Peer Discipline and Incentives Within Groups

David K. Levine and Salvatore Modica

The Question

- why do voters vote?
- why do farmers and bankers lobby?
- why do soldiers fight?
- why don't police report misconduct?
- and on and on

Answers of Economists

- altruism
- voluntary contribution to a public good

Both answers have an element of truth, but both forces are quantitatively insignificant

No successful society or organization has ever been based on volunteerism

feel free to shout “Workers of the world unite – you have nothing to lose but your chains” … and your jobs and incomes

We know the correct answer, we just don't put it in our models

Peer Discipline

- if you don't vote your friends will look down on you
- if you don't contribute to the farm or banker lobby your fellow farmers and bankers will shun you
- if you don't fight your fellow soldiers will probably kill you
- if you report misconduct of your fellow police officers...

Peer Discipline: The Model

- self-sustaining group discipline that overcomes free-riding problems through costly peer punishment
- take mechanism design approach – examine schemes that might be adopted by a collusive group to minimize the cost of enforcing actions which are not Nash equilibria in the absence of punishment
- adaptation of the Kandori model of social norms in which the punishers are distinct from the aggrieved

similar to:

- efficiency wage model (Shapiro Stiglitz)
- models of collusion proofness (Laffont)

these models have ignored incentive for punishers

The Setting

$N > 2$ identical members $i = 1, \ldots, N$ of a collusive group

group plays one time primitive game in period 0

which members choose actions $a^i \in A$ a finite set

expected payoff of a member $u(a^i, a^{-i})$.

let a^R be common action of members

shorthand: as $u(a^i, a^R) = u(a^i, a^R, \ldots, a^R)$

assume that there is at least one symmetric static Nash equilibrium:
$a^R \in A$ for all $a^i \in A$ we have $u(a^i, a^R) \leq u(a^R, a^R)$

The Question and Peer Monitoring

sustainability of actions a^R which are possibly not Nash equilibria through incentive compatible peer monitoring

based on Kandori's information systems approach

members audit each others behavior

accounts for the self-referential nature of punishment equilibria by supposing a potentially unlimited number of audit rounds $t = 1, 2, \ldots$

Signals

signals of behavior in the primitive games and in the subsequent auditing rounds

actions primitive game generate a signal of individual play $z^i \in \{0,1\}$

0 is bad and 1 is good

probability of the bad signal 0 about member i is $\pi_0(a^i, a^R)$

Audit Rounds

sequence of audit rounds $t = 1, 2, \ldots$

players matched in pairs as *auditor* i and *auditee* j

matching: members located on circle – identify member 0 with member N and member $N + 1$ with member 1

assume that $j = i - 1$: each member audits the member to his left

in round $t \geq 1$ auditor i assigned to audit member j chooses whether or not to conduct the audit

Audit Signals and Punishments

depending on whether audit is conducted or not bad-good signal $z_t^i \in \{0, 1\}$ generated

audit: bad signal probability π

no audit: bad signal probability $\pi^p \geq \pi$

audit conducted: privately observe signal $z_{t-1}^j \in \{0, 1\}$ of auditee in previous round

signal is 0 (bad) auditee is punished

punishment has cost to the auditee of $P > 0$

cost to the auditor of audit is $\theta_t P \geq 0$

stationarity: $\theta_t = \theta$ for $t > 1$

initial audit can have different cost

The Super Game

first: meeting in which members agree on a scheme to maximize the utility of group members

agree on a common action a^R and for each round $t = 0, 1, \ldots$ beginning with the primitive round 0 a probability δ_t that the next audit round will take place

$1 - \delta_t$ probability that the game ends after round t determined endogenously by the group.

auditing rounds take place quickly so no discounting beyond that induced by δ_t

Incentive Compatibility

group is bound by incentive constraints – only incentive compatible plans can be chosen

a plan $a^R, \delta_t|_{t=0}^{\infty}$ is *peer feasible* if the individual strategies of playing a^R in the primitive round and always conducting an audit in the audit rounds is a Nash equilibrium of the super-game induced by the continuation probabilities δ_t

at the initial meeting group may either choose a peer feasible plan, or it may choose a static Nash equilibrium of the primitive game together with $\delta_0 = 0$. Among these plans the group chooses the plan that maximizes the *ex ante* expected utility of the members

Enforceability

a^R is *enforceable* if there is some punishment scheme based on the signal such that a^R is incentive compatible

there must be some punishment P_1 such that for all a^i we have
$u(a^R, a^R) - \pi_0(a^R, a^R)P_1 \geq u(a^i, a^R) - \pi_0(a^i, a^R)P_1$

$\sigma_0(a^i, a^R) \equiv \pi_0(a^i, a^R) - \pi_0(a^R, a^R)$ called *signal increase*

for simplicity in the talk assume that $\sigma_0(a^i, a^R) > 0$ for $a^i \neq a^R$

write the incentive constraint as

$\widetilde{G}(a^i, a^R) = \frac{u(a^i, a^R) - u(a^R, a^R)}{\sigma_0(a^i, a^R)} \leq P$

define $G(a^R) \equiv \max\{0, \max_{a^i} \widetilde{G}(a^i, a^R)\}$

largest punishment needed for enforceability

more general definition possible

Peer Feasibility

audit signal increase $\sigma = \pi^P - \pi$

Theorem: *If the action a^R is not static Nash it is peer feasible for some $\delta_t|_{t=0}^{\infty}$ if and only if $P \geq G(a^R)$, $\theta_1/\sigma \leq 1$ and $\theta/\sigma < 1$, in which case the group optimally chooses the termination probabilities*

$\delta_0 = G(a^R)/P, \delta_{t>0} = \theta/\sigma.$

The corresponding utility attained by each member is

$$U = u(a^R, a^R) - \left(\pi_0(a^R, a^R) + \theta_1 + \frac{\theta_1(\theta+\pi)}{\sigma-\theta}\right) G(a^R).$$

Remark: $\theta_t P \leq \sigma P$ is the incentive constraint, it says the cost of an audit should be less than or equal to the increased cost of punishment incurred by not auditing

Summary of Optimal Auditing

utility net of minimum punishment cost

$$v(a^R) = u(a^R, a^R) - \pi_0(a^R, a^R)G(a^R)$$

unit cost of auditing

$$C = \theta_1 + \frac{\theta_1(\theta+\pi)}{\sigma-\theta}$$

optimum peer feasible utility from action a^R is $U = v(a^R) - CG(a^R)$

Optimal Plan

Either don't audit or optimally audit

If C is large choose static Nash

Theorem: *The optimal a^R has $v(a^R)$ and $G(a^R)$ weakly decreasing in C*

as the unit cost of auditing declines, it becomes optimal to accept larger gains to deviation in exchange for higher group net utility in the primitive game

Theorem: *C is increasing in $\theta_1, \theta, \pi, 1/\sigma$.*

A Public Good Contribution Game

might be attempting to corrupt a politician or it could be a consortium bidding on a contract.

each group member chooses between two actions $a^i \in A = \{0, 1\}$ is utility cost of contributing to the public good

contribution $a^i = 1$ this results in benefit to the group of $s > 1$ divided equally among all N members

$u(a^i, a^R)$

	$a^R = 0$	$a^R = 1$
$a^i = 0$	0	$s - (s/N)$
$a^i = 1$	$(s/N) - 1$	$s - 1$

assume that $\pi_0(a^i, a^R)$, π and π^p do not depend on group size

Public Good Theorem

Theorem: *Abbreviate* $\sigma_0 = \sigma_0(0,1) = \pi_0(0,1) - \pi_0(1,1)$. *Define*

$\overline{N}(s,P) =$

$$\begin{cases} s/\left(1 - \frac{\sigma_0(s-1)}{\pi_0(1,1)+C}\right) & \text{for} \quad s \leq 1 + [\pi_0(1,1)+C] \cdot \min\{P, 1/\sigma_0\} \\ s/(1-\sigma_0 P) & \text{for} \quad s \geq 1 + [\pi_0(1,1)+C]P,\ P < 1/\sigma_0 \\ \infty & \text{for} \quad s \geq 1 + [\pi_0(1,1)+C]/\sigma_0,\ P \geq 1/\sigma_0 \end{cases} .$$

For $N \leq s$ *the group contributes full effort, requires no costly auditing, and achieves utility* $U = u(1,1) = s-1$. *For* $s < N \leq \overline{N}(s,P)$ *and* $\theta_1/\sigma \leq 1, \theta/\sigma < 1$ *the group employs costly auditing, contributes full effort and achieves utility*

$$U = s - 1 - [\pi_0(1,1)+C][1-(s/N)]/\sigma_0.$$

For $N > \overline{N}(s,P)$ *or* $\theta_1/\sigma > 1$ *or* $\theta/\sigma \geq 1$ *the group contributes no effort and achieves utility* $U = 0$.

Interpretation of the Theorem

peer discipline not available if $\theta_1/\sigma > 1$ or $\theta/\sigma \geq 1$

- standard public good problem: group contributes full effort as long as individuals have adequate incentive to provide effort: $N \leq s$.
- once group becomes larger it ceases to provide effort

peer discipline is available when $\theta_1/\sigma \leq 1, \theta/\sigma < 1$

- full effort in the range $s < N \leq \overline{N}(s, P)$
- once group becomes larger it ceases to provide effort

if $\overline{N}(s, P)$ is finite qualitatively this similar to the pure public goods case

comparative statics of $\overline{N}(s, P)$ have expected monotonicity properties: lower cost of peer discipline as measured by smaller $\pi_0(1, 1) + C$ and larger σ_0 increase the size of group that can sustain effort

The Infinite Case

$\overline{N}(s,P) = \infty.$

requires:

- punishment be adequately large for the given initial signal quality - $P \geq 1/\sigma_0$
- s be sufficiently large: $s \geq 1 + [\pi_0(1,1) + C]/\sigma_0$

very different than public good case: contributions no matter how large the group is

Empirics of Very Large Groups

about two million farms in the United States

- similar to the paradox of voting: not very plausible that the individual lobbying efforts of a single farmer increase the chances of farm subsidies enough to be individually worthwhile
- we observe farm subsidies of similar per-farm value across countries with very different sizes: Japan and the United States, for example

Theory in Very Large Groups

suppose peer discipline technology and the benefit per farmer of farm subsidies s are roughly the same in the different countries

if $\overline{N}(s,P)$ is finite, then in countries with few farmers $N \leq \overline{N}(s,P)$ we should find lobbying effort and farm subsidies, while in countries with many farmers $N > \overline{N}(s,P)$ we should find no lobbying and no farm subsidies.

$\overline{N}(s,P) = \infty$ covers this fact: full effort is provided independent of group size, so no matter the number of farmers or size of country, the amount of per capita public good achieved should be roughly similar - as it is.

Olson and Group Size

goes against the Olson idea that larger groups should be less effective.

can a small group (farmers) is be more effective than a large group (of non-farmers)?

fixing the size of the stakes and varying group size (previously the stakes were proportional to the size of the group)

Fixed Prize

total benefit to the group when all contribute is $s_N N = S$

so $s_N = S/N$: for farmers the s_F corresponding to receiving farm subsidies is large since few farmers receive the subsidy

for non-farmers the s_{NF} corresponding to paying for farm subsidies is small since many non-farmers divide the costs

both groups have access to exactly the same peer discipline technology can have

$s_F \geq 1 + [\pi_0(1,1) + C]/\sigma_0$ for farmers

$s_{NF} < 1 + [\pi_0(1,1) + C]/\sigma_0$ for non-farmers

farmers will be effective and contribute full effort, but non-farmers will be ineffective and not contribute effort