ANONYMITY IN SOCIAL DILEMMAS: EVIDENCE FROM WASTE SORTING

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Abstract

Since in multiple-person social dilemmas agents can hide their actions behind the veil of anonymity, the free riding problem can be more severe than in two-person dilemmas. In this paper we investigate the external validity of experimental findings on the effect of anonymity in social dilemmas using field data on waste sorting. We compare the behavior of similar households sharing (or not) their bin for unsorted waste. Since households have to pay a fee proportional to their unsorted waste production, sharing the bin means sharing the fee. We find that, on average, household unsorted waste production is higher if three or more households share the same bin. Surprisingly, when two households share the same bin, unsorted waste production decreases.

Keywords: Incentives, Free Riding, Anonymity, Waste Management.

JEL codes: D01, D78, Q53.

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1. Introduction

Social dilemmas are situations in which the rational behavior of an individual leads to suboptimal outcomes from the collective standpoint. The dilemma arises because the dominant strategy for each individual – i.e. the strategy representing her best reply regardless of what anyone else does – yields to a Pareto inferior equilibrium. Social scientists have modeled social dilemmas using different *games*. Kollock (1998) classified these games as two-person dilemmas (prisoner's dilemma, assurance game and chicken game) and multiple-person dilemmas (public goods and tragedy of the commons). Dawes (1980) pointed out that moving from two-person to multiple-person dilemmas crosses a threshold in which *anonymity* becomes possible and free riding becomes more significant, because not all the actions are *visible* to all the actors. In addition, as the number of players increases, the cost one can impose on those who fail to cooperate are diffused and diluted, thus having less threatening impact (Olson, 1965; Isaac and Walker, 1988).

The literature in experimental economics has shown that decreasing anonymity raises the contribution in public goods games (Andreoni and Petrie, 2004; Bigoni and Suetens, 2012; Rege and Telle, 2004). For instance, Samak and Sheremeta (2013) show that when agents can be identified by others they contribute more because they want to avoid the shame associated with being a low contributor[1]. Visibility is also important to have an effective punishment in public goods games: in fact, the benefits of costly punishment diminishes when there is uncertainty regarding the realized endowment of subjects (Bornstein and Weisel, 2010; Patel et al., 2010) or contributions are not perfectly observed (Ambrus and Greiner, 2012; Grechenig et al., 2010).

[1] Andreoni and Bernheim (2009), Charness et al. (2007), Schram and Charness (2012) and Shaw et al. (2013) report similar findings in different games.

Several papers have investigated the role of action visibility using field data, in particular regarding charitable giving and voting.[2] However, to the best of our knowledge, we are the first to test the external validity of the detrimental effect of anonymity on cooperation in social dilemmas. For this purpose we use a unique dataset on waste production at the household level: the households in our dataset pay a per-unit fee (or pay-as-you-throw; PAYT[3] hereafter)[4] based on the amount of unsorted waste produced. We exploit the fact that when individual measurement of households' unsorted waste is not available or it is unpractical (for instance in apartment buildings) the municipality makes some households share the same bin for unsorted waste with one or multiple other households. When a bin is shared among two or more neighbors, PAYT is also shared in fixed proportions. Thus, for these households the decision to sort their waste – and therefore reduce the amount of residual waste – becomes a social dilemma and a free-riding problem can emerge. In fact, the benefit of sorting (a lower fee to pay) is shared with the neighbors using the same bin while the cost of sorting (time and effort devoted by the household) is borne entirely by the household.

2. Data

We use administrative panel data on unsorted waste bin emptyings at the household level in all the condominiums of six municipalities in the district of Treviso (Italy) over the period 2004-2008. The six municipalities have between 10 and 20 thousand inhabitants each, and

[2] Soetevent (2005) finds that visibility has a positive effect on donations to charities and Soetevent (2011) finds that individuals are more likely to donate in a door-to-door campaign when their donation can be observed by the solicitor. Lacetera and Macis (2010) show that individuals are more likely to donate blood when they receive publicly announced awards. Panagopoulos (2010) finds that the shame to be in a public list of non voters is effective to mobilize voters.

[3] PAYT is commonly used to promote sorting under a variety of different models depending on the region and municipality (see Kinnaman, 2006 and Bucciol et al. 2011).

[4] Since PAYT directly links the actual costs for waste disposal and individual households' production of unsorted waste, it makes disposal of unsorted waste costly just like other utilities (such as electricity or water) that are charged by unit of consumption.

are those in the district where households more frequently live in condominiums rather than free-standing residential buildings (59.91 percent of household units overall). The consortium that administers waste collection in all the municipalities aims at providing each household with one personal waste bin. However, when this is not possible (due to logistic reasons of collection or space), two or more households are given the same bin to be shared. More details about the environment and the collection system are reported in the appendix.

Our unit of reference is each household *i* in a given year *t*. The dataset contains such information as volume, number of emptyings (for waste bins), age, nationality, and number of household members (for households). Importantly, the dataset also informs on which households share the same bin and in which building they live. We then create a variable measuring the average volume of unsorted waste per day that can be attributed to a single household (*UW*). This is defined as the bin volume (*VOL*, in liters) times the household size (*SIZE*) and the number of bin emptyings (*EMPT*) in a year, and divided by the number of days (*DAYS*) of use by all the individuals in the *J* households sharing the same bin[5]:

$$UW_{i,t} = \frac{VOL_{i,t} \times EMPT_{i,t} \times SIZE_{i,t}}{\sum_{j=1}^{J} SIZE_{j,t} \times DAYS_{j,t}}$$

In particular notice that, if the bin is associated to more than one household ($J > 1$), the formula leaves room for free riding. This formula may seem a rough estimate of the average production of unsorted waste; however, it is coherent with the one municipalities apply to compute the fee. Everything else being equal, a lower level of *UW* indicates that the household accumulates less unsorted waste, because either it produces less waste overall, or it is efficient in waste sorting (i.e., it sorts a high proportion of waste for a given amount produced).

[5] Households may move, coming in an apartment (or leaving it) in any day of the year. The fee applied for the use of the waste management service is therefore adjusted for the number of days of effective use.

Our dataset comprises 18,389 observations on 6,969 households living in a condominium, with an average of 2.64 annual observations per household. This sample is obtained after ignoring observations with the 2.5% highest and the 2.5% lowest levels of *UW*, which look abnormal and might therefore bias our results; for instance, exceptionally low levels of *UW* may indicate that the apartment is rarely used. From the analysis we also exclude 182 observations with household heads outside the 20-80 age range, which may have peculiar consumption (and therefore waste) habits. Including them in the analysis, however, would not change our conclusions.

Table 1 reports summary statistics on our sample, overall and separately by number of users. It can be noticed that most of the observations (91.05%) regard households sharing the bin with nobody else, while 6.31% of the observations concern bins shared by two users (no anonymity) and the remaining 2.64% involve bins shared by three or more users (anonymity). Ideally, we would like to consider each number of bin users separately. However, the policy implemented by the municipalities makes it infrequent to observe the same number of users sharing a bin: for instance, we have only 77 observations on bins shared by three households, and 74 observations on bins shared by four households.

For this reason we consider four groups: one user per bin (no free riding), two users per bin (free riding without anonymity), three-six users (free riding with low degree of anonymity) and seven or more users (free riding with high degree of anonymity). We defined the last two groups in such a way to roughly have a similar number of observations, but different degrees of anonymity.[6]

[6] It may be that the number of bin users is larger than the number of households in the building. In fact, households may also share the bins with households living in a contiguous building.

TABLE 1. Average statistics

N. bin users	All	1 user	2 users	3-6 users	7+ users
Unsorted waste (liters per user per day)	2.147	2.049	1.782	6.566	6.147
Head age	38.645	38.828	36.253	38.214	37.851
Head foreign	0.213	0.201	0.331	0.354	0.377
Household moved to different location	0.017	0.008	0.137	0.026	0.033
N. household members	1.979	1.982	2.079	1.808	1.484
N. households in the building	5.638	5.567	6.046	4.033	11.033
N. bin users	1.248	1	2	4.439	12.488
Year	2006.614	2006.617	2006.695	2006.369	2006.326
Municipality 1: *Casier*	0.155	0.159	0.146	0.026	0.023
Municipality 2: *Paese*	0.202	0.201	0.200	0.358	0.056
Municipality 3: *Ponzano*	0.155	0.152	0.181	0.118	0.363
Municipality 4: *Preganziol*	0.201	0.209	0.170	0.033	0.000
Municipality 5: *Silea*	0.098	0.099	0.096	0.063	0.065
Municipality 6: *Villorba*	0.189	0.180	0.209	0.402	0.493
N. observations	18,389	16,742	1,161	271	215

3. Results

Table 2 reports the results of a regression analysis on the variable under investigation, using a pooled OLS model (Column 1), a panel random-effect model (RE, Column 2), and a panel fixed-effect model (FE, Column 3). In all the cases the dependent variable is the logarithm of *UW*. The specification includes dummy variables informing whether the household is sharing the bin with one or more other households, characteristics of the household (age and nationality of the head, household size, whether it moved from a different place during the year), number of other households in the building, and year. The three models provide similar findings with respect to our key variables (the number of users sharing the same bin). The statistical tests reported in the bottom part of Table 2 suggest that we should prefer the FE model of Column (3); this model is also more robust to wrong specification as it allows removing unobservable household-specific effects on waste behavior[7].

[7] As a robustness check, we replicated the same analysis where the dependent variable is now the logarithm of UW normalized by household size using different equivalence scales. The results, reported in the online appendix, are consistent with our benchmark findings.

TABLE 2. Free riding and anonymity

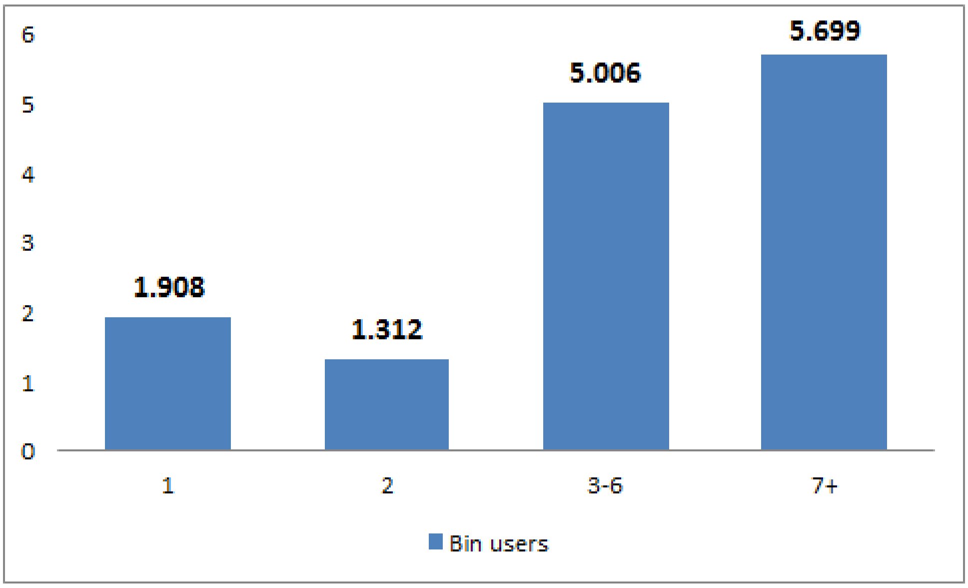
Method	(1) OLS	(2) RE	(3) FE
Bin shared by 2 users	-0.265***	-0.334***	-0.374***
	(0.022)	(0.019)	(0.022)
Bin shared by 3-6 users	1.181***	1.061***	0.965***
	(0.043)	(0.045)	(0.072)
Bin shared by 7 or more users	1.206***	1.177***	1.094***
	(0.049)	(0.051)	(0.081)
Age/10	-0.146***	-0.079**	0.634***
	(0.027)	(0.037)	(0.229)
$(Age/10)^2$	0.014***	0.007*	-0.082***
	(0.003)	(0.004)	(0.016)
Foreign	0.019	0.039**	
	(0.013)	(0.018)	
Household moved to different location	-0.038	-0.038	-0.060
	(0.041)	(0.035)	(0.044)
Ln(No. household members)	0.530***	0.453***	0.265***
	(0.010)	(0.013)	(0.024)
Ln(No. households in the building)	-0.024***	-0.040***	-0.076***
	(0.006)	(0.008)	(0.018)
Year 2006	-0.059***	-0.040***	-0.019
	(0.016)	(0.011)	(0.025)
Year 2007	-0.144***	-0.117***	-0.082*
	(0.015)	(0.012)	(0.043)
Year 2008	-0.176***	-0.148***	-0.103*
	(0.015)	(0.012)	(0.062)
Municipality: Casier	-0.093***	-0.095***	
	(0.017)	(0.025)	
Municipality: Ponzano	0.000	-0.002	
	(0.017)	(0.025)	
Municipality: Preganziol	-0.181***	-0.167***	
	(0.016)	(0.024)	
Municipality: Silea	-0.113***	-0.121***	
	(0.020)	(0.029)	
Municipality: Villorba	-0.033**	-0.026	
	(0.017)	(0.024)	
Constant	0.647***	0.543***	-0.681
	(0.060)	(0.080)	(0.742)
Observations	18,389	18,389	18,389
Number of users	6,969	6,969	6,969
R^2	0.201	0.198	0.103
R^2 within-group		0.072	0.079
Fraction of variance due to user effects		0.575	0.683
Test for random user effects		6,510.32	
(OLS vs. RE; chi-squared with 1 d.o.f.)		[0.000]	
Test for fixed user effects			31,634.72
(OLS vs. FE; chi-squared with 6,968 d.o.f.)			[0.000]
Test for random vs. fixed user effects			127.14
(RE vs.FE; chi-squared with 11 d.o.f.)			[0.000]

*Note: The dependent variable is the logarithm of the average unsorted waste (in liters per user per day). Standard errors in round brackets; p-values in square brackets; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.*

Our analysis shows that compared to bins with just one user, the production of waste falls when two users share a bin (-37.4%), while it rises when three or more users share the same bin (+96.5% with three-six users and +109.4% with seven or more users). The latest two effects are insignificantly different from each other according to an F test (statistic: 2.25; p-value: 0.13).

Figure 1 plots the average production of unsorted waste per day per household, predicted using the FE model, conditional on the number of users sharing the same bin and the average of the other explanatory variables. From the figure it is clear that the production of waste is relatively low when at most two users share the same bin, while it is larger when three or more users share the same bin.

FIGURE 1. Predictions of unsorted waste per user conditional on the number of bin users



Our results suggest that free riding is severe only when anonymity is possible (in groups of three or more users). The possibility of *peer monitoring* can not only mitigate free riding but also trigger a more virtuous behavior since such factors as *shame* or *fear of punishment* may induce even less motivated households, to increase their effort and attention in sorting. In groups of three or more users these factors are no longer relevant, since imperfect information prevents from detecting the actual behavior of each user. Interestingly, we observe that the free riding effect is identical in groups of different size whenever imperfect information is involved. Therefore, we argue that the key element for the emergence of free riding is anonymity.

One might argue that our finding that the production of waste falls when the bin is shared by two users is spurious and it depends on characteristics of the apartment that we do not observe. In fact, a potentially important omitted variable in our dataset is the apartment size. However, it is reasonable to assume that apartment size is highly correlated with household size that we observe and use as control variable in the analysis. We also think (as the consortium managing waste collection) that it is the number of people living in the house that should determine waste production. From Table 1 we know that the average number of household members is similar (and insignificantly different) in observations where the bin has one or two users (respectively 1.98 and 2.08). In contrast, the average number of household members is statistically smaller in observations with three-six bin users and especially with seven or more bin users (see again Table 1), which may suggest that users sharing the bin with more than one other user indeed live in smaller apartments. Since we find that more waste is produced in apartments where the bin is shared by three or more users, controlling for the fact that they are likely smaller we would find even larger free riding effects under anonymity than we do.

4. Conclusion

In this paper we investigate in the field if anonymity induces a free riding problem in social dilemmas. For this purpose we use a unique dataset on waste production at the household level and we estimate the net effect of free riding controlling for household, municipality and time characteristics. In particular, we test how anonymity affects free riding computing household production of waste when households share the same bin with one other user (where the author of misbehavior is indirectly observable) versus multiple users (where anonymity is higher and therefore misbehavior cannot be clearly identified).

We find that free riding is present only if multiple households share the same bin. On the contrary, when only two households share the same bin, average household waste production decreases. In other words, when each agent can (indirectly) observe the behavior of the other the free riding problem disappears and, actually, the effort and attention in sorting increases. Thus, we can conclude that peer monitoring can promote a more virtuous behavior even if we cannot distinguish between alternative explanations (shame or the fear of future punishment). This will be the objective of our future research.

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APPENDIX

A. Waste Collection

Some municipalities in the district of Treviso (Italy) are implementing a per-unit billing system for the management of municipal solid waste. Households pay, once every year, a fee according to a formula made of two parts: a fixed part – equal to everybody and proportional to the number of household members – and a variable part proportional to the number and the size of the bins for unsorted waste that are presented for emptying. The purpose of this monetary incentive is to limit the accumulation of unsorted waste.

In general, each household is endowed with its own bins. Waste collection follows a regular schedule; households willing to get rid of their waste, just place the bins out of their door in the scheduled days of the week. A transponder in the bin keeps track of all the emptyings attributed to a given household. The only exceptions are cases where two or more households share the same bin, which frequently arise in the context of condominiums for practical reasons. Also here, the common bin is placed out of the building for collection every time it is full. However, since it is not possible to identify the contribution of each household to the production of waste, the fee is determined by dividing the total cost of emptyings between the households sharing the bin, in a way proportional to their size. This imputation gives rise to a potential free riding problem, in that households might have a lower incentive to reduce the accumulation of waste, because their monetary penalty would then be split with one or more other households.

B. Robustness Checks

We replicate the benchmark analysis shown in Table 2, correcting the *UW* measure by the household size through equivalence scales. In general, there is no accepted method for determining equivalence scales, and for this purpose we use three alternatives: two OECD equivalence scales for consumption (modified and square root), as well as a scale derived from our data.

Regarding the OECD modified scale, we cannot measure it exactly because we do not have information on how many adults and children are present in the households. For this reason, we give to each member in addition to the head a weight of 0.5 – which corresponds to the weight of an adult in the OECD modified scale, and to the weight of a child in the old OECD scale (a.k.a. Oxford scale).

Due to this complication, in addition to the modified OECD equivalence scale we also consider the squared root OECD equivalence scale, and a “data-driven” equivalence scale that we construct on our own from the data. We derive this scale from the regression of the logarithm of the number of liters per user over dummy variables on household composition (2, 3, 4 or more members), plus age, age squared, foreign nationality, year and municipality dummies as control variables. The regression focuses only on those who do not share the bin with other users (16,742 observations) to neutralize potential free riding effects. The scale based on this regression gives a weight of 1.15 to a household made of two members, a weight of 1.32 to a household made of three members, and a weight of 1.36 to a household made of four or more members.

Appendix Table A1 reports the estimates of the coefficients in the fixed-effect regression model using the three definitions of equivalence scale. Our results remain virtually unchanged. In particular, we keep predicting a reduction of the production of unsorted waste in the case of two users, and a generalized increase in the case of three or more users – disregarding the actual number of users.

TABLE A1. Free riding and anonymity: equivalence scale correction

Equivalence scale	(1) Modified	(2) Squared-root	(3) Data-driven
Bin shared by 2 users	-0.374***	-0.374***	-0.375***
	(0.022)	(0.022)	(0.022)
Bin shared by 3-6 users	0.962***	0.965***	0.964***
	(0.072)	(0.072)	(0.072)
Bin shared by 7 or more users	1.097***	1.094***	1.093***
	(0.081)	(0.081)	(0.081)
Age/10	0.615***	0.634***	0.614***
	(0.229)	(0.229)	(0.229)
$(Age/10)^2$	-0.081***	-0.082***	-0.081***
	(0.016)	(0.016)	(0.016)
Household moved to different location	-0.058	-0.060	-0.062
	(0.044)	(0.044)	(0.043)
Ln(No. household members)	-0.383***	-0.235***	0.041*
	(0.024)	(0.024)	(0.024)
Ln(No. households in the building)	-0.076***	-0.076***	-0.076***
	(0.018)	(0.018)	(0.018)
Year 2006	-0.019	-0.019	-0.019
	(0.025)	(0.025)	(0.025)
Year 2007	-0.082*	-0.082*	-0.081*
	(0.043)	(0.043)	(0.043)
Year 2008	-0.104*	-0.103*	-0.102
	(0.062)	(0.062)	(0.062)
Constant	-0.619	-0.681	-0.624
	(0.741)	(0.742)	(0.741)
Observations	18,389	18,389	18,389
Number of users	6,969	6,969	6,969
R^2 within-group	0.107	0.090	0.075

*Note: The dependent variable is the logarithm of the average unsorted waste (in liters per user per day), corrected using a different equivalence scale in each column. Estimates are obtained with a fixed-effect regression model. Standard errors in round brackets; p-values in square brackets; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.*