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Timothy M. Waring
University of Maine, timothy.waring@maine.edu

Sandra Goff
University of Maine

Julia B. McGuire
University of Maine, julia.mcguire@maine.edu

Dylan Moore
University of Maine

Abigail Sullivan

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Article

Cooperation across Organizational Boundaries: Experimental Evidence from a Major Sustainability Science Project

Timothy M. Waring [1,*], Sandra Hughes Goff [1,†], Julia McGuire [1,†], Z. Dylan Moore [1,†] and Abigail Sullivan [2,†]

[1] Ecology and Environmental Sciences, School of Economics, Sustainable Solutions Initiative, University of Maine, Orono, ME 04469, USA; E-Mails: sandra.goff@maine.edu (S.H.G.); julia.mcguire@maine.edu (J.M.); zeraph.moore@gmail.com (Z.D.M.)

[2] School of Human Evolution and Social Change, Arizona State University, Tempe, AZ 85287, USA; E-Mail: sullivan.abiev@gmail.com (A.S.)

† These authors contributed equally to this work.

* Author to whom correspondence should be addressed; E-Mail: timothy.waring@maine.edu; Tel.: +1-207-581-3157; Fax: +1-207-581-4278.

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Abstract: Engaged research emphasizes researcher–stakeholder collaborations as means of improving the relevance of research outcomes and the chances for science-based decision-making. Sustainability science, as a form of engaged research, depends on the collaborative abilities and cooperative tendencies of researchers. We use an economic experiment to measure cooperation between university faculty, local citizens, and faculty engaged in a large sustainability science project to test a set of hypotheses: (1) faculty on the sustainability project will cooperate more with local residents than non-affiliated faculty, (2) sustainability faculty will have the highest level of internal cooperation of any group, and (3) that cooperation may vary due to academic training and culture in different departments amongst sustainability faculty. Our results demonstrate that affiliation with the sustainability project is not associated with differences in cooperation with local citizens or with in-group peers, but that disciplinary differences amongst sustainability faculty do correlate with cooperative tendencies within our sample. We also find that non-affiliated faculty cooperated less with each other than with faculty affiliated with the sustainability project. We conclude that economic experiments can be useful in discovering patterns of prosociality within institutional settings, and list challenges for further applications.

Keywords: public goods; cooperation; sustainability science; experiment; prosociality

1. Introduction

Leaders in the emerging field of sustainability science emphasize the importance of forging research collaborations that span organizational boundaries, disciplinary cultures and involve stakeholders in the research process as a central, defining feature of the endeavor [1]. These boundary-spanning efforts are seen as improving the legitimacy of the research in the view of society at large, and as improving the research itself by allowing research to be co-directed and the resultant knowledge to be co-produced by both scientists and stakeholders [2,3].

However, organizational and cultural boundaries are notoriously difficult to bridge. Many attempts as forging interdisciplinary, inter-organizational and cross-cultural collaborations fail. It is also difficult to detect the reason why some efforts to straddle those boundaries fail while others succeed. Do efforts aimed at improving the ability of scientists to work across such boundaries have a lasting impact on their collaborations, or willingness to cooperate with non-scientists? Here, we take advantage of a large collaborative sustainability science project to conduct experimental measurements of cooperation between research faculty and citizens.

In recent decades, behavioral experiments, a staple of psychology, have been incorporated into economics [4–6] and anthropology [7–9]. Behavioral experiments in economics have contributed to an important theoretical debate on the validity of rational actor theory [10]. Anthropologists use experimental methods to measure the influence of cultural variation on behavior, and argue for the importance of culture as a primary force of individual behavior and social change [11]. The interdisciplinary use of experimental methods seems to have enabled a new energy for synthesizing the core insights of the traditionally segregated social sciences. Experimental methods are therefore a valuable tool for building theoretical consensus. We argue that behavioral experiments also hold huge potential as an applied research tool.

Economic experiments in particular have a few features that lend themselves to applied questions of behavior within institutional settings. Economic experiments are conducted without deception, they employ incentives, and typically participants are given a full understanding of the complete game structure. These features, with appropriate customization of game structures and framing, allow applied practitioners to ask the question "how do individuals behave in a simplified, known context"? Generalized experiments such as the dictator game, the ultimatum game, and the trust game can be used to measure individual differences in norms of altruism, sharing, and trust, respectively. These measurements, applied appropriately within an organization, can be useful in detecting the effects of institutional structure or changes in dimensions of social capital. Putnam [12,13] included trust, reciprocity, the capacity for collective action, social identity and local social networks in his definition of social capital. Cooperation in particular is also typically considered a prerequisite to collective action, and a component of social capital. Alternatively, economic experiments can be crafted to match a specific institutional and resource scenario, such as the irrigation systems in Thailand and Columbia [14]. In this paper we explore the use of economic experiments for applied institutional research in an

academic setting in the former sense. We focus on a particular social change (a large research grant) in distinct institutional setting (a research university) as a source of individual behavioral change.

1.1. Sustainability Solutions Initiative

The Sustainability Solutions Initiative (SSI) is the result of a $20 million National Science Foundation research capacity building grant (#EPS-0904155) to the University of Maine. The SSI conducts sustainability science research on topics relevant to the state of Maine and includes research collaborations with ten partner institutions including many of the state's public and private colleges and universities. The SSI research model emphasizes an interdisciplinary approach to sustainability research, with the majority of research teams composed of both biophysical and social scientists. SSI research is also stakeholder driven, and researchers strive to engage relevant stakeholders to help design the research, interpret the results, and facilitate societal solutions based upon the research results. In summary, the grant supports five years of this sustainability-related social-ecological systems (SESs) research to "connect knowledge with action in ways that promote strong economies, vibrant communities, and healthy ecosystems in and beyond Maine" [15], and is composed of thirty-one research projects organized around small teams of investigators.

Universities are uniquely poised to serve as effective "boundary organizations" [16,17]. University projects like the SSI may have an enhanced ability to span other institutional and cultural boundaries in a sustained fashion to forge lasting connections. Boundary organizations create opportunities for collaboration between those in the scientific community and nonscientists [18–20]. To pursue beneficial solutions to societal challenges the SSI encourages its researchers to actively span the disciplinary, institutional, and cultural boundaries that often impede important partnerships. Many of the initiative's projects include heavy collaboration with groups outside of the university. The SSI's unique focus on boundary spanning renders its attempts to facilitate cross-boundary cooperation somewhat distinct from those of the overall university community. Therefore, we consider SSI to be a boundary organization for sustainability science.

These collaborative efforts consume considerable time and energy. Williams [21] describes boundary spanning as a process of building relationships, which "demands an investment in time to forge an effective working relationship and a readiness to visualize reality from the perspective of others". As a result, significant investments such as the NSF grant that created the SSI may be necessary to even begin such boundary spanning ventures. The question then arises, how successful are such major attempts at boundary spanning, and how can they be evaluated?

Efforts within the SSI to span various institutional and cultural boundaries have already been studied [22], including the interdisciplinary boundaries between researchers [23,24], and those boundaries that must be overcome to enable community-based research partnerships [25]. Here we apply a novel experimental methodology to explore cooperation across key institutional and cultural boundaries.

Three major boundaries that influence the outcomes of projects such as the SSI include the interdisciplinary boundary, the researcher–stakeholder boundary, and the town-gown boundary. These boundaries are distinct and carry separate challenges and complexities. The interdisciplinary boundary is well known to academics, and well-studied [26–28]. Within the SSI, faculty and doctoral students have been forced to face their significant disciplinary differences directly, with mixed results [23].

For SSI as for any academic research project, the interdisciplinary boundary is often the first and sometimes the only cultural or institutional boundary that researchers encounter, and it is fundamental, enduring, and poses considerable challenge for many research faculty [24].

A second critical boundary is that between academic researchers and stakeholders in the domains of society that sustainability science projects must reach. The researcher–stakeholder boundary is especially important in sustainability science and socially-engaged research projects [29]. In endeavors such as this project, stakeholders and researchers organize around a shared problem space, establish goals, work together to meet them, facilitating the growth of trust and increasingly efficient collaboration [21,30]. The SSI has successfully engaged a broad range of stakeholders across the state in problem-specific sustainability research [15].

A third boundary that is sometimes overlooked in sustainability science is that of the university relationship with the local community. Historically the relationships between a university and its local community, or "town and gown" cultural boundaries, have been especially difficult to bridge. Town and gown relationships are often characterized as ones in which mistrust limits collaboration [31]. However, there are examples of universities successfully engaging in research and other collaborations with local communities [31–34]. Silka [25] suggests that community based participatory research may benefit from adopting the some of the approaches of sustainability science. Similarly, boundary spanning organizations such as the SSI, in which major effort is directed toward the interdisciplinary boundary and the researcher-stakeholder boundary may be in the best position to also improve upon the town-gown relationship by forming, or being open to forming, researcher-citizen or project-municipal relationships and collaborations.

An organization such as SSI has multiple collaborative boundaries to overcome, including the disciplinary boundary, the stakeholder-researcher boundary and the town-gown boundary. Each of these boundaries entails unique challenges [22], and may require different approaches. Nonetheless, cooperation is a critical component of all such collaborations. This paper uses economic experiments to explore the patterns of cooperation across the disciplinary boundary and the town-gown boundary, to provide insight into the patterns of collaboration that emerge from university-lead sustainability solutions projects.

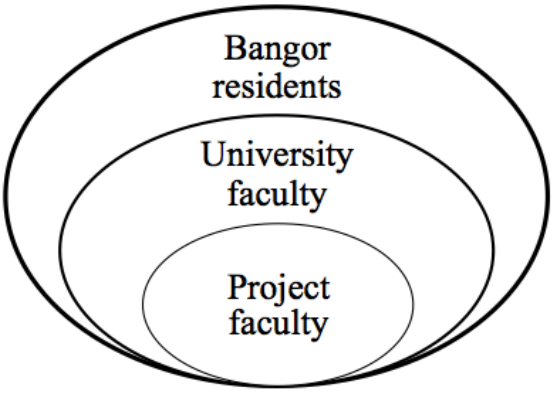
1.2. Study Description and Hypotheses

We studied patterns of cooperative behavior between the three groups of interest: (I) University of Maine faculty; (II) University of Maine faculty members who are also members of the SSI; and (III) residents of the Bangor metropolitan region. These groups form a nested hierarchy, with the SSI at the center, encompassed by University of Maine, itself a sub-set of the greater Bangor region population (Figure 1). We used an economic experiment to measure cooperation between each of these groups.

We created three hypotheses that follow on the collaborative nature of the SSI enterprise. First, the academic culture of SSI is focused on creating various types of partnerships outside the university. Thus, we consider it reasonable that SSI faculty will be more willing to cooperate with local partners on average than faculty from the rest of the university who have not been exposed to or supported in pursuing research with external stakeholders. Second, on the University of Maine's central campus, SSI is composed of a relatively small group of some ~60 faculty who interact frequently for seminars,

brown bags and research and business meetings. This collaboration has bred familiarity and interdependency between these researchers. Thus we hypothesize an increased willingness of SSI members to cooperate with each other in comparison to other groups. Finally, the SSI faces the persistent challenge of disciplinary boundaries. Due to the differences between disciplines regarding ontology, epistemology and ideology i.e., [35] we hypothesize that disciplines will vary in their proclivity for cooperative research, and thus in our experimental measure of cooperation. In summary, we hypothesize that (I) SSI faculty will cooperate more with Bangor residents than will UMaine faculty at large; (II) SSI faculty will have the highest level of internal cooperation of any group; and (III) that cooperation may vary due to academic training and culture in different departments. We expand on each of these hypotheses below.

Figure 1. Nested populations form the study groups. The Sustainability Solutions Initiative (SSI) is a small group of faculty within the University of Maine, which is itself a small part of the greater Bangor metropolitan region.



2. Methods

Economic measurements of social capital have tended to employ derivations of the trust game [36–38], which is asymmetrical in structure. Here, however, we aimed to measure the strength of commitment of two potential partners toward each other in a manner that matches the symmetry in a true mutualistic collaboration. Collaborative relationships such as those involved in University-community partnerships or interdisciplinary collaborations are symmetrical in nature. Because the trust game is asymmetrical, we instead used a public goods game to measure cooperation symmetrically.

We employed a dyadic, one-shot, asynchronous public goods game to measure cooperation between the three nested populations. These economic experiments are very general in nature, and do not simulate the details of an actual collaborative endeavor. Instead, these games provide a simple measurement of cooperation as an indication of the likelihood of successful collaboration between two participants in a general sense. Each participant played one game with an anonymous randomly selected member of each of the three populations. The identity of game partners was also unknown to both the participants and the experimenters at the time of data collection. Six experimenters conducted a total of 600 games, three for each of exactly 200 individuals. We sampled 41 SSI faculty (constituting a 75% sample), 81 University of Maine faculty (~12% sample), and 78 Bangor residents (~0.23% sample).

Participation differed between faculty and Bangor resident populations out of necessity. Faculty members were interviewed on campus over a period of many weeks, while Bangor residents were interviewed at a central location over two days. Faculty were invited to participate first by email, then by follow-up phone calls, and individual sessions were scheduled with those who agreed to an interview. Sessions were held in a private location, most commonly faculty offices. At the time of implementation there were 55 SSI faculty, excluding four involved in or aware of this project. All 55 were contacted, and 41 participated. The same procedure was used for a sample of non-SSI faculty selected randomly from a global list of nearly 700 UMaine faculty, of which 81 participated.

Bangor area residents were selected at random from the Bangor telephone book and called with an invitation to participate. This method produced a lower yield than with faculty, so flyers were posted at locations of high pedestrian traffic in Bangor, and the experiment was posted on craigslist.org. The games were played at a public location (Bangor Parks and Recreation building) in downtown Bangor over the course of two weekend days. A total of 78 residents participated. Bangor participants sat in a waiting room from which they were escorted to private stations in a separate room where the interview was conducted, and finally to a payment station.

Experimenters followed a script, and data were collected using touchscreen tablets to minimize human error. After cueing participants to read the informed consent notice on the tablet, experimenters retrieved the tablet, explained the game in detail and quizzed the participants about game mechanics in eight different situations. The number of errors was recorded. We did not provide any further information than the names of the groups participating—the participants cooperated based only on their previous knowledge of SSI, UMaine, and Bangor. Participants were then presented the three games in random order, for each of which they selected their single voluntary contribution.

Each of the three public goods games proceeded as follows. Participants selected a partner group from a hat, and the experimenter enabled that experiment and handed the tablet to the participant. Players then chose the amount for contribution to the common fund out of a ten-dollar endowment for each game. For each game, the common fund was then multiplied by a factor of 1.5 and divided by two; this amount was distributed to the two players. Participants then selected one group from the hat for which they were not paid, and were paid for the remaining two games. Bangor participants were paid immediately, faculty participants were paid upon the completion of data collection. A brief questionnaire followed the contribution choices.

After data collection was complete, random matches were made between players in all three groups. Because the samples were asymmetrical, random matches were made until all every participant had at least one match, and some participants in the smaller groups had two matches. Participants in all groups were paid only for their first random match.

3. Results and Discussion

As described previously, each participant in the experiment was asked to make a contribution to three different players, one from each of the three nested participant groups. This experimental design allows us to examine the ways in which these contributions might differ when the only information the participant receives is the group affiliation of the other player. The following analysis is designed to examine whether: (I) SSI participants are more generous toward Bangor partners than are UMaine

participants; (II) own-group preferences exist; and (III) SSI participant contributions differ across the academic discipline of the participant.

We start by presenting some descriptive and comparative statistics and then present the results of regression analysis. Table 1 presents mean contribution by each participant group to each of the three partner groups. An analysis of variance in contributions by donor groups reveals that only 7.4% of the variation was between groups, and demonstrating that when responses are pooled, there is no significant difference between groups ($F = 0.202$, $p = 0.895$). A second pooled ANOVA in contributions by recipient group found that only 15% of the variation was between groups, and failed to reject the traditional null hypothesis of no difference between group means ($F = 0.434$, $p = 0.728$) in the pooled dataset.

Table 1. Mean contributions of donors to dyadic public goods game by partner in US dollars. Contributions from two matched participants were invested in a shared fund, which grew in value and was then split evenly between the two participants.

		Partner		
Donor	**N**	**Bangor**	**SSI**	**UMaine**
Bangor	78	7.05	6.51	6.92
SSI	41	6.15	7.27	6.95
UMaine	81	6.43	7.28	6.74

These preliminary results beg the question of how cooperative contributions respond to treatment and control variables when recipient and donor are included. We employed multiple regression models to address our three hypotheses.

3.1. Control Variables

Control variables used in the models are based upon prior research demonstrating their significance in predicting contributions in cooperative games. Male gender (MALE) is used as a control variable because gender has often been found to influence behavior in public goods [39,40] and related experiments [41,42]. Strong identification with the partner group (STRONGID) is included because it can have a positive effect on contributions. STRONGID is a dummy variable taking on the value of 1 when participants answered the "How strongly do you identify yourself with (Bangor/SSI/UMaine)"? question as 4 or greater on a Likert scale of 1–5. If participants strongly identify with groups other than their own, then the difference between own group and other group contributions will be affected. Controlling for strong identification allows for the isolation of the group effect. Contributions are also likely to be affected by baseline individual differences in trust. For this reason, the variable TRUST is used as a control. This dummy variable takes on a value of 1 when participants answered all of the following three questions as 4 or greater on a Likert scale of 1–5: "How likely are you to trust a person of the following types? (1) Someone I know personally, (2) Someone with similar beliefs and values as myself, (3) Someone with compatible economic interests". The TRUST variable is expected to be positively correlated with contributions to partners.

3.2. Education and Income

Ideally, income or education variables would also be used as control variables, but these variables are too highly correlated with group membership in this sample. As well, education and income do not possess sufficient variation particularly when examining contributions made by SSI and UMaine participants, who, as faculty members, have all attained at least a graduate degree. Income differs across groups defined by Bangor group participant status as compared with the two faculty groups together (Chi-square = 51.548, p = 0.000). This is problematic for regression models due to collinearity between the dummy variable, BANGOR, and the income classes. Income is a categorical data series in this study. Education levels are also collinear with BANGOR, with education levels significantly lower for Bangor resident participants than for faculty. There is also evidence that at least one of the education code groups has a different income distribution (Chi-square = 50.776, p = 0.000), suggesting that there is likely collinearity between income and education level. While education and income variables are therefore omitted in the formal analysis, we return to them in the discussion and conclusion.

3.3. Models

We used two distinct types of regression to address our hypotheses. First, we used tobit model with a lower limit of 0 and upper limit of 10 to address the truncated dependent variable; participants were only able to contribute whole dollar amounts between \$0 and \$10. We also used an ordered probit model in which the contributions were categorized into three labeled groups: less than \$5 (free-rider), exactly \$5 (egalitarian), and greater than \$5 (cooperator). This model type was chosen because the difference between contributions of 2 and 3 dollars, for example, are not thought to have the same meaning as the difference between contributions of 5 and 6 dollars. These categories are perhaps more meaningful in terms of measuring the salient psychological cues that govern cooperative tendencies. For each hypothesis we implemented regressions with and without the hypothesized explanatory variables for both types of model. All models employ all three control variables, MALE, STRONGID, and TRUST. Tobit and ordered probit results are qualitatively similar. We report tobit model results in the main text, and provide full model specifications and regression results for both model families in the appendix.

3.3.1. Hypothesis 1: Boundary Spanning—Project Faculty Will Cooperate More with Bangor Residents than Other Faculty

To explain contributions to Bangor partners, we formulated models in which the dependent variable is contributions to Bangor partners ($CONTRIB_{BGR}$). One set of models pools observations from all three participant types, and a second set of models adds dummy variables for SSI and UMAINE participants. For example, we present the two tobit regression models used in hypothesis 1, below. All subsequent analyses are constructed in a similar fashion. We expected that SSI participants would cooperate more with Bangor residents than would UMaine faculty in general.

$$Contrib = \beta_0 + \beta_1 MALE + \beta_2 STRONGID + \beta_3 TRUST + \epsilon \quad (1)$$

$$Contrib = \beta_0 + \beta_1 MALE + \beta_2 STRONGID + \beta_3 TRUST + \alpha_0 SSI + \alpha_1 UMAINE + \epsilon \quad (2)$$

3.3.2. Hypothesis 2: Group Cooperation—Project Faculty Will Have the Highest Level of Internal Cooperation of Any Group

We explored this hypothesis by first seeking to understand whether or not participants hold a preference group-centric cooperation demonstrated by higher contributions to fellow group members than to members of other groups. We follow the same procedure we used for hypothesis 1 save that here we use three different dependent variables, one for each participant type, making for a total of 6 models. These models are implemented by restricting the sample to a single group of participants at a time. We run the pair of models once using only the 93 observations derived from SSI participants in order to determine whether or not SSI participants act more favorably towards SSI partners than they do towards UMaine or Bangor partners. They are then run again using the observations from only the UMaine participants and, subsequently, Bangor participants. We compare the resulting regression for each model set to determine whether there is a significant difference between contributions based upon partner group. This is accomplished through inclusion of two of three dummy variables, SSIPARTNER, UMPARTNER, and BGRPARTNER, depending upon which group is being examined. The donor participant is always designated as intercept category. We hypothesized participants of all types will prefer to cooperate with their peers of the same group, and that SSI participants would demonstrate the highest level of in-group cooperation.

3.3.3. Hypothesis 3: Disciplines—Contributions Will Differ by Academic Discipline within the Project

Our final question centers on the influence of academic discipline, broadly defined, on SSI participants' contributions to partners. The models used here to explore the relationship between academic discipline and contributions are similar to those used to examine own-group preference in hypothesis 2. Analyses were constructed to match the prior two hypotheses, with two model variants in which the hypothetical variables are either pooled or broken into dummy variables for each of the academic discipline groups. The discipline groups are social science, physical science and biological science, and are denoted with the variables SOCSCI (n = 11), PHYSCI (n = 5), and BIOSCI (n = 13), respectively. Finally, we a fourth dummy, OTHDISC, for those disciplines that do not fit in our simple typology. The variable SOCSCI (n = 2) is used as the intercept case, and the sample is restricted to SSI participants. We predicted that cooperative contributions will vary by academic discipline within SSI, but we do not have any further priors about such variation.

4. Results

Our results diverged from the hypothetical predictions in interesting ways. With regards to the first hypothesis, we found no significant difference in contributions to Bangor partners between SSI and UMaine participants. Second, we find evidence that the identity of one's own group influences cooperative partner preferences differently across our study populations. We did not find evidence that SSI participants contributed more to their own group than UMaine partners. However, our models suggest SSI participants were less likely to be cooperators when interacting with Bangor partners than

when interacting with their own group. However, that effect did not emerge in both tobit and probit model families. Surprisingly, however, the models suggest that for UMaine participants, there is a preference for cooperating with SSI partners over one's own group. Meanwhile, we find no evidence that Bangor participants exhibit any cooperative preference across their partner populations. Lastly, we find the strongest evidence for disciplinary influences on cooperation. Physical scientists amongst the SSI faculty tend to be less cooperative within this experiment, as evaluated across all four models. In addition, having a Bangor partner also decreases the probability of a contributing generously, for all disciplinary categories in SSI. Below we summarize the results of the regression analysis, and we present the full detail in the appendix.

4.1. Hypothesis 1: Boundary Spanning—Project Faculty Will Cooperate More with Bangor Residents than Other Faculty

The first set of models sought to determine whether there was a significant difference between contributions made by SSI participants and UMaine participants when giving to Bangor partners. We find no significant difference between contributions to Bangor partners made by SSI participants and those made by UMaine participants, for either tobit or probit variations. See the appendix for model specifications and regression tables.

4.2. Hypothesis 2: Group Cooperation—Project Faculty Will Have the Highest Level of Internal Cooperation of Any Group

Our next question addresses how own-group cooperation compares across groups. The preliminary ANOVA showed no differences across groups by donor or recipient. Against this background, we focus on whether or not participants in a given group demonstrate in-group cooperative preferences in comparison to those with other groups. As explained in the analysis section, models were run for all three participant types separately. The full results of all 12 regressions are presented in the appendix.

First, we examine contributions made by SSI participants. The probit model suggests the existence of possible own-group preference. In this model, giving to a Bangor partner is associated with a lower probability of making a contribution with a value that falls within the highest category. This means that SSI participants are less likely to be cooperators when interacting with Bangor partners than when interacting with their own group. The same effect was not found when SSI contributions to UMaine partners were considered. However, this effect was small (–0.529) and only significant at the 90% confidence level.

When we use observations from UMaine participants, we found no evidence for own-group preference in either tobit or probit variants. However, we did find mild evidence in the tobit model that UMaine participants prefer to cooperate more with SSI partners than with other UMaine faculty. UMaine participants tended to contribute $2 more to SSI participants than to other UMaine faculty, at the 90% confidence level. This set of models also finds significance in both MALE and TRUST variables. As expected, the signs of these coefficients are negative and positive, respectively.

We also ran the same model to determine whether an own-group preference exists for Bangor participants. No significant evidence was found to support any partner group effect for Bangor

participants. These models do not find any significant difference between partner groups when focusing solely on Bangor participants.

4.3. Hypothesis 3: Discipline—Contributions Will Differ by Academic Discipline within the Project

Finally, we tested if the type of academic discipline of SSI faculty members has any relationship with contributions to partners. Both families of models provide support for our hypothesis that contributions in the public goods game will vary according to academic discipline. We find that SSI faculty members who are physical scientists tend to be less cooperative within the context of this experiment. Estimates from the tobit model suggest that those in the physical sciences tend to contribute as much as $3 less on average than social scientists. This effect is found in all four models at the 95% and 90% confidence levels for tobit and probit models respectively. In addition, having a Bangor partner also decreases the probability of a contributing generously within the SSI population. Both the tobit and the ordered probit models find significance in the BGRPARTNER variable. The results of the disciplinary analysis are detailed in Table 2.

Table 2. Tobit regression show that academic discipline influences contributions made by SSI participants.

	Base model	**Disciplines**	**Disciplines& Partners**
Constant	6.831 ***	7.661 ***	9.121 ***
	(1.226)	(1.517)	(1.745)
Male	1.493	1.412	1.292
	(1.124)	(1.110)	(1.102)
Trust	0.718	0.651	0.673
	(1.102)	(1.103)	(1.087)
Strong Identification with Partner Group	0.129	−0.100	−0.680
	(1.063)	(1.048)	(1.255)
Physical Sciences		−2.958 **	−3.056 **
		(1.493)	(1.478)
Biological Sciences		−0.626	−0.708
		(1.177)	(1.168)
Other Discipline		1.815	1.697
		(2.315)	(2.281)
Bangor			−2.128 *
			(1.274)
UMaine			−0.897
			(1.303)
Log likelihood	−190.767	−187.900	−186.496
No. Observations	93	93	93

*, **, *** indicates significance at the 90%, 95%, and 99% level, respectively. Standard errors in parentheses.

5. Conclusions

We did not find strong evidence for two of our three hypotheses. We hypothesized that SSI players would contribute more to Bangor partners than would UMaine faculty in general because SSI faculty have had significant exposure to the concepts of boundary spanning, citizen-scientist collaboration, and cooperative stakeholder partnerships. Contrary to predictions, UMaine and SSI players cooperated with Bangor partners about equally. There are a number of ways to view this result, with hopeful and pessimistic overtones for the success of sustainability science projects. On the one hand, the results show no effect of participation in the sustainability project. But we do not believe that a lack of difference signals that the SSI organization has not enhanced the ability of its researchers to cooperate across institutional boundaries. To the contrary, SSI researchers have had developed significant ongoing collaborative partnerships with industry, municipal government, state government, non-profit organizations, primary schools, and other academic institutions, many of which would not have materialized without the organizational energy and funding that SSI provides. Thus, one explanation is that researcher–stakeholder partnerships are difficult to establish, develop only over a period of many years, require significant investments of energy and time to maintain. Moreover, Hutchins *et al.* [43] suggests that interest in developing community-university partnerships is in part a function of the helpfulness, institutional proximity, familiarity and levels of trust one has with a potential collaborator. In this sense, our measurement is imperfect because it does not measure collaborations made or in the making, but rather hypothetical relationships with anonymous partners. Unfortunately, logistical complexities made measuring cooperation with current SSI stakeholders impractical. The one-shot measurement of cooperation is necessarily artificial, and could be missing the effect of real behavioral change regarding cooperative research partnerships. However, it seems unlikely that the experiment does not measure some related tendency for initiating cooperation.

We suspect instead that the primary reason that SSI and UMaine players both contribute about the same amount to Bangor partners rather that the faculty at the land grant university are already willing to engage and cooperate with local citizens, as indeed they already have. Viewed in this way, the lack of difference suggests that the university may already be achieving some amount of the outreach that leading sustainability scientists call for [44,45], or at least researchers may be willing to do initiate such cooperative ventures. Perhaps, then land-grant universities present fertile ground for researcher–stakeholder collaborations in sustainability science. We conclude that the bar for successful cooperative researcher–stakeholder partnerships is very high indeed, and that efforts such as the SSI do not so much change faculty interest or willingness to collaborate with citizens as it does their ability to do so.

We also hypothesized an own-group cooperation bias such that SSI players would be more cooperative with other SSI players than with players form other groups. However, we did not find a strong pattern of own-group bias across any of our groups. To the contrary, the UMaine faculty tended to contribute more to SSI than to other UMaine faculty. However, SSI players did contribute more to other SSI players than to Bangor players. This might be a result of diffusion in the strength of group identity with population size. As the SSI is the smallest group, members simply interact more with each other than do those of UMaine faculty in general. Likewise, SSI and UMaine faculty share institutional environments while Bangor residents may share very little with each other.

Finally, we found strong evidence for our third hypothesis, that disciplinary differences may influence our measure of generalized cooperation. Within the SSI, physical scientists contribute less than other disciplinary categories across four distinct regression formulations. This difference is intriguing, and suggests that social and physical scientists may have a markedly different academic culture, with physical scientists being less inclined to short-term collaboration. Academics are likely conditioned by their disciplinary environments to have different expectations around collaboration. It is well known that many humanities some social sciences tend towards single-author publications, while a large fraction of the natural sciences commonly produce mostly multiple authored publications. A similar pattern could hold true for the collaborations that precede publication. This, in turn, could be due to the nature of their work. Project durations, funding patterns, and required people-hours for minimal research completion may influence the structure of successful collaborations in each field, and as a result the inclinations of researchers to even approach collaboration when the opportunity arises. Importantly, we do not consider this disciplinary difference to be an indictment of cooperation in the physical sciences at the University of Maine or within the SSI. Instead, we consider this a measure of a cultural difference that should be explored in the course of establishing strong interdisciplinary collaborations, as SSI continues to do.

This study demonstrates that simple experimental economic games measuring foundational dimensions of prosociality and social capital such as trust, cooperation, and reciprocity can be useful in measuring and diagnosing behavioral patterns within institutional settings for applied research, and can reveal unexpected results. With refinement, experimental economic games of this sort could be used to diagnose institutional performance and help to guide institutional design by directly assessing fundamental social outcomes. In the ideal context institutional design experiments could be conducted with such measures in mind, and outcomes evaluated via randomized controlled trials. There are, however, notable limitations in implementing behavioral experiments within an organization of limited size. One such limitation is the "small world" effect in small organizations in which the participants may be too socially proximate to the researchers themselves, and their behavior influenced by foreknowledge of the questions, methods or intentionality of the evaluators. Another limitation of these methods is the potential for the spread of negative impressions of embedded evaluators. Additionally, those seeking to employ experimental economics games as applied measures of institutional efficacy face additional challenges. One challenge is in how to tailor existing games to institutional structure while maintaining comparability with the literature. Another challenge is the importance of maintaining and building trust, even while measuring it, or related variables.

Despite these limitations and challenges, we believe that simple experimental economic games such as the public goods, dictator, ultimatum, and trust games have great potential in evaluating behavior within and between organizations and for improving institutional efficacy. This insight should be of particular interest to sustainability science efforts in which the need to bridge institutional and cultural boundaries is given such emphasis.

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Author Contributions

Waring designed and organized the study. Moore, McGuire and Sullivan collected the data, and were assisted by Sam Chase and Olivia Hecker. Goff analyzed the data. Waring and Goff wrote the paper.

Conflicts of Interest

The authors declare no conflict of interest.

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Appendix

Complete Model Specifications and Results

We constructed tobit and ordered probit models for each hypothesis, and compared models that include and exclude the variables of interest. Results that appear consistent across both types of model are given the highest level of certainty. Here we present all model specifications for each hypothesis followed by regression results. The dependent variable *Contrib* is associated with the continuous but truncated tobit regression models, and *ContribCat* with the ordered probit models which employ an ordered, categorized dependent variable. Interpretation is provided in the main text.

Hypothesis 1: When partnered with Bangor participants, SSI participants will cooperate more than will UMaine participants.

$$Contrib = \beta_0 + \beta_1 MALE + \beta_2 STRONGID + \beta_3 TRUST + \varepsilon \quad (3)$$

$$Contrib = \beta_0 + \beta_1 MALE + \beta_2 STRONGID + \beta_3 TRUST + \alpha_0 SSI + \alpha_1 UMAINE + \varepsilon \quad (4)$$

$$ContribCat = \beta_0 + \beta_1 MALE + \beta_2 STRONGID + \beta_3 TRUST + \varepsilon \quad (5)$$

$$ContribCat = \beta_0 + \beta_1 MALE + \beta_2 STRONGID + \beta_3 TRUST + \alpha_0 SSI + \alpha_1 UMAINE + \varepsilon \quad (6)$$

Table A1. Explaining contributions to Bangor partners—Models 1.1–1.4.

	Model 1.1	**Model 1.2**	**Model 1.3**	**Model 1.4**
Dependent Variable	Contribution (tobit)	Contribution (tobit)	Contribution category (ordered probit)	Contribution category (ordered probit)
Constant	7.034 *** (0.769)	7.547 *** (0.904)	1.021 *** (0.200)	1.090 *** (0.232)
Male	−0.105 (0.762)	−0.038 (0.763)	−0.309 * (0.186)	−0.300 (0.187)
Trust	0.672 (0.769)	0.719 (0.768)	0.191 (0.186)	0.196 (0.186)
Strong Identification with Partner Group	1.149 (0.732)	0.944 (0.758)	0.240 (0.175)	0.214 (0.182)
SSI Partner		−0.750 (1.059)		−0.090 (0.251)
UMaine Partner		−0.873 (0.808)		−0.120 (0.194)
Log likelihood	−390.477	−389.852	−181.516	−181.319
Restricted log likelihood			−184.971	−184.971
Significance level			0.075 **	0.199
Mu(01)			0.939 (0.108)	0.939 (0.108)
No. Observations	184	184	184	184

*, **, *** indicates significance at the 90%, 95%, and 99% level, respectively. Standard error in parentheses.

Hypothesis 2: Individuals will cooperate preferentially with their own groups.

$$Contrib = \beta_0 + \beta_1 MALE + \beta_2 STRONGID + \beta_3 TRUST + \varepsilon \quad (7)$$

$$Contrib = \beta_0 + \beta_1 MALE + \beta_2 STRONGID + \beta_3 TRUST + \alpha_0 SSIPARTNER + \alpha_1 UMPARTNER + \varepsilon \quad (8)$$

$$ContribCat = \beta_0 + \beta_1 MALE + \beta_2 STRONGID + \beta_3 TRUST + \varepsilon \quad (9)$$

$$ContribCat = \beta\_0 + \beta\_1\ MALE + \beta\_2\ STRONGID + \beta\_3\ TRUST + \alpha\_0\ SSIPARTNER + \alpha\_1\ UMPARTNER + \varepsilon \quad (10)$$

Models 2.1–2.4 are run separately for all three groups of participants, and are summarized in Tables A2–A4.

Table A2. Exploring own-group preference in SSI participants—Models 2.1–2.4.

	Model 2.1	**Model 2.2**	**Model 2.3**	**Model 2.4**
Dependent Variable	Contribution (tobit)	Contribution (tobit)	Contribution category (ordered probit)	Contribution category (ordered probit)
Constant	6.831 *** (1.226)	8.167 *** (1.489)	1.035 *** (0.317)	1.408 *** (0.392)
Male	1.493 (1.124)	1.415 (1.117)	0.403 (0.264)	0.369 (0.266)
Trust	0.718 (1.102)	0.738 (1.089)	0.091 (0.260)	0.099 (0.262)
Strong Identification with Partner Group	0.129 (1.063)	−0.314 (1.264)	0.083 (0.251)	−0.132 (0.304)
Bangor Partner		−2.054 (1.319)		−0.529 * (0.319)
UMaine Partner		−1.076 (1.347)		−0.082 (0.325)
Log likelihood	−190.767	−189.521	−82.859	−81.391
Restricted log likelihood			−84.047	−84.047
Significance level			0.498	0.379
Mu(01)			1.231 *** (0.188)	1.258 *** (0.192)
Observations	93	93	93	93

*, **, *** indicates significance at the 90%, 95%, and 99% level, respectively. Standard error in parentheses.

Table A3. Exploring own-group preference in UMaine participants—Models 2.1–2.4.

	Model 2.1	**Model 2.2**	**Model 2.3**	**Model 2.4**
Dependent Variable	Contribution (tobit)	Contribution (tobit)	Contribution category (ordered probit)	Contribution category (ordered probit)
Constant	7.248 *** (0.892)	6.073 *** (1.312)	1.107 *** (0.198)	1.030 *** (0.282)
Male	−0.008 (0.861)	−0.003 (0.854)	−0.314 * (0.182)	−0.311 * (0.183)
Trust	2.099 ** (0.840)	2.144 ** (0.833)	0.563 *** (0.177)	0.575 *** (0.178)
Strong Identification with Partner Group	0.254 (0.777)	1.150 (0.987)	0.068 (0.159)	0.159 (0.202)
Bangor Partner		0.209 (1.059)		−0.136 (0.218)

Table A3. *Cont.*

	Model 2.1	**Model 2.2**	**Model 2.3**	**Model 2.4**
SSI Partner		2.022* (1.204)		0.266 (0.247)
Log likelihood	−462.113	−460.041	−210.337	−208.309
Restricted log likelihood			−217.984	−217.984
Significance level			0.002	0.002
Mu(01)			0.950 *** (0.102)	0.961 *** (0.103)
Observations	225	225	225	225

*, **, *** indicates significance at the 90%, 95%, and 99% level, respectively. Standard error in parentheses.

Table A4. Exploring own-group preference in Bangor participants—Models 2.1–2.4.

	Model 2.1	**Model 2.2**	**Model 2.3**	**Model 2.4**
Dependent Variable	Contribution (tobit)	Contribution (tobit)	Contribution category (ordered probit)	Contribution category (ordered probit)
Constant	7.624 *** (0.665)	7.963 *** (0.956)	1.007 *** (0.158)	1.042 *** (0.217)
Male	0.310 (0.731)	0.292 (0.730)	−0.261 (0.161)	−0.263 (0.161)
Trust	0.190 (0.781)	0.240 (0.784)	−0.109 (0.170)	−0.103 (0.171)
Strong Identification with Partner Group	0.784 (0.796)	0.476 (0.911)	0.104 (0.174)	0.081 (0.198)
SSI Partner		−0.748 (0.998)		−0.054 (0.216)
UMaine Partner		−0.009 (0.926)		−0.263 (0.161)
Log likelihood	−488.480	−488.069		−226.241
Restricted log likelihood				−227.911
Significance level				0.648
Mu(01)			0.651 *** (0.081)	0.652 *** (0.081)
Observations	234	234	234	234

*, **, *** indicates significance at the 90%, 95%, and 99% level, respectively. Standard error in parentheses.

Hypothesis 3: SSI participant contributions will differ by academic discipline.

$$Contrib = \beta_0 + \beta_1 MALE + \beta_2 STRONGID + \beta_3 TRUST + \alpha_0 PHYSCI + \alpha_1 BIOSCI + \alpha_2 OTHDISC + \varepsilon \quad (11)$$

$$Contrib = \beta_0 + \beta_1 MALE + \beta_2 STRONGID + \beta_3 TRUST + \alpha_0 PHYSCI + \quad (12)$$

$$\alpha_1 BIOSCI + \alpha_2 OTHDISC + \alpha_3 BGRPARTNER + \alpha_4 UMPARTNER + \varepsilon$$

$$ContribCat = \beta_0 + \beta_1 MALE + \beta_2 STRONGID + \beta_3 TRUST + \alpha_0 PHYSCI + \alpha_1 BIOSCI + \alpha_2 OTHDISC + \varepsilon \quad (13)$$

$$ContribCat = \beta_0 + \beta_1 MALE + \beta_2 STRONGID + \beta_3 TRUST + \alpha_0 PHYSCI + \alpha_1 BIOSCI + \alpha_2 OTHDISC + \alpha_3 BGRPARTNER + \alpha_4 UMPARTNER + \varepsilon \quad (14)$$

Table A5. Correlations between academic discipline and contributions made by SSI participants.

	Model 3.1	**Model 3.2**	**Model 3.3**	**Model 3.4**
Dependent Variable	Contribution (tobit)	Contribution (tobit)	Contribution category (ordered probit)	Contribution category (ordered probit)
Constant	7.661 ***	9.121 ***	1.204 ***	1.666 ***
	(1.517)	(1.745)	(0.403)	(0.479)
Male	1.412	1.292	0.386	0.338
	(1.110)	(1.102)	(0.273)	(0.276)
Trust	0.651	0.673	0.057	0.066
	(1.103)	(1.087)	(0.272)	(0.275)
Strong Identification with Partner Group	−0.100	−0.680	0.047	−0.213
	(1.048)	(1.255)	(0.260)	(0.320)
Physical Sciences	−2.958 **	−3.056 **	−0.641 *	−0.717 *
	(1.493)	(1.478)	(0.361)	(0.367)
Biological Sciences	–0.626	−0.708	−0.014	−0.069
	(1.177)	(1.168)	(0.293)	(0.298)
Other Discipline	1.815	1.697	0.489	0.452
	(2.315)	(2.281)	(0.619)	(0.630)
Bangor		−2.128 *		−0.578 *
		(1.274)		(0.324)
UMaine		−0.897		−0.062
		(1.303)		(0.332)
Log likelihood	−187.900	−186.496	−80.229	−78.498
Restricted log likelihood			−84.047	−84.047
Significance level			0.266	0.196
Mu(01)			1.263 ***	1.296 ***
			(0.191)	
Observations	93	93	93	93

*, **, *** indicates significance at the 90%, 95%, and 99% level, respectively. Standard error in parentheses.