Stewardship signaling and the power of using social pressures to reduce nonpoint source pollution

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ABSTRACT

Nutrient runoff from agricultural land generates nonpoint source (NPS) water pollution that adversely affects water resource users. In the United States, we rely on agri-environmental programs that motivate farmers to voluntarily adopt best management practices (BMPs) that limit nutrient loss. A key policy challenge is determining how to persuade producers to curtail pollution while still retaining productive working landscapes. In this research, we use laboratory experiments with university students to test the impact of social pressures and communication on individual decisions that generate water pollution. We test the impact of these treatments with and without stewardship signaling, through which individuals can give credible signals about their environmental stewardship efforts. In the experiment, participants use flags to signal their use of a costly "green" technology that reduces the pollution generated by production. In the social pressure treatments, excessive pollution triggers a display of negative emotions (shaming) from the participants' community via their university mascot or peers. Communication is also tested by allowing participants to indicate displeasure in the production decisions of fellow group members. Results indicate that giving participants a mechanism to signal their individual stewardship actions is the most effective way to reduce pollution levels and encourage adoption of "green" technologies. A strong treatment effect persists with and without social pressures and communication. Policies that allow producers to demonstrate their commitment to environmental stewardship may encourage engagement in agricultural conservation initiatives.

Key words: nonpoint source pollution; water quality; mascots; social pressure; agri-environmental policy; ambient-pollution tax JEL: Q25, Q58, Q53, Q15

1. INTRODUCTION

Runoff from agricultural production is a leading contributor to nonpoint source (NPS) pollution in the United States (Xepapadeas 2011). According to the EPA, over 5,000 bodies of water in the United States are deemed impaired due to nutrients that are emitted primarily via NPS pollution (United States Environmental Protection Agency 2014). Mitigating NPS pollution is particularly challenging because it is often too costly, or impossible, to measure pollution generated by individual producers; therefore, pollution must be monitored and addressed at larger scales (e.g., watershed-scale) (Segerson 1988). Furthermore, agricultural NPS pollution is not regulated under the Clean Water Act, so we rely on voluntary adoption of best management practices (BMPs) to reduce nutrient and sediment runoff (Ribaudo 2015).

One way to address NPS pollution at a landscape-scale is to identify and implement cost-effective approaches in which everyone is held accountable for ambient pollution levels. Previous research has analyzed the impact of financial incentives, like taxes and subsidies, that are tied to ambient pollution levels (Segerson 1988; Spraggon 2002; Spraggon 2004; Suter, Vossler and Poe 2009). However, the feasibility of implementing policies that penalize or reward producers based on ambient pollution levels is limited for multiple reasons related to politics and concerns about fairness. Acknowledging this reality, there has been a growing interest in measuring the effects of nonpecuniary incentives that motivate behavioral changes related to environmental stewardship.

This research analyzes behavioral responses to social pressures designed to mitigate NPS pollution. We test the effects of stewardship signaling and shaming by peers and a community mascot. We also evaluate the effectiveness of these interventions with and without communication among subjects. Rather than relying on policy approaches that require establishing and maintaining a system of fines and penalties that can be both costly and time-consuming, we demonstrate how social pressures can impact individual decisions regarding production and pollution levels. Social pressures are generated in an economic experiment with 1) the use of a stewardship signaling mechanism through which participants are able to demonstrate their adoption of a costly, pollution-reducing technology, 2) videos indicating disappointment (shaming) about high ambient pollution levels from peers within the participants' community or from a community mascot, and 3) communication among participants.

Results suggest that individuals reduce emissions when they are able to demonstrate their stewardship using credible signals that are visible to their peers. The effect of stewardship signals persists with and without community social pressures and communication. Communication alone is insufficient to reduce ambient pollution below the pollution threshold.

Motivation and background

NPS pollution via runoff typically refers to sediment, phosphorus, and nitrogen carried into bodies of water during and after precipitation. When excess nitrogen and phosphorus enter a body of water, eutrophication can occur, resulting in detrimental algal blooms and hypoxia that generate economic losses due to lost ecosystem services (Xepapadeas 2011). People rely on healthy water resources for personal consumption and for recreational amenities like fishing, swimming, and boating. Dodds et al. (2009) estimate that damages caused from eutrophication amount to $2.2 billion annually in the United States alone, which substantially reduces the value of the benefits derived from water resources.

Many agri-environmental issues, like NPS pollution, are addressed through government programs that pay producers to voluntarily adopt conservation practices that reduce negative externalities such as runoff. However, these programs are costly and thus limited in their scope. Economic research has pointed to policies that can address NPS pollution using penalties and subsidies based on ambient pollution levels. First proposed by Segerson (1988), ambient pollution policies have been widely explored in the economic literature (Spraggon 2002; Spraggon 2004; Suter et al. 2009). Ambient policies rely on regulatory mechanisms that penalize or reward groups of producers depending on how total ambient pollution levels compare to a predetermined goal. Under an ambient tax (subsidy), all producers are fined (paid) if ambient pollution levels are greater (less) than the set threshold, thereby creating a group liability (Segerson 1988). By construction, these policies hold all farmers responsible for pollution outcomes. The group liability design attempts to achieve lower levels of NPS pollution by instilling a greater sense of responsibility among producers.

Despite the presence of an ambient pollution tax or subsidy, the possibility for free riders prevails. A group may reach their pollution goal by having some firms copiously reduce their pollution below the socially equitable level while free riding firms continue to pollute excessively. Because of the ambient nature of this program, free riders gain the benefit of receiving a subsidy or avoiding a penalty without taking costly actions to reduce pollution. Situations like this call into question whether such polices are equitable, which has limited the support of these policies in practice.

Ambient policies have encountered resistance due to the fact that each person cannot be held precisely accountable for their specific actions within a watershed. Additionally, in the United States, crop producers are typically permitted to manage their land with little regulatory oversight. For these reasons, we rely on programs that motivate voluntary actions to reduce pollution. Funding for federal and state conservation programs is currently insufficient to pay all producers to adopt BMPs; therefore, we need to identify alternative approaches to motivate environmental stewardship actions.

Across the country, voluntary environmental programs (VEP) are being used to encourage producers to adopt more environmentally-friendly practices (Segerson and Miceli 1998). Many types of voluntary incentive programs exist; however, this paper will only focus on programs that involve stewardship signaling. Agri-environmental stewardship signaling typically refers to programs through which a producer is certified for using environmentally-friendly production practices that surpass mandates or requirements.

One example of a stewardship certification program is the Michigan Agriculture Environmental Assurance Program (MAEAP). Through this program, producers can place a sign on their property to signal their environmental responsibility after they are approved by the Michigan Department of Agriculture and Rural Development (Chantorn 2013). Displayed in Figure 1, the sign shows a river running through a green landscape with, "This Farm is Environmentally Verified" prominently displayed at the top. There are three phases that must be completed to receive MAEAP verification: 1) education; 2) farm-specific risk assessment; and 3) third-party on-farm verification that environmentally-friendly practices have been implemented. By displaying this sign on the front of their property, producers are able to publicly differentiate themselves from other producers, as well as signal their environmental responsibility to their community.

Stewardship certification programs, like MAEAP, connect into the social constructs of a producer's community to influence land management decisions. Armstrong and Huck (2010) explain that sometimes social preferences rather than profit (in this case avoiding environmental damages from pollution) can play a role in a firm's decision-making, and social pressures are often dictated through face-to-face communication or comparison between firms. Through social interactions, a group mentality is formed that reduce the role of profits in the decisions that firms make. Using a laboratory experiment, Butler et al. (2015) studied the impact of having a community mascot interact with students in a disappointing manner when the students collectively exceeded predetermined pollution goals. The mascot's interaction with students provided a nudge of a social pressure that reduced subsequent polluting behavior.

By testing the effectiveness of low-cost social nudges for reducing individual and group-level pollution, our research builds upon previous ambient pollution research and the literature on stewardship signaling and social pressures. Motivated by an experiment by Butler, Fooks, Messer, and Palm-Forster (2015) that measured the effectiveness of using mascots to change polluting behavior, this research tests three social pressure treatments: 1) stewardship signaling, 2) community pressure from a mascot or peers, and 3) communication among participants. The effectiveness of these interventions at reducing NPS pollution is evaluated by analyzing participants' individual production and pollution decisions and group-level pollution outcomes in a laboratory experiment.

2. METHODOLOGY

Experimental Design Summary

We designed a laboratory economic experiment in which student participants acted as managers of generic firms that generated pollution as a byproduct of production. In a series of independent rounds, each participant made two decisions – a production and a technology decision – that affected their firm's profits and pollution. We describe our treatments in detail in the next section.

Experiment sessions were conducted with 144 undergraduate students at a large East Coast public university in the United States. Eighteen students participated in each session, and subjects were randomly assigned to a group consisting of six people. Participants were recruited via email using lists managed by the university's economics department and the experimental economics laboratory. The emails stated that participants would be paid an average of $30 for a 90-minute economic decision-making study; no other information about the experiment was provided prior to the session.

Each experiment session consisted of four phases, including 1) instruction, 2) practice rounds, 3) experimental rounds, and 4) a short survey. There were eight parts in the experiment, and each part was comprised of five rounds. The experiment was conducted using Surface Pro tablets using Willow (Weel 2016). In each round, participants chose among ten different production decisions (A-J) and between two technology decisions (Technology 1 and Technology 2) as shown in Table 1. The ten production decisions start with low production (profit) and pollution levels, both increasing as you move down the list of production decision options, until production decision 'G' where pollution continues to increase but production (profit) starts to decrease. Technology 1 represented a conventional technology, whereas Technology 2 represented a "green" technology. Technology 2 was more costly for the participant (105 experimental dollars more), but generated less pollution for each level of production.

Participants were assigned to groups of six that resembled watersheds (groups were independent), and groups were randomly reassigned before each new treatment period. In each round, pollution generated by each of the six firms was added together to determine the ambient pollution level for the group. The experiment involved homogeneous individuals, where the relationship between production decisions and pollution was the same for everyone in a watershed group. The six members of each group sat in a semicircle around a large television screen, and an experiment administrator sat at the center of each semicircle. Groups were randomly reassigned before each treatment (part) and remained consistent for the five rounds in each part.

[Insert Table 1 here]

Earnings based on firm profits were generated as experimental dollars that were then converted into US dollars and paid to participants in cash at the end of the experiment. One US dollar equaled 910 experimental dollars. Experiment sessions lasted between 1.5 – 2 hours with average earnings of $30.

Table 2 displays the functions that generated Production Income and Pollution for each production decision and technology choice. A suboptimal tax was applied in each treatment, which equaled half of the marginal damages of pollution (i.e., 26 experimental dollars per unit of pollution). By using a suboptimal tax throughout the entire experiment, behavioral effects induced by nonmonetary incentives can be measured because the tax incentive alone is not sufficient to reduce pollution to the optimal level. In each round of the experiment, the ambient pollution goal for each group was set at the socially efficient level of pollution (18 units). If aggregate group pollution exceeded the threshold of 18 units, all participants in that group paid a tax of 26 experimental dollars for every unit of pollution above 18 units. For example, if total pollution was 21 within a group, every member of that group was taxed 78 experimental dollars ((21-18) *26) = 78.

[Insert Table 2 here]

Treatments

This experiment included eight within-subject treatments and two between-subject treatments as depicted in Table 3. Within-subject treatments (T1-T8) were combinations of stewardship signaling, community pressure, and communication. The social pressure messenger was a between-subject treatment – in half of the sessions, negative feedback originated from the university mascot, whereas a group of university students provided negative feedback in the other half of the sessions. Each treatment consisted of five rounds. To avoid ordering effects, the order of the treatments was varied across sessions using an orthogonal experimental design. The ordering of treatments in each of the eight sessions are presented in Table 4.

[Insert Table 3 here]

[Insert Table 4 here]

Using the laboratory experiment, we tested the following treatments:

1.) *Stewardship signaling:* Subjects provided credible stewardship signals by placing small green flags on the front of their desks if they chose to use a costly "green" production technology (Technology 2). Within a group, all participants could visibly see who was displaying their flag. Participants were instructed to put up or take down their flags after each round has ended during a 17-second pause between rounds. During this time, participants could electronically view summary results of all previous rounds in the current part. Dividers were set up between groups to ensure that groups could not observe outcomes of other groups.

2.) *Community feedback from a mascot or peer group:* Community feedback was provided via videos in which a community mascot or a peer group showed displeasure with groups who exceed the pollution threshold of 18 units. If the threshold was exceeded, the videos were shown after the round during the 17-second pause in which previous results were presented to subjects. The videos were played on televisions located at the front of each group's semicircle. Groups could only view their own televisions. The videos were recorded in front of an iconic community building on the university campus. If group pollution did not exceed the threshold, images of the iconic building were displayed. To assure that participants looked up at the television, participants wore headphones and heard a series of beeps during the duration of the videos. Additionally, to further direct their attention to the televisions, participants' individual Surface Pros displayed a pop-up message that said "Please look at the TV" when videos were displayed.

3.) *Communication:* The communication treatments allowed participants to send pre-determined messages to other group members. The predetermined message stated, "Think about the rest of the group; do the right thing." Communication was only allowed via the Surface Pro tablets using this predetermined message. The message had a negative tone, indicating dissatisfaction with the participants' production decisions, and the message could only be seen by the sender and recipient. Producers could choose to send messages to as many members in their group (or none) as they desired.

Participants had identification numbers on their desks and nametags with the same number, so they could clearly determine to whom they wanted to send messages. However, identification numbers of senders were not revealed to the message recipient. In each round, all communication decisions were made prior to making production and technology decisions. Production and technology decisions could not be submitted until *all* 18 participants had submitted (or declined to send) and received messages.

Empirical methods

We formally test the effects of the treatments on individual technology decisions and ambient pollution. Random effects probit models are used to analyze how the treatments affected individual technology decisions. A linear random effects model is used to test the treatment effects on individual- and group-level pollution.

A random effects probit model is used to model scenarios in which the dependent variable is binary, like whether or not an individual used the "green" technology. The probit model uses a nonlinear functional form to estimate the probability of an event occurring ($Y = 1$) (Stock and Watson 2011). A binary dependent variable, like our binary technology decision, is best fit using a probit model. Our dependent variable, $TECH_{ir}$, equals one if Technology 2 was chosen by individual *i* in round *r* and zero otherwise. Random effects are used to account for the individual and idiosyncratic errors across rounds. We specify our model as,

$$\begin{aligned} TECH_{ir} = {} & \beta_0 + \beta_1 Signal + \beta_2 Communication + \beta_3 Mascot + \beta_4 Peers \\ & + \beta_5 Signal\ x\ Mascot + \beta_6 Signal\ x\ Peers + +\lambda_1 MessRec_{ir} \\ & + \lambda_2 MessSent_{ir} + \sum_{s=1}^{8} \theta_s Session_{s,i} + \delta\, RoundOrder_{ir} + \mu_i + \omega_{ir} \end{aligned} \tag{1}$$

where, *Signal, Communication, Mascot, and Peers* are binary variables that equal one when the associated treatment is applied and zero otherwise. *SignalxMascot and SignalxPeers* are binary interaction terms used to estimate the effect of interactions between main treatments. $Session_i$ represents a set of binary variables that equal one for each session 1-8, and *RoundOrder* is the order in which each participant saw each of the rounds in the experiment, which is an integer value between 1 and 40. The individual-level and idiosyncratic (individual-round) errors are μ_i and ω_{ir}, respectively. Positive coefficients indicate that increasing values of the independent variable increase the probability that Technology 2 is selected.

We use a linear random effects model to estimate treatment effects on individual and group-level pollution. The null hypothesis under a random effects model is that the mean effect is zero. Rejecting the null indicates that the treatment has a significant effect on the dependent variable. We estimate two models in which the dependent variable, Y_{kr}, is either 1) *IndivdualPollution*, the unique pollution level of individual *i* in round *r*, or 2) *GroupPollution*, the aggregate pollution from group *j* in round *r*. We specify these models as,

$$Y_{kr} = \beta_0 + \beta_1 Signal_{kr} + \beta_2 Communication_{kr} + \beta_3 Mascot_{kr} + \beta_4 Peers + \beta_5 Signal\ x\ Mascot_{kr} + \beta_6 Signal\ x\ Peers_{kr} + \lambda_1 MessRec_{kr} + \lambda_2 MessSent_{kr} + \sum_{s=1}^{8} \theta_s Session_{s,k} + \delta\ RoundOrder_{kr} + \mu_k + \omega_{kr} \quad (2)$$

where, $k \in \{i, j\}$, depending upon the level of observation (individual or group). We use the same regressors as we presented in Model (1). The μ_k term is the individual- or group-specific random effect, and ω_{kr} is the idiosyncratic error.

We also evaluate results from Model (1) and Model (2) when independent variables are added to control for the number of messages sent (*MessSent*) and received (*MessRec*) during the messaging treatments.

3. RESULTS

We econometrically analyze our treatment effects on individual technology decisions and individual and group-level pollution. All data was analyzed using the statistical software program, STATA (StataCorp 2013).

Average ambient pollution outcomes for each treatment are presented in Table 5.These results show that average group pollution was lowest when stewardship signaling was coupled with the community mascot video, while rounds with only communication resulted in the highest average group pollution. Overall, stewardship signaling reduced pollution when paired with any of the other community feedback and communication treatments.

[Insert Table 5 here]

The probit model estimates of the treatment effects on technology decisions are presented in Table 6. Stewardship signaling has a positive, statistically significant effect on adoption of Technology 2, the "green" technology. Conversely, communication has a significant negative effect on adoption of Technology 2. Session fixed effects are used to control for ordering effects, and results suggest that session six has a positive effect on adoption of Technology 2. The coefficient on *RoundOrder* is negative and significant at the 1% level, indicating that participants were less likely to select Technology 2 as the experiment progressed. All three of the interaction terms are insignificant for the probit models.

[Insert Table 6 here]

Estimates from two random effects models of individual pollution are presented in Table 7. Stewardship signaling significantly reduces individual pollution, and participants reduced pollution in response to community feedback via mascots and peers. The coefficient on a binary variable for session eight is positive and significant, indicating increased pollution by participants in this session. The significant coefficient on *RoundOrder* indicates that participants were more likely to generate more individual pollution in later rounds of the experiment. No interaction effects are present in these models.

We include variables for messages sent and received in Model 2 (Table 7). Messages received is significant at the 1% level with a negative correlation, so the more messages participants received, the more likely they were to decrease their individual pollution.

[Insert Table 7 here]

Results for models analyzing group pollution are presented in Table 8. Stewardship signaling has a negative and significant effect on aggregate group pollution, which is consistent with the results for individual pollution. The coefficient on the *Peer* indicator variable is negative and significant at the 5% level, indicating that groups were more likely to have lower individual pollution levels in parts where participants were subject to community videos when their group exceeded the predetermined pollution threshold. Sessions two, four, five, seven, and eight are significant at the 1%, and session three at the 5% level, all with positive correlation. Round order is significant at the 1% level, indicating that groups were more likely to have higher group pollution levels as the experiment progressed.

[Insert Table 8 here]

4. DISCUSSION

NPS pollution from agricultural runoff is a persistent problem in the United States; therefore, it is imperative to identify ways to reduce runoff from agricultural land in a manner that is both simple and cost-effective. This study analyzed how social pressures affect producers' land management decisions, which generate pollution. We tested the impact of stewardship signaling, negative community feedback, and communication on production decisions and pollution emissions in an economic experiment in a laboratory.

Results of multiple analyses suggest that stewardship signaling is the most effective social pressure for inducing more environmentally-conscious land management decisions and mitigating pollution. We also found that negative social pressure from a group of peers was more effective at reducing pollution relative to negative pressure originating from a community mascot.

Stewardship certification programs across the United States aim to use social pressures to nudge producers toward environmentally-friendly production decisions that generate less pollution. Initiatives like MAEAP provide producers with credible signals of their stewardship through signage and other types of recognition that are observable to members of their community. Being able to provide a credible signal of one's stewardship motivates individuals to reduce pollution, as people want to appear "green" to their peers. By creating an open dialogue through local town hall meetings and discussions with producers and state agricultural departments, communities may be able to reduce pollution concentrations in local waterbodies. These approaches are attractive because they represent economical and effective ways to reduce NPS pollution and protect common water resources.

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TABLES

Table 1. Decision table

Management Decisions	Technology 1		Technology 2	
	Production Income	Pollution	Production Income	Pollution
A	440	0.0	335	0.0
B	550	1.0	445	0.5
C	640	2.0	535	1.0
D	710	3.0	605	1.5
E	760	4.0	655	2.0
F	790	5.0	685	2.5
G	800	6.0	695	3.0
H	790	7.0	685	3.5
I	760	8.0	655	4.0
J	710	9.0	605	4.5

Table 2. Production and damage functions

Function/ Parameter	Functional form
Production Function *(x=emissions)*	a-b(e-x)^2
Damage Function	d*x
a	800
b	10
e	6
d	52
Additional Cost of Technology 2	105
Privately-optimal emission level (per firm)	6
Socially-optimal emissions level (per firm)	3

Table 3. Within-subject treatment design

		Group Feedback and Communication			
		None	*Community video*[a]	*Community video*[a] *with communication*	*Communication alone*
Technology Signal	*No*	T1 (control)	T3	T5	T7
	Yes	T2	T4	T6	T8

[a] Negative community feedback was displayed via video when pollution exceeded the stated threshold. In the video, feedback originated from either a community mascot or from peers.

Table 4. Treatment ordering by session

Session	Video Type (between-subject treatment)	T1	T2	T3	T4	T5	T6	T7	T8
		(within-subject treatments)							
1	Mascot	1	2	3	4	5	6	7	8
2	Mascot	2	1	4	3	6	5	8	7
3	Mascot	8	7	6	5	4	3	2	1
4	Mascot	7	8	5	6	3	4	1	2
5	Peers	1	2	3	4	5	6	7	8
6	Peers	2	1	4	3	6	5	8	7
7	Peers	8	7	6	5	4	3	2	1
8	Peers	7	8	5	6	3	4	1	2

Table 5. Mean group pollution outcomes for each treatment

		Communication and Group Feedback					
		No Communication			*Communication*		
		No Video	*Mascot Video*	*Peer Video*	*No video*	*Mascot Video*	*Peer Video*
Technology Signal	*No*	21.45 (n=120) [21.21, 21.70]	21.18 (n=60) [20.87, 21.49]	21.71 (n=60) [21.36, 22.05]	21.88 (n=120) [21.64, 22.12]	21.63 (n=60) [21.33, 21.94]	21.32 (n=60) [20.95, 21.70]
	Yes	20.62 (n=120) [20.40, 20.83]	20.18 (n=60) [19.89, 20.48]	20.33 (n=60) [20.00, 20.65]	21.22 (n=120) [20.98, 21.46]	20.34 (n=60) [20.06, 20.62]	20.49 (n=60) [20.19, 20.80]

Table 6. Random effects probit regression on technology decisions

Variables	**DV = Technology 2 (= 0 or 1)**	
	Model A	Model B
Treatment effect		
Signal	0.7188***	0.6576***
	(0.0969)	(0.1154)
Communication	-0.1579**	--
	(0.0716)	
Mascot	-0.00509	0.0953
	(0.0993)	(0.1327)
Peer	0.0449	-0.0273
	(0.0914)	(0.1209)
Signal-communication interaction	0.0702	
	(0.0906)	
Signal-mascot interaction	0.0444	-0.0625
	(0.1174)	(0.1697)
Signal-peer interaction	0.0302	-0.0056
	(0.1311)	(0.1756)
Messaging		
Messages received		0.0212
		(0.0371)
Messages sent		0.0173
		(0.0201)
Session fixed effect		
Session 2	-0.0559	-0.0094
	(0.3747)	(0.4533)
Session 3	0.4241	0.4215
	(0.3132)	(0.3913)
Session 4	0.0749	0.1163
	(0.3212)	(0.3577)
Session 5	0.3655	0.6410
	(0.3677)	(0.4401)
Session 6	0.8266***	1.0959***
	(0.3123)	(0.4219)
Session 7	0.2788	0.4449
	(0.3223)	(0.4203)
Session 8	-0.1504	-0.0869
	(0.3596)	(0.4416)

Round	-0.0198***	-0.0244***
	(0.0031)	0.0073
Constant	-0.9228***	-1.0905***
	(0.2491)	(0.3625)
N	5760	2880

***, ** Denotes statistical significance at the 1% level and 5% level, respectively.

Table 7. Linear random effects model of individual pollution,

Variables	**DV = Individual Pollution**	
	Model C	Model D
Treatment effect		
Signal	-0.1377*** (0.0485)	-0.1346** (0.0604)
Communication	0.0639 (0.0488)	--
Mascot	-0.0613 (0.0525)	-0.1160 (0.0774)
Peer	-0.1332*** (0.0491)	-0.1378* (0.0753)
Signal-communication interaction	-0.0260 (0.0582)	--
Signal-mascot interaction	0.0663 (0.0651)	0.1020 (0.0884)
Signal-community interaction	0.0594 (0.0630)	0.0311 (0.0883)
Messaging		
Messages received		-0.0568*** (0.0194)
Messages sent		-0.0207 (0.0131)
Session fixed effect		
Session 2	0.3660 (0.2426)	0.4716* (0.2559)
Session 3	0.1181 (0.2383)	0.5166** (0.2616)
Session 4	0.2319 (0.1846)	0.6502*** (0.2120)
Session 5	0.1856 (0.2293)	0.3624 (0.2302)
Session 6	-0.0054 (0.2148)	0.0823 (0.2523)
Session 7	0.3175 (0.2221)	0.5147* (0.2639)
Session 8	0.6030** (0.2456)	0.9343*** (0.3102)

Round	0.0107***	0.0194***
	(0.0021)	(0.0044)
Constant	3.0934***	2.8380***
	(0.1253)	(0.2133)
N	5760	2880

***, ** Denotes statistical significance at the 1% level and 5% level, respectively. Robust standard errors are in parentheses.

Table 8. Linear random effects model of group pollution,

Variables	**DV = Group Pollution**	
	Model E	Model F
Treatment effect		
Signal	-0.8333*** (0.3189)	-0.6892 (0.4314)
Communication	0.3783 (0.2772)	--
Mascot	-0.3903 (0.3694)	-0.7288 (0.4799)
Peer	-0.8306** (0.4239)	-0.8234 (0.6071)
Signal-communication interaction	-0.1501 (0.3604)	--
Signal-mascot interaction	0.4219 (0.5202)	0.6819 (0.7152)
Signal-peer interaction	0.3195 (0.5236)	0.0534 (0.8412)
Messaging		
Messages received		-0.1114 (0.1430)
Messages sent		-0.1026 (0.0802)
Session fixed effect		
Session 2	2.1604*** (0.4061)	1.9039*** (0.5924)
Session 3	0.7143** (0.3081)	2.4509*** (0.8735)
Session 4	1.3690*** (0.3713)	2.8420*** (0.8921)
Session 5	1.1102*** (0.3881)	1.1772 (0.7824)
Session 6	-0.0182 (0.4334)	-0.0846 (0.6773)
Session 7	1.9203*** (0.3671)	2.4803*** (0.7754)
Session 8	3.625*** (0.4290)	4.6718*** (0.9054)

Round	0.0643***	0.1178***
	(0.0094)	(0.0256)
Constant	18.5709***	16.9321***
	(0.3520)	(1.0170)
N	960	480

FIGURES

Figure 1. Stewardship verification sign for the Michigan Agricultural and Environmental Assurance Program (MAEAP) (Leland 2017)