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Could two be worse than one? Individuals` investments in multiple public bads

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Abstract

We analyze a multiple collective goods game where individuals allocate their endowment between a private good and two identical public bads. Results show that the mean of investments into a public bad account increases by 14.2% when individuals face two rather than only one bad account. Moreover, this framing increases pure free riding behavior from 31.83% to 52.67%.

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1. Introduction

Despite the existence of a vast literature on public goods games, only few studies have experimentally focused on public *bads* situations (e.g. Andreoni 1995 or Moxnes and van der Heijden 2003). Generally, the investments into a public goods game are different of those into a public *bads* game. Andreoni (1995) showed that subjects cooperate more often in presence of positive externalities and in comparison less often in situations where externalities are negative, even when the expected payoffs are the same. For Andreoni (1995), this difference is due to an asymmetric behavior between doing something good, i.e. the "*warm-glow*" and doing something bad, the "*cold-prickle*". Nevertheless, public *bads* games may be more relevant depending on the situation that we want to study. For instance, a product which is made through a harmful environmental process generates an individual utility for the consumer as well as negative externalities for everyone, including the consumer himself. In this case, cooperation towards a collective investment means that harmful products are substituted by goods which are more respectful for the environment.

The supply of goods is predominantly composed of products which generate negative externalities (public *bads*), in contrast to products which generate positive ones (public goods), or those generating no externality (private goods). Therefore, we can state that individuals take their consumption decisions in a multiple public *bads* context.
This configuration can have an impact on consumer decisions and on social welfare. From a psychological point of view, the *Support theory* suggests that unpacking a collective account into identical parts generally increases its support, in comparison to the alternative (Rottenstreich and Tversky 1997, p.406). From an experimental economics point of view, Bernasconi et al. (2009) show an increase in contribution of 43.6% when a single public good is split into two identical public goods. As public goods games do not automatically produce the same results as those of public *bads* games, we conducted a decontextualized laboratory experiment to test the same psychological artefact, i.e. the *unpacking effect*, but in a situation of multiple public *bads*.
"*To unpack*" means to divide one collective account into two identical and substitutable components. Mathematically, the sum of the investments and the expected payoffs of the different parts are equal to their counterparts corresponding to a situation where one single public good is considered. Thus, each individual contribution can be considered either as an investment in the whole project, or as an investment in at least one of its subparts. Although objectively these two cases are equivalent, subjectively individuals may view them differently. Even if multiple public goods games recently raised more attention (e.g. Cherry and Dickinson 2008; Bernasconi et al. 2009), multiple public *bads* games have never been experimentally tested.

In view of theoretical predictions of the *Support Theory* and of the existing experiences in economics, it is unclear in which direction the unpacking effect will unfold in a public *bads* situation. We compare a standard public *bads* game, with a design where subjects face two *unpacked* public *bads*, in order to analyze the differences between the mean level of investment and the variations of the *pure free riding behavior*[1].

[1] Inspired by Isaac et al. (1984), pure freeriding behavior appears if, during a period, a participant invests all of his tokens into public bad(s) account(s).

2 Experiment

2.1 Experimental design and treatments

Two treatments were conducted. Table I shows the characteristics of each treatment. Every treatment implied six groups of five students with a partner design and carried on 20 periods. Every participant has been endowed with 20 tokens per period. It was not possible to reuse tokens from a current period to another.

Table I: Experimental treatments.

Treatments	1PB	2PB
Sessions	2	2
Size of groups	5	5
Participants	30	30
Periods	20	20
Tokens / period	20	20
Observations	600	600

The baseline (1PB) is similar to the public bad framework used by Moxnes and Van der Heijden (2003). Every participant had to allocate 20 tokens between a private good and a public bad. In the 1PB treatment, the payoff function for every subject was:

$$\pi_i = 0.4x_i + 0.7y_i - 0.1\left(\sum_{j=1}^{n} y_j\right) \quad where\ x_i + y_i = 20 \qquad (1)$$

The unpacking treatment (2PB) is inspired by a framework from Bernasconi et al. (2009). Every participant had to allocate 20 tokens between a private good and two public *bads.* The 2PB treatment only differs by the number of public bad accounts that the players face, but mathematically the first statement is strictly equal to the second. Thus the payoff function was:

$$\pi_i = 0.4x_i + 0.7y_i - 0.1\left(\sum_{j=1}^{n} y_j\right) + 0.7z_i - 0.1\left(\sum_{j=1}^{n} z_j\right) \quad where\ x_i + y_i + z_i = 20 \qquad (2)$$

Both profit functions are linear. In the treatment 1PB, the unique Nash equilibrium is: $y_i = 20$ $\forall$ i. And in the treatment 2PB any combination such as: $y_i + z_i = 20$ $\forall$ i, is a Nash equilibrium. In both cases the individual payoff of the Nash equilibrium is: $\pi_i = 4$ $\forall$ i. The Pareto social optimum is reached when all group members invest all of their tokens into the private good. In both cases the individual payoff of the Pareto social optimal is $\pi_i = 8$ $\forall$ i.

The difference in investments between treatments will enable us to test the hypothesis that unpacking has an impact on the level of investment in a public bad.

2.2 Experimental procedures

The experiment took place at the University of Strasbourg in May 2013. Sixty subjects were recruited using ORSEE (Greiner 2004) and nobody had participated in more than one session. The program was implemented by the web platform EconPlay (www.econplay.fr).

Upon arrival and until the end of the experiment, participants could not communicate together. Instructions were distributed and read out loud (see Online Appendix 1 and 2). After reading, participants were randomly and anonymously assigned to a terminal. A set of control questions was implemented to ensure participants understood the game. Finally, participants played a trial period to become familiar with the graphical user interface. During a period, each participant had to allocate an integer number of tokens between 0 and 20 between several investments. After each period, participants were given information on the aggregate level of their group contribution. On average each player earned 15 € (cumulative payoff) over the course of a one-hour experiment.

3. Results

Overall observations reveal differences between treatments on the mean investments and on the proportion of pure free riding behavior.

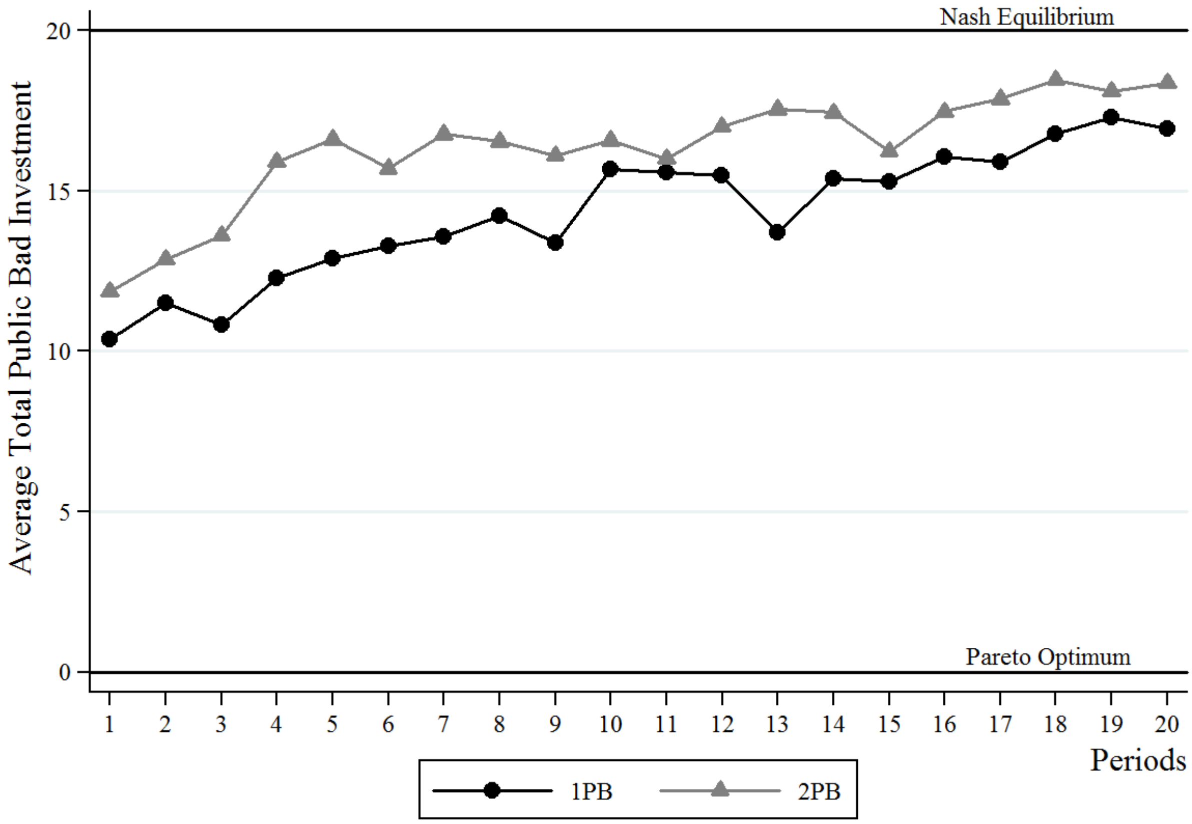
3.1 The unpacking effect on the mean investments

The means of the investments for the twenty periods in both treatments are illustrated in Figure 1.

The level of investments to the public bad is at each period higher in the 2PB treatment. This difference remains stable although the treatment effect decreases over time. A Wilcoxon-Mann-Whitney rank sum test (two-sided) reveals that unpacking the public bad affects positively and significantly (5%) the mean of the investments into this account. This result is also confirmed (1%) by a 2 sample Kolmogorov-Smirnov test for equality of distribution functions.

Overall subjects invested on average 14.2% more in the bad account when they faced two rather than only one public bad. The difference in mean investments is however less important than in the case described by Bernasconi et al. (2009), where a single public good split into two identical public goods resulted in a 43.6% increase in mean investment. This gap may be consistent with the results from Andreoni (1995) who compares the difference between a positive and a negative public good situation.

Figure 1: Mean public bad investments per period.



We analyze the public bad investment through a Generalized Least Squares model (G.L.S.). We also run a Tobit panel data regression as there are a substantial number of censored data: 5.17% at the lower limit (pure cooperation) and 42.25% at the upper limit (pure free riding). There are 60 subjects (2 treatments * 6 groups * 5 participants). We assume that the sample observations on participant i's (i= 1, ... , 60) are independent during each period t (t= 1, ... , 20). Therefore, the Tobit can specify a latent variable given by:

$$Y_{it}^{*} = \alpha \mathrm{X}_{\mathrm{it}} + \mu_i + \varepsilon_{it} \tag{3}$$

Where Y_{it}^{*} is a latent variable representing subject i's utility level at period t. X_{it} is a (k × 1) vector of k explanatory variables. α is the (k × 1) regression vector to be estimated. $\mu_i \rightarrow N(0, \sigma^2{}_{\mu_i})$ is the individual-specific random effect and $\varepsilon_{it} \rightarrow N(0, \sigma^2{}_{\varepsilon})$ is the mean zero error term. Y_{it}^{*} is observed as the value of Y_{it}:

$$\begin{cases} Y_{it} = 0 \text{ if } Y_{it}^{*} \leq 0 \\ Y_{it} = \alpha X_{it} + \mu_i + \varepsilon_{it} \text{ if } 0 < Y_{it}^{*} < 20 \\ Y_{it} = 20 \text{ if } Y_{it}^{*} \geq 20 \end{cases}$$

Our model can be written as:

$$Y_{it} = a_0 + a_1 Treatment_{it} + a_2 Period_{it} + \mu_i + \varepsilon_{it} \tag{4}$$

Where Y_{it} is the individual investment to the public bad (G.L.S.) or dummy variable (Tobit). *Treatment* is a dummy variable equal to 0 for the treatment 1PB and equal to 1 if for the treatment 2PB.

Period allows us to assess the effect of time on investment and cooperation.
Control variables such as gender, level of study, discipline of study and age were tested, but they were not found to be significant.

Table II: Panel data regression results

Dependent variable: Individual public bad investment				
	(1)		(2)	
Independent variables	G.L.S.		Tobit	
Treatment	2.03 *	(1.11)	4.86 ***	(1.79)
Period	0.29 ***	(0.03)	0.53 ***	(0.04)
Intercept	11.29 ***	(1.07)	10.57 ***	(1.31)
Overall R^2	0.11			
Log. Likelihood			-2518.712	
Number of observations	1200		1200	
Left-censored observations			62	
Right-censored observations			507	
Uncensored observations			631	

Notes:
- This table reports coefficient estimates (standard errors in parentheses) from a linear random effects model.
- (1) corresponds to the estimation of the model by a panel G.L.S. random effect.
- (2) corresponds to the estimation of the model by a panel Tobit random effect (left and right censored).
- Significance level is denoted as follows: *p<0.1, **p<0.05 and ***p<0.01.

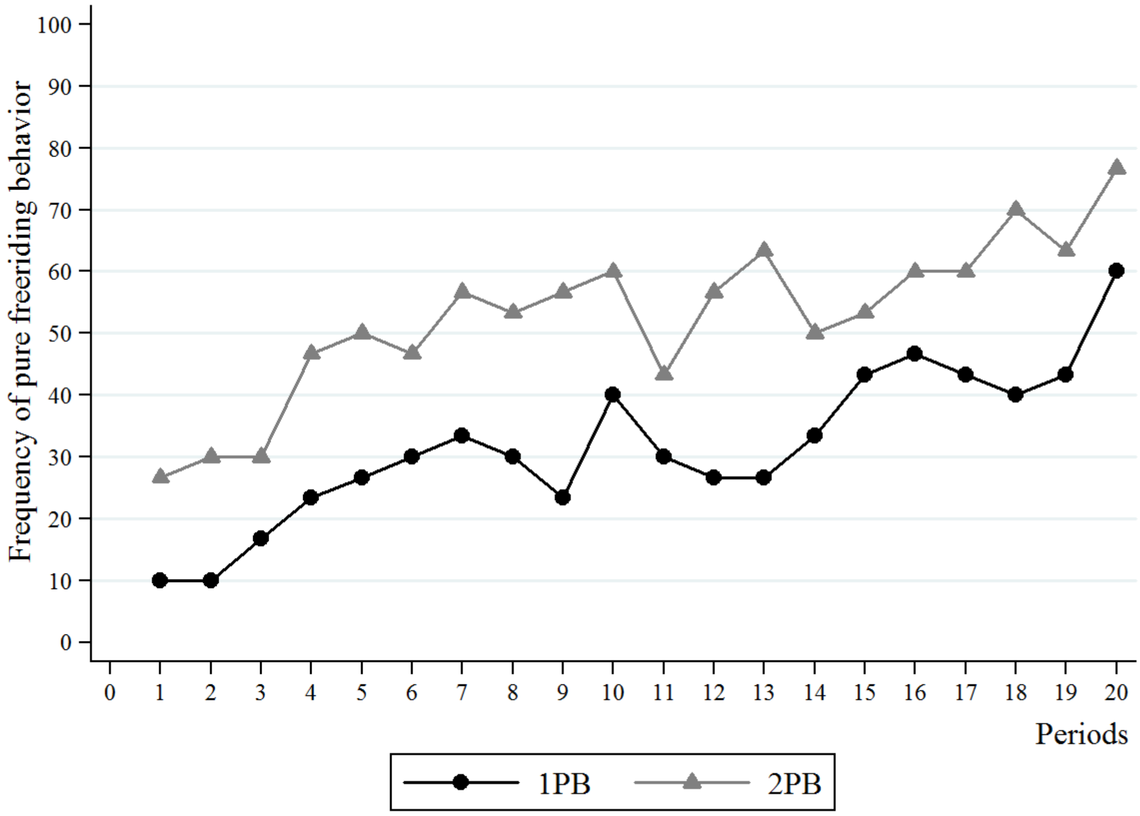
The panel regressions results reported in Table II are in line with the "Wilcoxon-Mann-Whitney" non-parametric analysis. The treatment variable has a positive effect on the level of public bad investment (significant at 10% for the panel G.L.S. regressions and at 1% for the panel Tobit regressions).

The period variable, positive and significant at 1% for both regressions, indicates that as the period increases, the mean investments to the public bad progressively increases.

3.2 The unpacking effect on the pure free riding behavior

Figure 2 reveals at each period a strong difference between treatments effects on the frequency of pure free riding behavior. On the whole, the difference between treatments is stable over time. We expected that *ceteris paribus*, the unpacking effect would increase pure free riding behavior independently of time.

Figure 2: Frequency of pure free riding behavior per period (%)



In order to focus on pure free riding behavior, we implemented a Probit panel data regression. Assume that participant i (i= 1, ... , 60) has a probability to be a pure free rider in period t (t= 1, ... , 20) given by:

$$Y_{it}^{*} = \alpha' \mathrm{X}_{\mathrm{it}} + \mu_i + \varepsilon_{it} \qquad (5)$$

Where Y_{it}^{*} is a latent variable representing subject i's utility level at period t. X_{it} is a (k × 1) vector of k explanatory variables. α' is the (k × 1) regression vector to be estimated. $\mu_i \rightarrow N(0, \sigma^2{}_{\mu_i})$ is the individual-specific random effect and $\varepsilon_{it} \rightarrow N(0, \sigma^2{}_{\varepsilon})$ is the mean zero error term. The model assumes that prob($Y_{it} = 0/X_{it}$) = prob($Y_{it}^{*} < 20/X_{it}$) = F($-\alpha' X_{it}$) and prob($Y_{it} = 1/ X_{it}$) = prob($Y_{it}^{*} = 20 / X_{it}$) = 1−F($-\alpha' X_{it}$), where F(.) is the cumulative normal distribution.
Our model can be written as:

$$Y_{it}^{*} = a_0 + a_1 Treatment_{it} + a_2 Period_{it} + \mu_i + \varepsilon_{it} \qquad (6)$$

Treatment is a dummy variable equal to 0 for the treatment 1PB and equal to 1 if for the treatment 2 PB. *Period* allows us to assess the effect of time on investment and cooperation. $\mu_i \rightarrow N(0, \sigma^2{}_{\mu_i})$ is the individual-specific random effect and $\varepsilon_{it} \rightarrow N(0, \sigma^2{}_{\varepsilon})$ is the mean zero error term. Control variables such as gender, level of study, discipline of study and age were tested, but they were not found to be significant.

Table III: Probit panel data regression results

Dependent variable: Pure free riding behavior		
Independent variables	Probit	
Treatment	0.95 ***	(0.33)
Period	0.08 ***	(0.01)
Intercept	-1.58 ***	(0.26)
Log. Likelihood	-569.70363	
Number of observations	1 200	

Notes:
- This table reports coefficient estimates (standard errors in parentheses) from a linear random effects model.
- Significance level is denoted as follows: *p<0.1, **p<0.05 and ***p<0.01.

The treatment effect, positive and significant at 1%, indicates that the unpacking effect increases the subjects' propensity to become a pure free rider during a given period, compared to a standard public *bads* situation (Table III).
Period has also a positive and significant at 1% on increasing the probability to be a pure free rider (Table III). Along with the time, the probability to adopt a pure free riding behavior increases.

4. Conclusion

As suggested by the *Support theory* (Rottenstreich and Tversky 1997, p.406), unpacking a collective account into identical parts generally increased its support, in comparison to the alternative(s). Bernasconi et al. (2009) found that the unpacking effect increased the level of investment in the context of a public goods game. We found a similar result when unpacking is applied to a public *bads* game.

The unpacking effect increases the attraction of the public bad account through at least two different mechanisms:
(1) Through the presence of an additional public bad per se. In a situation of subadditivity ($f(A)+f(B)\geq f(A+B)$), an individual contributes in total more tokens into each subpart than the total he would contribute into one single bundled account. In our experiment, participants invest tokens into the both public *bads* accounts in 64% of the observations of the 2PB sample.
(2) And/or by having different expectations about the behaviors of the others members in the treatment 2PB. According to the *Support theory*, it can be rational for an individual in the context of an additional public bad to expect an increased mean investment from the other members of his group into the global public bad. The presence of an additional public bad per se induces an even higher domination of the non-cooperative strategy on the cooperative one.

The unpacking effect increases strongly and significantly the proportion of pure free riding behavior and this phenomenon seems to be independent of time. That is to say, the difference of the average contributions between both treatments has remained stable over time.

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