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Dynamic Public Goods[1]

Abstract

We conduct a dynamic public-good experiment: The subjects receive an endowment only in the first period of the experiment. After that the subjects' endowment consists of the previous periods' payoff. Although the potential benefit through the dynamics is huge the subjects fail massively to contribute. This can be attributed mostly to cooperative subjects running out of resources.

1.1 Introduction

A commonly used tool in experimental economics research on cooperation is the public-good game, also known as voluntary contribution mechanism (VCM).[2] In many variations of VCM experiments in a multi-period setting, the subjects receive a fresh endowment every period. The subjects thus are allowed to repeat their decision with fresh resources; a decision in one period does not have the consequence of potentially losing resources in the next period – given the anonymity of the participants within the experiment and no kind of a reputation building mechanism. But in some settings it might be interesting whether it makes a difference if a decision in one period has consequences for all other periods. As a real life example, think of a small society in an agricultural context: If such a small community is cooperating successfully in one year and by cooperating is having a plentiful harvest, then this improves its survival probability and furthermore possibly enables it to invest in technology which in turn could improve the harvest in the next year. Until now surprisingly little research has been conducted on comparable dynamics especially in the

[1] This part is based on a joint project with Simon Gächter, Torsten Huck, Bettina Rockenbach.

[2] See Ledyard (1995) for an older, Gächter and Herrmann (2009) as well as Chaudhuri (2011) for more recent reviews.

public-good context. We will give an overview on related literature in the next section.

Unlike a standard public-good experiment with a constant endowment over all periods we created a dynamic variant wherein the subjects receive an initial endowment only in the beginning of the experiment. Each subjects' endowment from there on will equal the profit of the previous period. Thus there could be a remarkable growth and a huge benefit if all subjects contribute all the time. However, there is a free-riding incentive and the danger of losing almost everything.

To decompose the impact of the dynamics we first compare the initial treatment with a treatment where subjects are randomly assigned to an endowment history of the dynamic public-good treatment and add two other treatments – one standard public-good experiment and a public-good experiment with equal but per-period increasing endowment.

We find indeed an effect of the dynamics. Contributions deteriorate in the course of the dynamic experiment much faster compared with the other treatments. We attribute this detrimental development mostly to cooperators running out of resources while we observe only minor differences in the behavior of the subjects between the dynamic and the other three treatments.

1.2 Related Literature

Dynamics

The term "dynamic" in the public-good context can be interpreted in different ways. Fershtman and Nitzan (1991) for example theoretically investigated the effect of an exogenously introduced decay in a continuous public-good problem with infinite duration where contributions are aggregated. The decay makes it necessary to provide a certain contribution level for it to survive and the contributions were added up over the time. Thus it resembles more some kind of a threshold public-good but with a dynamic component. They found that under certain circumstances an equilibrium might emerge but if the subjects act conditional the contribution will deteriorate. Noussair and Soo (2008) introduced some dynamics by letting the marginal per capita return change in a step-wise fashion if a certain threshold of the sum of contributions (50%) was met. In this setting only a minority of groups with deteriorating contributions emerged but there was a great heterogeneity among the group contribution paths.

In our interpretation dynamic means that the subjects have to live with the resources (i.e., endowments) created by their payoffs during the experiment. Most closely related in this regard is Gürerk et al. (2010b). Like

in our dynamic experiment the subjects in this study received an initial endowment that was equal in the first period. The profit of one period was the endowment of the next period. The difference to our experiment is that the subjects' total payoff of Gürerk et al. (2010b) only consisted in the profit of the last period while in our experiment it is the sum of all period-profits. The authors compared a dynamic public-good treatment without punishment option with a dynamic treatment with a punishment option included. They observed a decreasing trend of contributions relative to the endowment without the punishment option contrasting with the sanctioning treatment where the contributions remained at the same level. The detrimental effects of the punishment – i.e., efficiency losses – are slightly more than compensated by the benefits of the induced higher contributions leading to almost equal final wealth levels.

Another strand of the experimental literature that could very roughly be attributed to our definition of dynamics is that which combines a real effort with an experiment wherein the profit of the real effort is connected to the later endowment. One paper in this regard would be Cherry et al. (2005). In their experiment the subjects' endowments for a one-shot public-good game were earned by taking a GMAT questionnaire beforehand. They found no impact of the source of the endowment heterogeneity – whether it was endogenously earned or exogenously assigned. This is somewhat opposite to another paper of the same authors – Cherry et al. (2002) – who found a strong impact in a dictator game context: If the endowment was self-earned the subjects behaved much more selfish.

Heterogeneity

Our experiment leads in one treatment to within-group differences in the endowments, in one treatment caused by the actions of the subjects (endogenous heterogeneity) and in another treatment because the subjects will follow a randomly assigned endowment history of the dynamic treatment (exogenous heterogeneity).

There is plenty of literature on the heterogeneity of endowments[3] with somewhat mixed results. One can distinguish between those experiments that assign heterogeneous endowments with or without the influence of the subjects. We will refer to the latter as exogenous heterogeneity. In fact most experiments on heterogeneity can be regarded as falling into that category. A few others introduce heterogeneity by different actions before the public-good actually was conducted – we call this endogenous heterogeneity. For the latter the aforementioned paper of Cherry et al.

[3]There can be of course also heterogeneity in the ability allowing some subjects to be more 'productive' than others.

(2005) would be an example. A special kind would be household money experiments. In those the people bring in their own money at the beginning of the experiment (Clark, 2002; Harrison, 2007, for example)).

Cherry et al. (2005) found lower contributions with exogenous as well as endogenous heterogeneity in the sense of earned heterogeneous endowments compared with homogeneous endowments in their one shot public-good setting. Contrary to that, Chan et al. (1999) concluded that (exogenous) heterogeneity increased the cooperation level in a non-communication environment. Their public-good design was slightly unusual and the heterogeneity was differently distributed in comparison to Cherry et al. (2005). Levati et al. (2007) observed mixed results in a public-good in presence of a leader who was inducing higher contributions with (endogenous) heterogeneity than compared with homogeneity in the endowments. Anderson et al. (2008) reported a negative impact of (endogenous) inequality of endowments.

In the context of step-level public-goods we also discovered mixed results in the literature. While van Dijk and Wilke (1995) observed that participants with different endowments contributed the same percentage of the endowments – which was further support to van Dijk and Grodzka (1992), Aquino et al. (1992) wrote that in their experiments the cooperation was lower with higher resource inequality – independent of the framing. Bagnoli and McKee (1991) and Rapoport and Suleiman (1993) reported evidence for inequality reducing the contributions to the group account while on the contrary Marwell and Ames (1979), Marwell and Ames (1980) did not discover a difference.

Sutter and Weck-Hannemann (2003) introduced some asymmetry by two different minimum contribution levels. Those levels were either externally imposed or the subjects could vote if the asymmetric rule is implemented. The externally set rule produced higher contributions.

Another article invoking a dynamic component is Sadrieh and Verbon (2006). Although they did not use the classical linear public-good design having a non-linear production function and only three choices (cooperate, sabotage or Nash) their design has the character of a public-good. An important additional difference is that the payoffs were determined by the subjects' share of the total production. They allowed the accumulation of endowments over 5 periods and furthermore tested different degrees of heterogeneity in endowments and different distributions of endowments (i.e., number of lowly-endowed subjects). The authors observed that the degree of heterogeneity had no effect on the contribution level and on the growth in the dynamic game while a static variant experienced a positive effect of a greater degree of heterogeneity.

Reuben and Riedl (2009) found no difference in their treatments with

heterogeneous endowments without punishment although with punishment they seem to agree on certain social norms that are then enforced: Subjects with higher endowment should thus contribute more.

Summing up, results on the impact of heterogeneity are mixed. It seems to be very dependent on the context whether contributions are higher, equal or lower. We will contribute to this literature by adding insights on the dynamics of endogenous heterogeneity and compare them with exogenous heterogeneity.

1.3 Experimental Design

At the center of our experiments is the dynamic linear public-good treatment over 20 periods which we dub DYN. The subjects received in the first period a start endowment of $e_{i,t=1} = 20$ experimental units. They could contribute these to a public-good. The contributions were multiplied by the factor $a = 1.4$ and equally distributed among the $n = 4$ group members. The profit of the current round was then the endowment of the subjects in the next period:

$$\pi_{i,t} = \underbrace{\pi_{i,t-1}}_{endowment} - c_{i,t} + \frac{a}{n}\sum_{j=1}^{n} c_{j,t}\,. \tag{1.1}$$

This is similar to Gürerk et al. (2010b). Our experiment differs to theirs in the regard that the wealth level that was relevant for the subjects' payment at the end of their experiment was $\Omega_i = \pi_{i,T}$ while ours was $\Omega_i = \sum_{t=1}^{T} \pi_{i,t}$. A second difference was that their a was larger (1.6).

Since we wanted to investigate the effect of the dynamics in the main treatment we separated the different factors that could have an effect on the contribution levels. Thus beside the DYN treatment we created the HIST treatment in which the heterogeneous endowment is exogenously introduced in as much as one subject was randomly assigned to a unique endowment history path of a subject of the DYN treatment. The CONST treatment is the control treatment and resembles the classical linear public-good experiment with the difference that the endowment was the average endowment of the DYN treatment over all periods. The INC treatment then deals with the issue that we observed per period increasing endowments in DYN. In consequence we created this treatment as control for the increasing endowment effect and assigned the per period average of DYN as the per period equal endowment for all subjects in this treatment. Table 1.1 summarizes the treatments.

The experiments were conducted at the University of Erfurt using z-tree (Fischbacher, 2007) for the experiment and ORSEE (Greiner, 2004) for the recruitment. The total number of participants was 160.