



Growth and inequality in public good provision[☆]



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ABSTRACT

In a novel experimental design, we study public good games with dynamic interdependencies, where each agent's wealth at the end of period t serves as her endowment in $t + 1$. In this setting, growth and inequality arise endogenously allowing us to address new questions regarding their interplay and effect on cooperation. We find that amounts contributed are increasing over time even in the absence of punishment possibilities. Variation in wealth is substantial with the richest groups earning more than ten times what the poorest groups earn. Introducing the possibility of punishment does not increase wealth and in some cases even decreases it. In the presence of a punishment option, inequality in early periods is strongly negatively correlated with group income in later periods, highlighting negative interaction effects between endogenous inequality and punishment.

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1. Introduction

1.1. Motivation

Social dilemmas, where collective and private interests are in conflict, abound in economic and social life. Public good games have been used across disciplines as the standard tool to study a wide array of social dilemma situations. These include joint ventures (Grossman and Shapiro, 1986), R&D cooperation (Cozzi, 1999; Kamien et al., 1992), political action funds of special interest groups or parties (Dawes et al., 1986), multilateral foreign aid and effort provision in work teams (Ostrom, 1990; Hamilton et al., 2003; Tirole, 1986). But also pricing or market sharing agreements by firms

(Green and Porter, 1984) as well as many economic activities in the family (Becker, 1981) can be thought of as instances of cooperation that can be modeled with public good games. One feature that is common to many of these examples is that there are dynamic interdependencies: not only will the same set of people interact again, but previous outcomes affect future endowments (both in terms of the stock of physical and social capital).

In this paper, we present a novel experimental design that captures such dynamic interdependencies. Our design builds on what has become the workhorse model to study public good provision in experiments (see e.g. Isaac et al. (1984), Andreoni (1995) or Fischbacher and Gächter (2010) among many others): participants are matched in fixed groups of four people to play the public good game for 10 or 15 periods. As in most other public good experiments, we focus on the most challenging social dilemma situations, where the unique subgame perfect Nash equilibrium prescribes zero contributions by all group members, but where efficiency requires group members to contribute their entire endowment. We also conduct experiments where each group member can punish other group members by reducing their first stage earnings at a cost to themselves (Ostrom et al., 1992; Fehr and Gächter, 2000; Andreoni et al., 2003).

The key difference to previous research using this “standard” design is that each participant's wealth at the end of a period

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constitutes their endowment for the next period, whereas in the “standard design” endowments are allocated exogenously and tend to be the same in each round.¹ In our design, endowments are created endogenously, which leads to dynamic interdependencies.

We focus on two important implications of introducing these interdependencies. First, if overall contributions today are high, then there will be higher wealth in the next period (*growth*). Second, heterogeneity in contributions today creates *inequality* in endowments in the following period. Growth and inequality can interact with the possibility of punishment in different ways. The threat of punishment can lead to higher growth if it induces higher contributions, but punishment executed on the outcome path can induce a multiplier effect which can hamper growth severely. Maybe more interestingly, punishment can interact with inequality in non-trivial ways. In particular, rich group members can be largely “immune” to punishment by poorer group members, if the punishment that poor group members can afford is too small relative to the richest group member’s wealth. As all endowment can be used for punishment, rich group members, on the other hand, might be able to punish others harshly at a relatively low cost to themselves. This asymmetry of punishment possibilities translates wealth inequality into inequality in power to punish. In addition, in unequal groups richer group members will typically be free-riders implying that punishment power could be in the “wrong hands”. This raises the question of whether punishment will be as effective in increasing contributions and group income as it has been in settings without these dynamic interdependencies.

Our main findings can be summarized as follows. Even in the absence of punishment contribution and wealth levels display a strictly increasing trend over time. In terms of the realized potential for growth and the level of inequality, there is a lot of variation across groups. Individual earnings range between 2 Euros and 241 Euros. The Gini coefficient assumes the full range between 0 (equal wealth of all group members) and 1 (one group member appropriates the entire wealth) in the experiment.

Punishment (or the possibility thereof) does *not* increase wealth. This is true in both the 10 and 15-period variations despite the fact that people tend to contribute more in the treatment with punishment in the 10-period variations. We find evidence for two mechanisms behind this result: (i) in groups where inequality is high (above median) there is more anti-social than pro-social punishment, i.e. shirkers punish contributors more than vice versa and (ii) much of this punishment happens in early periods implying that resources are taken away exponentially.²

While the possibility of punishment does not increase wealth and in some cases even strictly decreases it, it also does not increase inequality on average. This is true despite the inequality-increasing presence of anti-social punishment. Analysis of data from Herrmann et al. (2008) shows that, in a comparable standard setting, punishment increases both wealth and inequality. In terms of the relationship between inequality and growth, we find that inequality in period 2 is strongly negatively correlated with wealth in period 10 in the treatment with punishment possibilities. In particular, a 1% increase in inequality in period 2 leads to a $\approx 0.5\%$ decrease in wealth

in period 10. Inequality and growth are positively related across groups with below median wealth and negatively related across groups with above median wealth.

In interpreting these results, it is important to note how the setting we introduce differs from the standard public good game described above. There are two main differences: (i) there is no consumption until the last round in our setting, i.e. one’s entire wealth can be reinvested at the end of the period and (ii) endowments are endogenous, i.e. determined by previous outcomes. $R + D$ cooperation often displays these features, but also the evolution of societies could be viewed under this lens. In the standard setting, by contrast, there is full consumption, i.e. no wealth can be reinvested and endowments are exogenous (and stationary). Volunteering, e.g. at a food bank, seems a good example falling into this category. Other types of volunteering, such as in natural conservation and archiving, are examples involving stationary exogenous endowments, but no or little consumption. The case of full consumption with endogenous endowments describes the one-shot game. Finally, note that many applications, such as infrastructure investments, multilateral foreign aid or pricing agreements will fall somewhere in between these extremes with some, but not full consumption and with partially endogenous endowments.

1.2. Literature review

To our knowledge, our experiment is the first to study public good provision with dynamic interdependencies and endogenously arising asymmetric punishment possibilities.³ As such, it contributes to studies of public goods with dynamic interdependencies more broadly. These include Battaglini et al. (2016) who study the Markov perfect equilibrium dynamics in the provision of a durable public good over time where there is consumption in each period. They find evidence of significant under-provision relative to the interior equilibrium. Duffy et al. (2007) studied threshold public good games with multiple contribution rounds, where, theoretically, “completion equilibria” (with positive contributions) do exist. They find that, as in the standard setting, contributions do decline over time (see also Croson and Marks, 1998 among others). Noussair and Soo (2008) and Cadigan et al. (2011) study dynamic public good settings where the current return from the public good depends on past contributions. Other studies link public good games over time via explicit reputation mechanisms (e.g. Milinski et al., 2002). Rockenbach and Wolff (2017) have recently studied a setting where games are linked via endowments. They use a non-linear exchange rate, though, which effectively eliminates the possibility of exponential growth and contains inequality. Consequently, their results are more similar to those obtained in the standard setting.

Our results also contribute to research on the impact of inequality on public good provision. Most existing literature has studied the effects of *exogenous* income inequality. Chan et al. (1996) experimentally test a prediction by Bergstrom et al. (1986), where public good provision increases with inequality in the income distribution in an equilibrium with positive contributions. They find that group behaviour conforms with the theoretical prediction. Other authors have found that exogenous income inequality decreases contributions (van Dijk et al., 2002; Ostrom et al., 1994) or found no effect (Chan et al., 1999). Reuben and Riedl (2013) find that without punishment there is no effect of income inequality on contributions, while with punishment participants contribute proportionally

¹ Throughout the paper, we will use the expression “standard design” to refer to the many studies of linear voluntary contribution experiments, where the one shot game is repeated for some number of periods. See Ledyard (1995) for a survey of the earlier literature and Chaudhury (2011) or Chapter 6 in Plott and Smith (2009) for a survey of more recent results.

² History books report many examples where “shirking group members” have assumed power by exploiting asymmetric punishment opportunities. Standard Oil reportedly sent out thugs to raid the premises of competitors as a form of punishment (Josephson, 1962). Adler (1985) discusses endogenously arising asymmetries in punishment possibilities in a study of upper-level drug-dealing and Johnson and Earle (1987) among North-American Indians.

³ In an unpublished Master thesis, Huck (2006) has conducted a dynamic public good game without the possibility of punishment and related contributions to personality characteristics elicited in a questionnaire. He also did not analyze growth and inequality but, like us, he finds a pattern of increasing contributions (in terms of absolute amounts) and no endgame effect. See also Grosse (2011) who studies versions of dynamic public good games and finds that relative contributions decline over time.

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