Econ 2230: Public Economics

Lecture 9: Mechanism Design – lab evidence

Review from last

- Mechanism design objective: how can we get people to truthfully reveal how much they like the public good such that we secure efficient provision
  - Over reporting if no consequences of the bid
  - Under reporting if the bid generally affects the individual's payment towards the public good.
- We want to find "incentive compatible mechanisms," that is schemes where it is in everyone's interest to correctly report how much they value the good
- Implementation
  - Dominant strategy
  - Nash

Outline

Lab evidence

1. Dominant strategy implementation
   i. Tideman (1983)
   ii. Attiyeh, Franciosi and Isaac (1998)
   iii. Kawagoe and Mori
2. Nash implementation
   i. Chen and Plot (1996), Chen and Tang (1998), Chen and Gazzale (2003)
   ii. Swarthout and Walker (2009)

1. Dominant strategy implementation

- Clarke-Groves Mechanism
  1. Individuals report their value for the bridge v_i
  2. Decision
     i. If sum of bids – cost of project >0 build project
     ii. If sum of bids – cost of project <0 don't build
  3. If the individual's value was decisive, i.e.
     i. sum of others' bids < cost < sum of all bids
     ii. charge the individual = cost of project – sum of others' bids

Clarke-Groves: Characteristics

1. Dominant strategy to truthfully reveal your type
2. Secures efficient provision of the public good
3. Budget is not generally balanced (costly to incentivize truth revelation)
4. Collusion may be profittable

(reviews: Public Choice special issue 1977, Rothkopf, 2007)

- Does the problem of budget balance increase or decrease with n?
- Tideman and Tullock (1977) decrease because likelihood of being pivotal decreases

Dominant strategy implementation

- Can we secure efficient provision?
- Impossibility theorems:
- Gibbard (1973) and Satterthwaite (1975): if every possible preference is admissible, and if the mechanism always must have a dominant strategy, and the set of alternatives greater than two, then the outcomes that must be chosen must be exactly those chosen by simply assigning one agent to be a dictator
- Could restrict the set of preferences to quasi-linear
- Green and Laffont (1977):
  - Truth telling is only a dominant strategy in the Clarke-Groves mechanisms.
  - There is no social choice function that is truthfully implementable in dominant strategies and secures efficient provision and budget-balance.

Experimental studies of CG mechanism

- Saw that GC not budget balanced – a greater problem with small n
- Crucial question is whether it is truth revealing: Do subjects when presented with the CG mechanism reveal their type?
- Lessons to be learned from existing lab studies
- CG closely related to second price Vickrey auction
  - Dominant strategy to reveal your type
  - Consequence of bid only when pivotal
  - Often call CG for the Vickrey-Clarke-Groves (VCG) mechanism
- Kagel and Levin (EJ 1993) participants in second price auctions do not bid their evaluations
  - N=5: find that 6 pct bid below valuation, 67 pct bid above
  - N=10: find 9 pct bid below, 58 pct bid above
  - Explanations?
- Movement towards revelation with time (Cox et al, 1996)
- Public good experiments show over contributions

Experimental studies of CG mechanism

- Tideman (1983)
  - Conducted study at VPI fraternities
  - Paid to make decisions using a CG mechanism
  - Incentives for truthful revelation explained
  - Size of groups varied from 11 to 62 students
  - A total of 96 decisions
  - Clarke tax
    - specified in $ or hrs worked for fraternity (concerns?)
    - tax allowed in a range at some fraternities (concerns?)
- How to examine efficiency?
- What is an inferior but simple alternative to CG?
- Rank efficiency relative to outcome that would have occurred under majority rule. I.e., to what extent is the decision reversed when intensity of preferences can be expressed

Tideman (1983)

- 9/96 decisions were reversed as a result of the CG mechanism relative to the majority rule.
- Increase in efficiency as measured by the intensity of preferences for those elections is overcome by the clarke tax
- Survey
  - Fairness? 12/178 thought the loss of one-man-one-vote was unfortunate
  - Demand revelation:
    - Participants reported understanding process
    - 21% reported overstating their preferences on occasion
    - 46% reported understating their preferences on occasion
  - Reported attraction: coalitions
  - When given the option of adopting policy for future decisions all said no
- Conclude: CG workable and "it increases the efficiency of binary decisions" (thoughts?)

Experimental studies of CG mechanism

- Tideman
  - Concerns:
    - Absent information on preferences difficult to assess whether changes in outcomes relative to majority rule is good or bad.
    - Participants instructed on what the dominant strategy is, thus do not know if mechanism incentivize people to reveal their type
- Laboratory allows us to manipulate preferences.
- Attiyeh, Franciosi and Isaac (1998):
  - Compare outcome of CG on a binary outcome to the outcome that would result from majority rule
  - Design:
    - Paired in groups of 5
    - Ten periods, a base payment of $3 per session
    - Cost of provision $0,
    - Induced values received new valuations each period (if negative value of outcome must pay the experimenter)

Tideman

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Attiyeh, Franciosi and Isaac (1998):

Table 1.

Period	v1	v2	v3	v4	v5	Surplus if provided	Dominant strategy outcome	tax
01.00	–01.72	07.19	08.47	10.00	00.76	24.70	Y	XXX
02.00	09.07	02.92	–07.88	–07.50	–01.83	–05.22	N	04.94
03.00	08.63	–08.68	05.63	–04.67	05.11	06.02	Y	02.61
04.00	–00.31	09.32	–05.85	–05.10	05.90	03.96	Y	07.30
05.00	02.15	–00.60	–07.82	01.62	03.56	–01.09	N	06.73
06.00	–08.35	03.25	02.94	06.65	–00.48	04.01	Y	02.64
07.00	08.95	–03.93	06.60	–02.79	–07.85	00.98	Y	13.59
08.00	02.11	03.87	10.00	–00.20	01.98	17.76	Y	XXX
09.00	07.23	–06.40	–08.85	–05.05	–06.67	–19.74	N	XXX
10.00	06.87	00.55	–01.44	09.64	04.94	20.56	Y	XXX

Attiyeh, Franciosi and Isaac (1998):

Subject No. 1 **Period 1**

Your payoff if the project is implemented: **-$1.72**
(Enter in column 2 of your PAYOFF SHEET)

Would you prefer the project be implemented? **YES** **NO**

How much do you bid in support of your position? ___________

****

Tax ____________(Enter in column 5 of your PAYOFF SHEET)

Your payoff this period ______________(Enter in column 6 of your PAYOFF SHEET)

Figure 1. A sample bid card.

- Framed in terms of positive bids in favor of position

Attiyeh, Franciosi and Isaac (1998):

- Findings
  1. Truth revelation
     i. 10% bid truthfully (21 out of 200 bids, 10 from one person)
     ii. 18% come within 25 cents (37 out of 200)
     iii. 195/197 bid with right sign (both + and –) Not just confusion
     iv. No increase in truth revelation over time
  2. Efficiency:
     i. 70% of decisions result in efficient provision (had they instead used majority rule the number would also be 70%)
     ii. Clarke tax a direct loss of efficiency.

Attiyeh, Franciosi and Isaac (1998):

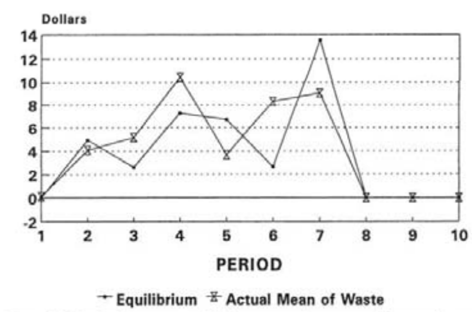

Figure 2. Mechanism waste: equilibrium vs. actual average of four experiments

More efficient than predicted in 3 periods, less in 4 periods

Attiyeh, Franciosi and Isaac (1998):

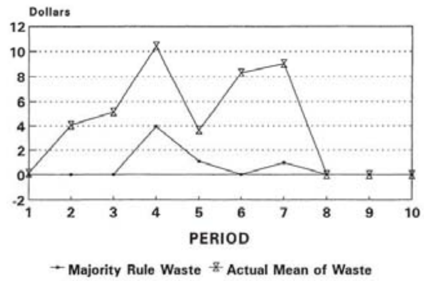

Figure 3. Actual waste vs. majority rule theoretical waste: average of four experiments.

In no period does the CG outperform majority rule

Attiyeh, Franciosi and Isaac (1998):

- Additional treatment: Perhaps greater incentive for truth revelation in larger groups. May be that people hold off on bidding for fear of paying tax.
- Example:
  - N=3: v_i={-1, -1, 5}, t_i={0, 0, 2},
  - N=6: v_i={-1, -1, 5, -1, -1, 5}, t_i={0, 0, 0, 0, 0, 0}
  - In larger group less likely that you are pivotal and face the tax
  - Note however that the incentive to tell the truth also is weaker
- Redo experiment with n=10
  - Replicate values
  - 8% report truthfully, 10% within 25 cents
  - Clarke tax does decrease (interpretation? Consistent with theory?)
- With larger n less truth revelation, but less tax and thus less efficiency loss

Attiyeh, Franciosi and Isaac (1998):

- Pattern of bidding
  - Positive values: overbid on low values and underbid on high values;
  - Negative values: underbid on low values and overbid on high values;
  - Why does bidding work differently here- why don't participants seem to learn.
  - Hypothesize that may be because more difficult to learn here
    - Vickrey – overbid nothing may happen, but may also get a direct and immediate loss
    - CG – can bid your valuation and still lose, when failing to bid valuation may not lose
- Conclusion:
  - No evidence that the truth revelation incentives are transparent in the CG mechanism
  - No evidence that CG does better than majority rule
  - Implications for field studies?

Kawagoe and Mori (Public Choice 2001)

- Hypothesis: misrepresentation perhaps due to it being a weakly dominant strategy to tell truth. Only hurt by lie when pivotal thus limited incentive to play or learn the dominant strategy
- There are always strategies other than truth-telling that do no worse for a subject than truthtelling
- Makes it difficult for subjects to understand that truth-telling is the unique dominant strategy for the mechanism, unless they have comprehensive understanding of the payoff structure, with the result that subjects often do not play the dominant strategy
- Suggest one could overcome the problem of weak incentive compatibility by giving the subjects more information about the payoff structure.
- Examine effect of providing more information on the payoff structure

Kawagoe and Mori (2001)

- Three information treatments
  - Non-Enforcement: subjects assigned a fixed value and the mechanism was explained without a payoff table (Info 1)
  - Wide Enforcement : subjects randomly assigned values each round and the mechanism was explained without a payoff table (similar to Attiyeh et al.) (Info 2)
  - Deep Enforcement: subjects assigned a fixed value and given a detailed payoff table. (Info 3)

Kawagoe and Mori (2001)

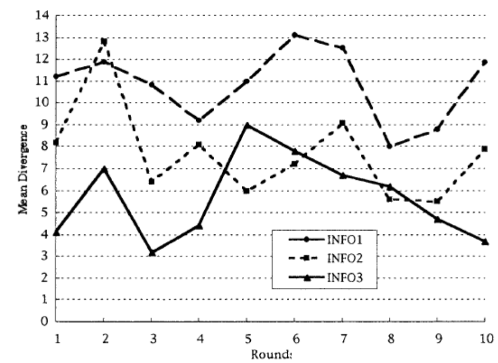

Figure 1. Mean divergences from true value.

Kawagoe and Mori (2001)

Enforcement Treatment		Truthful bids	Efficient
Non	Fixed value	17%	40%
	No payoff table		
Wide	Random value	14%	70%
	Payoff table		
Deep	Fixed value	47%	90%
	Payoff table		

- Detailed information about the payoff structure significantly improved the rate of dominant strategy play – however more than half still fail to reveal their type.
- Budget surplus not the only problem for implementation in dominant strategies

2: Nash Implementation

- Groves-Ledyard Mechanism
- Mechanism:
  - Message:
    - $S = (s_1, s_2, \ldots, s_n)$
    - s_i = Agent i sends a message that reports the amount i would like the government to add or subtract from amounts requested by others
  - Allocation rule:
    - Provision: $g(s) = \Sigma_i s_i$
    - Tax: $t_i(s_i) = q\cdot g(s)/n + [\gamma/2]\cdot[(n-1)/n]\cdot\{[s_i - \mu(s_j)]^2 - \sigma(s_i)^2\}$
    - where
      - $\mu(s_j)$ mean of $s_{j\neq i}$, $\mu(s_j) = \Sigma_j s_j/(n-1)$
      - $\sigma(s_j)$ variance of $\sigma(s_{j\neq i}) = \Sigma_j [s_j - \mu(s_j)]/(n-2)$
      - $\gamma>0$ penalty for deviating from the mean

2: Nash Implementation

- Chen and Plott (1996)
  - assess the performance of the Groves-Ledyard mechanism under different punishment parameters.
  - by varying the punishment parameter the dynamics and stability changed dramatically.
  - for a large enough γ, the system converged to its stage game Nash equilibrium very quickly and remained stable; while under a small γ, the system did not converge to its stage game Nash equilibrium.
- Chen and Tang (1998)
  - Replicate this finding with more independent sessions and a longer time series (100 rounds) in an experiment designed to study the learning dynamics.

Chen and Plott

The constant unit cost of the public good is $q = 5$. The valuation functions are quadratic,

$$V_i(X) = A_i X - B_i X^2 + \alpha_i\,,$$

and the GL cost function, in this specific design is

$$C_i(x_i \mid S_i, \sigma_i) = X + \frac{\gamma}{2}\left[\frac{4}{5}(x_i - \mu_i)^2 - \sigma_i^2\right].$$

Table 2
Parameter and Lindahl equilibrium values

Parameter / Subject ID	A_i	B_i	α_i	x_i^e ($\gamma = 1$)	x_i^e ($\gamma = 100$)
1	−1	0	55	−1	1
2	5	0.5	35	0	1
3	10	0.9	20	1	1
4	20	1.8	0	2	1
5	15	1.2	5	3	1
Σ	49	4.4	115	5	5

Table 3
Features of experiments

Experiments	Period 1–30 (Session a)	Period 31–60 (Session b)
0219-93	$\gamma = 1$	$\gamma = 100$
0304-93	$\gamma = 100$	$\gamma = 1$
0305-93	$\gamma = 100$	$\gamma = 1$
0401-93	$\gamma = 1$	$\gamma = 100$

- What effect should γ have on revelation? Provision?

Table 4
Aggregate frequency of choices and efficiency

Incentives	Session	N	f_0	f_1	f_2	f_3	f_4	f_5^*	f_6	f_7	f_8	f_9	f_{10}	f_{11}	f_{12}	f_{13}	Average level	Efficiency
	0219-93a	25	0.04	0.12	0.16	0.20	0.04	0.12*	0.12	0.08	0.04	0.04	0.00	0.04	0.00	0.00	4.20	0.845
	0304-93b	25	0.04	0.04	0.04	0.16	0.08	0.36*	0.12	0.04	0.08	0.00	0.00	0.00	0.00	0.04	4.88	0.883
$\gamma = 1$	0305-93b	26	0.00	0.00	0.04	0.12	0.27	0.38*	0.11	0.04	0.00	0.00	0.00	0.00	0.04	0.00	4.85	0.942
	0401-93a	25	0.00	0.00	0.00	0.12	0.32	0.24*	0.24	0.04	0.04	0.00	0.00	0.00	0.00	0.00	4.88	0.975
	Average		0.02	0.04	0.06	0.15	0.18	0.28*	0.14	0.05	0.04	0.01	0.00	0.01	0.01	0.01	4.70	0.911
	0219-93b	25	0.00	0.00	0.00	0.04	0.20	0.52*	0.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.96	0.987
	0304-93a	25	0.00	0.00	0.04	0.12	0.24	0.44*	0.04	0.12	0.00	0.00	0.00	0.00	0.00	0.00	4.68	0.967
$\gamma = 100$	0305-93a	25	0.00	0.00	0.04	0.12	0.20	0.28*	0.24	0.12	0.00	0.00	0.00	0.00	0.00	0.00	4.92	0.963
	0401-93b	25	0.00	0.00	0.00	0.00	0.16	0.64*	0.16	0.04	0.00	0.00	0.00	0.00	0.00	0.00	5.08	0.989
	Average		0.00	0.00	0.02	0.07	0.20	0.47*	0.17	0.07	0.00	0.00	0.00	0.00	0.00	0.00	4.91	0.977

Table 5
Subject 1's frequency of choices

Incentives	Session	N	f_{-2}	f_{-1}	f_0	f_1	f_2	f_3	f_4	f_5	f_6
	0129-93a	25	0.04	0.56*	0.04	0.16	0.20	0.00	0.00	0.00	0.00
	0304-93b	25	0.96	0.00*	0.00	0.00	0.00	0.00	0.00	0.00	0.04
$\gamma = 1$	0305-93b	26	0.58	0.23*	0.11	0.04	0.00	0.00	0.00	0.00	0.04
	0401-93a	25	0.12	0.76*	0.12	0.00	0.00	0.00	0.00	0.00	0.00
	Average		0.42	0.39*	0.07	0.05	0.05	0.00	0.00	0.00	0.02
	0219-93b	25	0.00	0.00	0.04	0.92*	0.04	0.00	0.00	0.00	0.00
	0304-93a	25	0.00	0.04	0.20	0.56*	0.20	0.00	0.00	0.00	0.00
$\gamma = 100$	0305-93a	25	0.00	0.04	0.24	0.56*	0.16	0.00	0.00	0.00	0.00
	0401-93b	25	0.00	0.00	0.12	0.80*	0.08	0.00	0.00	0.00	0.00
	Average		0.00	0.02	0.15	0.71*	0.14	0.00	0.00	0.00	0.00

- γ = 1: prediction -1
- γ = 100: prediction 1

Table 6
Subject 2's frequency of choices

Incentives	Session	N	f_{-2}	f_{-1}	f_0	f_1	f_2	f_3	f_4	f_5	f_6
	0129-93a	25	0.08	0.32	0.48*	0.12	0.00	0.00	0.00	0.00	0.00
	0304-93b	25	0.28	0.24	0.36*	0.12	0.00	0.00	0.00	0.00	0.00
$\gamma = 1$	0305-93b	26	0.00	0.08	0.31*	0.61	0.00	0.00	0.00	0.00	0.00
	0401-93a	25	0.00	0.04	0.84*	0.12	0.00	0.00	0.00	0.00	0.00
	Average		0.09	0.17	0.50*	0.24	0.00	0.00	0.00	0.00	0.00
	0219-93b	25	0.00	0.00	0.12	0.80*	0.08	0.00	0.00	0.00	0.00
	0304-93a	25	0.00	0.04	0.28	0.56*	0.08	0.04	0.00	0.00	0.00
$\gamma = 100$	0305-93a	25	0.00	0.00	0.20	0.68*	0.12	0.00	0.00	0.00	0.00
	0401-93b	25	0.00	0.00	0.04	0.96*	0.00	0.00	0.00	0.00	0.00
	Average		0.00	0.01	0.16	0.75*	0.07	0.01	0.00	0.00	0.00

- γ = 1: prediction 0
- γ = 100: prediction 1

- Chen & Plott 96
  - GL100 (γ = 100) > GL1 (γ = 1)
  - The single most important factor that affects the subjects' probabilities of choosing best responses is γ. An increase in γ leads to an increase in the probability of an individual choosing his best response
  - High $\gamma \Rightarrow$ better convergence
- the dynamics might dependon the value of a free parameter, even though that parameter does not affect the Nash equilibrium outcomes.

- Chen & Tang 98
  - Replicate the Chen and Plott finding: GL100 > GL1
  - Argue supermodularity is sufficient for convergence
  - If agents use best responses in a sequence of repeated stage GL mechanisms, messages will converge to Nash equilibrium if agents' strategies are strategic complements
  - In supermodular games, each player's marginal utility of increasing her strategy rises with increases in her rival's strategies, so that (roughly) the players' strategies are "strategic complements."Players' best responses are increasing functions of others actions (and strategy spaces are compact)

Chen and Gazzale (2003)

- Clarifies the conditions under which learning in games produces convergence to Nash equilibria in practice.
- Experimentally investigate the role of supermodularity: systematically set the parameters below, close to, at, and above the threshold at which players strategies are strategic complements
- Milgrom and Roberts (1990) prove that, in supermodular games, learning algorithms consistent with adaptive learning converge to the Nash equilibrium strategy profiles.
- While games with strategic complementarities ought to converge robustly to the Nash equilibrium, games without strategic complementarities may also converge

Chen and Gazzale

- Results confirm the findings of previous experimental studies that supermodular games perform significantly better than games far below the supermodular threshold.
- From a little below the threshold to the threshold, however, the change in convergence level is statistically insignificant, “near-supermodular games perform like supermodular ones.” “close is just as good”

Arifovic & Ledyard 03

- Examine speed of convergence: speed in GL50 < GL100 < GL150
- Results: GL50 is not supermodular, still converges, and converges faster than $\gamma = 100$ or 150 (threshold for strategic complementarity at $\gamma = 80$)
- Conclude:
  - strategic complementarity is not a necessary condition for convergence
  - strategic complementarity can not be used as a guide to the rate of convergence
- Healy and Mathevet, 2011
  - Contractive mechanisms (rather than super modular) needed for dynamic stability

Swarthout and Walker (2009)

- Consequences of moving from a continuous to a discrete action space substantial. May explain the experimental findings of Chen and Plott and Chen and Tang
- Equilibria
  - Continuous action space: The GL mechanism has a unique and Pareto efficient equilibrium.
  - Discrete action space: The GL mechanism often has multiple pure strategy equilibria—often an enormous number of them—and there is nothing to single out any of the equilibria as focal . Furthermore many of them are not efficient.

Swarthout and Walker (2009)

- Supermodular
  - Under a broad class of parametrizations of the GL mechanism the resulting noncooperative game is supermodular; this is true whether the action spaces are continuous or discrete.
  - Continuous action space: supermodularity ensures that any “adaptive” behavior by the participants will converge to the unique, Pareto optimal equilibrium (Milgrom and Roberts 1990).
  - Discrete action space: the set of equilibrium outcomes generally large and supermodularity no longer guarantees efficient outcomes

Swarthout and Walker Example

- Three people, x-public good, y-tax

$$u_1(x, y_1) = 8x - \frac{1}{2}x^2 - y_1, \quad u_2(x, y_2) = 10x - \frac{1}{2}x^2 - y_2, \quad u_3(x, y_3) = 15x - \frac{1}{2}x^2 - y_3$$

- Cost c=3
- What is the efficient provision of x?

Swarthout and Walker: Example

- Preferences

$$u_1(x, y_1) = 8x - \frac{1}{2}x^2 - y_1, \quad u_2(x, y_2) = 10x - \frac{1}{2}x^2 - y_2, \quad u_3(x, y_3) = 15x - \frac{1}{2}x^2 - y_3$$

- Continuous messages and penalty => efficient provision

$$y_i = \frac{1}{n}cx + \frac{\gamma}{2}\left[\frac{n-1}{n}(m_i - \mu_{-i})^2 - \sigma^2_{-i}\right]$$

$$m_1 = \frac{10}{3} - \frac{3}{\gamma}, \quad m_2 = \frac{10}{3} - \frac{1}{\gamma}, \quad m_3 = \frac{10}{3} + \frac{4}{\gamma}$$

Swarthout and Walker: Example

- Discrete messages:
  - The penalty for deviating from the mean of others is increasing in γ
  - Suppose limit messages to integers: pick the integer closest to the mean of others. For sufficiently high γ the only Nash equilibria are symmetric profiles, profiles in which all three participants choose the same message. As we increase γ, more and more of these symmetric profiles become equilibria.
- The number of Nash equilibria and their efficiency properties depend critically upon the details of the mechanism— the value of the mechanism's parameter γ, and the message space.

Swarthout and Walker: Example

Table 1 Equilibria in the example (integer messages)

Gamma	# of Equilibria	Common Messages m_i in Equilibria	Provision Levels of the Public Good (x)	Smallest Surplus
$\gamma = 1$	3	m_i not all the same	10	150
$2 \le \gamma \le 13$	1	m_i not all the same	10	150
$14 \le \gamma \le 22$	2	3, 4	9, 12	144
$23 \le \gamma \le 31$	4	2, 3, 4, 5	6, 9, 12, 15	112.5
$32 \le \gamma \le 40$	6	1, … , 6	3, 6, 9, 12, 15, 18	54
$41 \le \gamma \le 49$	8	0, …, 7	0, 3, 6, 9, 12, 15, 18, 21	-31.5
$50 \le \gamma \le 58$	9	0, …, 8	0, 3, 6, 9, 12, 15, 18, 21, 24	-144
$59 \le \gamma \le 67$	10	0, …, 9	0, 3, 6, 9, 12, 15, 18, 21, 24, 27	-283.5
$68 \le \gamma$	11	0, …, 10	0, 3, 6, 9, 12, 15, 18, 21, 24, 27, 30	-450

Swarthout and Walker

- Review results in Chen and Plott and Chen and Tang

Table 3 Continuous-space equilibria in the C&P and C&T experiments

Treatment	γ	Continuous-space equilibrium					x
		m_1	m_2	m_3	m_4	m_5	
CP-1	1	−1	0	1	2	3	5
CP-100	100	0.98	0.99	1	1.01	1.02	5
CT-1	1	−15	25	−5	15	5	25
CT-100	100	4.8	5.2	4.9	5.1	5	25

Swarthout and Walker

- Summary of CP and CT results:
  - CT-100: subjects' choices converged quickly to (m_1, m_2, m_3, m_4, m_5) = (5, 5, 5, 5, 5)
  - CP-100: subjects generally chose messages near (m_1, m_2, m_3, m_4, m_5) = (1, 1, 1, 1, 1), but did not coordinate on any particular profile of messages.
  - CP-1 and CT-1: choices never converged, and the public good level was generally not the Pareto amount.

Table 4 Equilibria in the C&P experiment

γ	#NE	Common messages m_i in NE	Provision levels of the public good	smallest surplus
1	9	m_i not all the same	5	110
2	4	m_i not all the same	5	110
3	2	m_i not all the same	5	110
4	0			
$5 \le \gamma \le 31$	1	1	5	110
$32 \le \gamma \le 38$	2	m_i not all the same	5, 9	39.6
$39 \le \gamma \le 43$	2	1, 2	5, 10	0
$44 \le \gamma \le 83$	3	0, 1, 2	0, 5 10	0
$84 \le \gamma \le 87$	4	0, 1, 2, 3	0, 5, 10, 15	-330
$88 \le \gamma \le 127$	5	-1, ... , 3	-5, 0, 5, 10, 15	-330

Table 5 Equilibria in the C&T experiment

γ	# NE	Common messages m_i in NE	Provision levels of the public good	Smallest surplus
1	1445	m_i not all the same	25	525
2	97	m_i not all the same	25	525
3	54	m_i not all the same	25	525
4	22	m_i not all the same	25	525
5	9	m_i not all the same	25	525
6	14	m_i not all the same	25	525
7	4	m_i not all the same	25	525
8	3	m_i not all the same	25	525
9	2	m_i not all the same	25	525
10	3	m_i not all the same	25	525
$11 \le \gamma \le 13$	1	m_i not all the same	25	525
$14 \le \gamma \le 17$	2	m_i not all the same	25	525
$18 \le \gamma \le 35$	1	m_i not all the same	25	525
$36 \le \gamma \le 46$	0			
$47 \le \gamma \le 129$	1	5	25	525

Next

- February 14
- Voting
  - MR
  - Arrow's impossibility theorem
  - Gibbard-Satterthwaite Impossibility Theorem
- MasColell, Whinston and Green, Chapters 21