Volunteering under population uncertainty

Fabian Winter, Adrian Hillenbrand

Max Planck Institute for Research on Collective Goods, Bonn
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Diffusion of Responsibility in the Volunteer’s Dilemma Game (Diekmann, 1985)

- 38 observers (N=38)
- Everyone wants to see Kitty being rescued (benefit $b$)
- Calling the police is costly, but the costs are small (cost $c$)

<table>
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<th>other cooperators:</th>
<th>0</th>
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<th>2</th>
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<tbody>
<tr>
<td>Cooperate</td>
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<td>0</td>
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- 39 equilibria, 38 pure and 1 mixed
- mixed equilibrium: call police with probability $p^*$
A model of Diffusion of Responsibility

\[ \hat{p} = 1 - \left( \frac{c}{b} \right) \frac{N}{N-1} \]

\[ p^* = 1 - \left( \frac{c}{b} \right) \frac{1}{N-1} \]
In many cases decision makers are not aware of the number of other players

- Barbecue at the park
- writing a Wikipedia article
- private call for stem cell donation
- ...
The theoretical literature on population uncertainty


Bertrand Halevy, Milchtaich (2005), Ritzberger (2009)

Contest Myerson & Wärneryd (2006), Lim, Matros (2009)

Coordination Makris (2007, 2009)

Cooperation no theory
Population uncertainty and cooperation – Experimental evidence

- sequential CPR and PPG, results mixed

DG Kim (wp, 2015)
- Population uncertainty $\rightarrow$ lower cooperation (linear PGG)
- Higher $N_{min} \rightarrow$ lower cooperation
- more uncertainty $\rightarrow$ more cooperation

Ioannou, Makris (wp, 2015)
- Lower coordination rate under population uncertainty
Does population uncertainty influence behavior in the cooperation problems?

- Theory (it does)
- Experiment (it does)

Potential mechanisms:

- Perceived pivotality (no)
- Risk aversion (no)
Volunteer’s Dilemma Game (Diekmann, 1985)

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\[ \Gamma = \langle N, (A_i)_{i \in N}, (v_i)_{i \in N} \rangle \]

Population uncertainty can be manipulated via spread \( s \):

\[ N \sim \mathcal{U}(N_e - s, N_e, N_e + s), s \in \mathbb{N} : 0 \leq s < N_e \]
Volunteering under certainty

\[ N \sim \mathcal{U}(N_e - s, N_e, N_e + s), s \in \mathbb{N} : 0 \leq s < N_e \]

Case 1: The standard VoD, N is certain and common knowledge

- \( s = 0 \)
- \( N \sim \mathcal{U}(N_e) \)
- N asymmetric pure-strategy equilibria
- one symmetric mixed strategy equilibrium

\[ p_c^* = 1 - \left( \frac{c}{b} \right)^{\frac{1}{N-1}} \]
Volunteering under uncertainty

\[ N \sim \mathcal{U}(N_e - s, N_e, N_e + s), s \in \mathbb{N} : 0 \leq s < N_e \]

Case 2 (low uncertainty): \( s = 1, N_e = 3 \)

- \( N \sim \mathcal{U}(2, 3, 4) \)
- symmetric pure-strategy equilibria for very low \( c \) and \( s = N_e - 1 \)
- one symmetric mixed strategy equilibrium

\[ p^* = p \quad \text{s.t.} \quad \frac{1}{3}(1 - p)^{n-s-1} + \frac{1}{3}(1 - p)^{n-1} + \frac{1}{3}(1 - p)^{n+s-1} = \frac{c}{b} \]
Predictions

high costs (c/b = .9)

predicted volunteering rate for different Ne

spread s around Ne

low costs (c/b = .1)

predicted volunteering rate for different Ne

spread s around Ne
Treatments

certainty: $N_e = 3, c/b = .5, s = 0$

low uncertainty: $N_e = 3, c/b = .5, s = 1 \rightarrow N \sim U(2, 3, 4)$

high certainty: $N_e = 3, c/b = .5, s = 2 \rightarrow N \sim U(1, 3, 5)$
Predictions

intermediate costs \((c/b = .5)\)

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<tr>
<th>Spread of (N_c) around (N_c)</th>
<th>Predicted Volunteering Rate</th>
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<tbody>
<tr>
<td>certain ((N=3))</td>
<td>.29</td>
</tr>
<tr>
<td>low uncertainty (2,3,4)</td>
<td>.31</td>
</tr>
<tr>
<td>high uncertainty (1,3,5)</td>
<td>.39</td>
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Volunteer’s Dilemma game (working on a project)

- one-shot
- between-subjects
- subjects know expected $N_e$ and spread $s$

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<th>certain</th>
<th>$N = 3$ revealed</th>
<th>Choice</th>
<th>Beliefs</th>
<th>Payoff</th>
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<tr>
<td>uncertain</td>
<td>Choice</td>
<td>Beliefs</td>
<td>$N \in {3 - s, 3, 3 + s}$ revealed</td>
<td></td>
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Results
Are you pivotal?

“How many of the other cooperated in your group?”
Is it important that *YOU* are pivotal?

“We replace your choice with someone else’s choice. How many subjects are cooperating in your group now?”

![Graph showing the number of volunteers if I am replaced under certain, low uncertainty, and high uncertainty conditions.](image_url)
my pivotality= (\# volunteers + me) – (\# volunteers if I am replaced)

\[
\tilde{x} = -0.15 \\
ci(-0.39/0.09)
\]

\[
\tilde{x} = -0.31 \\
ci(-0.64/0.02)
\]

\[
\tilde{x} = -0.38 \\
ci(-0.58/0.17)
\]
Behavioral Mechanism: Risk-Aversion

(Crosetto, Fillippin, 2013)
Summary

• Volunteer’s Dilemma with population uncertainty
• Cooperation rate (weakly) higher under population uncertainty
• Higher expected number of other volunteers in uncertain
  → Subjects overestimate their importance under uncertainty
• a higher feeling of influence plays a role
• risk aversion does not
benefit $b$, cost $c$, $p$ is probability to cooperate of others, $x$ is number of other cooperators. $s$ is the spread, $n$ is the mean, we assume mean-preserving-spread

FOC: $b - c = b(Prob(x \geq 1)) = bf(n, s, p)$

$$f(n, s, p) = q_1(1-(1-p)^{n-s-1}) + q_2(1-(1-p)^{n-1}) + q_3(1-(1-p)^{n+s-1})$$

(The right hand side of the above equation becomes sth like $b*1-b*...$).

Simplified:

$$q_1(1-p)^{n-s-1} + q_2(1-p)^{n-1} + q_3(1-p)^{n+s-1} = \frac{c}{b}$$

For $s = 0$ and $q_1, q_3=0$ this collapses to the standard formula.

In the experiment we have $q_1 = \frac{1}{3}$
In the experiment we have $q_1 = q_2 = q_3 = \frac{1}{3}$

$$\frac{1}{3}(1 - p)^{n-s-1} + \frac{1}{3}(1 - p)^{n-1} + \frac{1}{3}(1 - p)^{n+s-1} = \frac{c}{b} \quad (1)$$

Looking at this:

- $(1 - p)^z$ is convex in $z$

→ the above equation 1 is a convex combination and therefore always higher than $(1 - p)^{n-1}$.

→ The lhs of equation 1 is higher in the uncertain case compared to the certain case for each! $p$.

→ The lhs is decreasing in $p$ for a given $n$.

→ The equilibrium level $p$ is always higher under uncertainty (siehe Graphik auf deiner Tafel unten rechts ;))