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LEADING BY EXAMPLE TO PROTECT THE ENVIRONMENT; DO THE COSTS OF LEADING MATTER?

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Leading by example to protect the environment;

Do the costs of leading matter?*

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Abstract

Environmentalists often urge their home countries to take a leading role in reducing global environmental problems like climate change. A pertinent question is: will examples set by leading nations influence others to follow suit, and if so, do the costs of leading matter? For instance, will costly domestic reductions have a stronger effect on followers than purchases of cheap emission permits abroad? To investigate these questions we have conducted two treatments in a public bad experiment in which leaders have different costs of leading. Our findings suggest that higher costs of leading lead to stronger effects of a given leader example. Randomly chosen leaders lead by example and set better examples if it is less costly to do so. Finally, there seems to be a limit to the leader effect and it may decrease over time.

JEL classification codes: C92, H41, Q50

Keywords: experiment, leadership, public bad, climate change

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1. Introduction

Global commons problems like climate change require some sort of cooperation to avoid inefficient and undesirable outcomes. This is suggested by theory, empirical evidence, and laboratory experiments of common pool resource games and public bad games (see e.g., Ostrom et al. 1992, Ostrom 1994, Vyrastekova and van Soest 2003). Since the costs of inefficient management could be very large, it is important to investigate mechanisms that could lead to increased voluntary cooperation in the first place and to the establishment of treaties in the second place.

One possible mechanism to improve group cooperation in social dilemmas could be the appointment of a group 'leader' (Messick and Brewer 1983). Yet, empirical evidence on the effectiveness of leadership as a means to stimulate cooperation is scarce, and most studies use data collected in laboratory experiments. For example, experiments in the social psychological literature have identified several types, styles, and aspects of leadership that affect cooperation, including group identification (Van Vugt and De Cremer 1999), group stability (Van Vugt et al. 2004), feelings of entitlement (De Cremer and van Dijk 2005), leader fairness (Wit and Wilke 1988), leader election (van Dijk et al. 2003), and preference for leadership (Messick et al. 1983). Economic experiments thus far have mainly focused on one of the simplest possible forms of leadership, leading by example. Leading by example in social dilemmas refers to a setting in which leaders are first movers but have no formal authority; the only thing they can do is to set a good example, for instance by cutting back their usage of the common resource, and to make this known to other group members, hoping that their good examples inspire followers to take similar actions. Conclusions from these experiments are somewhat ambiguous. For instance, Güth et al. (2007) report that

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installing a leader leads to significantly higher levels of cooperation (which we will call the leadership effect) in a public good game whereas Gächter and Renner (2003) find no significant difference between treatments with and without a leader. In a public bad setting, Moxnes and van der Heijden (2003) observe a positive effect of leadership. In that study, however, leaders were confederates who were instructed to set very good examples.

Most of these leadership experiments have been symmetric, apart from the order of moves.[1] Typically, it is assumed that the costs and benefits of cooperative actions are the same for all players, which may not always be the case in the real world. The starting point and the novel feature of our paper is that leaders and followers may differ. In particular, we introduce a difference in costs, i.e. the costs of making a cooperative choice are or are not the same for leaders and followers, depending on the treatment. This type of asymmetry enables us to address the issue whether the costs of leadership are important for cooperation in a social dilemma situation. This question is for instance relevant when leading nations have to choose between costly reductions in domestic greenhouse gas emissions and purchases of cheap emission permits abroad. If the costs of leading matter for the hypothesized leadership effect, a nation may provoke more global emission reduction per unit cost of abatement by costly domestic reductions than by low cost purchases of permits abroad.

The answer to the question about the effect of costs is not clear a priori. Two opposing factors may be present. On the one hand, leaders could be expected to set better examples, e.g., make lower investments in the public bad if it is less costly for them to do so.[2] On the other hand, followers may be less inclined to follow a leader when they

know that setting a good example is not very costly for the leader. Our design allows us to test both these intuitions and to examine the relative strengths of these factors.

The remainder of this paper is organized as follows. The next section describes the public bad experiment. The experimental design has two treatments: high and low costs of leading. Section 3 presents results and analyzes data; section 4 concludes. We find that regardless of costs, randomly chosen leaders tend to set good examples, with the best examples set for low costs. Higher costs of leading lead to stronger leadership effects. The leadership effect may reflect both the leadership institution and the goodness of the example set. The effect has its limitations and is reduced over time.

2. Experiment and procedures

We present the game, theoretical predictions, and procedures.

2.1. A public bad game with a leader

The social dilemma situation we consider is characterized by a conflict between an individual's interest and the common interest. One could for instance think about a global environmental problem like climate change, where there is a conflict between an agent's or individual country's interest to pollute and the broader, social interest of the collective to reduce pollution. In order to mimic such a persistent environmental problem, which usually requires numerous policy initiatives, we use a public bad experiment with multiple rounds and a partner design (Andreoni 1988), i.e. the composition of the groups remains the same over all rounds.

The experimental design is a slight variation on a standard simultaneous public bad game (see e.g. Andreoni 1995), which we call a public bad game with a leader. In this

game, not all subjects make their investment decisions simultaneously but one subject moves first (Moxnes and van der Heijden 2003). That is, one group member is randomly selected to be the *leader* (for all rounds to be played) and this leader first decides how much to invest in the public bad. The other group members (the followers) are informed about the leader's investment and then choose their investments individually and simultaneously. We have run two treatments of the public bad game with a leader. In both treatments subjects play in fixed groups of five, and in each round subjects are endowed with 20 tokens, which they allocate between two projects: project A (the public bad) and project B.

In the basic leader treatment, the return on the two projects is the same for leaders and followers. For all subjects, investing in project A (B) gives a direct *private* return of 0.7 (0.4) per token invested. Besides, project A has a negative external effect: each token invested in this project yields a negative return of 0.1 to *all* group members. So, payoff π_i to individual i (i=1, 2, ..., 5) when she or he invests x_i^A in project A and x_i^B in project B reads

$$\pi_i = 0.7x_i^A + 0.4x_i^B - 0.1\sum_{j=1}^{5} x_j^A \tag{1}$$

where x_j^A denotes the investment in project A (the public bad) by subject j (j=1, 2, ..., 5), and $x_i^A + x_i^B = 20$, $\forall i$. Using this last equality, we rewrite (1) as

$$\pi_i = 8.0 + 0.2x_i^A - 0.1\sum_{j\neq i} x_j^A \tag{2}$$

Because in this treatment leaders and followers have the same costs of investing in project B and the same pay-off function we call it the Same-Leader-Cost treatment or SLC.

To test for effects of different leader costs, we have introduced a second leader treatment, the No-Leader-Cost treatment or NLC. The only distinction from treatment SLC is that *only* for the leader the return on project B is increased from 0.4 (as in Equation 1) to 0.6. The leader's payoff function for treatment NLC thus reads:

$$\pi_L = 0.7x_L^A + 0.6x_L^B - 0.1\sum_{j=1}^{5} x_j^A = 12.0 - 0.1\sum_{j \neq L} x_j^A \tag{3}$$

whereas follower payoffs are still given by (1). From equation (3) one can see that in treatment NLC leaders have no costs of acting socially and that the leaders' payoffs only depend on x_j^A, the investments of others. It is important to note that even though the leaders' own contribution levels do not affect their payoffs, it is *not* true that leaders always have higher payoffs than followers in this treatment. For example, if the leader and all followers invest 20, there is no investment in project B and the leader has no advantage over the followers. Starting in this position, any reduction in investment in project A that the leader makes will only benefit the followers and hence make them better off than the leader. If all followers invest 15, followers will be better off than the leader for leader investments below 5 tokens.

In the experiment, it was common knowledge among all subjects that the payoff functions for the leader and the followers were the same in treatment SLC and different in treatment NLC. Finally, note that in our experiment the same subject has the leader role over all rounds reflecting that roles are likely to change only slowly. This mimics a

situation in which leadership is seen as a persistent phenomenon, as it usually is in our view. Alternatively, the leader's role may rotate. Güth et al. (2007) have compared fixed and rotating leadership in a public good experiment and found no significant difference between the two institutions. For recent experimental studies on endogenous leadership, see Arbak and Villeval (2007) and Bruttel and Fischbacher (2010).

2.2. Theoretical predictions

In the one-shot version of treatment SLC purely selfish, money-maximizing followers have a dominant strategy to invest their total endowment in the public bad, irrespective of the leader's investment. A backward induction argument then implies an investment of 20 in the public bad for a selfish and rational leader as well. Hence, the unique Nash equilibrium is $x_i^A = 20$ for all group members i, with a total investment of 100 tokens in project A and individual payoff of $\pi_i = 4 \; \forall i$. The socially optimal outcome is obtained by full cooperation, however. If all members of a group invested the total endowment in project B, i.e. $x_i^A = 0$ for all group members i, the payoff to each player would double, $\pi_i = 8 \; \forall i$. In case of multiple rounds the Nash prediction for the last round is the same as in the one-shot version and therefore, by backward induction, for all previous rounds as well.

The theoretical prediction for treatment NLC is less clear. Selfish and rational followers are still expected to invest 20 in the public bad. However, selfish leaders would be indifferent and no unique hypothesis for the investment by leaders in treatment NLC can be identified. The only option leaders have to affect their own payoffs is to somehow influence followers to invest less in project A. Because setting a good

example is not directly costly in treatment NLC one could hypothesize that leaders in this treatment would invest less in the public bad than in treatment SLC.

Numerous experiments have shown, though, that people do not always behave in a selfish and rational way. They may for instance also partly be motivated by other-regarding preferences. In addition, findings from some of the economic experiments mentioned in the introduction suggest that leaders often set a good example[3] and that followers have a tendency to follow their leaders. If leader investments in the public bad are lower in treatment NLC than in treatment SLC one could hypothesize that followers will invest less in treatment NLC as well.

However, the latter hypothesis needs to be tested empirically because of a counter argument. Followers may appreciate the good examples set by the leader in treatment NLC less because they know the leader does not have to make a sacrifice. The behavioral reaction of followers may thus be that in treatment NLC they are less inclined to follow their leader than in treatment SLC where it is costly to lead by example. This implies that although leaders can be expected to set better examples in treatment NLC, followers' reactions in response to a given example may be weaker. It is unclear ex ante which effect will dominate.

In Appendix 1 this somewhat loose intuition is supported by a more formal analysis under the assumption of inequality aversion (Fehr and Schmidt 1999, and Bolton and Ockenfels 2000). We show that in treatment SLC followers should be more sensitive to the leader's example than in treatment NLC. Under certain conditions an equilibrium with all subjects investing zero in the public bad can be sustained in treatment SLC.

Inequality aversion may be an explanation for some of the leadership effects found in previous economic experiments and our design offers further possibilities to examine inequality aversion because of the asymmetry in costs. For treatment NLC, Appendix 1 shows that an equilibrium where all invest zero cannot be sustained. Furthermore, we show that even though setting the best example is not directly costly for leaders in treatment NLC, they may not do so if they are inequality averse and anticipate followers' reactions.

In addition to examining effects of costs, our experiment may give indications about saturation of the leadership effect as a function of example set (nonlinearity) and about the development of the effect over time. It will also help distinguish effects of the leadership institution and the size of the example set by leaders.

2.3. The experimental procedure

Seven sessions with the leader treatments were conducted in which in total nineteen groups of five subjects participated. In each of the seven sessions we ran both leader treatments, i.e. we employed a within-subject design. To control for order effects nine groups started with ten rounds of treatment SLC and then played ten rounds of treatment NLC; the sequencing was reversed for the remaining ten groups.

The subjects were students from the Norwegian School of Economics and Business Administration in Bergen. They were recruited from classes in the same period for both treatments. No subject had previous experience in any related experiment and none of them participated in more than one session. Subjects were told that they could earn between NOK 100 and 180 ($12.50–$22.50 at that time) in about one hour (circa 1.5 to

2.7 times a typical hourly wage of students in Norway). They knew that rewards were contingent on performance.

Upon arrival subjects were randomly seated behind computers such that groups were formed in a random way. The computers were separated by curtains, and subjects could not identify the other members in their group. Instructions (in Norwegian) were distributed and read aloud by the experimenter. An English translation of the instructions of treatment SLC can be found in Appendix 2.

Before the first round was played, the leaders were privately informed via the computer screen that they were randomly chosen as leaders in their group. In all sessions, all parameters of the experiment were common knowledge to all subjects including the asymmetry in the payoff functions between the leader and the followers in treatment NLC. Subjects knew from the very beginning that they would play ten rounds in the experiment, and then another ten rounds with a slightly different design (exact wording in appendix). In each round subjects had to decide how many tokens out of the endowment of 20 tokens they wanted to invest in project A; the remaining number was automatically invested in project B. At the end of each round, subjects were informed about the individual decisions of the group members and their own payoff for the round. Information about individual decisions was provided to avoid asymmetries between the leader, for whom the investment had to be revealed, and the other players. After the last round, subjects were privately paid their earnings from all rounds. Each session lasted for about one hour and average earnings (including NOK 20 for showing up) were NOK 116.7 ($\approx$ \$15).

3. Results

We first present average results over rounds. In section 3.2, we consider the developments of investments over rounds, and in section 3.3 we discuss our findings.

3.1. Results based on average investments over rounds

Tables 1a and 1b present for all 19 groups the average investments in the public bad (project A) over rounds and over group members. Sessions are labeled A through G.[4] Within each session groups are numbered. The two tables differ with respect to treatment order.

[Insert Tables 1a and 1b about here]

The tables show that average investment levels are closer to the Nash prediction of 20 than to the socially efficient level of zero. This indicates that in both treatments subjects behave on average as weak free riders, which is in line with findings in standard simultaneous public bad and public good experiments.

The costs of leading are important for the examples set by leaders: leaders invest significantly less in treatment NLC than in treatment SLC. This holds both for the first ten rounds (10.57 versus 14.79) as well as for the last ten rounds (12.03 versus 15.90). According to a non-parametric two-sided Mann-Whitney U test these differences are statistically significant ($p=0.01$, $n_1=10$, $n_2=9$ for rounds 1-10, and $p=0.03$, $n_1=9$, $n_2=10$ for rounds 11-20).[5]

Tables 1a and 1b show that even though average leader investments are considerably different, followers invest on average the same in treatments SLC and NLC, namely

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15.53 and 15.21 in rounds 1-10, and 17.76 and 17.10 in rounds 11-20 , respectively. Consequently, the null hypothesis that follower investments in the two treatments are equal cannot be rejected ($p=0.55$, $n_1=9$, $n_2=10$ for rounds 1-10, and $p=0.24$, $n_1=10$, $n_2=9$ for rounds 11-20, Mann-Whitney U test).

Irrespective of the costs of leadership, leaders invest significantly less in the public bad than followers do ($p=0.001$ for treatment SLC and $p=0.000$ for treatment NLC, $n=19$, matched-pairs signed-ranks Wilcoxon test). When taking averages over both leaders and followers, average group investments in the public bad are significantly lower in treatment NLC than in treatment SLC ($p=0.038$, $n=19$, Wilcoxon test). Thus, on the aggregate level the costs of leading seem to matter.

Then we turn to the question about effects of leadership institution versus effects of example set by leaders. Group level data may shed some light on this issue. Figure 1 shows data points for average leader and follower investments over rounds for all groups in the two treatments. Symbols differ for the first and last ten rounds. First notice that except for three cases, all data points lie on or to the left of the line denoting equal leader and follower investments, i.e. in nearly all groups followers invest on average more than their leaders.

[Insert Figure 1 about here]

To see if average follower investments vary with average leader investments we perform a regression on the data points in Figure 1. Pooled data for rounds 1-10 suggest that follower investments are not influenced by the leader investment at all; the slope

coefficient is not different from zero (p=0.58). When looking at pooled data for rounds 11-20, the slope is positive and highly significant (p=0.0003). We obtain similar results when using separate data for treatments SLC and NLC. In the first 10 rounds both slopes are not different from zero (p=0.93 and p=0.76); in the last 10 rounds we find p-values of respectively 0.0002 and 0.06. Hence, it seems that at first it is the leader institution and not the size of the example that matters.

Figure 1 suggests that there is no big difference between the leadership effect of ordinary and very good examples; the effect seems to saturate. Average follower investments never go below a lower limit, no matter how low the average leader investments are. A comparison to results in Moxnes and van der Heijden (2003) supports this finding. Their instructed leaders invested on average much less than in the present experiment, namely only 3.10 tokens. They found average follower investments of 15.38 as compared to 15.53 in the present experiment. Only the first 10 rounds of the two experiments are directly comparable since the last 10 rounds followed respectively 'no leader' and NLC treatments. Subjects were recruited from the same student population and at approximately the same time. Taken together, these data suggest that very strong examples may not have much more influence on followers than moderate examples.

3.2. Results based on investments round by round

Figures 2a and 2b show time-series for average investments over groups for leaders (thin lines) and followers (thick lines), for treatment orders SLC-NLC and NLC-SLC respectively. Both leader and follower investments tend to increase over rounds, which is in accordance with results from previous public good and public bad experiments (Ledyard 1995).

The figures demonstrate that for both treatments average leader investments are lower than follower investments in most cases. The gap between average leader and follower investments tends to be larger in the first round of a treatment (rounds 1 and 11) than in ensuing rounds. In particular, average first round leader investments are just above 5 in treatment NLC and just above 10 in treatment SLC. A closer inspection of data for individual players reveals that 11 out of 19 leaders set the best possible example in the first round of treatment NLC (by investing zero in the public bad), versus 4 out of 19 leaders in treatment SLC. At the same time, 2 (4) leaders set the worst possible example by investing 20 in the public bad in the first round in treatment NLC (SLC).

Interestingly, leaders in treatment NLC also choose to increase investments over time in spite of no costs of leading. Hence, the major tendency seems to be that leaders start out by setting very good examples, and then adjust their investments to reduce the distance to the follower investments.

To get more detailed results, we have run a regression analysis in which we use group-level data for each and every round rather than the averages over groups shown in Figures 2a and 2b. We specify the following model for average follower investments $\bar{x}^F_{i,t}$ in group i in round t:

$$\bar{x}^F_{i,t} = \beta_0 + \beta_1 S_i + \beta_2 F_i + (\beta_3 + \beta_4 S_i + \beta_5 F_i)x^L_{i,t} + \beta_6 t + \varepsilon_{i,t} \qquad (4)$$

where $x_{i,t}^L$ is the leader investment in the same group. The dummy variable S_i captures the effect of leader costs and takes the value 1 (0) in treatment SLC (NLC). The dummy variable F_i represents treatment order and takes the value 1 (0) in rounds 1-10 (11-20). The expression in parentheses captures the effect of the example set by the leader; this effect is allowed to vary with the two dummy variables. Finally we capture the effect of round number t. When estimating the model we use robust standard errors by taking into account that observations are independent across groups but not necessarily within groups because of repeated interactions (by using the option robust cluster in Stata). The regression results are depicted in Table 2.

[Insert Table 2 about here]

As a first observation note the typical and highly significant tendency for investments to increase over time (β_6), within 10 round periods. More importantly, the regression results provide additional information on the leader effect. First note that the total effect of the leadership *institution* cannot be estimated by comparing two treatments that both have a leader institution. However, β_1 (p=0.055) measures how leader costs influence the effect of the institution; higher costs lead to a stronger effect. The effect of the leadership *institution* declines over time, β_2 (p=0.013). The effect has the same size as that for leader costs.

The effect of the size of the *example* set is captured by parameters β_3, β_4, and β_5. In the case of no costs (NLC), β_3 signals a positive leadership effect of 0.08; it is highly significant. When the leader incurs costs of leading, this effect increases from 0.08 to 0.20 (SLC treatment); the increase β_4 being statistically significant (p=0.024). The

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effect of the *example* set on follower behavior is therefore stronger when the costs of leading are higher. Finally, the effect of the *example* set does not decline over time, β_5 is not significantly different from zero. Since we have assumed a linear model, the results represent some average over the range of observed leader investments; it does not capture saturation.

3.3. Discussion

The regression results suggest that leader costs both influence the effect of the leadership institution and the effect of the example set. This is consistent with the predictions of the model of inequality aversion in Appendix 1. The model shows that sufficiently inequality averse followers are more sensitive to the leader's example in treatment SLC than in treatment NLC. In addition, the outcome in which all followers invest the same amount as their leader (and less than 20) may be an equilibrium in treatment SLC but not in treatment NLC. The latter prediction is also supported by detailed data from the experiment. When focusing on the instances in which a follower invests exactly the same amount as the leader in the group, it turns out that 53 of the 76 followers follow the leader more often in treatment SLC than in NLC, whereas the reverse holds for only 15 followers (for the remaining 8 followers the frequencies are the same in both treatments).

Regarding leaders, we find the expected effect of costs; lower costs lead to stronger examples set. Inequality aversion may explain why leaders invest at all in treatment NLC when it is not costly to invest zero. When NLC came first (second) in a session, followers invested on average 15.21 (17.10). For these investment levels, inequality aversion implies that leaders should have invested 5.63 (11.30) in order to equalize payoffs between themselves and the average follower. Average leader investments in

these two cases were respectively 10.57 and 12.03. The observed investments are rather close to the predictions from inequality aversion although they are somewhat higher, particularly when NLC comes first.

Another, speculative explanation why leaders would invest at all in treatment NLC could be that leaders try to use the level of investments as a device for punishments or rewards in a kind of tit-for-tat strategy. That is, leaders that start out with zero or low investments and later increase their contributions may do so to punish followers for high investments. Those that start at high values may want to find out about the follower contributions first and then possibly reward low contributions by reducing their own investments. Leaders starting at intermediate levels may want to leave both options open.[6] Our data show that in NLC leaders on average tend to vary investments more over rounds than followers (standard deviations of respectively 7.03 and 4.83) and on average leaders tend to have lower positive first order autocorrelations than followers (respectively 0.02 and 0.29). Hence, leaders do seem to be more active in changing investments than followers indicating a certain desire to influence followers.

In order to understand better how leaders react to follower behavior we have regressed leader investments in round *t* on several explanatory variables, such as round, treatment dummy and the average followers' investment in round *t-1* (results not presented here but available upon request from the authors). The latter estimate turns out to be positive and highly significant. Similarly, if we estimate the effect of changes in follower investments on changes in leader investments that coefficient is also significant. The fact that leaders respond to higher follower investments by increasing their investments could also be seen as support for the use of some kind of (modified) tit-for–tat strategy.[7]

4. Conclusions

We have investigated an issue that has been neglected in the leadership literature thus far, namely the question whether the costs of setting a good example have an effect on the investments in a public bad. The standard public bad experiment, with five subjects in a group making their investments decisions simultaneously was altered such that one person was a first mover (Moxnes and van der Heijden 2003). This person, the leader, was randomly selected and, by deciding first he could set a good or bad example. After being informed about the group leader's decision, four 'followers' made their investment decisions simultaneously. In order to examine the effect of the cost of leadership, we had two treatments: in the same-leader-costs treatment (SLC) leaders and followers had the same costs, while in the no-leader-costs treatment (NLC) it was not costly for the leader to abstain from investing in the public bad, i.e. setting a good example was not costly for the leader.

We found that randomly selected leaders tend to set good examples by investing less in the public bad than followers, with the best examples set for low costs. However, leaders do not reduce investments to zero when they have no costs of leading. Rather their investments seem to reflect inequality aversion, and they may also try to influence the group of followers by some tit-for-tat strategy.

We are aware that our results should be interpreted carefully and cannot be applied directly to the real world. However, we think our results raise some very interesting questions and therefore it seems worthwhile to consider possible implications for real world policies. Outside of the laboratory, one normally thinks of leaders as self selected.[8] Particularly high costs of pollution or low costs of abatement may be

motivating factors. Moral obligations and status earned by taking a lead may be other motivations. Simple selfishness may also suffice if the number of players is as small as it was in our experiment.[9] If one takes the results of the experimental design literally, one could speculate that for instance the United Nations could officially designate leaders in different regions of the world, and expect that they rise to the challenge.

Our results indicate that higher costs of leading motivate followers to invest less in the public bad for given examples set by leaders. Regressions over rounds show that higher leader costs both increase the effect of the leader institution and the effect of the size of the leader example.

It follows from our results and previous studies that taking a leading role will provoke greater reductions in global environmental problems than what follows directly from local abatement. Side effects such as diffusion of technology and of innovative public policies to stimulate abatement may also help other nations increase their ambitions and thus strengthen the leadership effect further. Our results also show that the leadership effect seems to saturate; below a certain point further reductions in leader investments seem to have no or little effect. This finding suggests that it is probably better if two nations go half way in leading, rather than one going all the way.

Our experiment went over 20 rounds with two consecutive leader treatments. As in all public bad and public good experiments the willingness to contribute towards the common good declines over rounds. Both average follower investments and the regression over rounds suggest that investments in the public bad are higher in the second than in the first treatment. A certain tendency for the leadership effect to decline

over time may be counteracted if at each stage irreversible (international) treaties are put in place to prevent reversals towards free riding. Once a treaty is in place, there may be a "restart" effect where new leadership initiatives may again have some effect.

While simplified laboratory experiments should not be expected to give very precise predictions of real world effects of leadership, our experiment could say something about general underlying tendencies to cooperate, to set good examples, and to follow leaders (see Smith 1982, on parallelism). The results point out a potentially important mechanism to increase voluntary contributions and to strengthen negotiations of treaties to solve global environmental problems. The current experiment investigates one of the simplest situations in which leadership may contribute and can therefore be seen as a first step to get more insights in the functioning of and limits of a leadership institution.

Unlike in the real world, in the experiment players are anonymous to each other, there is no communication (see Bohnet and Frey 1995, Isaac and Walker 1988; 1991), no institutions for negotiations of allowable quotas and laws determining punishment (see Bianco and Bates 1990 for a theoretical discussion and Ostrom et al. 1992 for empirical evidence), no missing or distorted information about other players, no political processes, no NGOs such as environmental groups and polluter organizations, and the only punishment option lies in hard to anticipate and interpret future investment decisions. Furthermore, other nations' awareness of the example set may be higher or lower than in the experiment, the costs of abatement may be higher or lower, leaders will not be chosen randomly, and there may be side effects such as profits from sales of new technologies influencing expected leader payoffs. Further studies may include field

studies of cases where leadership may have played a role. The effects of any of the left-out factors could be interesting topics for much further (experimental) research.

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Appendix 1: The Fehr-Schmidt model in a public bad game with different costs of leading by example

The Fehr-Schmidt model assumes that the utility function of player i takes the following form:

$$U_i = \pi_i - \frac{\alpha_i}{n-1}\sum_{j \neq i}\max\left\{0, \pi_j - \pi_i\right\} - \frac{\beta_i}{n-1}\sum_{j \neq i}\max\left\{0, \pi_i - \pi_j\right\},$$

where π_i denotes the monetary payoffs of player i, the parameter α_i measures the utility loss from disadvantageous inequality (i.e. the individual's inferiority aversion) and the parameter β_i measures the utility loss from advantageous inequality (i.e. the individual's superiority aversion). The standard assumptions are that $0 \leq \beta_i < 1$, $\beta_i \leq \alpha_i$ (Fehr and Schmidt, 1999)

For both treatments SLC and NLC, the inefficient equilibrium in which all group members invest the maximum amount in the public bad remains an equilibrium for any values of the inequality parameters. Rather than writing down a full-fledged equilibrium analysis we derive conditions on β_i and α_i for which additional, more efficient, equilibria can be supported. In particular we want to show that there exist situations in which followers follow the leader in treatment SLC but not in treatment NLC.

For reasons of convenience the payoff functions for followers and leaders are repeated here. Followers' payoffs in both treatments and leaders' payoff in treatment SLC read

$\pi_i = 8.0 + 0.2x_i^A - 0.1\sum_{j \neq i} x_j^A$, while leaders' payoff in treatment NLC is given by

$\pi_L = 12.0 - 0.1\sum_{j \neq L} x_j^A$.

Treatment SLC

Given the leader's investment $x_L{}^A$, suppose $x_i^A = x_L^A = x \; \forall i$, with $x<20$, i.e. all group members invest the same, but less than the maximum in the public bad. We want to derive for which parameter values this can be an equilibrium in treatment SLC. With these investments, the individual monetary payoffs are

$$\pi_i = 8 + 0.2x_i^A - 0.1(x_L^A + 3x) = 8 - 0.2x \; \forall i \text{ and thus } U_i(x_i^A = x) = 8 - 0.2x.$$

If subject *i* deviates, he would always want to invest more (since by investing less the monetary payoffs decrease and utility is lost because of increased inequality). Thus suppose $x_i^A = x + \varepsilon$, with $\varepsilon > 0$.[10] Then $\pi_i = 8 + 0.2(x + \varepsilon) - 0.1(4x) = 8 - 0.2x + 0.2\varepsilon$

whereas $\pi_j = 8 + 0.2x - 0.1(3x + x + \varepsilon) = 8 - 0.2x - 0.1\varepsilon \; \forall j \neq i$. Consequently,

$$U_i(x_i^A = x + \varepsilon) = 8 - 0.2x + 0.2\varepsilon - \frac{\beta_i}{4}(4 \times 0.3\varepsilon) = 8 - 0.2x + 0.2\varepsilon - 0.3\beta_i\varepsilon.$$

For $x_i^A = x_L^A = x$ to be an equilibrium, $U_i(x_i^A = x) \geq U_i(x_i^A = x + \varepsilon)$. That is

$8 - 0.2x - (8 - 0.2x + 0.2\varepsilon - 0.3\beta_i\varepsilon) = 0.3\beta_i\varepsilon - 0.2\varepsilon = 0.2\varepsilon(1.5\beta_i - 1) \geq 0$, which holds if and only if $\beta_i \geq 2/3$.

This means that in treatment SLC all situations in which everyone invests the same amount can be subgame perfect equilibria if followers are sufficiently inequality averse.

Treatment NLC

Given $x_L{}^A$ we derive if, and under which conditions $x_i^A = x_L^A = x \; \forall i$, with $x<20$, can be an equilibrium in treatment NLC. With these investments, the individual monetary payoffs for followers are $\pi_i = 8 + 0.2x_i^A - 0.1(x_L^A + 3x) = 8 - 0.2x \; \forall i \neq L$ whereas the

leader earns $\pi_L = 12 - 0.1 \times 4x = 12 - 0.4x$. Utility for follower i is thus

$$U_i(x_i^A = x) = 8 - 0.2x - \frac{\alpha_i}{4}(4 - 0.2x).$$

Suppose follower i deviates and chooses $x_i^A = x + \varepsilon$, with $\varepsilon > 0$. The resulting monetary

payoffs are $\pi_i = 8 + 0.2(x + \varepsilon) - 0.1(4x) = 8 - 0.2x + 0.2\varepsilon$,

$\pi_j = 8 + 0.2x - 0.1(3x + x + \varepsilon) = 8 - 0.2x - 0.1\varepsilon$ $\forall j \neq i$, and

$\pi_L = 12 - 0.1(3x + x + \varepsilon) = 12 - 0.4x - 0.1\varepsilon$. Consequently,

$$U_i(x_i^A = x + \varepsilon) = 8 - 0.2x + 0.2\varepsilon - \frac{\beta_i}{4}(3 \times 0.3\varepsilon) - \frac{\alpha_i}{4}(4 - 0.2x - 0.3\varepsilon) =$$
$$8 - 0.2x + 0.2\varepsilon - \frac{0.9\beta_i \varepsilon}{4} - \frac{\alpha_i}{4}(4 - 0.2x - 0.3\varepsilon).$$

$U_i(x_i^A = x) \geq U_i(x_i^A = x + \varepsilon)$ if and only if

$8 - 0.2x - \frac{\alpha_i}{4}(4 - 0.2x) \geq 8 - 0.2x + 0.2\varepsilon - \frac{0.9\beta_i \varepsilon}{4} - \frac{\alpha_i}{4}(4 - 0.2x - 0.3\varepsilon)$. Thus

$0.2\varepsilon - \frac{0.9\beta_i \varepsilon}{4} + \frac{0.3\varepsilon\alpha_i}{4} \leq 0$, which implies $2\varepsilon - \frac{9}{4}\beta_i\varepsilon + \frac{3}{4}\alpha_i\varepsilon = \varepsilon(2 - \frac{9}{4}\beta_i + \frac{3}{4}\alpha_i) \leq 0$.

But given $\varepsilon > 0$ this cannot hold as $2 - \frac{9}{4}\beta_i + \frac{3}{4}\alpha_i \geq 2 - \frac{9}{4}\beta_i + \frac{3}{4}\beta_i = 2 - \frac{6}{4}\beta_i > 0$ for the

standard assumptions $0 \leq \beta_i < 1$, $\beta_i \leq \alpha_i$.

This implies that an inequality averse follower i always has an incentive to deviate and

therefore more efficient outcomes of the type $x_i^A = x_L^A = x$ $\forall i$ with x < 20 cannot be

supported as equilibria in treatment NLC. If inequality averse leaders anticipate this

reaction of the followers they may have an incentive to set $x_L^A > 0$ or even $x_L^A = 20$, even

though setting the best example is not directly costly for them in this treatment.

Conclusion

The analysis in this appendix illustrates that under certain conditions followers may choose $x_i^A = x_L^A = x \; \forall i$ with x < 20 in treatment SLC but not in treatment NLC. In particular, the efficient and socially optimal level of investments $x_i^A = 0 \; \forall i$ can only be an equilibrium in treatment SLC. The reason is that sufficiently inequality averse followers don't want leaders to earn more or less than themselves. Therefore, these followers are more likely to follow their leaders in treatment SLC. The analysis also demonstrates why leaders in treatment NLC may invest positive amounts rather than zero.

Appendix 2: Instructions for the experiment (not for publication)

This appendix contains an English translation of the instructions for the Same-Leader-Cost treatment (SLC).

Welcome

This is an experiment to investigate investing behaviour. The instructions are simple. If you follow them carefully, you can earn a considerable amount of money. Earnings will be paid in cash immediately after the experiment. In addition, you receive NOK 20 for showing up. The money has been supplied by the Norwegian Research Council.

In the experiment you first have to make 10 investment decisions, one in each round. After that we will change the design slightly and there will be 10 additional decision rounds. The payoffs of all 20 rounds determine your total earnings.

During the experiment you belong to a group together with four other subjects, which are the same persons all the time. Your payoffs will depend on your own decisions and on what the other four members of your group decide. The design is such that nobody is able to find out which persons belong to a group and what decisions persons have made. In other words, you are anonymous.

Investments and payoffs

In each round, you (and all others in your group) can invest an endowment of NOK 20. So, in total, NOK 100 per round is invested. You can invest in two different projects: project A and project B. You write down how much you want to invest in project A, the rest of your endowment is then automatically invested in project B. Project A yields a

direct payoff of NOK 0.70 per crown invested. Note, however, that in addition to the payoff for yourself, investing in project A yields an additional cost of NOK 0.10 per crown invested for you and the other four members in your group. Similarly, investments in project A by the other members give a cost for you and the other subjects. Project B yields a direct payoff of NOK 0.40 per crown invested. Investments in project B have no (indirect) impact on the payoffs for others. All persons in a group are in the same position.

To make it easier to see the consequences for your payoffs of the investment decisions made by you and the others, we have computed the payoffs for several combinations. To limit the size of the table we only mention investments in steps of 5. However, you can use all integers from 0 up to and including 20 when you choose your investment in project A.

An example shows how the numbers in the table are computed. Assume that you invest NOK 10 in project A. Then you receive a direct payoff of NOK 7 from project A. The rest of your endowment, NOK 10, is automatically invested in project B, and yields a payoff of NOK 4. Together this generates a direct payoff of NOK 11. Assume furthermore that the other four persons in your group invest on average NOK 5 in project A. That gives a total investment of NOK 20 in project A for these four persons. Together with your own investment of NOK 10 this gives a total investment in project A of NOK 30. This yields a cost of NOK 3 for you (and for the others). A direct payoff of NOK minus a cost of NOK 3 gives your own payoff of NOK 8.

Table to calculate your own payoff per round

Average investment in project A by others	Your own investment In project A				
	0	5	10	15	20
0	8	9	10	11	12
5	6	7	8	9	10
10	4	5	6	7	8
15	2	3	4	5	6
20	0	1	2	3	4

Practical design

Before you, at your monitor you see three windows. There is one window with two buttons to click on, one to send your investment decision, the other one to receive information. You should only click on these buttons when the experimenter tells you to do so, in order to synchronize the game. The investments are entered in the box "Investment in A" in the "Decision" window. In this window you must also enter the number of the round, which will be called out by the experimenter in each new round. After you have filled in this window, it is necessary that you push the "Invest"-button twice. The investment decision is sent when there is a sound from your computer. The same sound is made when you click on "Get Information".

The window "Information" shows your last investment in project A, and the payoff for that round. The window also shows how much the other four subjects in your group have invested in the previous round.

In each group, one subject is selected to be the leader for all rounds to be played. Before the other subjects decide, they get to see the leader's investment in project A in the round. The subjects that are selected as leaders see this in the "Information" window. I will use the expressions "leader" and "others".

After 10 rounds we inform you about the changes in the rules for the last 10 rounds.

For your own sake, and for our sake in case something goes wrong with the computer or the network, please fill in your investment in project A for every round at the enclosed form. At the end, you sign the form such that we have a receipt for the payoffs. Your payoffs are tax-free.

Do not look at other monitors and do not communicate with any of the other participants. You can now ask questions for clarification.

Good luck.

Tables and Figures

Table 1a: Average investments in the public bad in the leader treatments for the group
and for leaders and followers separately. Treatment order: SLC-NLC.

Group	SLC (rounds 1-10)			NLC (rounds 11-20)		
	average	leaders	followers	average	leaders	followers
A_1	13.20	13.30	13.18	14.66	11.90	15.35
A_2	14.28	14.00	14.35	16.90	15.00	17.38
A_3	15.38	19.20	14.43	18.44	18.00	18.55
C_1	15.50	15.63	15.47	16.88	13.13	17.81
C_2	17.88	16.25	18.28	16.50	12.50	17.50
C_3	14.88	13.75	15.16	14.75	10.00	15.94
D_1	16.14	16.00	16.18	14.70	5.50	17.00
D_2	15.84	13.50	16.43	14.18	8.50	15.60
D_3	15.36	11.50	16.33	17.76	13.70	18.78
Average	15.38	14.79	15.53	16.09	12.03	17.10

Table 1b: Average investments in the public bad in the leader treatments for the group and for leaders and followers separately. Treatment order: NLC-SLC.

group	NLC (rounds 1-10)			SLC (rounds 11-20)		
	average	leaders	followers	average	leaders	followers
B_1	14.08	12.50	14.48	19.30	19.90	19.15
B_2	13.26	8.80	14.38	16.30	14.00	16.88
B_3	14.12	9.00	15.40	18.50	17.00	18.88
E_1	14.66	9.70	15.90	17.10	15.70	17.45
E_2	14.10	10.00	15.13	18.30	17.50	18.50
E_3	15.80	17.00	15.50	14.92	12.00	15.65
F_1	15.38	8.80	17.03	18.50	16.50	19.00
F_2	12.50	5.50	14.25	15.00	12.00	15.75
G_1	13.74	9.00	14.93	17.62	16.60	17.88
G_2	15.20	15.40	15.15	18.30	17.80	18.43
Average	14.28	10.57	15.21	17.38	15.90	17.76

Table 2: Estimation results of equation (4). Average follower investment in group i in round t as dependent variable.

Variable	Symbol	Coeff.	*p*-value
Constant	β_0	13.87	0.000
Effect of leader costs	β_1	-1.58	0.055
Effect of first treatment	β_2	-1.51	0.013
Effect of leader example	β_3	0.08	0.007
Effect of leader costs on effect of leader example	β_4	0.12	0.024
Effect of first treatment on effect of leader example	β_5	-0.03	0.439
Effect of round number	β_6	0.43	0.000

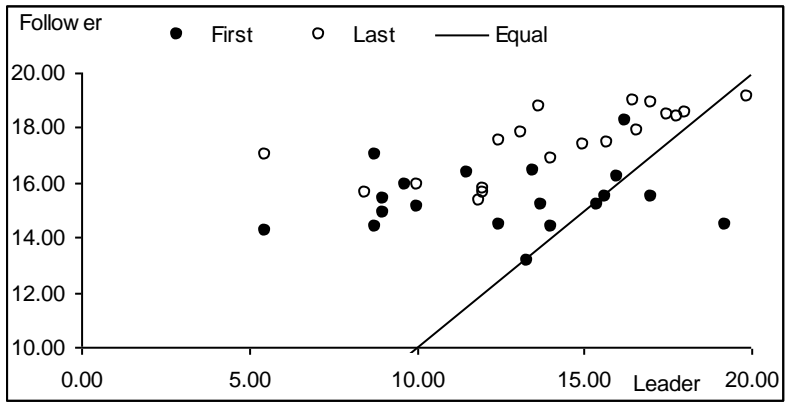Note: R^2=0.36, F=43.40, n=368.

Figure 1: Data points showing average leader and corresponding follower investments for all groups in first ten rounds and last ten rounds, and a line for equal leader and follower investments.
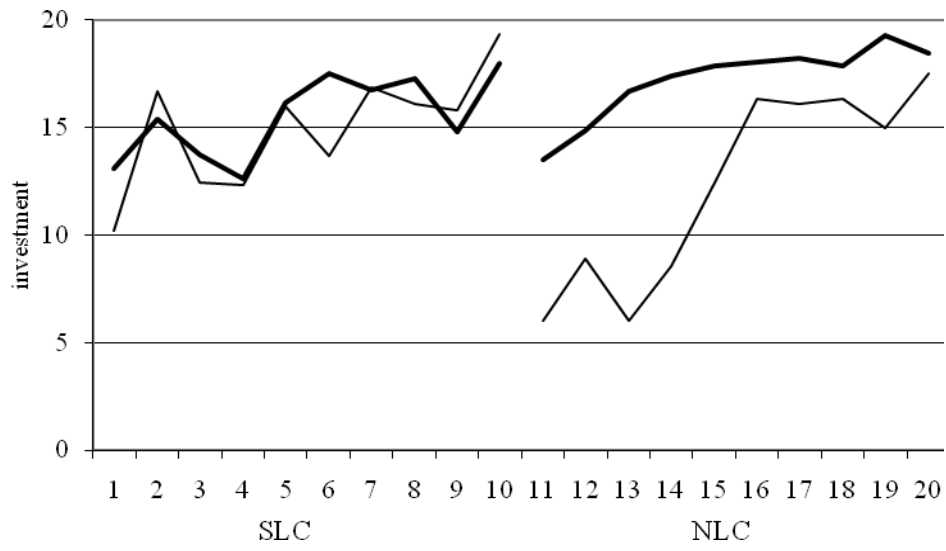
Figure 2a: Development of the average investment in the public bad across rounds for followers (thick lines) and leaders (thin lines). Treatment order SLC-NLC.
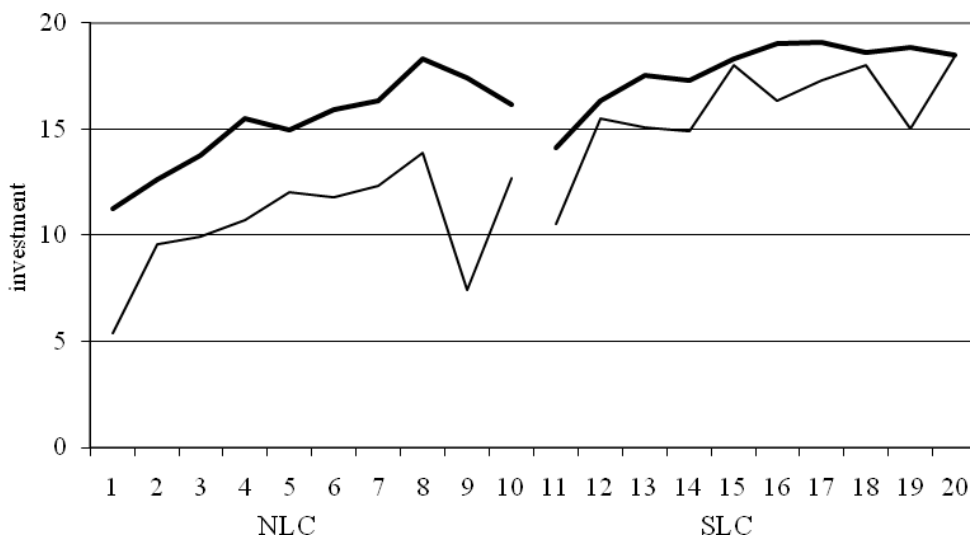
Figure 2b: Development of the average investment in the public bad across rounds for followers (thick lines) and leaders (thin lines). Treatment order NLC-SLC.

Endnotes

[1] Some experiments have introduced other forms of asymmetry, though. For instance, Levati et al. (2007) have conducted a four-person public good experiment with a leader where two group members had a low endowment and the other two group members had a high endowment. Other experiments have incorporated asymmetry in two-person games by giving or not giving the leader private information in order to investigate the effects of signaling and reciprocity (see e.g. Potters et al. 2007 for a voluntary contributions environment and Meidinger and Villeval 2002, for a team production environment).

[2] This intuition is similar to the conjecture by Brandts et al. (2007) that in order to overcome coordination failure in a weakest-link game the player(s) with the lowest effort costs should act as leader(s). Their experimental results do not support this hypothesis; instead leadership is largely driven by subjects with the most common cost type. However, in their study all players move simultaneously such that leading by example within a round, as we consider, is not possible.

[3] In contrast, some social psychological studies about leadership suggest that leaders may set a bad example. Findings from these experiments indicate that merely assigning people to a leader role may increase a leader's tendency to behave selfishly and to make self-benefiting choices at the expense of others, for instance because leaders feel more privileged or entitled to do so (e.g., Samuelson and Allison 1994, De Cremer and Van Dijk, 2005). This would imply for our setting that leaders would invest a lot in the public bad, and probably more than followers.

[4] Different from the computerized sessions, in session C we used a rather time consuming manual procedure, receiving and passing out information on slips of paper. To save time each treatment consisted of only eight rounds in this session. Otherwise the setting was the same as in the computerized sessions (including the room). It is sometimes argued that contact between subjects and experimenters could influence the experimental results (Hoffman et al. 1994). However, as we find no significant differences between the manual and computerized sessions, like Bolton et al. (1998) and Weimann (1994) we pool all data.

[5] Unless indicated otherwise, all tests are two-sided and based on (strictly independent) group level observations.

[6] In our experiment leaders can only punish collectively, and they can only do so by increasing their investment in the public bad. It would be an interesting extension for future experiments to see what leaders would do if they could punish individual followers like in Fehr and Gächter (2000).

[7] This raises the question who influences who, i.e. could it also be that a good example set by a follower works as good for the other followers as a good example set by the leader? We think this is not the case. First, as mentioned in the introduction, several experimental studies have documented a positive effect of leadership. Furthermore, Moxnes and Van der Heijden (2003) find no evidence that group member follow followers, even though some followers show very cooperative behavior. In addition, Rivas and Sutter (2008) report that if in a public goods game leaders contribute *after* the other group members the average group contribution is similar to that in a public good game without a leader. This suggests that a good example by a 'visible' leader works better.

[8] In reality, leaders are often elected rather than randomly chosen, and this could affect the results. In a public good experiment, Güth et al. (2007) find that leaders that are selected by the group behave similarly as appointed leaders. In addition, there are no significant differences between average contributions to the public good when groups have an elected or appointed leader. Rivas and Sutter (2008), on the other hand, find that endogenous leadership is much more efficient than exogenously imposed leadership.

[9] In the SLC treatment average payoffs for leaders were slightly lower (4.75) than for followers (4.97). However, average leader payoffs were slightly higher than obtained in a comparable experiment with no leader (4.50), Moxnes and Van der Heijden (2003).

[10] Actually, because the utility function is piecewise linear, if someone deviates he would always want to deviate to the maximum, i.e. $x_i^A = 20$. To simplify the analysis we examine the more general case here.