Implementing a Lindahl Equilibrium With A Modified Tatonnement Mechanism: Some Preliminary Experimental Results*

by

Brian R. Binger
Purdue University

Elizabeth Hoffman
Purdue University

and

Arlington W. Williams
Indiana University

February 1985

Preliminary Draft: Please do not Quote

*Prepared for Presentation at the Public Choice Society Meetings, February 21-23, 1985, New Orleans, LA. Financial support from Eli Lilly and Company, the Purdue Research Foundation and the National Science Foundation is gratefully acknowledged.

I. Introduction

There has been considerable experimental work on private goods auction markets[1] and on incentive-compatible public goods allocation mechanisms.[2] But, with one exception (Joyce, 1984), there has been no experimental work on classical tatonnement mechanisms of any kind.[3] This is despite the fact that most theoretical work on markets assumes such a mechanism.

This paper reports preliminary experimental results on implementing a tatonnement mechanism for allocating public goods (Binger and Hoffman, 1985). The experiments are conducted on the PLATO interactive computer system, which acts as both the auctioneer and the passive medium of information transfer and display. In addition, we discuss strategies and problems regarding the design and implementation of computerized versions of such mechanisms.

bee Hoffman and Spitzer (1985), Plott (1982), Smith (1982), and Wilde (1981) for surveys of that literature.

See Plott (1979) tor a review of the literature up to 1979. More recent work includes Coursey and Smith (1982); Ferejohn, Forsythe, Noll, and Palfrey (1980); Isaac, McCue, and Plott (1980, 1982); Isaac, Walker, and Thomas (1984); Kim, Walker, and Dawes (forthcoming); Schneider and Poaaerehne (1981); and Smith (1980).

The PBS Station Cooperative (Ferejohn, Forsythe, and Noll, 1979 a,b) might also be categorized as a tatonnement mechanism; and Smith, Williams, Bratton, and Vannoni (1982) looked at "tatonnement" voting versions of sealed bid auctions.

II. The Mechanism

The mechanism, which is fully developed in Binger and Hoffman (1985), is basically a modified Lindahl mechanism (Lindahl, 1958; and Malinvaud, 1971) that significantly reduces the Lindahl mechanism's incentive to misrepresent. It does that by using lump-sum taxes and transfers and an adjustment mechanism with properties similar to demand-revealing mechanisms, such as those developed by Groves and Ledyard (1977) and Tideman and Tullock (1976).

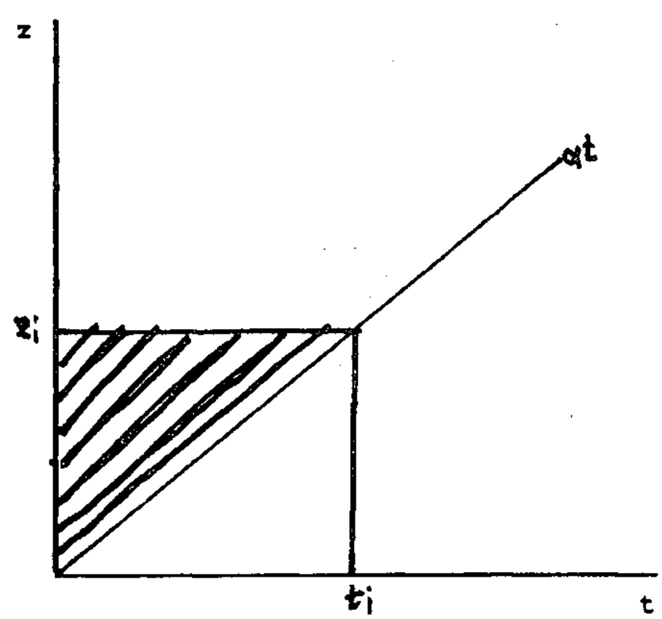
At each iteration of the mechanism, the auctioneer sends each participant (i) a private message, telling him his personalized price for the public good (z_i) and a net personalized lump-sum tax or transfer (τ_i). The personalized prices always sum to the marginal cost of providing the public good and the net taxes and transfers always sum to zero. Given the messages received, each participant is asked to respond by proposing a quantity of the public good (Y_i). Choosing a quantity implies the participant will contribute ($z_i Y_i + \tau_i$) towards the group's purchase of the public good. The auctioneer then checks for a public goods equilibrium. At such an equilibrium all participants propose the same quantity of the public good and unanimously vote to accept the proposed allocation as final.

Assuming myopic utility maximization, an equilibrium will always be a Lindahl equilibrium (thus Pareto Optimal) and the budget will always balance. If the equilibrium condition is not satisfied, the auctioneer uses an indirect excess demand method for adjusting both the personalized prices and the net taxes and transfers. By using the responses of the other participants instead of the individual participant's responses, the mechanism significantly reduces the individual incentive to misrepresent demand for the public good.

The adjustment mechanism uses parameters which are initially chosen by the auctioneer and are then themselves adjusted at each iteration. First, there is a common parameter (α), which defines a linear function (αt), which goes through the origin. Each participant is then assigned a value for t along that function (t_i). The t_i's are defined so that each participant's personalized price (z_i) is equal to αt_i and the personalized prices sum to the marginal cost of providing the public good. Figure 1 illustrates the relationship between z_i and t_i: z_i is the value of the function αt at t_i.

Figure 1

The Relationship Between z_i and t_i



The lump-sum taxes and transfers are also constructed from α and the t_i's. Each participant receives a transfer or subsidy equal to the shaded area in Figure 1,

$$\frac{\alpha t_i^2}{2}.$$

and pays a tax (T_i), which is a function of the other participant's t's:

$$T_i = f(t_{)i(}),$$

Where the notation)i(means all participants other than i. The lump-sum taxes are constructed to add up to the subsidies so that the net taxes and transfers equal zero:

$$\sum_{i=1}^{n} T_i - \sum_{i=1}^{n} \frac{\alpha t_i^2}{2} = 0.$$

For example:

$$T_i = \sum_{j \neq i} \frac{\alpha t_j^2}{2(n-1)}.$$

Summing over i:

$$\sum_{i=1}^{n} \sum_{j \neq i} \frac{\alpha t_j^2}{2(n-1)} = \frac{n-1}{n-1} \sum_{i=1}^{n} \frac{\alpha t_i^2}{2} = \sum_{i=1}^{n} \frac{\alpha t_i^2}{2}$$

Before outlining the adjustment process, we summarize the variables discussed above.

Let $i = 1,\ldots,n$ represent the consumers

α = linear schedule parameter

αt = linear schedule

t_i = i's quantity along the αt function

S_i = i's subsidy along the αt function

$$S_i = \frac{\alpha t_i^2}{2}$$

Y_i = i's proposed quantity of Y

p_y = marginal cost of Y

z_i = i's personalized price,

T_i = i's lump-sum tax based on the other participants' responses

$$T_i = \sum_{j \neq i} \frac{\alpha t_j^2}{2(n-1)}$$

$\tau_i = T_i - S_i$ = i's net tax and transfer

$C_i = z_i Y_i + \tau_i$ = i's contribution of a private (numeraire) good should Y_i be the group's choice

The adjustment mechanism uses an indirect excess demand method. At each iteration, after each participant has sent his Y_i message, the auctioneer calculates a variable (y_i) for each individual as the difference between Y_i and t_i:

$$y_i = Y_i - t_i$$

The excess demand method is that t_i is treated as a i's demand in a hypothetical auxiliary market and the sum of the other participants' y_j's is treated as the corresponding supply. An "equilibrium" in this hypothetical market would have:

$$t_i = \sum_{j \neq i} y_j, \quad \forall i.$$

i's demand = supply from $j \neq i$

This "equilibrium" constitutes a fixed point of the adjustment process and implies a public goods equilibrium as well. To see that, note that:

$$y_i = Y_i - \sum_{j \neq i} y_j, \quad \forall i$$

at a fixed point. Thus:

$$Y_i = \sum_{i=1}^{n} y_i = Y, \ \forall i.$$

There is also an equilibrium value for α consistent with the fixed point. By construction, the personalized prices always sum to p_y:

$$p_y = \sum_{i=1}^{n} z_i = \sum_{i=1}^{n} \alpha t_i = \alpha \sum_{i=1}^{n} \sum_{j \neq i} y_j = \alpha(n-1) \sum_{i=1}^{n} y_i$$

$$= \alpha(n-1)Y.$$

Therefore:

$$\alpha = \frac{p_y}{(n-1)Y} \text{ in equilibrium.}$$

If the responses do not generate such an equilibrium, the auctioneer adjusts personalized prices as a function of "excess demand" in the hypothetical auxiliary market and then normalizes so that they sum to the marginal cost of the public good.

$$z_i = \frac{\alpha[t_i + \gamma(t_i - \sum_{j \neq i} y_j)]}{\sum_{k=1}^{n} \{\alpha[t_k + \gamma(t_k - \sum_{r \neq k} y_r)]\}} p_y, \quad 0 < \gamma < 1$$

This formulation ensures that

$$p_y = \sum_{i=1}^{n} z_i.$$

The auctioneer also adjusts α as a function of the difference between the previous value and the value consistent with the average of the participant's Y_i responses.

$$\alpha' = \alpha + \delta\left[\alpha - \frac{p_y}{\frac{(n-1)}{n}\sum_{i=1}^{n} Y_i}\right], \quad 0 < \delta < 1$$

Next, the t_i's to be used to calculate the taxes and subsidies are defined so that $z_i = \alpha t_i$:

$$t_i' = \frac{z_i}{\alpha'}$$

Thus,

$$\sum_{i=1}^{n} \alpha' t_i' = p_y$$

These t_i's allow calculations of new T_i's, S_i's, and τ_i's:

$$T_i = \frac{\alpha'}{2(n-1)} \sum_{j \neq i} (t_j')^2$$

$$S_i = \frac{\alpha'(t_i')^2}{2}$$

$$\tau_i = T_i - S_i$$

In the next round, each participant chooses Y_i, conditional upon these new parameters:

$$Y_i = Y_i(\phi_i;\ z_i,\ \tau_i), \text{ where}$$

ϕ_i = a vector of behavioral parameters.

Choosing Y_i implies a contribution of:

$$C_i = z_i Y_i + \tau_i.$$

By induction, at each iteration m:

$$z_i^m = \frac{\alpha^{m-1}[t_i^{m-1} + \gamma(t_i^{m-1} - \sum_{j\neq i} y_j^m)]}{\sum_{k=1}^{n} (\alpha^{m-1}[t_k^{m-1} + \gamma(t_k^{m-1} - \sum_{r\neq k} y_r^m)])}$$

$$\alpha^m = \alpha^{m-1} + \delta\left[\alpha^{m-1} - \frac{p_y}{\frac{(n-1)}{n}\sum_{i=1}^{n} Y_i^{m-1}}\right]$$

$$t_i^m = \frac{z_i^m}{\alpha^m}$$

$$T_i^m = \frac{\alpha^m}{2(n-1)} \sum_{j\neq i} (t_j^m)^2$$

$$S_i^m = \frac{\alpha^m (t_i^m)^2}{2}$$

$$\tau_i^m = T_i^m - S_i^m$$

$$Y_i^m = Y_i(\phi_i;\ z^{m-1},\ \tau_i^{m-1})$$

$$C_i^m = z_i^m Y_i^m + \tau_i^m$$

The equilibrium conditions are:

$$Y_1^m = \ldots = Y_n^m$$

$$t_i^{m-1} = \sum_{j\neq i} y_j^m, \quad \forall i,$$

where,

$y_i^m = Y_i^m - t_i^{m-1}$ = i's hypothetical supply

t_i^{m-1} = i's hypothetical demand

The process continues until a fixed point is reached according to some convergence criterion.

The auctioneer begins this process by choosing an arbitrary common value for Y, equal to Y^0. Initialized values for the other parameters are then calculated from Y^0. The initialization is constructed to be consistent with the equilibrium conditions, in case the auctioneer happens to choose an equilibrium Y as Y^0. The initialized values of the parameters are constructed as follows:

Y^0 = an arbitrary common initial value for Y

$$\alpha^0 = \frac{p_y}{(n-1)Y^0}$$

$$z_i^0 = \frac{p_y}{n}$$

$$t_i^0 = \frac{z_i^0}{\alpha^0}$$

$$S_i^0 = \frac{\alpha^0 (t_i^0)^2}{2} .$$

$$T_i^0 = \frac{\alpha^0}{n-1} \sum_{j \neq i} \frac{(t_j^0)^2}{2} .$$

$$\tau_i^0 = T_i^0 - S_i^0 = 0$$

At the first iteration, each participant is sent the message $(z_i^0, 0)$ and asked to respond with Y_i^1. The mechanism then proceeds as described above.

III. Towards An Experimental Design

A. Step 1: Computer Simulation

Before doing experiments with human subjects, we first ran many computer simulations of the mechanism. First, we wanted to see if the mechanism would converge at all. Then, we developed a version in which responses were constrained to be integers. Our reasoning was that the mechanism was quite complicated and that the perceived level of task complexity would be reduced if responses were given in integers. Moreover, in both experimental implementations and naturally-occurring applications, the theoretically appealing assumption of strict continuity in the commodity space (and hence the message space for subject responses) would be difficult to maintain.

The computer program specified myopic maximization of either a Cobb-Douglas or some other CES utility function, choosing Y_i and a private good quantity (x_i) at each iteration. Each hypothetical participant was given an initial endowment of x_i, equal to x_i^0. Thus, at each iteration,

$$x_i = x_i^0 - z_i Y_i - \tau_i$$

For simplicity, the price ration, p_y/p_x was assumed to be 1.

Computer simulations of the adjustment process were absolutely necessary, prior to the design and implementation of an interactive version of the mechanism for experimental testing with human subjects.[4] Most importantly, discrete tâtonnement processes are known to be sensitive to the adjustment parameters (Hands, 1983). Ours was no exception, especially with the integer constraint on quantity. Thus, much simulation work was needed in order to find a set of adjustment parameters (δ and γ) for which convergence was relatively robust to changes in starting Y's and in utility parameters. We ended up making δ and γ functions of the number of itera-

----

[4] See Hoffman, Marsden, and Whinston (1984 and forthcoming) for general discussions of the role of computer simulation in experimental analysis.

tions. Y starts out small and increases, while δ starts out closer to 1 and decreases.[5]

Given the complexity of the mechanism, it was also clearly important to establish that it would generate a Lindahl equilibrium under the assumption of myopic maximization before incurring the expense of using human subjects. If computer simulations had not converged there would have been little hope for convergence with human subjects. For that reason, we began by simulating computable Cobb-Douglas equilibria.[6] We then moved to CES utility functions with different elasticities of substitution. For these we began with an equilibrium Y and solved for utility parameters and endowments plus net taxes consistent with that equilibrium.[7] Simulations were run for groups of 3 and 6 participants. We found our adjustment parameters to be generally robust for elasticities of substitution between .2 and 2 and for starting Y's from about one fourth to three times the equilibrium.[8]

----

[5] Copies of the FORTRAN computer program used for these simulations are available from Brian Binger on request.

[6] Binger and Hoffman (1985) computes equilibria for n people, identical Cobb-Douglas; 2 people, different Cobb-Douglas; and n people, different log-linear utility functions.

[7] Smith (1982) discusses induced valuation over two commodities. The basic techniques for two-commodity induced valuation are outlined in Williams, Smith, and Ledyard (1984).

[8] We also ran a simulation with the parameters used by Smith (1980) in the first PLATO public goods experiment. The mechanism converged to the Lindahl quantity in <u>one</u> iteration.

B. Step 2: Pilot Experiments With Human Subjects

Having established that the mechanism was generally robust under the assumption of myopic utility maximization, we utilized the PLATO computer resources at Indiana University to develop a fully computerized, terminal-interactive version for use with human subjects.[9] At each iteration, subjects are presented with a table showing the payoff, in "PLATO dollars", associated with various combinations of x and Y. The displayed Y values are always integers. Each subject is then asked to respond with a proposed integer quantity of Y. The conversion rate from PLATO dollars to U.S. dollars is given in the instructions and reiterated upon reaching a potential final allocation in the experiment.[10]

Figure 2 shows a sample screen display seen by a participant prior to entering a Y proposal in a decision-making round. The profit table is constructed by starting at zero units of Y and the initial endowment of the private good, x. The net lump-sum tax is automatically subtracted from the subject's endowment. Increments of Y_i are obtained by reducing x_i at the rate of z_i for each additional unit of Y. Payoffs (in PLATO dollars) are CES utility values corresponding to those quantities of x and Y.

At each iteration, subjects were presented with new payoff sheets, reflecting the adjusted personalized prices and lump-sum taxes and transfers. The adjustment mechanism was not explained to the subjects, but they

----

[9] A sample version of the experimental instructions is given in the appendix.

[10] See Forsythe, Palfrey, and Plott (1982) for a discussion of the use of artificial currencies in experimental markets.

Figure 2. Sample Screen Display and Profit Table

You are Agent 1. This is Round 1.

Good Y	Good X	Profit	Good Y	Good X	Profit	Good Y	Good X	Profit
0	55.1	$ 0.00	25	46.7	$309.15	50	38.4	$330.94
1	54.7	$ 87.68	26	46.4	$311.53	51	38.1	$330.64
2	54.4	$123.78	27	46.1	$313.74	52	37.7	$330.27
3	54.1	$149.09	28	45.7	$315.77	53	37.4	$329.84
4	53.7	$168.89	29	45.4	$317.65	54	37.1	$329.35
5	53.4	$185.20	30	45.1	$319.38	55	36.7	$328.79
6	53.1	$199.08	31	44.7	$320.97	56	36.4	$328.18
7	52.7	$211.13	32	44.4	$322.43	57	36.1	$327.50
8	52.4	$221.77	33	44.1	$323.75	58	35.7	$326.77
9	52.1	$231.26	34	43.7	$324.95	59	35.4	$325.99
10	51.7	$239.81	35	43.4	$326.04	60	35.1	$325.15
11	51.4	$247.55	36	43.1	$327.02	61	34.7	$324.25
12	51.1	$254.60	37	42.7	$327.88	62	34.4	$323.30
13	50.7	$261.05	38	42.4	$328.64	63	34.1	$322.30
14	50.4	$266.98	39	42.1	$329.31	64	33.7	$321.25
15	50.1	$272.44	40	41.7	$329.88	65	33.4	$320.15
16	49.7	$277.48	41	41.4	$330.35	66	33.1	$319.01
17	49.4	$282.14	42	41.1	$330.74	67	32.7	$317.81
18	49.1	$286.46	43	40.7	$331.04	68	32.4	$316.57
19	48.7	$290.47	44	40.4	$331.25	69	32.1	$315.27
20	48.4	$294.18	45	40.1	$331.39	70	31.7	$313.94
21	48.1	$297.64	46	39.7	$331.45	71	31.4	$312.56
22	47.7	$300.84	47	39.4	$331.43	72	31.1	$311.13
23	47.4	$303.82	48	39.1	$331.34	73	30.7	$309.66
24	47.1	$306.59	49	38.7	$331.17	74	30.4	$308.15

Enter your proposed size of Good Y >

(Press -ERASE- to correct typing errors.)

were told that their responses would not directly affect the adjustment of their own parameters.[11] The stopping rule of the mechanism was a unanimous vote on a unanimously proposed Y.

In our first pilot experiments we suggested no strategies to the subjects and gave them no information about the choices of the other participants. We wanted to see if subjects presented with no information would simply maximize myopically as assumed in the theory (Binger and Hoffman, 1985) and the computer simulations. Two difficulties emerged. First, subjects did not conclude on their own that myopic maximization would lead to an equilibriua. Second, having no information about the others' choices, they tried to randomly compromise instead of maximize. The results were somewhat frustrating for both subjects and experimenters.

Normally in experimental markets it is considered poor experimental technique to give subjects any coaching on appropriate behavior. This is because most experimental work is designed to provide greater understanding of some naturally-occurring institution. For that reason the experimenter seeks to make the experimental institution parallel to the naturally-occurring one.[12] Since participants in naturally-occurring institutions are given no coaching, information on appropriate strategies is withheld in the experimental laboratory.

The mechanism investigated in this research is not a naturally-

----

11 See Appendix, p. A12.

12 *See Hoffman, Marsden, and Whinston (1984 and forthcoming), Hoffman and Spitzer (1985), and Smith (1982). Smith (1982) formalized the idea. Psychologists use the term _external validity_ (Campbell and Stanley, 1966).

occurring one, however. Rather, it is a constructed one, to which participants would submit in hopes of reaching a better joint decision than they could reach without using it. For that reason, there is much to be gained from experimenting with the instructions to participants and with the mechanics of the institution itself. If informing the participants of the potential advantages of individual (myopic) maximization in the context of the mechanism facilitates the mechanism's operation, then there is no reason why it should not be employed. In the same vein, if telling participants what the others have chosen helps to reduce the frequency of random, nonmaximizing responses, then there is no compelling reason why they should not be told.

At one point we found that less information can facilitate the mechanism's operation also. At first (experiments 001 and 002) we were informing participants of their t_i's and z_i's. We found that the t_i's seemed to serve as focal points, encouraging participants to compromise on low quantities. With the profit tables in the experiment, the z_i's were simply extraneous information. In a naturally-occurring application, however, the z_i's would have to be displayed, since the auctioneer would not be displaying subject payoffs for each (x,Y) combination. Moreover, this difference between the experimental setting and a naturally-occurring application does not present a problem, since the operation of the mechanism does not require that the auctioneer have any information on the participants' utility or profit functions. On the other hand, the t_i's need never be displayed, since they are only used for adjustment of the parameters by the auctioneer.

In the next pilot experiment we informed participants what the others were responding at each iteration and we added a paragraph to the instructions, telling subjects that the mechanism was designed to take their most preferred choices to a mutually agreeable group agreement. These changes greatly facilitated convergence, but they also introduced a new difficulty. Subjects were likely to agree on a quantity (usually at or near the predicted quantity) before the hypothetical auxiliary markets had cleared. For example, in experiment 008, subjects agreed on 36 units of Y (34 was the predicted Y) after 16 rounds, but the auxiliary market-clearing conditions were never satisfied.

Given that they were choosing an equilibrium which was "close" to the predicted quantity, it seemed needlessly frustrating for the subjects to continue having to respond in order to satisfy all the equilibrium conditions. The only problem was that in the integer version the budget might not exactly balance if the auxiliary markets did not clear, even though the budget must always balance without that constraint. The third round of pilot experiments introduced a budget-balancing modification, which allowed the mechanism to stop as soon as the subjects agreed on a quantity, even if the auxiliary markets did not clear.

IV Pilot Experimental Results

Table 1 summarizes the experimental results referred to above. As you can see, when subjects are coached and kept apprised of one anothers' choices, they tend to choose the predicted quantity.

Table 1

Pilot Experimental Results

Exp. #	π(x,Y)	Lindahl Y	Actual Y	Final Round	Knew Others' Y Proposals?	Stressed Myopic π Max Strategy?	Vote on all Unanimous Y?
1. Three Subjects							
001	CD1[1]	60	52	29	yes	no	no
002	CD2	60	--	9	no	no	no
	chaos -- no sign of convergence, stopped after round 9						
002x	CD2	60	46	18	yes	yes(verbal)	no
003	CES1[2]	57	57	24	yes	no	no
004	CES1	57	--	18	no	no	no
	chaos -- no sign of convergence, stopped after round 18						
004x	CES1	57	57	18	no	yes[3,4]	no
005	CES2	41	41	37	no	yes[5]	no
006	CES2	41	41	20	yes	yes	no
007	CES3	34	42	20	yes	yes	no
008	CES3	34	--	50[6]	yes	yes	no
008x	CES3	34	34	13	yes	yes[4]	no
009	CES3	34	30	8	yes	yes+[7]	yes
010	CES3	34	34	26	yes	yes+	yes
2. Six Subjects							
010	CES4	50	49	15	yes	yes+	yes

[1] Refers to Cobb-Douglas utility function, version 1.

[2] Refers to CES utility function, version 1

[3] See Appendix, p. A11 for text.

[4] Stressed verbally also.

[5] Reiterated verbally after round 32.

[6] Subjects agreed on 36 units of Y after 16 rounds, but auxiliary markets never cleared.

[7] More emphasis given in instructions. See Appendix, p. 17.

V. Conclusions and Research Agenda

Implementing the tatonnement process for the allocation of public goods developed by Binger and Hoffman (1985) is shown to be feasible. In fact, in general, convergence is found to be reasonably rapid. Experimental testing of such a mechanism requires the use of novel experimental techniques, however. Prior computer simulation of the mechanism has been suggested (Hoffman, Marsden, and Whinston, 1984 and forthcoming), but this is the first[13] application as a tool for experimental design. The importance of the simulations for this experimental study may lead to their wider use in future experimental designs.

In addition, the instructions have not previously been used to suggest alternative behaviors to subjects in market experiments. While it would not be appropriate to coach subjects when a naturally-occurring institution is being studied experimentally, suggesting strategies to subjects should not be overlooked in future experimental studies of designed institutions.

Our current research plan is to continue with pilot experiments until the basic design seems generally robust and then run a set of identical replications of the final design. One of the next improvements we plan to make in the basic design is to change the utility functions and the function which converts PLATO dollars to U.S. dollars in order to get larger marginal payoffs in the neighborhood of each participant's profit-maximizing choice.

---

[13] In the pre-computer age, however, Chamberlin (1948) did use a form of simulation to design his original market experiments.

After that, we intend to run parallel experiments using a straight Lindahl mechanism (without the indirect adjustment process). Then, we plan to explore the issue of manipulation by sophisticated players. We might, for example, take experienced subjects and explain the operation of our mechanism and the straight Lindahl mechanism. Then we night have then try to successfully manipulate each mechanism. Other questions we plan to explore are the role of group size and whether the mechanism is robust if preferences are random or follow a known stochastic process.

Our end goal is to have a mechanism which has been thoroughly tested in the experimental laboratory. We envision that this mechanism might be used by a firm trying to get different divisions to agree on the size of a central computer system or by a group of firms who sell the same product and wish to share advertising or some other common expenses.

References

Brian R. Binger and Elizabeth Hoffman (1985), "A New Approach to the Efficient Allocation of Public Goods," Purdue University Xerox.

D.T. Campbell and J.C. Stanley (1966), Experimental and Quasi-Experimental Designs for Research.

Edward H. Chamberlin (1948), "An Experimental Imperfect Market," Journal of Political Economy 56:95.

Don L. Coursey and Vernon L. Smith (1982), "Experimental Tests of an Allocation Mechanism for Private, Public, or Externality Goods," University of Arizona Xerox.

John A. Ferejohn, Robert Forsythe, and Roger Noll (1979a), "An Experimental Analysis of Decision Making Procedures for Discrete Public Goods: A Case Study of a Problem in Institutional Design," in V.L. Smith (ed.) Research in Experimental Economics.

———————— (1979b), "Practical Aspects of the Construction of Decentralized Decision-Making Systems for Public Goods, in C. Russell (ed.) Collective Decision Making.

John A. Ferejohn, Robert Forsythe, Roger G. Noll, and Thomas R. Palfrey (1980), "An Experimental Examination of Auction Mechanisms for Discrete Public Goods," CALTECH Social Science Working Paper #262.

Robert Forsythe, Thomas R. Palfrey, and Charles R. Plott (1982), "Asset Valuation in an Experimental Market," Econometrica 50:537.

Groves, T. and Ledyard, J. (1977), "Optimal Allocation of Public Goods: A Solution to the Free Rider Problem," Econometrica, 45:783-810.

Douglas W. Hands (1983), "Stability in a Discrete Time Model of the Walrasian Tâtonnement," Journal of Economic Dynamics and Control 6:399-411.

Elizabeth Hoffman, James R. Marsden, and Andrew A. Whinston (1984), "Efficient Use of Economic Data," Purdue University Xerox.

———————— (forthcoming), "Laboratory Experimentation and Computer Simulation: An Introduction to the Use of Experimental and Process Model Data in Economic Analysis," in J. Kagel and L. Green (eds.) Advances in Behavioral Economics.

Elizabeth Hoffman and Matthew L. Spitzer (1985), "Experimental Law and Economics: An Introduction," Columbia Law Review, forthcoming.

R. Mark Isaac, Kenneth T. McCue, and Charles R. Plott (1980), "Nash Equilibrium in Public Goods Provision: Free Riding in Experimentally Controlled Markets," University of Arizona Xerox.

——————————— (1982), "Public Goods Provision in an Experimental Environment," CALTECH Social Science Working Paper #428.

R. Mark Isaac, James M. Walker, and Susan H. Thomas (1984), "Divergent Evidence on Free Riding: An Experimental Examination of Possible Explanations." Public Choice 43: 113-149.

Patrick Joyce (1984), "The Walrasian Tâtonnement Mechanism and Information, Rand Journal of Economics 15(3):416-425.

O. Kim, M. Walker, and W. Dawes (forthcoming), "The Free Rider Problem: Experimental Evidence," Public Choice.

Lindahl, E. (1958), "Just Taxation -- A Positive Solution," English trans. in R.A. Musgrave and A. Peacock (eds.), Classics in the Theory of Public Finance, (New York: St. Martins).

Malinvaud, E. (1971), "A Planning Approach to the Public Goods Problem," Swedish Journal of Economics, 73:96-112.

Charles R. Plott (1979), "The Application of Laboratory Experimental Methods to Public Choice," in C. Russell (ed.) Collective Decision Making.

——————— (1982), "Industrial Organization Theory and Experimental Economics," Journal of Economic Literature, 20:1485.

F. Schneider and W.W.Pommerehne (1981), "Free Riding and Collective Action: An Experiment in Public Microeconomics," Quarterly Journal of Economics, 689-704.

Vernon L. Smith (1980), "Experiments with a Decentralized Mechanism for Public Good Decisions, American Economic Review, 70:584.

——————— (1982), "Microeconomic Systems as an Experimental Science," American Economic Review, 72:923.

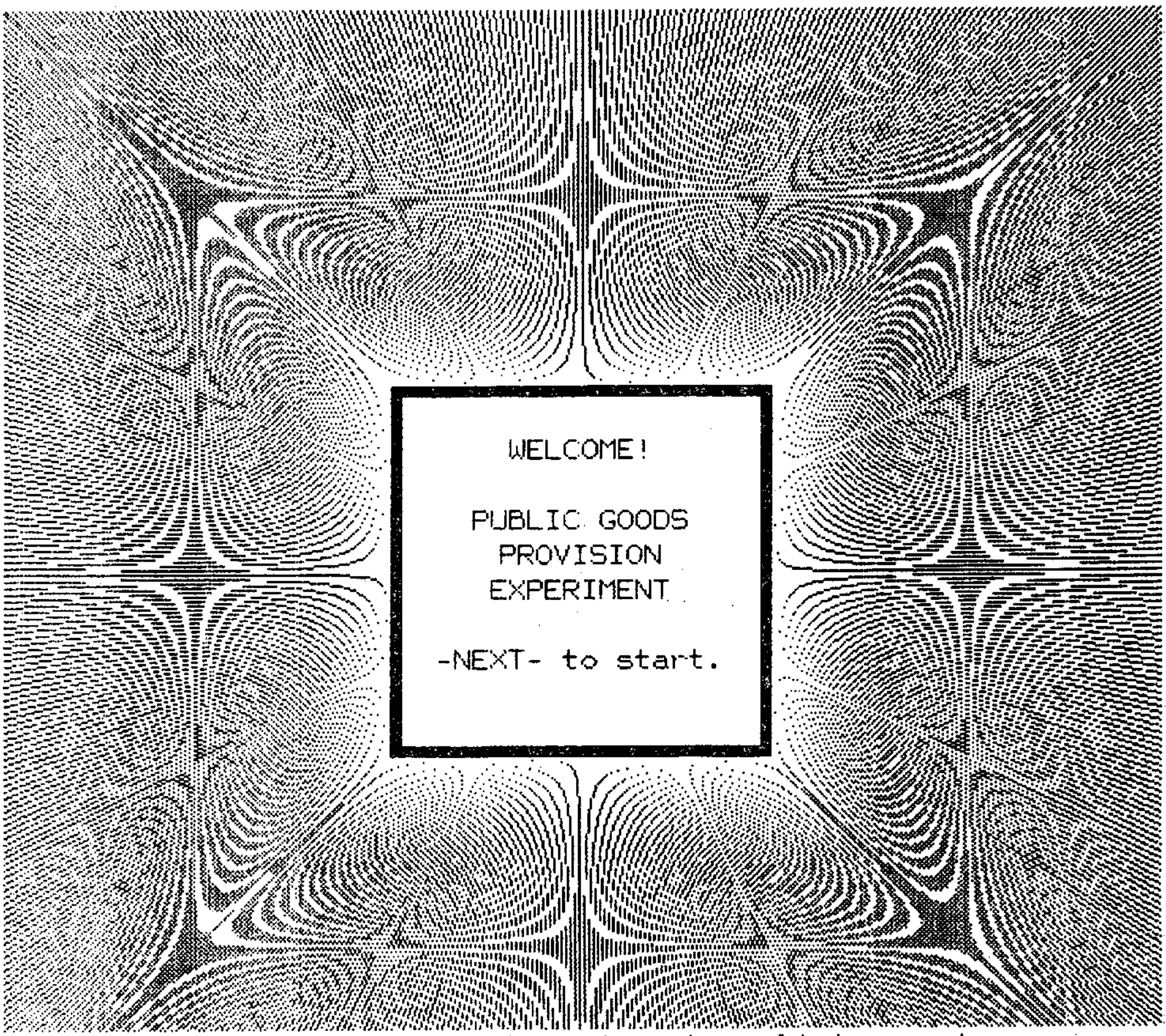
Vernon L. Smith, Arlington W. Williams, W.K. Bratton and M. Vannoni (1982), "Competitive Market Institutions: Double Auctions vs. Sealed Bid-Offer Auctions," American Economic Review 72:58.

Tideman, T.N. and Tullock, G. (1976), "A New and Superior Process for Making Public Choices," Journal of Political Economy, 84:1145-59.

Louis L. Wilde (1981), "On the Use of Laboratory Experiments in Economics," in J.C. Pitt (ed.) Philosophy in Economics.

Arlington W. Williams, Vernon L. Smith, and John O. Ledyard (1984), "Simultaneous Trading in Two Competitive Markets: An Experimental Examination," Indiana University Xerox.

Appendix: Instructions Presented by Plato



A cooperative research venture brought to you by:

Brian Binger and Elisabeth Hoffman, Purdue University

Arlington Williams, Indiana University

In the experiment you will be Agent #1.

Please type in your LAST NAME after the arrow below.

> ____________

(This information is used solely to help distribute the cash earnings at the end of the experiment.)

Press -NEXT- when you are finished entering your name.

Press -ERASE- to correct typing errors.

INSTRUCTIONS

This is an experiment in the economics of group decision making. Various research foundations have provided funds for the conduct of this research. The instructions are simple, and if you follow them carefully and make good decisions YOU MAY EARN A CONSIDERABLE AMOUNT OF MONEY which will be PAID TO YOU IN CASH at the end of the experiment.

Press -NEXT- when you have finished reading.

INSTRUCTIONS

From this point on, all reference to dollar and cent amounts will be in terms of "PLATO dollars". At the conclusion of the experiment you will be paid at the rate of 8.85 U.S. dollars (cash) for each PLATO dollar that you earn in the experiment. Please notice that your cash payment at the end of the experiment will depend directly on the number of PLATO dollars that you earn.

Press -NEXT- when you have finished reading.

You are a member of a group which must jointly decide on the size of a common (or "public") facility and then share the cost of providing this facility to the group. This facility will be *referred* to as "Y" and the size of the facility will be measured in terms of "units" of Y. For example, Y could denote a group-use area and the size of Y might be measured in acres. Thus, Y=3 would denote a 3 acre area, Y=10 a 10 acre area and Y=0 would denote no area at all!

Press -NEXT- to continue or -BACK- to review.

The cost of the common facility (Y) must be covered by the group's contribution of a "private" good that will be denoted as X. For each unit of Y that the group decides to provide, the group (as a whole) must contribute 1 unit of X. The group's contribution is simply the summation of each agent's individual contribution of X. Each agent will be endowed with some amount of X. Your personal endowment is X = 55. You should not assume that each agent's endowment of X is the same as your endowment. It may be either the same or quite different.

Press -NEXT- to continue or -BACK- to review.

Your cash payment at the experiment's conclusion will be determined by BOTH the number of units of X you have remaining AND the size of the common facility (Y) that the group decides to provide. The size of the common facility must be agreed to UNANIMOUSLY by the group within 50 decision-making rounds or a "disagreement outcome" will be imposed on the group. This simply means that each agent's payment will be based on Y = 0 and X = the agent's initial endowment. Your personal disagreement outcome would thus be Y=0, X=55.08 and would result in a final payment of 0.00 PLATO dollars which would convert to $ 0.00 U.S. dollars.

For your information, your profits are determined using the following formula:

your profit in PLATO dollars =

$$8 \times (0.2878\ Y^{-0.25} \times 0.7123\ X^{-0.25})^{1/-0.25}$$

There is no reason for you to remember this formula. PLATO will automatically calculate and display the profit associated with all Y,X combinations that you will be asked to choose between in the experiment.

Press -NEXT- to continue or -BACK- to review.

Each decision-making round will proceed as follows:

1.) You (and all other agents) will be presented with a table of Y,X combinations and the associated payment that you would receive if Y units of the common facility were provided and you had X units of your private-good endowment remaining.

2.) You will indicate the Y,X combination on the table that you find most desirable. The Y number is your proposal for a common facility size and the X number is the amount of X that you propose to keep rather than contribute to covering the cost of providing Y.

3.) When all agents have submitted their decisions, PLATO will check to see if there is UNANIMOUS agreement as to the number of units of Y that the group will provide and whether the group's proposed contributions of X cover the cost of providing Y.

4.) If unanimous agreement on the amount of Y to provide is reached and group contributions of X cover the cost of the proposed facility size, the experiment will end. If either of these conditions is not met, the group will be informed of this and will move on to the next decision-making round.

Press -NEXT- to continue or -BACK- to review.

Agent #1's choice table...INSTRUCTIVE EXAMPLE ONLY.

Good Y	Good X	Profit	Good Y	Good X	Profit	Good Y	Good X	Profit
0	55.1	$ 0.00	20	48.4	$294.18	40	41.7	$329.88
1	54.7	$ 87.68	21	48.1	$297.64	41	41.4	$330.35
2	54.4	$123.78	22	47.7	$300.84	42	41.1	$330.74
3	54.1	$149.09	23	47.4	$303.82	43	40.7	$331.04
4	53.7	$168.89	24	47.1	$306.59	44	40.4	$331.25
5	53.4	$185.20	25	46.7	$309.15	45	40.1	$331.39
6	53.1	$199.08	26	46.4	$311.53	46	39.7	$331.45
7	52.7	$211.13	27	46.1	$313.74	47	39.4	$331.43
8	52.4	$221.77	28	45.7	$315.77	48	39.1	$331.34
9	52.1	$231.26	29	45.4	$317.65	49	38.7	$331.17
10	51.7	$239.81	30	45.1	$319.38	50	38.4	$330.94
11	51.4	$247.55	31	44.7	$320.97	51	38.1	$330.64
12	51.1	$254.60	32	44.4	$322.43	52	37.7	$330.27
13	50.7	$261.05	33	44.1	$323.75	53	37.4	$329.84
14	50.4	$266.98	34	43.7	$324.95	54	37.1	$329.35
15	50.1	$272.44	35	43.4	$326.04	55	36.7	$328.79
16	49.7	$277.48	36	43.1	$327.02	56	36.4	$328.18
17	49.4	$282.14	37	42.7	$327.88	57	36.1	$327.50
18	49.1	$286.46	38	42.4	$328.64	58	35.7	$326.77
19	48.7	$290.47	39	42.1	$329.31	59	35.4	$325.99

This is an example of what your choice table might look like during a decision-making round in the experiment. In fact, it is probably very similar to what you will see during the first round of the actual experiment. After your choice table appears on your viewing screen in each round, you will be asked to choose an amount of good Y that you want to propose to the group. Press -NEXT- to continue.

Agent #1's choice table...INSTRUCTIVE EXAMPLE ONLY.

Good Y	Good X	Profit	Good Y	Good X	Profit	Good Y	Good X	Profit
0	55.1	$ 0.00	20	48.4	$294.18	40	41.7	$329.88
1	54.7	$ 87.68	21	48.1	$297.64	41	41.4	$330.35
2	54.4	$123.78	22	47.7	$300.84	42	41.1	$330.74
3	54.1	$149.09	23	47.4	$303.82	43	40.7	$331.04
4	53.7	$168.89	24	47.1	$306.59	44	40.4	$331.25
5	53.4	$185.20	25	46.7	$309.15	45	40.1	$331.39
6	53.1	$199.08	26	46.4	$311.53	46	39.7	$331.45
7	52.7	$211.13	27	46.1	$313.74	47	39.4	$331.43
8	52.4	$221.77	28	45.7	$315.77	48	39.1	$331.34
9	52.1	$231.26	29	45.4	$317.65	49	38.7	$331.17
10	51.7	$239.81	30	45.1	$319.38	50	38.4	$330.94
11	51.4	$247.55	31	44.7	$320.97	51	38.1	$330.64
12	51.1	$254.60	32	44.4	$322.43	52	37.7	$330.27
13	50.7	$261.05	33	44.1	$323.75	53	37.4	$329.84
14	50.4	$266.98	34	43.7	$324.95	54	37.1	$329.35
15	50.1	$272.44	35	43.4	$326.04	55	36.7	$328.79
16	49.7	$277.48	36	43.1	$327.02	56	36.4	$328.18
17	49.4	$282.14	37	42.7	$327.88	57	36.1	$327.50
18	49.1	$286.46	38	42.4	$328.64	58	35.7	$326.77
19	48.7	$290.47	39	42.1	$329.31	59	35.4	$325.99

Notice that your choice of an amount of good Y to propose to the group implies that you are willing to contribute a specific amount of your private endowment of good X to cover the cost of providing good Y. This amount is equal to your endowment of X (55.08) minus the X amount paired with your choice of Y (the amount of X you choose to keep rather than contribute). Press -NEXT- to continue or -BACK- to review.

Agent #1's choice table...INSTRUCTIVE EXAMPLE ONLY.

Good Y	Good X	Profit	Good Y	Good X	Profit	Good Y	Good X	Profit
0	55.1	$ 0.00	20	48.4	$294.18	40	41.7	$329.88
1	54.7	$ 87.68	21	48.1	$297.64	41	41.4	$330.35
2	54.4	$123.78	22	47.7	$300.84	42	41.1	$330.74
3	54.1	$149.09	23	47.4	$303.82	43	40.7	$331.04
4	53.7	$168.89	24	47.1	$306.59	44	40.4	$331.25
5	53.4	$185.20	25	46.7	$309.15	45	40.1	$331.39
6	53.1	$199.08	26	46.4	$311.53	46	39.7	$331.45
7	52.7	$211.13	27	46.1	$313.74	47	39.4	$331.43
8	52.4	$221.77	28	45.7	$315.77	48	39.1	$331.34
9	52.1	$231.26	29	45.4	$317.65	49	38.7	$331.17
10	51.7	$239.81	30	45.1	$319.38	50	38.4	$330.94
11	51.4	$247.55	31	44.7	$320.97	51	38.1	$330.64
12	51.1	$254.60	32	44.4	$322.43	52	37.7	$330.27
13	50.7	$261.05	33	44.1	$323.75	53	37.4	$329.84
14	50.4	$266.98	34	43.7	$324.95	54	37.1	$329.35
15	50.1	$272.44	35	43.4	$326.04	55	36.7	$328.79
16	49.7	$277.48	36	43.1	$327.02	56	36.4	$328.18
17	49.4	$282.14	37	42.7	$327.88	57	36.1	$327.50
18	49.1	$286.46	38	42.4	$328.64	58	35.7	$326.77
19	48.7	$290.47	39	42.1	$329.31	59	35.4	$325.99

You are free to pick any Y,X combination displayed on your choice table as your proposal. The other group members are not told the X contribution or potential profit associated with your proposal (and you are not told theirs'). At the end of each round, PLATO will check the proposals and either end the experiment or move on to the next round.

Press -NEXT- to continue or -BACK- to review.

Agent #1's choice table...INSTRUCTIVE EXAMPLE ONLY.

Good Y	Good X	Profit	Good Y	Good X	Profit	Good Y	Good X	Profit
0	55.1	$ 0.00	20	48.4	$294.18	40	41.7	$329.88
1	54.7	$ 87.68	21	48.1	$297.64	41	41.4	$330.35
2	54.4	$123.78	22	47.7	$300.84	42	41.1	$330.74
3	54.1	$149.09	23	47.4	$303.82	43	40.7	$331.04
4	53.7	$168.89	24	47.1	$306.59	44	40.4	$331.25
5	53.4	$185.20	25	46.7	$309.15	45	40.1	$331.39
6	53.1	$199.08	26	46.4	$311.53	46	39.7	$331.45
7	52.7	$211.13	27	46.1	$313.74	47	39.4	$331.43
8	52.4	$221.77	28	45.7	$315.77	48	39.1	$331.34
9	52.1	$231.26	29	45.4	$317.65	49	38.7	$331.17
10	51.7	$239.81	30	45.1	$319.38	50	38.4	$330.94
11	51.4	$247.55	31	44.7	$320.97	51	38.1	$330.64
12	51.1	$254.60	32	44.4	$322.43	52	37.7	$330.27
13	50.7	$261.05	33	44.1	$323.75	53	37.4	$329.84
14	50.4	$266.98	34	43.7	$324.95	54	37.1	$329.35
15	50.1	$272.44	35	43.4	$326.04	55	36.7	$328.79
16	49.7	$277.48	36	43.1	$327.02	56	36.4	$328.18
17	49.4	$282.14	37	42.7	$327.88	57	36.1	$327.50
18	49.1	$286.46	38	42.4	$328.64	58	35.7	$326.77
19	48.7	$290.47	39	42.1	$329.31	59	35.4	$325.99

Please note that it is quite acceptable for you to pick the most profitable Y,X combination in your choice table. In fact, proposing this combination may actually assist the group in coming to an agreement. The PLATO program is designed to help coordinate agents' most desirable Y,X combinations in each round into an agreeable outcome.

Press -NEXT- to continue or -BACK- to review.

Agent #1's choice table...INSTRUCTIVE EXAMPLE ONLY.

Good Y	Good X	Profit	Good Y	Good X	Profit	Good Y	Good X	Profit
0	55.1	$ 0.00	20	48.4	$294.18	40	41.7	$329.88
1	54.7	$ 87.68	21	48.1	$297.64	41	41.4	$330.35
2	54.4	$123.78	22	47.7	$300.84	42	41.1	$330.74
3	54.1	$149.09	23	47.4	$303.82	43	40.7	$331.04
4	53.7	$168.89	24	47.1	$306.59	44	40.4	$331.25
5	53.4	$185.20	25	46.7	$309.15	45	40.1	$331.39
6	53.1	$199.08	26	46.4	$311.53	46	39.7	$331.45
7	52.7	$211.13	27	46.1	$313.74	47	39.4	$331.43
8	52.4	$221.77	28	45.7	$315.77	48	39.1	$331.34
9	52.1	$231.26	29	45.4	$317.65	49	38.7	$331.17
10	51.7	$239.81	30	45.1	$319.38	50	38.4	$330.94
11	51.4	$247.55	31	44.7	$320.97	51	38.1	$330.64
12	51.1	$254.60	32	44.4	$322.43	52	37.7	$330.27
13	50.7	$261.05	33	44.1	$323.75	53	37.4	$329.84
14	50.4	$266.98	34	43.7	$324.95	54	37.1	$329.35
15	50.1	$272.44	35	43.4	$326.04	55	36.7	$328.79
16	49.7	$277.48	36	43.1	$327.02	56	36.4	$328.18
17	49.4	$282.14	37	42.7	$327.88	57	36.1	$327.50
18	49.1	$286.46	38	42.4	$328.64	58	35.7	$326.77
19	48.7	$290.47	39	42.1	$329.31	59	35.4	$325.99

Your choice table is determined primarily by the OTHER agent's proposals in the previous round, NOT primarily by your own proposal. This is true for all other agents in the group as well. The actual formula that PLATO uses to calculate these things is too complex to be of any practical value to you.

Press -NEXT- to continue or -BACK- to review.

Agent #1's choice table...INSTRUCTIVE EXAMPLE ONLY.

Good Y	Good X	Profit	Good Y	Good X	Profit	Good Y	Good X	Profit
0	55.1	$ 0.00	20	48.4	$294.18	40	41.7	$329.88
1	54.7	$ 87.68	21	48.1	$297.64	41	41.4	$330.35
2	54.4	$123.78	22	47.7	$300.84	42	41.1	$330.74
3	54.1	$149.09	23	47.4	$303.82	43	40.7	$331.04
4	53.7	$168.89	24	47.1	$306.59	44	40.4	$331.25
5	53.4	$185.20	25	46.7	$309.15	45	40.1	$331.39
6	53.1	$199.08	26	46.4	$311.53	46	39.7	$331.45
7	52.7	$211.13	27	46.1	$313.74	47	39.4	$331.43
8	52.4	$221.77	28	45.7	$315.77	48	39.1	$331.34
9	52.1	$231.26	29	45.4	$317.65	49	38.7	$331.17
10	51.7	$239.81	30	45.1	$319.38	50	38.4	$330.94
11	51.4	$247.55	31	44.7	$320.97	51	38.1	$330.64
12	51.1	$254.60	32	44.4	$322.43	52	37.7	$330.27
13	50.7	$261.05	33	44.1	$323.75	53	37.4	$329.84
14	50.4	$266.98	34	43.7	$324.95	54	37.1	$329.35
15	50.1	$272.44	35	43.4	$326.04	55	36.7	$328.79
16	49.7	$277.48	36	43.1	$327.02	56	36.4	$328.18
17	49.4	$282.14	37	42.7	$327.88	57	36.1	$327.50
18	49.1	$286.46	38	42.4	$328.64	58	35.7	$326.77
19	48.7	$290.47	39	42.1	$329.31	59	35.4	$325.99

In order to make sure that the procedures just outlined are clear. Let's work through an example together.
Given the choice table shown above, enter the amount of Y that you would propose to the group if this were an actual decision-making round in the experiment.
Type in your response now. It will appear here »
Press -NEXT- when you are done, -ERASE- to correct typos.

Agent #1's choice table...INSTRUCTIVE EXAMPLE ONLY.

Good Y	Good X	Profit	Good Y	Good X	Profit	Good Y	Good X	Profit
0	55.1	$ 0.00	20	48.4	$294.18	40	41.7	$329.88
1	54.7	$ 87.68	21	48.1	$297.64	41	41.4	$330.35
2	54.4	$123.78	22	47.7	$300.84	42	41.1	$330.74
3	54.1	$149.09	23	47.4	$303.82	43	40.7	$331.04
4	53.7	$168.89	24	47.1	$306.59	44	40.4	$331.25
5	53.4	$185.20	25	46.7	$309.15	45	40.1	$331.39
6	53.1	$199.08	26	46.4	$311.53	**46**	**39.7**	**$331.45**
7	52.7	$211.13	27	46.1	$313.74	47	39.4	$331.43
8	52.4	$221.77	28	45.7	$315.77	48	39.1	$331.34
9	52.1	$231.26	29	45.4	$317.65	49	38.7	$331.17
10	51.7	$239.81	30	45.1	$319.38	50	38.4	$330.94
11	51.4	$247.55	31	44.7	$320.97	51	38.1	$330.64
12	51.1	$254.60	32	44.4	$322.43	52	37.7	$330.27
13	50.7	$261.05	33	44.1	$323.75	53	37.4	$329.84
14	50.4	$266.98	34	43.7	$324.95	54	37.1	$329.35
15	50.1	$272.44	35	43.4	$326.04	55	36.7	$328.79
16	49.7	$277.48	36	43.1	$327.02	56	36.4	$328.18
17	49.4	$282.14	37	42.7	$327.88	57	36.1	$327.50
18	49.1	$286.46	38	42.4	$328.64	58	35.7	$326.77
19	48.7	$290.47	39	42.1	$329.31	59	35.4	$325.99

At this point in an actual decision-making round, you will be told to press the -LAB- key to confirm your choice or press the -BACK- key to reenter your choice.

Press the -LAB- key now to continue, press -BACK- to review.

Agent #1's choice table...INSTRUCTIVE EXAMPLE ONLY.

Good Y	Good X	Profit	Good Y	Good X	Profit	Good Y	Good X	Profit
0	55.1	$ 0.00	20	48.4	$294.18	40	41.7	$329.88
1	54.7	$ 87.68	21	48.1	$297.64	41	41.4	$330.35
2	54.4	$123.78	22	47.7	$300.84	42	41.1	$330.74
3	54.1	$149.09	23	47.4	$303.82	43	40.7	$331.04
4	53.7	$168.89	24	47.1	$306.59	44	40.4	$331.25
5	53.4	$185.20	25	46.7	$309.15	45	40.1	$331.39
6	53.1	$199.08	26	46.4	$311.53	**46**	**39.7**	**$331.45**
7	52.7	$211.13	27	46.1	$313.74	47	39.4	$331.43
8	52.4	$221.77	28	45.7	$315.77	48	39.1	$331.34
9	52.1	$231.26	29	45.4	$317.65	49	38.7	$331.17
10	51.7	$239.81	30	45.1	$319.38	50	38.4	$330.94
11	51.4	$247.55	31	44.7	$320.97	51	38.1	$330.64
12	51.1	$254.60	32	44.4	$322.43	52	37.7	$330.27
13	50.7	$261.05	33	44.1	$323.75	53	37.4	$329.84
14	50.4	$266.98	34	43.7	$324.95	54	37.1	$329.35
15	50.1	$272.44	35	43.4	$326.04	55	36.7	$328.79
16	49.7	$277.48	36	43.1	$327.02	56	36.4	$328.18
17	49.4	$282.14	37	42.7	$327.88	57	36.1	$327.50
18	49.1	$286.46	38	42.4	$328.64	58	35.7	$326.77
19	48.7	$290.47	39	42.1	$329.31	59	35.4	$325.99

PLATO would now wait for everyone in the group to finish before proceding. If the group were to come to an agreement based on this round's proposals, how many PLATO dollars would you earn for being in this experiment? ≫
Press -NEXT- when you are done, -ERASE- to correct typos.

Agent #1's choice table...INSTRUCTIVE EXAMPLE ONLY.

Good Y	Good X	Profit	Good Y	Good X	Profit	Good Y	Good X	Profit
0	55.1	$ 0.00	20	48.4	$294.18	40	41.7	$329.88
1	54.7	$ 87.68	21	48.1	$297.64	41	41.4	$330.35
2	54.4	$123.78	22	47.7	$300.84	42	41.1	$330.74
3	54.1	$149.09	23	47.4	$303.82	43	40.7	$331.04
4	53.7	$168.89	24	47.1	$306.59	44	40.4	$331.25
5	53.4	$185.20	25	46.7	$309.15	45	40.1	$331.39
6	53.1	$199.08	26	46.4	$311.53	**46**	**39.7**	**$331.45**
7	52.7	$211.13	27	46.1	$313.74	47	39.4	$331.43
8	52.4	$221.77	28	45.7	$315.77	48	39.1	$331.34
9	52.1	$231.26	29	45.4	$317.65	49	38.7	$331.17
10	51.7	$239.81	30	45.1	$319.38	50	38.4	$330.94
11	51.4	$247.55	31	44.7	$320.97	51	38.1	$330.64
12	51.1	$254.60	32	44.4	$322.43	52	37.7	$330.27
13	50.7	$261.05	33	44.1	$323.75	53	37.4	$329.84
14	50.4	$266.98	34	43.7	$324.95	54	37.1	$329.35
15	50.1	$272.44	35	43.4	$326.04	55	36.7	$328.79
16	49.7	$277.48	36	43.1	$327.02	56	36.4	$328.18
17	49.4	$282.14	37	42.7	$327.88	57	36.1	$327.50
18	49.1	$286.46	38	42.4	$328.64	58	35.7	$326.77
19	48.7	$290.47	39	42.1	$329.31	59	35.4	$325.99

Very good! The 331.45 PLATO dollars would convert to a FINAL CASH PAYMENT of $ 16.57 U.S. dollars.

Press -NEXT- to continue or -BACK- to review.

Be patient and don't get upset or discouraged if the group does not come to a unanimous agreement quickly. It may take numerous decision-making rounds (perhaps 20 or even more) for the group to unanimously agree on the amount of good Y to purchase.

Please remember that in each round you are free to propose any of the Y,X combinations in your choice table but that choosing the Y,X combination that you personally find most desirable may actually assist the group in coming to a unanimous agreement. The mechanism is designed to collect Y,X proposals from each agent and then to change each agent's choice table until the most desirable Y,X combination for each individual occurs at the same Y amount. When this happens, the group can come to an agreement on the amount of Y to provide if everyone simply chooses the Y,X combination in their choice table that they personally find most desirable.

Press -NEXT- to continue or -BACK- to review.

This the end of the instructions

Now that you have read the instructions, you are free to stay for the experiment or to leave. If you do not wish to participate in the experiment please inform the monitor of your decision now.

If you wish to participate in the experiment:

Press -NEXT- to move on to the actual experiment

Press -BACK- to review the instructions.

If you have a question that was not adequately addressed by the instructions, please raise your hand and ask the experiment monitor for assistance.

Are you sure you are ready to continue?

You will not be able to return to the instructions if you proceed beyond this point.

Press -NEXT- to move on to the experiment,

Press -BACK- to return to instructions.

You are Agent #1. Round 1 coming up.

Waiting for 2 people to get ready.

Please be patient.