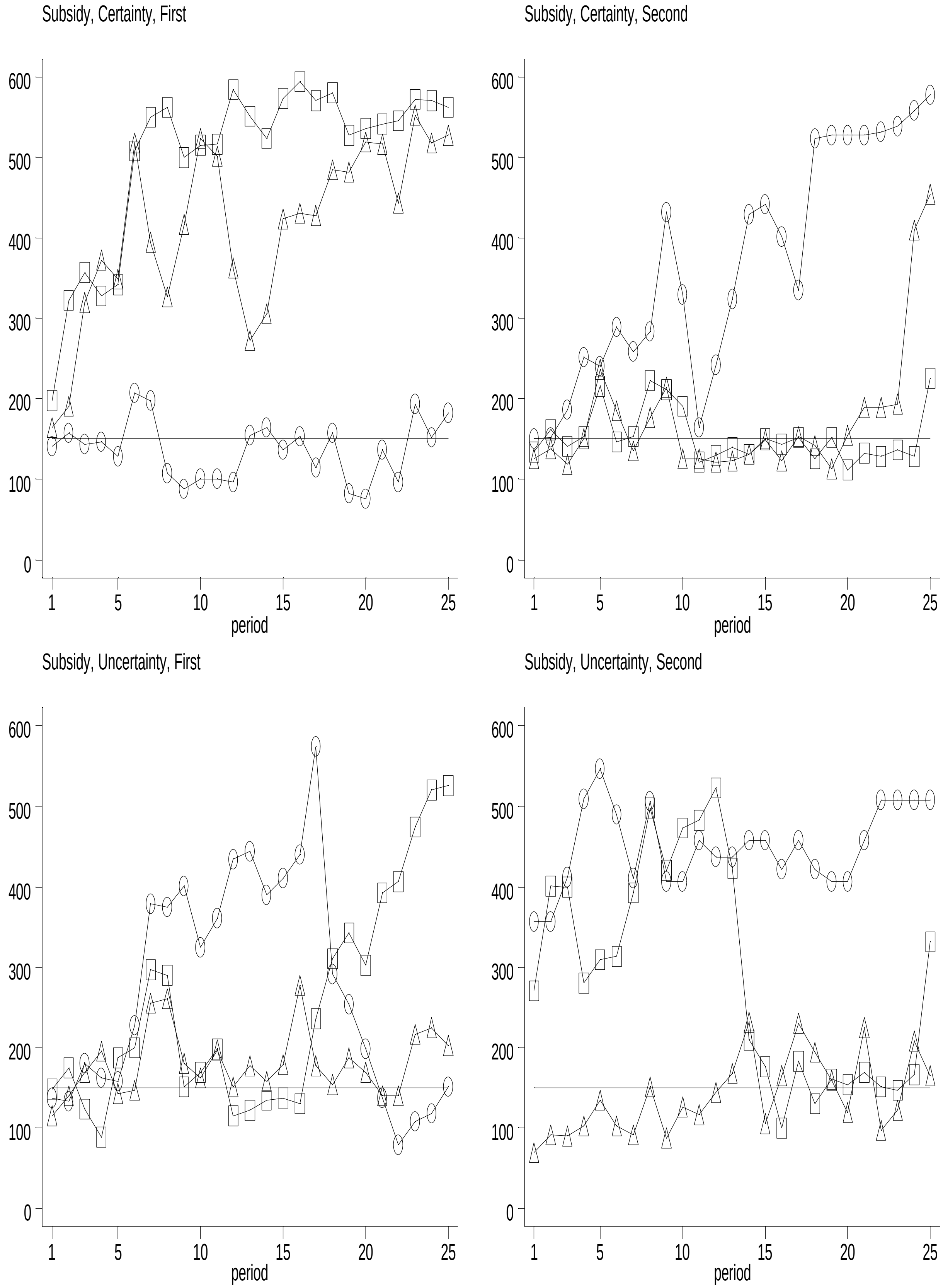


Figure 8: Group Fine Sessions

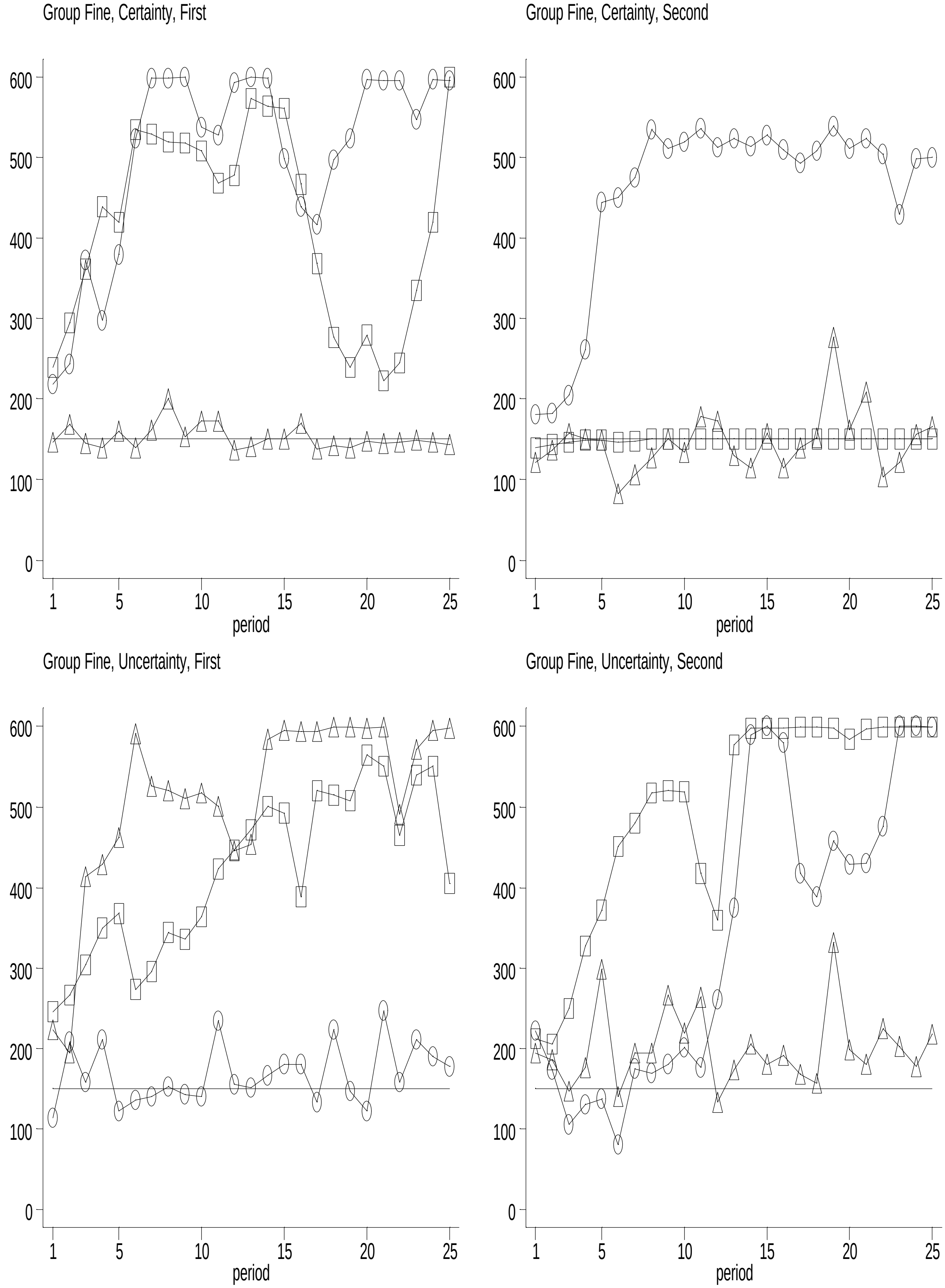


Figure 9

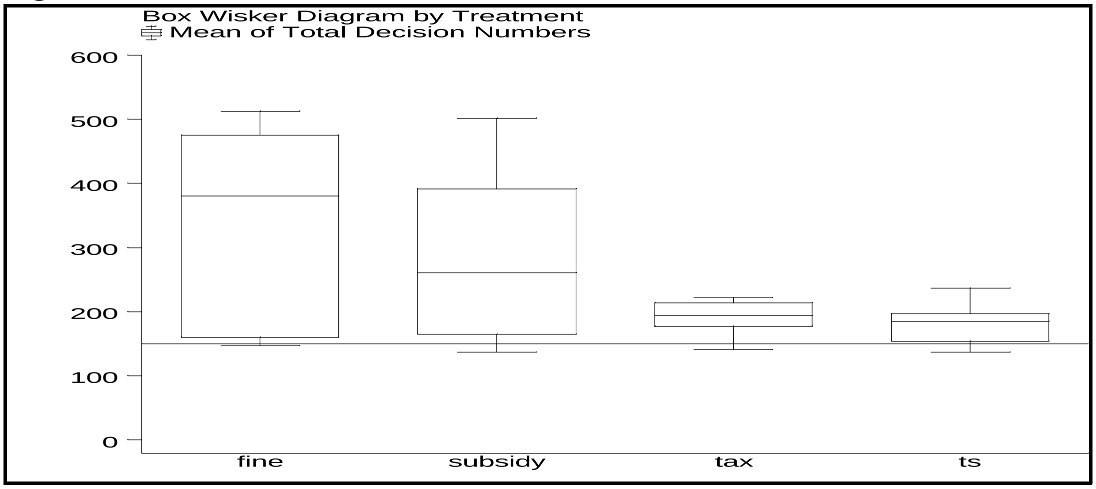


Figure 10 Certainty

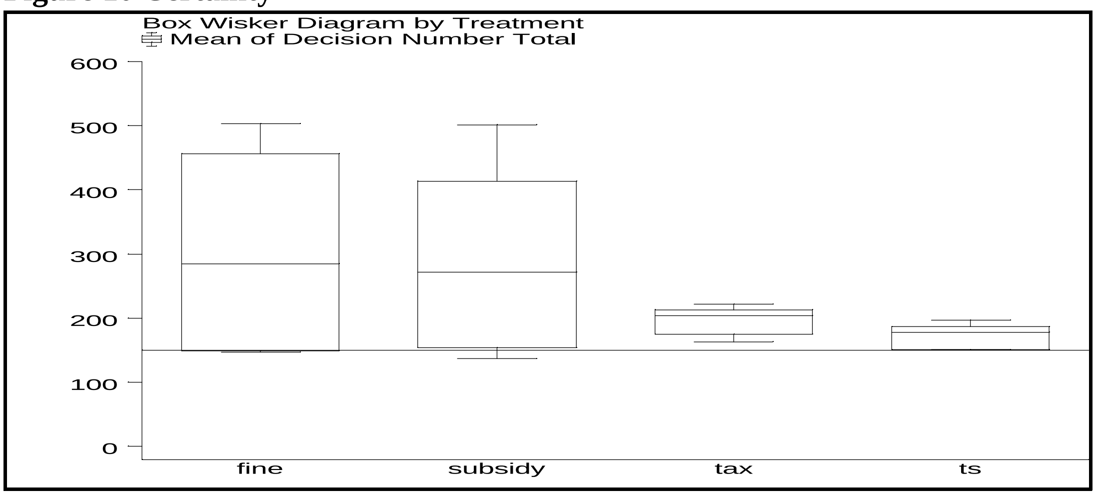


Figure 11 Uncertainty

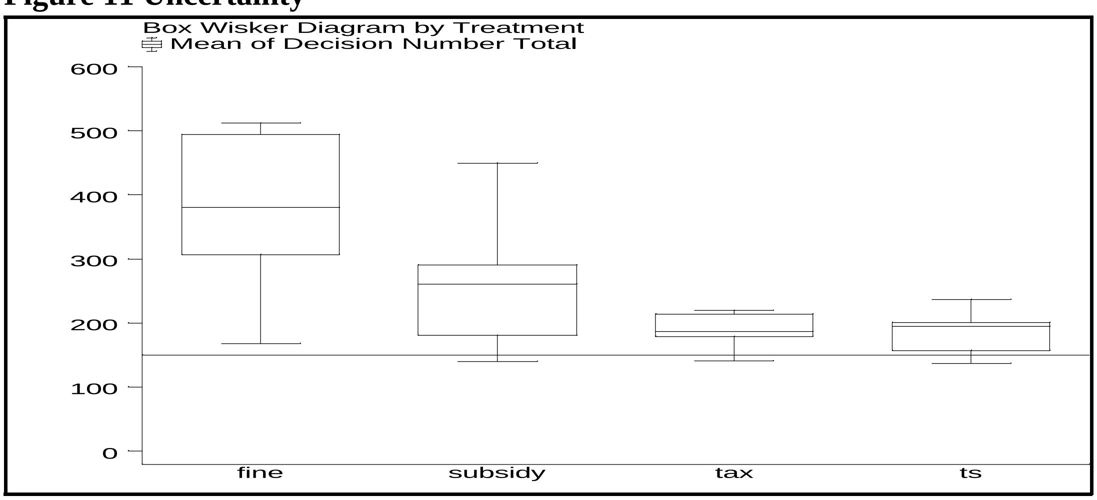


Figure 12 Certainty

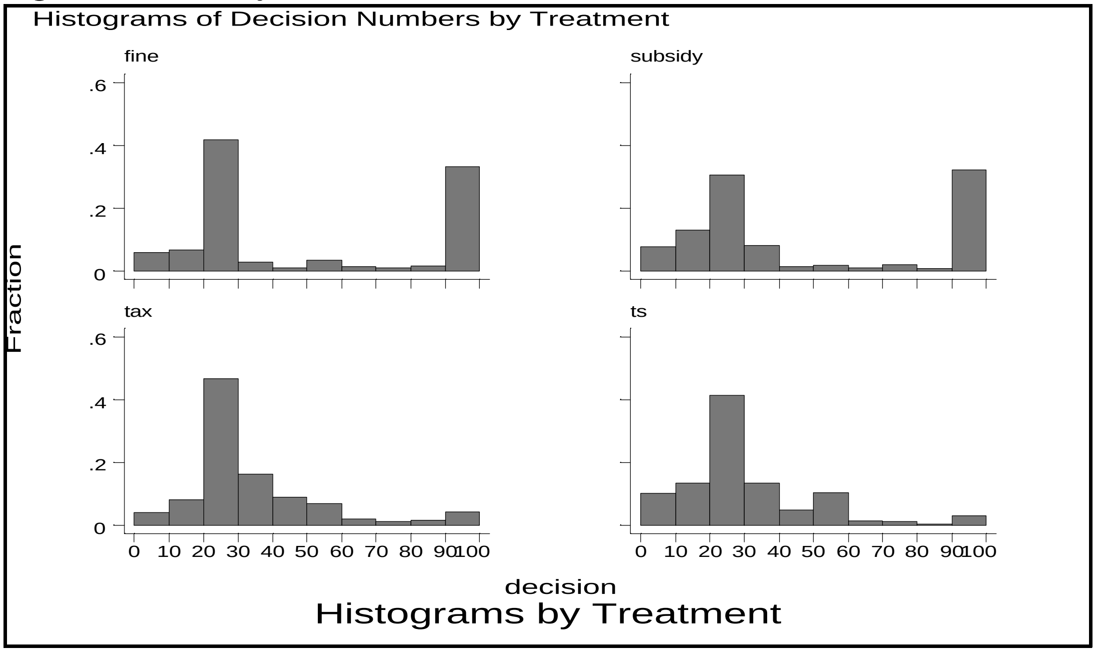
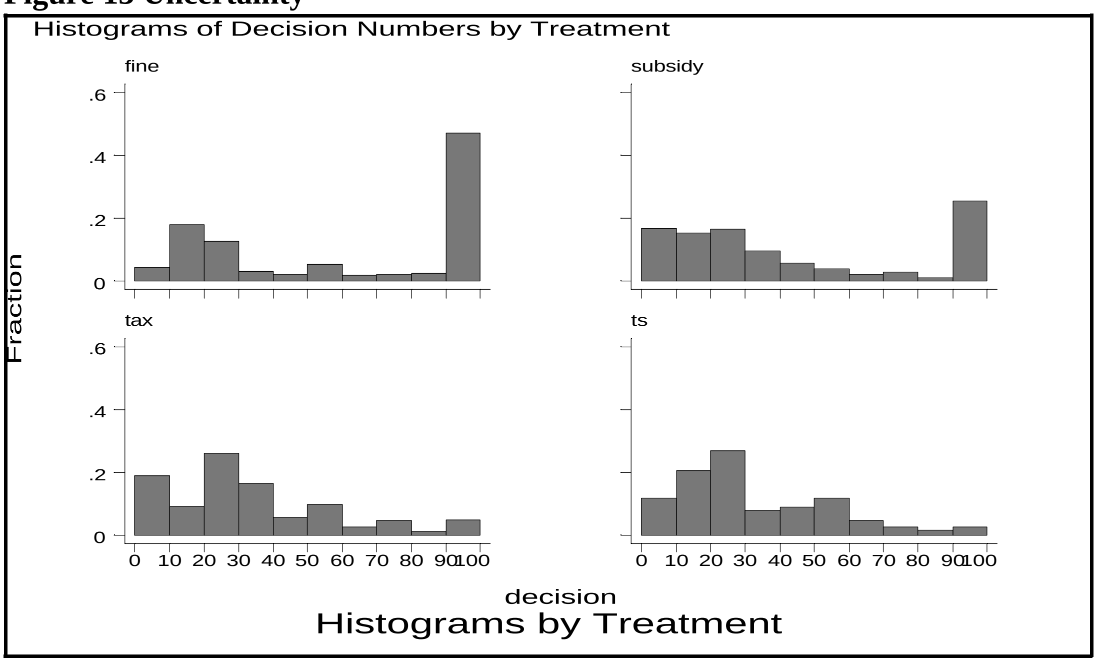


Figure 13 Uncertainty



Instructions

This is an experiment in the economics of decision making. During the experiment your payoffs will be reported in lab dollars. At the end of the experiment your total earnings in lab dollars will be converted to Canadian dollars and you will be paid in cash. If you follow the instructions carefully you may earn a considerable amount of money. This research has been funded by various agencies.

Before we begin the actual experiment please fill out the form labelled lotteries which will be found in your folder. For each choice please put an X in the column beside Option A or Option B. After today's session one of the choices will be selected at random, the lottery will be conducted and you will be paid depending on your choice and the outcome from the lottery. Once you have completed the form raise your hand and it will be collected.

Overview

Today's session will be conducted using the computer network located in our laboratory. The session will consist of 2 parts which will each last 25 periods. We will begin after everyone has finished reading the instructions and completed 5 practice periods. Please refrain from talking during the experiment. Each period will proceed as follows.

What the Computer does	**What you do**
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 section	

Now here are the details.

Part 1

You have been assigned to a group of six (yourself and five other) participants. This will be your group for the entire experiment. Everyone in your group has the same instructions. This part will consist of 25 periods. In each period you (and the others in your group) will be asked to choose a number between 0 and 100 and to 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:

Total Payoff = Private Payoff + Group Payoff

Your Private Payoff depends only on your own Decision Number. Table 1 in your folder shows the Private Payoff for each possible Decision Number. For example if your Decision Number were 60 Table 1 shows that your Private Payoff would be 21.80 lab dollars. Or if you had chosen 30 your Private Payoff would be 15.20 lab dollars. Notice that the higher your Decision Number the higher your Private Payoff.

The Group Payoff depends only on the Group Total and is the same for everyone in the group. If the Group Total is greater than 150 then the Group Payoff will be zero. If the Group Total is less than or equal to 150, the Group Payoff is a positive value equal to 30% of the difference between 150 and the Group Total, plus 22.50. The Group Payoff can be written as the following function of the Group Total:

$$\text{Group Payoff} = \begin{cases} 0 & \text{if Group Total} > 150 \\ 0.3*(\ 150 - \text{Group Total}\ ) + 22.50 & \text{if Group Total} \leq 150 \end{cases}$$

For example if the Group Total were 130 then the Group Payoff for every member of the group would be 0.3*(150-130) + 22.50 = 28.50 lab dollars. Similarly if the Group total were 100 then the Group Payoff for every member of the group would be 0.3*(150 -100) + 22.50 = 37.50 lab dollars. Notice that the lower the Group Total is below 150 the more positive (higher) the Group Payoff.

As a simple example, suppose that you chose 60, everyone else in your group chose 20. The Group Total would be 160 (the sum of your decision number and the decision numbers of everyone else in your group), your Private Payoff would be 21.80, the Group Payoff would be Zero, and your Total Payoff would be 21.80 lab dollars.

Now suppose, that you had chosen 30 in the above example. The Group Total would be 130, your Private Payoff 15.20, the Group Payoff would be 28.50, and your Total Payoff would be 43.70 lab dollars. Notice that the higher your Decision Number the higher your Private Payoff. But, the higher your Decision Number the higher the Group Total and the lower the Group Payoff.

Your payment for this part of the experiment will be the sum of your earnings in each of the 25 periods. Your earnings for this part will be converted from lab dollars to Canadian at the rate of 0.017 Canadian dollars per Lab dollar (each lab dollar is worth 1.7 cents Canadian).

Please answer the following question:

Use table 1 to fill in the portion of the record sheet below assuming that you chose 75, the group total was 125 and the group payoff is 30% of the difference between 150 and the group total plus 22.50 if the group total is below 150 and zero otherwise.

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. The practice periods will differ from the actual periods in that the Group Total will be your decision number plus a random number chosen by the computer. The Group Total in the practice periods will be your decision number plus a random number between 0 and 500. This random number is chosen by the computer so that each number between and including 0 and 500 has an equal chance of being selected.

Once the first practice period starts you will notice that the game window on the computer screen has four sections. The first section describes the Group Payoff function. This function is the same as described in the instructions above. The second section is labelled Scratch Pad. Using the Scratch Pad, you will be able to determine your payoff from different combinations of values for your Decision Number and the Group Total. Notice that you can change the Decision Number and the Group Total by typing numbers into the edit boxes or by using the arrow buttons located beside the edit boxes. Also notice that changing the Decision Number changes the Group Total. This is because the Group Total is the sum of your Decision Number, the Decision Numbers of those in your group and the random number and as a result when your Decision Number increases so does the Group Total. The third section of the screen is where you type your Decision Number. Once you have chosen your Decision Number and typed it into the edit box click on the Ok button to complete this part of the period. The fourth section of the screen contains two tabs which allow you to switch between the main screen and the history screen. If you click on the tab labelled history you will be able to see the outcome of all of the previous period in which you have participated. Please feel free to raise your hand and ask any questions you may have.

To help you understand the Scratch Pad please pick any number between 0 and 100 and type it into the box beside Your Decision Number on the scratch pad. 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.

Once the practice periods have been completed we will begin the 25 periods for which you will be paid at the end of today's session.

Part 2 - Instructions

This phase of the experiment will also consist of 25 periods. You (and everyone else) are in the same group as you were before. The only difference from the previous section is in how the Group Payoff is calculated. Once this part begins you will notice that you have an opening balance of 250 lab dollars. If you should lose your opening balance you will receive no payment for this part of the experiment.

As before, in each period you (and the others in your group) will be asked to enter a number between 0 and 100 on your computer screen. This is your **Decision Number**.

Your Total Payoff for the period is the sum of a Private Payoff and a Group Payoff:

Total Payoff = Private Payoff + Group Payoff

Your Private Payoff is determined by Table 1 as before. For example if your Decision Number were 60 Table 1 shows that your private payoff would be 21.80 lab dollars. Or if you had chosen 30 your Private Payoff would be 15.20 lab dollars. Notice that the higher your Decision Number the higher your Private Payoff.

The Group Payoff depends only on the Group Total and is the same for everyone in the group. If the Group Total is less than or equal to 150 then the Group Payoff will be zero. If the Group Total is greater than 150, the Group Payoff is -24. The Group Payoff can be written as the following function of the Group Total:

$$\text{Group Payoff} = \begin{cases} -24 & \text{if Group Total} > 150 \\ 0 & \text{if Group Total} \leq 150 \end{cases}$$

For example if the Group Total were 200 then the Group Payoff for every member of the group would be -24 lab dollars. Whereas, if the Group Total were 100 then the Group Payoff for every member of the group would be 0 lab dollars.

As a simple example, suppose that you chose 60 and everyone else in your group chose 20. The Group Total would be 160 (the sum of your decision number and the decision numbers of everyone else in your group), your Private Payoff would be 21.80, the Group Payoff would be -24, and your Total Payoff would be -2.20 lab dollars.

Now suppose, that you had chosen 30 in the above example. The Group Total would be 130, your Private Payoff 15.20, the Group Payoff would be 0, and your Total Payoff would be 15.20 lab dollars. Notice that the higher your Decision Number the higher your Private Payoff. But, the higher your Decision Number the higher the Group Total and the lower the Group 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 0.025 Canadian dollars per Lab dollar (each lab dollar is worth 2 ½ cents Canadian). In the event that you do lose your opening balance you will be informed by the computer that you are Bankrupt and will not be able to participate in the rest of this part of the experiment. At this point the rest of the people in your group will be informed that there is now one less person whose decision number is being added into the group total.

Please answer the following question:

Use table 1 to fill in the portion of the record sheet below assuming that you chose 75, the group total was 125 and the group payoff is -24 if the group total is above 150 and zero otherwise.

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.

TABLE 1: Private Payoff Schedule

Choice	Private Payoff
0	5.00
1	5.40
2	5.79
3	6.18
4	6.57
5	6.95
6	7.33
7	7.70
8	8.07
9	8.44
10	8.80
11	9.16
12	9.51
13	9.86
14	10.21
15	10.55
16	10.89
17	11.22
18	11.55
19	11.88
20	12.20
21	12.52
22	12.83
23	13.14
24	13.45
25	13.75
26	14.05
27	14.34
28	14.63
29	14.92
30	15.20
31	15.48
32	15.75
33	16.02
34	16.29
35	16.55
36	16.81
37	17.06
38	17.31
39	17.56
40	17.80
41	18.04
42	18.27
43	18.50
44	18.73
45	18.95
46	19.17
47	19.38
48	19.59
49	19.80
50	20.00

Choice	Private Payoff
51	20.20
52	20.39
53	20.58
54	20.77
55	20.95
56	21.13
57	21.30
58	21.47
59	21.64
60	21.80
61	21.96
62	22.11
63	22.26
64	22.41
65	22.55
66	22.69
67	22.82
68	22.95
69	23.08
70	23.20
71	23.32
72	23.43
73	23.54
74	23.65
75	23.75
76	23.85
77	23.94
78	24.03
79	24.12
80	24.20
81	24.28
82	24.35
83	24.42
84	24.49
85	24.55
86	24.61
87	24.66
88	24.71
89	24.76
90	24.80
91	24.84
92	24.87
93	24.90
94	24.93
95	24.95
96	24.97
97	24.98
98	24.99
99	25.00
100	25.00

Lotteries   Participant Number: ________

For Each of the following nineteen choices put an X in the column following either Option A or B. One of the choices will be selected at random and the lottery to determine your payment will be conducted at the end of the experiment. At the end of the experiment the 19 balls numbered 1 through 19 will be placed in the lottery game. The first ball selected by the machine will determine which option will determine your payoff. Then 20 balls numbered 1 through 20 will be placed in the machine and another ball will be selected to determine the outcome of the lottery in option B.

Choice	Option A		Option B	
1	$5 for sure		$10 if the number is greater than 1 (95% chance) versus $0 if the number is 1 (5% chance)	
2	$5 for sure		$10 if the number is greater than 2 (90% chance) versus $0 if the number is 2 or less (10% chance)	
3	$5 for sure		$10 if the number is greater than 3 (85% chance) versus $0 if the number is 3 or less (15% chance)	
4	$5 for sure		$10 if the number is greater than 4 (80% chance) versus $0 if the number is 4 or less (20% chance)	
5	$5 for sure		$10 if the number is greater than 5 (75% chance) versus $0 if the number is 5 or less (25% chance)	
6	$5 for sure		$10 if the number is greater than 6 (70% chance) versus $0 if the number is 6 or less (30% chance)	
7	$5 for sure		$10 if the number is greater than 7 (65% chance) versus $0 if the number is 7 or less (35% chance)	
8	$5 for sure		$10 if the number is greater than 8 (60% chance) versus $0 if the number is 8 or less (40% chance)	
9	$5 for sure		$10 if the number is greater than 9 (55% chance) versus $0 if the number is 9 or less (45% chance)	
10	$5 for sure		$10 if the number is greater than 10 (50% chance) versus $0 if the number is 10 or less (50% chance)	
11	$5 for sure		$10 if the number is greater than 11 (45% chance) versus $0 if the number is 11 or less (55% chance)	
12	$5 for sure		$10 if the number is greater than 12 (40% chance) versus $0 if the number is 12 or less (60% chance)	
13	$5 for sure		$10 if the number is greater than 13 (35% chance) versus $0 if the number is 13 or less (65% chance)	

14	$5 for sure		$10 if the number is greater than 14 (30% chance) versus $0 if the number is 14 or less (70% chance)	
15	$5 for sure		$10 if the number is greater than 15 (25% chance) versus $0 if the number is 15 or less (75% chance)	
16	$5 for sure		$10 if the number is greater than 16 (20% chance) versus $0 if the number is 16 or less (80% chance)	
17	$5 for sure		$10 if the number is greater than 17 (15% chance) versus $0 if the number is 17 or less (85% chance)	
18	$5 for sure		$10 if the number is greater than 18 (10% chance) versus $0 if the number is 18 or less (90% chance)	
19	$5 for sure		$10 if the number is greater than 19 (5% chance) versus $0 if the number is 19 or less (95% chance)	