Adding a Carrot to the Stick? A Field Experiment on the Use of Lotteries Against Free-Riding*

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Abstract

This paper presents a field experiment testing the possibility to use lotteries to combat free-riding in the context of local public transportation. We organize a lottery whose participation is linked to purchasing an on-board bus travel ticket. The lottery is then implemented in half of the buses operating in a medium size Italian city. We exploit the random buses allocation to a specific timetable and route to isolate the effect of the lottery introduction on the number of tickets bought. Results show that the lottery introduction significantly reduces free-riding and that the increase in revenue from tickets sold more than compensate the lottery cost.

1 Introduction

Legal systems consist of norms that are legally enforced. Enforcement could happen through "sticks", like fines, damages and imprisonment, or through "carrots", like bonus and rewards. Enforcement systems traditionally rely on sticks and most of the literature on the topic focus on optimal deterrence and efficient punishment (Becker, 1968, Polinsky and Shavell, 2000). According to law and economics scholarship, sticks are usually preferred to carrots because of their comparative efficiency Drezner (1999), Dari-Mattiacci and De Geest (2009). Indeed, although both enforcement tools are costly to use, the (costless) threat to punish can be repeated several times without having to use punishment resources when parties comply. The same is not possible with carrots, since every time a party complies the cost of rewarding her has to be borne.

Despite the efficiency argument in favor of sticks, modern legal systems are characterized by an increasing use of carrots to achieve compliance (De Geest and Dari-Mattiacci, 2013). Scholars point out this tendency in fields such as criminal law (Corman and Mocan, 2005, Polinsky, 2015), patent and copyright law (Gordon, 1992, Kesan, 2002), tax evasion (Fabbri and Hemels, 2013, Riggall, 2006), environmental protection (Chang, 1997, Zhang and Flick, 2001) and public health (Rothschild, 1999).

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Several reasons has been suggested for explaining the rise of rewards and bonuses over punishments. First, the complexity of modern societies makes increasingly difficult for the lawmaker to understand the effort required from an individual to comply (De Geest and Dari-Mattiacci, 2013). For instance, families could have different costs when an household has to join the army or lawmakers may not know who has the capabilities to spend time developing new software. Hence, when compliance costs are highly heterogeneous among agents and difficult to estimate, using sticks may artificially increase inequality and generate unjust punishment. Moreover, studies in psychology and behavioral economics show that in many situations a mix of rewards and punishments is the efficient solution to achieve compliance (Andreoni et al., 2003, Falkinger and Walther, 1991, Fehr and Schmidt, 2007). Finally, even in situations where carrots are a less efficient policy choice, politicians and lawmakers often opt for rewards and bonuses since these enforcement tools are positively perceived by voters (Galle, 2012).

Given the increasing use of carrots as enforcement tools in substitution or together with traditional sticks, it seems of paramount importance to design efficient reward systems and to test empirically their effectiveness. In this paper, we report results of a field experiment that tests the possibility to add a reward mechanism to the traditional enforcement based on sanctions in order to reduce free-riding in public transportations. In Europe, local public transportation systems are mostly available for all to use such that anyone can board and each is expected to voluntarily pay the fare. Free riders caught not paying are subject to penalty. The system works very imperfectly: free-riding is widespread, revenue is reduced, and more of the cost of the facility is financed by taxpayers.

In our experiment, we reward individuals' compliance, namely the purchasing of a valid travel ticket on a public transport, with lottery tickets. Abundant theoretical and empirical contributions underline the effectiveness of lotteries in steering agents' behavior (Clotfelter and Cook, 1991, McCaffrey, 1994, Morgan, 2000). Indeed, lotteries are widely used by private companies to increase customers' brand loyalty and increasing revenues as well as from governments and other organizations as a fund-raising tool see for example (Thaler and Ziemba, 1988). Moreover, in recent years some countries implemented policies based on lotteries in order to fight tax evasion, achieving noteworthy results (Fabbri, 2015, Naritomi, 2013, Wan, 2010). However, the implementation of lottery policies by the public sector as an instrument to achieve compliance remains rare and few contributions were able to test the effectiveness of lottery-based policies in the field. To our best knowledge, no field study investigated the implementation of lottery policies to reduce free-riding in public transportation.

The experiment took place in a medium-size Italian municipality. In collaboration with the public company that manages local public transportation, we designed a lottery whose participation is linked to the on-board purchase and of bus travel tickets. Our theoretical model predicts that, when such a lottery is implemented, the increase in revenue from tickets sold will more than compensate the cost of the lottery prizes. As explained in detail below, we implemented the lottery only for a subset of the buses operating in the area served by the bus company. We then took advantage of the randomization process that allocates buses to a specific route and timetable in order to isolate the effect of the lottery on tickets' sales. Hence, the design of our experiment allows a clean comparison between a sample of buses taking part in the lottery and a control group of buses excluded from participation.

Results could be summarized as follow. First, during the experimental period, buses that implemented the lottery sold a number of tickets significantly higher than buses not implementing the lottery. The increase in revenue from ticket sold caused by the lottery introduction more than compensate the cost of the lottery prizes. Second, during the experimental period the total number of tickets sold by the bus company is significantly lower than in the pre- and post- experimental period. Albeit data from previous years suggest that the decreasing in tickets sold might be due to seasonality, our data does not allow ruling out that the reduction in the number of tickets sold is caused by crowding-out of intrinsic motivation to pay the ticket fare.

2 Experimental Design

The experiment was implemented in the city of Rimini, Italy, in cooperation with Start Romagna s.p.a., the public-owned company providing local bus transportation, and Agenzia Mobilità, the local agency in charge of coordinating public transportation services in the Rimini province. The bus company has a total 158 buses operating in the urban area of Rimini, all of them identical except for an identifying unique serial number. When boarding a bus, passengers are supposed to have a ticket. A standard hourly ticket can be purchased off-board, for a price of €1.20. Alternatively, it can be purchased on-board, with an extra charge of €0.80, using an automatic machine installed in each of the buses. In an attempt to limit opportunistic behaviors, ticket inspectors randomly monitor travelers and sanction free riders. However, despite this enforcement activity, a consistent fraction of travelers continues to free ride when using public bus transportation[1].

A key characteristic for the implementation of our experiment is the process characterizing the allocation of each bus to a specific route and timetable. Indeed, this allocation is perfectly random and therefore impossible to foresee until few minutes in advance even for the company employees. Consequently, each one of the 158 buses has in principle the same likelihood to serve a specific route and time in any given day.

Our experiment targeted travelers that are entering a bus without an off-board purchased ticket and that faced the choice either to buy an on-board ticket through the automatic machines or to act as free-rides. We advised START Romagna during the organization of a lottery whose participation was linked to the purchase of on-board travel tickets. From the entire sample of buses operating in Rimini we randomly selected a subsample of 50 buses participating to the lottery ("treated sample" onward). Inside each of these 50 buses, posters and fliers were affixed to inform customers that the bus was participating to the lottery. In order to rule out travelers' self-selection, we designed and located posters and fliers with the objective to make

[1]An alternative strategy to prevent free-riding adopted in some countries consists in admitting on-board only travelers with a regular ticket or that purchase the ticket directly from the driver. This solution has been attempted for a period in Rimini as well as in other Italian cities. However, it was quickly abandoned due to its associated costs: the queue of passengers wanting to purchase tickets on-board created continuous delays and the long buses stops inside the medieval structure of narrow streets characterizing most of the Italian cities tilted the entire city traffic.

impossible noticing them before being on-board. Therefore, for travelers waiting to enter a bus the treated sample was indistinguishable from the remaining buses ("control sample" onward).

The lottery assigned six prizes of Euro 500 each[2] among the tickets sold on-board of the treated sample during the period November 15^{th} - December 15^{th} 2014. Specifically, there has been three extractions relative to periods of different length, each one assigning two prizes: the first two prizes were assigned to ticket sold during the period November 15^{th} - 21^{st}, the second couple of prizes to ticket sold between November 22^{nd} and December 1^{st}, the remaining two prizes to tickets sold during December 2^{nd} - 15^{th}. To identify the lottery winners, we exploited the fact that a serial number uniquely identifies each ticket purchased on-board. In the days immediately after each of the three lottery periods, two serial numbers were drawn from the list of all the on-board tickets sold in the treated sample. The person possessing the ticket having the correspondent serial number printed on it was entitled to claim the prize. During the 31 days of the experimental period a total of 7653 on-board tickets were sold in the city of Rimini.

Before proceeding, we would like to highlight an important feature of our design. In order to rule out possible demand effects, we wished the population to perceive the lottery as a "marketing strategy" implemented by the bus company to reward compliant customers rather than an experiment run for scientific purposes. Therefore, during the lottery promotional campaign and in the content of the informative posters and flyers we carefully avoided to mention the scientific nature of the research.

3 Theoretical Predictions

Suppose that the economy consist of a set of $N = (1, 2, ..., n)$ consumers, which for simplicity is normalized to unity, with quasi-linear utility

$$U_i = y_i + h_i(G) \tag{1}$$

where y_i is a numeraire good denoting the current level of income/wealth of consumer i, and $G \in \mathbb{R}$ denotes the level of public good provided. To conserve the concavity of the utility function we will assume that consumers experience diminishing marginal utility from the fruition of the public good i.e. $h_i'(.) > 0$ and $h_i''(.) < 0$, $\forall i$. Personal wealth can be used as a direct source of consumption or can be exchanged on a one-for-one basis for some level of the public good G.

A benevolent planner will try to maximise aggregate surplus in the economy by choosing total wealth in the economy that should be transformed into the public good. Therefore a social planner chooses $G \leq \sum_{i=1}^{n} y_i$ to maximise

$$W = \sum_{i=1}^{n} (y_i + h_i(G)) - G \tag{2}$$

[2] Italian regulation forbids to assign monetary prize as a lottery compensation, therefore we opted for a voucher of the equivalent amount that could be used in a well-known food chain store.

The optimal amount of public good provided, $G^* > 0$ solves

$$\sum_{i=1}^{n} h_i'(G^*) = 1 \tag{3}$$

such that marginal benefit from an additional units of the public good has to be equal to its marginal cost. Any positive level of public good at the equilibrium is said to be socially desirable. However if

$$\sum_{i=1}^{n} h_i'(0) < 1 \tag{4}$$

then it is not optimal to provide any positive level of public good so the public good is said to be socially undesirable.

Assume, that the public good is provided by a local transportation authority, exclusively in the form of public transportation, by means of the contributions of its consumers. For simplicity we will assume that individuals are homogenous in the amount of public good consumed, or in our case bus travels, which is given by t and is normalized to one so that total travel are equal to $T = \sum_{i=1}^{n} t = N$ which is also the number of total consumers. Consumers differ in the amount of contribution that they provide for every travel, which is denoted by $x_i \in [0, 1]$, with $X = \sum_{i=1}^{n} x_i$ being the total contributions of all consumers buying a regular travel ticket. If total contributions and total number of travels coincide (i.e. $x_i = t$) we would have $G = N$, however since not every consumer is assumed to perfectly contribute we have $G = X$. Due to this imperfect contribution every consumers face a positive probability of being fined, $p = (1-x_i)/(N-X)$, which is decreasing in their contributing effort (x_i) and decreasing in the number of non contributing consumers $(N - X)$[3] . Given the contributions of all other consumers, i chooses x_i to maximises

$$U_i = y_i - x_i + h_i(X) - \frac{1 - x_i}{N - X} F \tag{5}$$

To show that the introduction of a lottery related to how much consumers contribute is able to increase overall contributions and the level of public good we will show that aggregate contributions after the introduction

[3]To justify why $p(.)$ is decreasing in the total number of free riders we assume that: T represents the total working time of a fare collector; c and s are the time for a normal control to a contributing agent and a sanction to a free-rider respectively (with $s > c$); N is the total number of passengers with f being the free-riders percentage ($N_F = f \cdot N$)); C is the overall number of controls and $S = f \cdot C$ the total number of sanction. Thus, the time budget constraint of the fare collector is

$$T = C \cdot c + S \cdot s = C(c + s \cdot f)$$

from which the total number of controls is given by

$$C = \frac{T}{(c + s \cdot f)}$$

and the probability of being controlled (or sanctioned for a free-rider) is

$$(1 - x_i)\frac{C}{N} = (1 - x_i)\frac{S}{N_F} = (1 - x_i)\frac{T}{N(C + s \cdot f)} = p(x_i, N_F)$$

which is decreasing in the number of free riders and in the individual's contribution (i.e. x_i).

of the lottery increase in two different cases: (1) without the fine (i.e. $F = 0$) and (2) with the fine. This will allow us to prove that the introduction of the lottery is able to increase contributions and decrease free-riding not only by itself but also coupled with another incentivating mechanism (e.g. punishment).

To model the case where the fine is absent we will assume that $F = 0$ in equation (5) in order to have

$$U_i = y_i - x_i + h_i(X) \tag{6}$$

A Nash equilibrium to this voluntary game is represented by the set of N contribution amounts $(x_1^V, x_2^V, ..., x_N^V)$, such that the equilibrium level of public good is given by $G^V = X^V$.[4] For quasi-linear utility this equilibrium entails an under provision of the public good with respect to the socially desirable first best of equation (3) (See Bergstrom et al. (1986), Morgan (2000)). This is due to the fact that contributors do not internalize the benefit that their single contribution will do to everyone else, thus under-contributing relative to the social optimum. In our framework a consumer is under-contributing to the public good by not buying a regular travel ticket, creating a negative externality to the other consumers related to: (1) monitoring costs and (2) service lower than optimal.

Assume that, in order to reduce free-riding and under provision, the local transportation authority chooses a prize, R that has to be awarded to a contributing consumer. This prize is equal for every consumer and of known value. The $i - th$ probability of being awarded the price is given by

$$q(x_i, x_{-i}) = \frac{x_i}{X}$$

Since the local transportation has to finance this prize, the public good provision is now given by $G = X - R$. The (expected) utility function of the $i - th$, contributing, consumer is now

$$EU_i = y_i - x_i + h_i(X - R) + \frac{x_i}{X} R \tag{7}$$

For simplicity we will make the following assumptions regarding equation (7)

Assumption 1. *EU_i is*

1. *Twice continuously differentiable and concave in x_i*

2. $$\left.\frac{\partial EU_i}{\partial x_i}\right|_{x_i=0, x_J=y_j} > 0 \qquad \left.\frac{\partial EU_i}{\partial x_i}\right|_{x_i=y_i} < 0$$

The first assumption allows us to characterize the equilibrium by means of first order condition while the second ensures that such solution is interior.

[4]Where V stands for voluntary contribution

Differentiating (7) with respect to x_i yields the following FOC, for an internal solution

$$\frac{X_{-i}}{X^2}R - 1 + h_i'(X - R) = 0 \tag{8}$$

where X_{-i} is the total contribution of all consumers excluding i. Equation (8) can be rearranged as follows

$$h_i'(X - R) + \frac{X_{-i}}{X^2}R = 1 \tag{9}$$

from which marginal benefits from an increase in x_i has to be equal to its marginal costs. The two terms on the LHS of equation (9) represents the marginal benefit from an increases in x_i and are respectively the marginal utility effect and the increase in the probability of winning the price R; while the term on the RHS represents the marginal cost of increasing x_i.

Proposition 3.1. *The introduction of the lottery increases the level of public good, reduces free-riding and increases individual's contributions.*

Proof. Assuming that X^V is the equilibrium level of contributions to the public good solving the problem under $R = 0$ if we sum (8) over the total number of contributing consumers (i.e. n^V) we have

$$\sum_{i=1}^{n^V} h_i'(X^V - R) - n^V + (n^V - 1)\frac{R}{X^V} = 0 \tag{10}$$

Assume, without any loss of generality, that the number of contributors stay fixed or increase. Under this circumstances it is easy to show that the level of public good under (10) is increasing in the amount of price and thus choosing any $R > 0$ would result in increased contributions and a higher level of public good. To do so let's sum equation (8) over the first m contributing consumers

$$\sum_{i=1}^{m} h_i'(X^m - R) - m + (m - 1)\frac{R}{X^m} = 0 \tag{11}$$

where X^m is represents the total level of contributions of the first m consumers

Differentiating with respect to R

$$\sum_{i=1}^{m} h_i''(X^m - R)\frac{\partial X^m}{\partial R} - \sum_{i=1}^{m} h_i'(X^m - R) + \frac{(m-1)}{X^m} - \frac{\partial X^m}{\partial R}\frac{(m-1)}{(X^m)^2}R = 0$$

If we rearrange it we arrive at an expression for $\partial X^m / \partial R$

$$\frac{\partial X^m}{\partial R} = \frac{-\sum_{i=1}^{m} \cdot h_i''(X^m - R) + (m-1)(1/X^m)}{-\sum_{i=1}^{m} h_i''(X^m - R) + (m-1)(1/X^m)(R/(X^m)} \geq 1$$

where the inequality holds since $R/X^m < 1$, making the numerator greater than the denominator. Recall that

$$\frac{\partial G^m}{\partial R} = \frac{\partial (X^m - R)}{\partial R} = \frac{\partial X^m}{\partial R} - 1 \geq 0$$

Therefore the amount of public good provided is higher and increasing in R. Moreover since the number of contributors is kept constant but the level of public good is higher this means that average contributions have to be higher. ■

Proposition 3.1 shows the positive effect that the introduction of the lottery has on the equilibrium level of public good, in the case where the fine is absent. By means of a lottery, awarding the contributing consumers, the local transportation authority is able to self-finance the reward R by means of an increased level of public good due to higher contributions. Intuitively the introduction of the prize induces individuals to contribute more not because they have internalized the positive externality that their contribution has on the overall provision of the public good, but because the introduction of the prize creates a negative externality which compensates for this positive free-riding externality. In fact, when a consumer purchases more tickets, or goes from being a free-rider to a regular contributor, he reduces the chances of winning for all other consumers, creating a negative externality.

Now we turn to the case in which individuals face a positive probability of being fined if their contributions differ from the level of public good's consumption. In order to show that, after the introduction of the lottery, there is a decrease in the number of free-riders which do not contributes at all to G, let's compare the utility of a (partial) contributing agent (equation 7) with the one of a free-rider with $x_i = 0$.

$$EU_i^C = y_i - x_i + h_i(G) + \frac{x_i}{X}R \tag{12a}$$

$$EU_i^{NC} = y_i + g_i(G) - \frac{1}{N - X}F \tag{12b}$$

where C stands for contributing and NC for non contributing (i.e. free riders).

Equation (12a) is the expected utility for a contributing agent and it is identical to equation (5) with the introduction of the fine; while equation (12b) is the expected utility for a free-rider agent which is not contributing to the public good (i.e. $x_i = 0$), facing a given probability of being fined which is the inverse of the total number of non-contributing agents in the economy $(N - X)$.

Intuitively if $\partial U^C/\partial x_i \geq \partial U^{NC}/\partial x_i$, the marginal utility of additional wealth devoted to the public good is greater than an additional effort in free-riding. This condition results in the following threshold level an incentivating fine for free riders[5]

$$\bar{F^L} = \frac{1}{p_{x_i}}\left[(1 - h'(G)) - \frac{X_{-i}}{X}\frac{R}{R+G}\right] \tag{13}$$

Equation (14) shows that any value of the fine greater than $\bar{F^L}$ will provide an incentive to the free-riders to

[5] With $p_{x_i} = \dfrac{\partial (1 - x_i)/(N - X)}{\partial x_i}$.

start to contribute. From equation (14) we notice that $\bar{F^L}$ is decreasing in the level of the prize, in fact

$$\frac{\partial \bar{F^L}}{\partial R} = -\frac{1}{(R+G)^2}\frac{X_{-i}}{X} < 0$$

resulting in the following proposition.

Proposition 3.2. *The introduction of the lottery decreases the number of free-riders.*

Proof. If we compare $\bar{F^L}$ with the voluntary contribution optimal level of the fine (i.e. the case when $R = 0$)

$$\bar{F^V} = \frac{1}{p_{x_i}}(1 - h'(G)) \tag{14}$$

we notice that $\bar{F^V} > \bar{F^L}$, from which is easy to see that the introduction of the lottery decreases the threshold at which a free-rider is willing to start to contribute, which implicitly increases the number of free-riders which decide to start contributing. ■

In conclusion, the introduction of a lottery, related to the fruition of the public good, is not only able to increase contributions from currently contributing agents (see Proposition 3.1) but is also able to induce free-riders to start to contribute (see Proposition 3.2).

4 Results

As a first step, we want to verify that there are no systematic differences in buses belonging to control and treated groups except for the introduction of the lottery during the experimental period. If the partition of buses between treated and control group effectively follows a random process, we expect to find no significant difference in the average number of tickets purchased on-board in the periods before or after the experiment. Figure 1 plots the average daily number of tickets sold per bus in control and treated groups during the experimental period and in the months before and after the experiment. Results from a t-test for the comparison of means show that, both in the pre- and in the post- experimental periods, tickets sold are on average the same in the two groups (p-value 0.43 and 0.31 for the pre-experimental and the post-experimental periods respectively). However, if we focus on the period when the lottery is implemented, we can see that each bus belonging to the treated group sells on average roughly 1.1 tickets more per day than buses belonging to the control group. A test for comparison of means confirms that this difference is statistically significant at the 1% level (p-value 0.005, t-test two side).

We continue by estimating the effect of the lottery through a random-effects model, which exploits the panel structure of our data-set, in which each bus is observed for 92 days. We consider the period October 15^{th} 2014 - January 15^{th} 2015 (the lottery period +/- one month). We cluster standard errors at the bus level, allowing therefore the error terms to be serially correlated within bus. Table 1 reports the results. In model 1, the dependent variable is the number of tickets sold per day by each bus. We regress it on the dummy

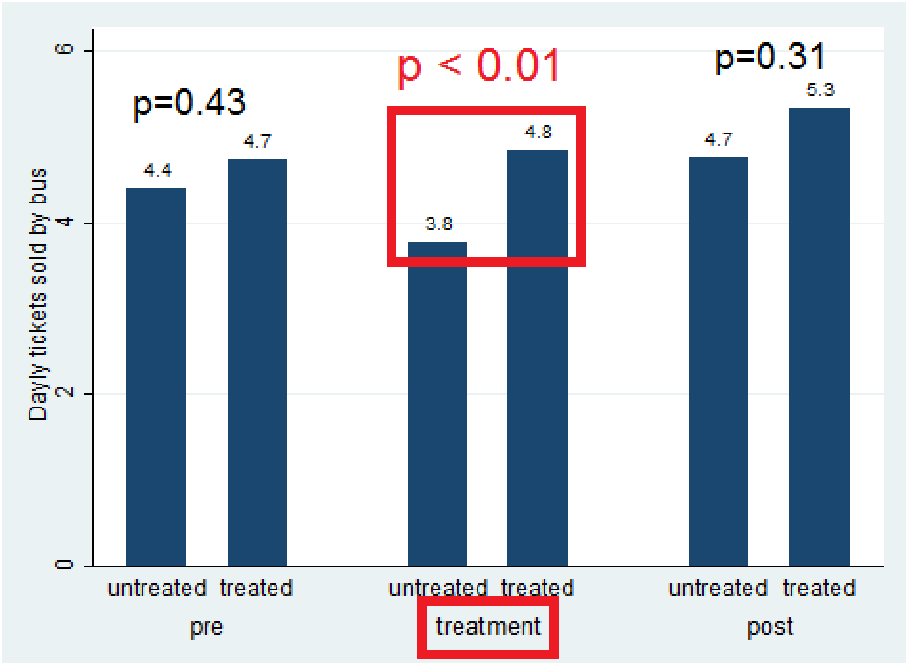

Figure 1: Average daily sales per bus, lottery period and month previous and following.

variable *Treated* equal to 1 for the treated buses, the variable *phase* that takes value 0, 1 or 2 respectively for pre-treatment, treatment and post-treatment period, the variable *day_of_week* where Monday=1 and controls for daily temperature and rain fall. The coefficient of the interaction between *Treatment*phase* for buses belonging to the treated group during the lottery period is positive and statistically significant, suggesting that the introduction of the lottery increases the number of on-board tickets purchased by travelers[6].

We continue the analysis investigating how travelers react to the provision of lotteries incentives. Recall that we run three lotteries of different length (7, 10 and 14 days respectively) where prizes are kept constant. We perform the same estimation as above introducing the variable *extraction* that takes value 1 for the period of the 7-day lottery, 2 for the 10-day lottery, 3 for the 14-day lottery and 0 otherwise. Model 2 of table 1 reports the results.

From the coefficient of the interaction terms between *Treated* and and *extraction*, we see that the 7-day lottery has an impact positive and statistically significant at the 1% level on the number of on-board tickets sold. The effect of the other two lotteries remains positive but becomes only weakly statistically significant and the effect is roughly halved if compared to the 7-day lottery.

[6]As we mentioned above, on-board tickets are €0.80 more costly than regular tickets purchased off-board. The Italian government offers a wide array of gambling products characterized by a higher expected return and smaller transaction costs for collecting eventual prizes compared to the bus lottery. Therefore, given the availability of these alternative gambling opportunities, we consider unlikely that travelers substitute off-board tickets with on-board ones because the lottery is in place. Nonetheless, in order to exclude this possibility, we are in the process of collecting data also regarding the number of off-board ticket purchased and validated during the period of analysis.

Table 1: Daily On-board Tickets Sold per Bus

	model (1)		model (2)	
1.Treated x 1.phase	0.575**	(0.28)		
1.Treated x 2.phase	-0.310	(0.29)		
1.phase	-1.265***	(0.27)		
2.phase	-0.521	(0.43)		
1.Treated	0.372	(0.34)	0.220	(0.31)
1.Treated x 1.extraction			1.235***	(0.43)
1.Treated x 2.extraction			0.612*	(0.36)
1.Treated x 3.extraction			0.561*	(0.32)
1.extraction			-1.129***	(0.29)
2.extraction			-1.070***	(0.24)
3.extraction			-0.869***	(0.21)
N	5547		5547	

Notes: Random-effects GLS regression: dep. var. *Records*, SE clustered at bus level. Significance levels: * p<0.10, ** p<0.05, *** p<0.01. Other controls include: constant, day, day-of-week, daily mean temperature, daily rain fall.

Finally, we can verify if the increase in revenue generated by the lottery introduction is able to compensate the cost of the lottery prizes. A quick calculation shows that the lottery introduction determined an average daily increase of 1.1 ticket sold in each of the 50 buses in the treated sample and therefore generates a revenue increase of roughly €3400, that more than compensate the Euro 3000 paid out as lottery prizes. Therefore, we can summarize our first set of results as follow:

Result 1 *During the months preceding and following the lottery period, buses in the treated and control groups sell an equal amount of on-board tickets. The introduction of the lottery determines a significant increase in the number of tickets sold in the treated group compared to the control group. The cost of the lottery prizes is more than compensate by the consequent revenue increase. Finally, for a given prize amount, the shorter the lottery period (i.e. the higher the probability to win the prize) the higher is the impact of the lottery introduction on the number of tickets sold.*

We proceed with the analysis by verifying if the implementation of the lottery has a more general effect on the propensity of travelers to purchase on-board tickets. It is well-known that the introduction of a monetary compensation for complying with an obligation (in our framework, contributing to a public good) may crowd-out intrinsic motivation (Andreoni, 1993, Bohnet et al., 2001). As a consequence, some agents that would voluntarily comply with the obligation of purchasing a travel ticket may revise their behavior once the lottery is implemented.

We investigate this possibility by focusing on the total number of tickets in control and treated groups during the lottery period and the preceding/following months. Figure 3 reports average daily on-board ticket sales per bus relative to these three periods. The period when the lottery is implemented registers a decrease in tickets sold if compared to pre and post periods. A test for the comparison of means indicates that, during the lottery period, the drop in the number of tickets sold is statistically significant at the 1% level (t-test

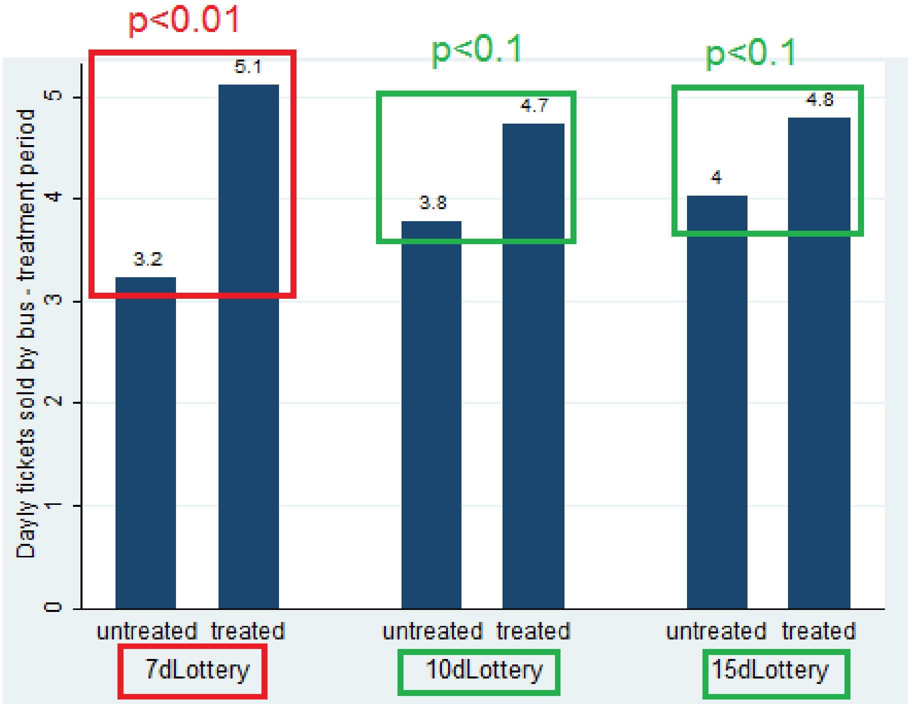

Figure 2: Lottery month, average daily sales per bus, by lottery length.

two sided). Also, from the coefficients of the variable *1.phase* in table 1 we see that, even controlling for mean temperature, rain fall and day of the week sales, during the lottery month the total number of on-board tickets sold is statistically significant lower at 1% level with respect to both the previous and following month.

In order to shed light on this phenomenon, we compared data for treated and control groups in the lottery period plus and minus one month with data coming from the same period of the year but one year before the lottery took place. Figure 4 reports the overtime evolution of on-board tickets sold during the lottery period and adjacent months and in the same time span one year before. The period November 15^{th} - December 15^{th} registers in both cases a lower number of tickets sold if compared to the preceding and following months. Moreover, during this period the average number of on-board tickets sold is statistically the same in the two years (4.1 in year 2013 vs. 4.30 in year 2014, t-test two side p-value 0.86).

Instead, if we consider treated and control groups separately in the two years, we find some differences. Specifically, in the year preceding the lottery implementation, control buses sold more tickets than control buses in the lottery year (4.28 vs. 3.76), however the difference is not statistically significant (p-value 0.19, t-test two side). Instead, in the year before the lottery implementation treated buses sold significantly less tickets than treated buses in the lottery year (4.23 vs. 4.84) and the difference is weakly statistically significant (p-value 0.08).

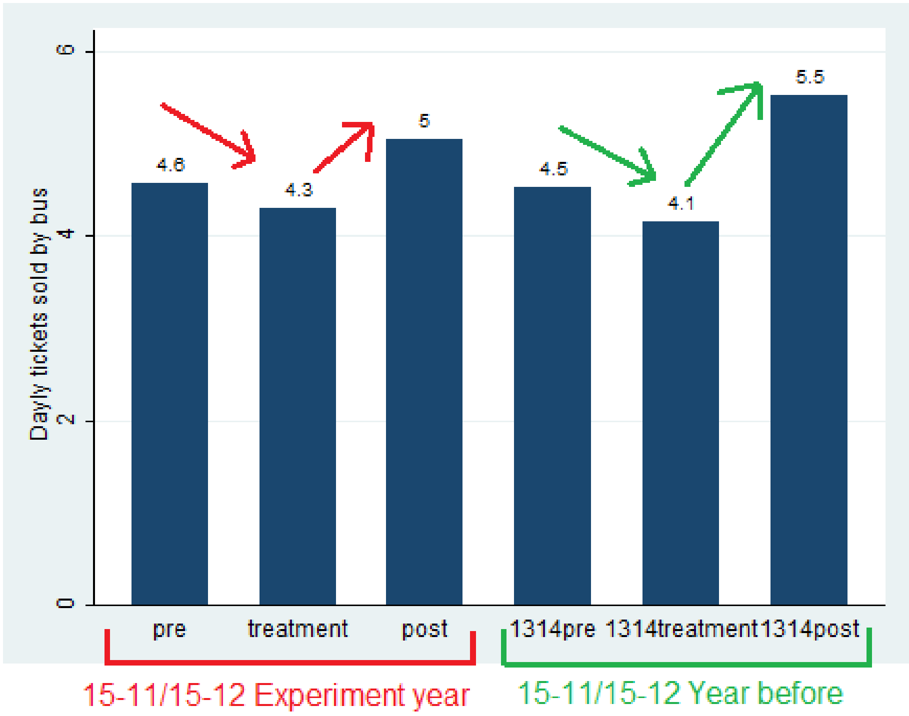

Figure 3: Average daily on-board tickets sold per bus, 10/15/2013 - 1/15/2014 and 10/15/2014 - 1/15/2015, by treatment, months before and following.

Therefore, while we observe a similar and statistically significant momentary drop in the number of tickets sold during the period 15^{th} - December 15^{th} both during the lottery year and in the year before, nevertheless our data do not allow us to exclude that the implementation of the lottery crowded-out a fraction of voluntary compliant agents. At the present moment, we are trying to obtain the data that would make possible to analyze this issue.

In conclusion, we can summarize the second set of results as follow:

Result 2 *During the month when the lottery is implemented we register a significant decrease in the total number of on-board tickets sold with respect to the previous and following months. An analysis of the corresponding three months of the year before the lottery shows a similar cyclical pattern. However, given our data, we are for the moment unable to assess if the reduction in on-board tickets sold is determined by cyclical fluctuations or if the lottery implementation generated among passengers a crowding-out effect of voluntary compliance.*

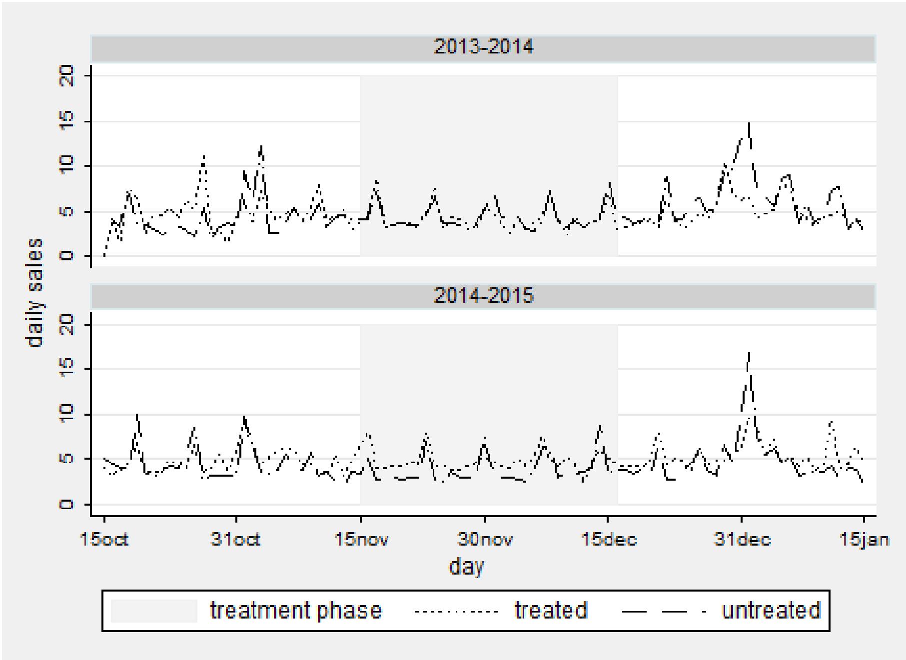

Figure 4: Average daily on-board tickets sold per bus, 10/15/2013 - 1/15/2014 and 10/15/2014 - 1/15/2015.

5 Conclusion

In this paper, we test the possibility to use lotteries in order to combat free-riding in the context of local public transportation. We set up a field experiment in collaboration with a public-owned transportation company in a medium size Italian municipality. We organized a lottery whose participation was connected to purchasing an on-board bus travel ticket. We created two samples of treated and control buses by implementing the lottery only in the former. Inside treated buses, posters and flyers were informing passengers of the possibility to participate in the lottery. We repeated the lottery three times, keeping the prize constant while varying the lottery length (7, 10 and 14 days). The random sorting of buses to specific timetables and routes in the city allows us to isolate the causal effect of the lottery introduction on tickets sold.

Our theoretical model predicts that the lottery introduction generates an increase in the number of tickets sold and that the consequent increase in revenue more than compensate the cost of the lottery prizes. Results confirm the model hypothesis. During the experimental period, passengers in treated buses purchase a number of ticket statistically higher (p-value ¡.01). The difference is observed in all the three lotteries, albeit in the 7 days one it is statistically significant at 1% level while in the other two lotteries it is only weakly significant. Furthermore, data show that during the experimental period the total number of tickets sold decreases in compared to the preceding and following months. While data on the year before our experiment took place show the same pattern, therefore suggesting that the reduction is caused by a seasonal fluctuation, we cannot exclude that the lottery crowds-out voluntary payments of the travel fare.

In recent years, law and economics scholar investigated extensively enforcement methods of legal norms alternative to punishment and sanctions (Grabosky, 1995, Sefton et al., 2007, Vedung et al., 1998). However, most of the contributions have been either theoretical (De Geest and Dari-Mattiacci, 2013, Frey, 2004) or focused on experimental laboratory evidence (Houser et al., 2008, Sutter et al., 2010). This paper contributes to the literature by modelling the theoretical properties of a reward system based on lotteries and by testing empirically its effectiveness into the field.

Results of this project have potential for application to other common property resource problems. Furthermore, they suggest a zero-cost policy tool to increase compliance that can be implemented by public organization in substitution or as a complement of traditional enforcement tools.

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