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# Saliency of Law Enforcement: A Field Experiment

## Abstract

We conduct a field experiment to examine whether the deterrent effect of law enforcement can be strengthened by making law enforcement activities more salient. Our focus is on illegal disposal of household garbage in residential areas. At a random subset of 56 locations in a city in the Netherlands, law enforcement officers supplemented their regular enforcement activities by the practice of putting bright warning labels on illegally disposed garbage bags saying that the item was “Found by law enforcement; fine minimally 90 euros”. We find evidence for a substantial reduction in illegal disposal of garbage as a result of the treatment at locations with garbage disposal containers, but not at locations with glass/paper disposal containers. Overall, the estimated treatment effect is negative, but imprecisely estimated.

JEL-Codes: C930, K420.

Keywords: law enforcement, deterrence, perception, saliency, disorder.

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## 1. Introduction

Governments around the world spend substantial resources on law enforcement in an attempt to reduce crime. While the success of such policies is sometimes debated in the popular media, scholars in criminology and economics have by now built up a substantial body of evidence showing that police commonly drive down crime, even though the size of the effect depends on the exact context and the way resources are deployed (Durlauf and Nagin 2011, Nagin 2013, Nagin 2016, Chalfin and McCrary 2017). The evidence also suggests that deterrence tends to be the primary mechanism responsible for the crime-reducing effect (Draca and Machin 2015).

A critical factor determining the size of the deterrent effect of law enforcement is its salience among potential offenders. Salience refers here to the awareness of the chance of getting caught and the subsequent consequences, and as such is an essential mediator of deterrence. It has been shown that potential offenders are not always fully aware of the parameters of law enforcement. Instead, they develop beliefs based on experiences and observations, with personal experiences of what does and does not happen after they commit an illegal act being a major determinant of those beliefs (Sah 1991, Lochner 2007, Hjalmarsson 2009, Rincke and Traxler 2011, Anwar and Loughran 2011, Loughran et al. 2014). Learning about law enforcement based on personal experiences is likely to be slow, however. Generally, the chance of getting caught is low. Consequently, chances are that beliefs about the expected punishment – the product of the chance of getting caught and the punishment – are rarely updated. If potential offenders tend to underestimate the expected punishment in the absence of recent experiences, then they may engage in illegal acts that they would have refrained from if the punishment had been correctly anticipated. Underestimation of the expected punishment may result from being ill-informed, but also from heavily discounting events that have not occurred recently. Moreover, beliefs may be correct, but need not be part of active knowledge. As argued in Bordalo et al. (2013), not all that is known is part of active knowledge, since people cannot attend to everything at once.

In situations like these, greater deterrence might be produced by increasing people's salience of law enforcement deployment, as suggested by Jolls, Sunstein, and Thaler (1998). They provide an appealing example in the context of parking fines. The practice of putting small, plain parking

tickets under the windshield wiper could be replaced by a policy of sticking large, brightly-colored tickets that read 'violation' in large letters. The cost of doing so are minimal, but the existing enforcement activities suddenly become much more apparent to all those passing by. As a result, potential offenders may be more likely to be deterred.

Our paper is the first to put this idea to the test. We conducted a natural field experiment in which we increased the salience of law enforcement at a random subset of 56 locations for a period of five weeks and observed the behavioral response in terms of the number of violations. We also examine displacement of illegal disposal.

The experiment took place in the city of Heerlen, the Netherlands. We study a type of disorderly behavior that is known to be a major irritant in residential areas: illegal disposal of household garbage.<sup>1</sup> Given the public outcry and the empirical evidence that a disorderly environment may drive further degradation of the neighborhood (Cialdini et al. 1990, Keizer et al. 2008, Dur and Vollaard 2015, Keuschnigg and Wolbring 2015), many local authorities put a lot of effort in keeping the streets clean. In the city of Heerlen, service workers clean all garbage disposal locations scattered around the city on a daily basis. Moreover, two full-time officers have the sole task to detect and fine offending households at the 56 supposedly messiest locations in the city. These locations include locations with shared garbage bag disposal containers close to homes as well as locations with glass and paper disposal containers at thoroughfares and on squares. The latter type of container has a small opening for bottles or paper and is free to use. Garbage bag disposal containers have a larger opening, but only operate after inserting a card that is exclusively issued to nearby households, with each recorded use costing one euro. The fee of one euro is meant to provide an incentive for households to reduce waste.

In violation with the rules, residents regularly dump garbage bags and all kinds of discarded household items next to both types of containers, creating a mess.<sup>2</sup> The two full-time officers make

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<sup>1</sup> Together with speeding and dog feces, littering – which includes illegal disposal of garbage – is reported to be one the three major nuisance crimes in the Netherlands Crime and Disorder Survey (Statistics Netherlands 2014).

<sup>2</sup> When residents want to dispose large items that do not fit into the garbage container, they are supposed to call for pick-up by city workers at their home address or to bring those items to one of the local garbage depots themselves.

a daily round along the locations, and search for name and address identifiers in illegally disposed garbage. At the start of our experiment, this intensive enforcement policy had been in place for almost one and a half years. Even though the fine is 90 euro and the chance of being detected is about 5 percent on average, the problem persisted. The muted response to a relatively high expected penalty of 4.50 euro (0.05 times 90 euro) for a rule violation with presumably small benefits (avoiding the fee of 1.00 euro and a bit of effort) provided an ideal setting for an experiment aimed at increasing the salience of existing law enforcement activity.

In the treatment condition, the officers made their activities more salient by marking illegally disposed garbage bags with bright orange labels saying that the item was found by law enforcement and punishable to a fine of 90 euros. The warning labels were visible until the next emptying of the underground container, which commonly took place after a couple of hours to a full day. A benefit of our setting is that it excludes shaming as an alternative mechanism for why such a treatment would be effective. The garbage bags cannot be linked to an offender other than by the investigative efforts of the officers.

Our results are as follows. The estimated average treatment effect is a reduction in illegal garbage disposal by about 12%, but the effect is not statistically significant at conventional levels. Further exploration of the data show that the effect is stronger during weeks with a relatively high treatment intensity and at container locations that were relatively clean in the baseline period, but these estimates are not statistically significantly different from the effects at other weeks or locations. We also find that the effect is much larger (a reduction of 60 percent) and statistically significant at locations with garbage bag containers, while a treatment effect seems absent at locations with glass and paper disposal containers. We find some evidence for displacement of illegal disposal. The latter finding should be no surprise since the warning labels also partly reveal which locations are surveilled and which locations are not surveilled.

We did not anticipate a difference in treatment effect between locations with garbage bag disposal containers and locations with glass/paper disposal containers, but can think of four plausible explanations. First, since glass and paper containers are located further away from homes, the warning labels are less conspicuous, making exposure to the treatment weaker. Second, the type of

offender may differ. While those going to a glass and paper container with a garbage bag are lawbreakers by definition, such need not be the case at the other type of locations. Third, at locations with garbage bag containers people can more easily switch to the legal option by putting the bag in the container rather than next to it, whereas at glass and paper containers the only way of doing the right thing is to not dispose the garbage bag at that location. In other words, the cost of the legal alternative is lower at locations where we find a large treatment effect. Fourth, glass/paper containers are also cleaned on Saturdays, which limits the visibility of the warning labels over the weekend at those locations.

Our paper contributes to the literature on deterrence. We provide tentative evidence that the size of the deterrent effect is dependent on the salience of law enforcement activity. Our findings provide an explanation for a puzzle in the deterrence literature: seemingly similar policy changes can lead to very different behavioral responses. Take the response to harsher penalties. Drago et al. (2009) find considerably lower recidivism after a plausibly exogenous positive shock in expected prison sentences. Other large exogenous shocks in expected prison sentences resulted in no (Hjalmarsson 2009; Loeffler and Chalfin 2017) or a very small behavioral effect (Lee and McCrary 2017). The variation in findings may be related to the salience of the shock. Drago et al. (2009) rely on a collective pardon that commuted residual prison sentences into a suspended sentence; Hjalmarsson (2009), Loeffler and Chalfin (2017), and Lee and McCrary (2017) rely on the change in penalties when reaching the age of criminal majority. It is imaginable that a suspended sentence for a convicted offender is much more salient than the difference of being charged under the adult rather than the juvenile justice system as of a certain date. Indeed, Hjalmarsson (2009) shows that perceptions of the expected penalty change very little when reaching the age of criminal majority. Our paper also provides an explanation for the persistence of forms of crime that do not seem to pay (Wilson and Abrahamse 1998; Reilly, Rickman and Witt 2012). Offenders may simply be overly optimistic about the expected return to crime if the upside is salient. The opposite should then also be true: when the downside is salient, we should not observe crime that does seem to pay.

Our findings are of direct relevance to deterrence policy. Enhancing the salience of law enforcement can be a relatively swift and cheap way of reducing crime and disorder. It can reduce crime and

disorder in two ways. First, salience can correct unjustified beliefs that enforcement policy is lax. As such, it can substitute for actual experience with the long arm of the law, cutting short a drawn-out process of adjustment of individual beliefs (as documented in Lochner 2007 and Rincke and Traxler 2011, for instance). It can be seen as an efficient way of bringing behavior in line with the expected punishment. Second, it may make potential offenders more attentive to the probability of being detected and the consequences thereof. Rather than having to increase the probability of getting caught, which is costly, or increasing the efficiency or effectiveness of law enforcement, which has proven to be difficult, simply attracting the attention to law enforcement activity may have the desired behavioral effect.<sup>3</sup> The treatment should not be seen as independent from the parameters of law enforcement, however. It does not involve any deception; it just emphasizes the current law enforcement policy.

Closely related to our paper are five recent studies in the tax compliance literature: Kleven et al. (2011), Fellner et al. (2013), Bott et al. (2015), Perez-Truglia and Trioano (2015), and Chirico et al. (2016). These studies provide evidence for a deterrent effect of notifications in letters about the threat of being audited and the penalty for tax evasion.<sup>4</sup> Similar to our paper, these treatments made the expected penalty more salient at a low cost. Our approach is different in manipulating the salience of law enforcement activity itself rather than notifying potential offenders of future enforcement policy. We share this feature with a study by Lu et al. (2016). They find that when the police send cell phone text messages to drivers citing their recent traffic violations, the likelihood of future traffic violations reduces substantially. In other treatments, the police sent messages advocating safe driving or warnings about widespread use by the police of video cameras to detect traffic violations. These messages did not have any effect, suggesting that it is not the surprise of receiving a message from the police that drives the response. Obviously, a limitation of their treatment is that it only reminds people who were already fined in the past. Our treatment affects a much broader population of potential offenders.

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<sup>3</sup> Our data do not allow us to assess whether the behavioral effect is driven by an adjustment in beliefs or a change in attention.

<sup>4</sup> See also Apesteguia et al. (2013) and Telle (2013) who study similar interventions by public libraries and environmental protection agencies, respectively.



Our paper also contributes to the broader literature on salience and decision making. How attention-grabbing cues – or camouflaged features – affect choices has been studied in several contexts, including product choice (Drèze et al. 1994; Chetty et al. 2009; Bordalo et al. 2013), price setting behavior (Finkelstein 2009; Grubb 2015), personal finance (Stango and Zinman 2014), and social security benefits (Brinch et al. 2017). Apart from the literature discussed above, salience has not been studied within the context of illegal behavior.

The remainder of this paper is structured as follows. The next section presents the contextual background. Section 3 discusses the treatment, data collection, and empirical strategy. Section 4 presents the estimation results. Section 5 concludes.

## **2. Contextual background**

### *Garbage disposal containers*

The field experiment was conducted in the city of Heerlen in the south of the Netherlands from August 11 until October 25, 2013. Heerlen has a population of 87,000 and counts 286 garbage bag disposal locations and 72 glass and paper disposal locations (see Figure 1). Glass and paper containers tend to be concentrated in groups of four; garbage bag disposal containers tend to be stand-alone. Thus the latter type of containers are spatially far more dispersed.<sup>5</sup>

The part of an underground garbage bag disposal container (pictured on the left) that is visible at street level features a lid that is to be opened to dispose of garbage. It can only be used by nearby residents. It operates after inserting an electronic pass. Use of the container is recorded and costs 1 euro per time. Households receive a bill from the city annually. In contrast, use of the glass and paper disposal containers (pictured on the right) is free. These containers have a small opening for bottles or paper and are placed at central locations such as squares or thoroughfares.

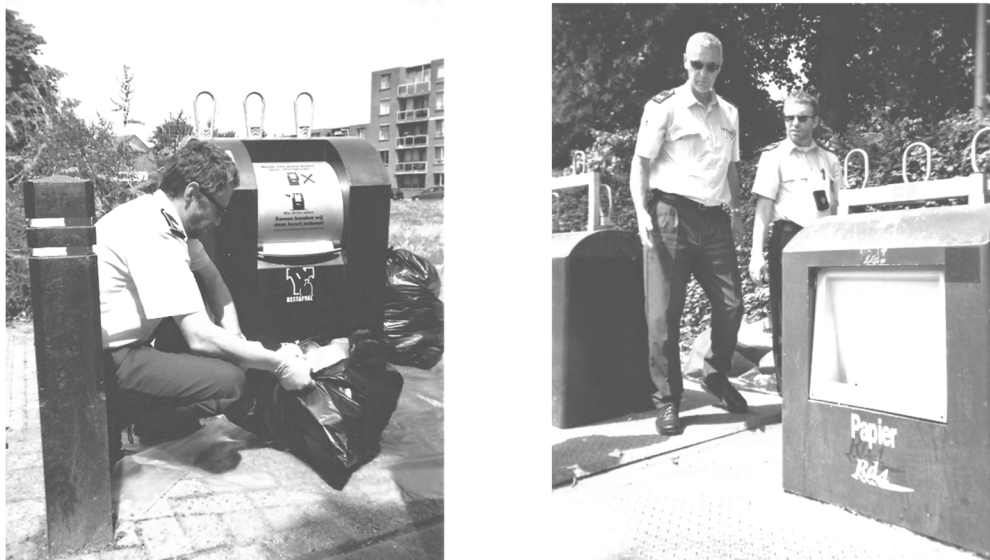
As discussed in the introduction, illegal disposal of garbage bags and discarded household items next to the disposal containers is reported as a major nuisance in surveys. Even a minor tendency for illegal disposal creates a sense of disorder that most residents strongly dislike: a rough estimate

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<sup>5</sup> The total number of glass and paper containers in the city is actually roughly similar to the total number of garbage bag disposal containers.

suggests that 95 percent of garbage bags in our sample are legally disposed (a similar estimate is not available for legal disposal of discarded household items).<sup>6</sup>

Figure 1. *Garbage bag disposal container (left) and paper and glass disposal container (right), featuring officers*



The private benefits of illegal disposal of a garbage bag consist of a euro saved and not having to put in the effort of opening the lid and pulling the lever. That is a small effort, but it requires the use of some force, and residents may get their hands wet or dirty.<sup>7</sup> Illegal disposal of household items such as a couch saves the effort of setting up an appointment for pick up by service workers of the Department of Sanitation or of legal disposal at the municipality collection depot.

The private costs of illegal disposal of a garbage bag consist of the expected penalty and the moral cost of not doing the right thing. For illegal disposal of household items, the perceived penalty is

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<sup>6</sup> This estimate is based on the following back-of-the-envelope calculation. On average, a person produced 3.6 kilos of residual waste per week in Heerlen in 2014 (Statistics Netherlands 2015). Total production of garbage bags per week per container location is 55 garbage bags (3.6 kilos of residual waste per person per week\*2.2 persons per household\*60 households per container location\*7/60 to convert kilos to bags). As discussed below, the Sanitation Department finds 2.75 illegally disposed garbage bags per location per week on average. This implies a rate of legal disposal of 95 percent.

<sup>7</sup> In very rare cases, doing the right thing is impossible, because the container is inoperative or other garbage blocks access to the container. From data we collected, we know that only 2 percent of the time garbage disposal containers cannot be used for technical reasons. We also know that in the vast majority of the cases where garbage had been dumped, it did not hinder residents from reaching the container and opening the lid. In 75 percent of the cases that any garbage was present in the baseline period, the total volume was less than 0.35 m<sup>3</sup> (the equivalent of 3.5 garbage bags).

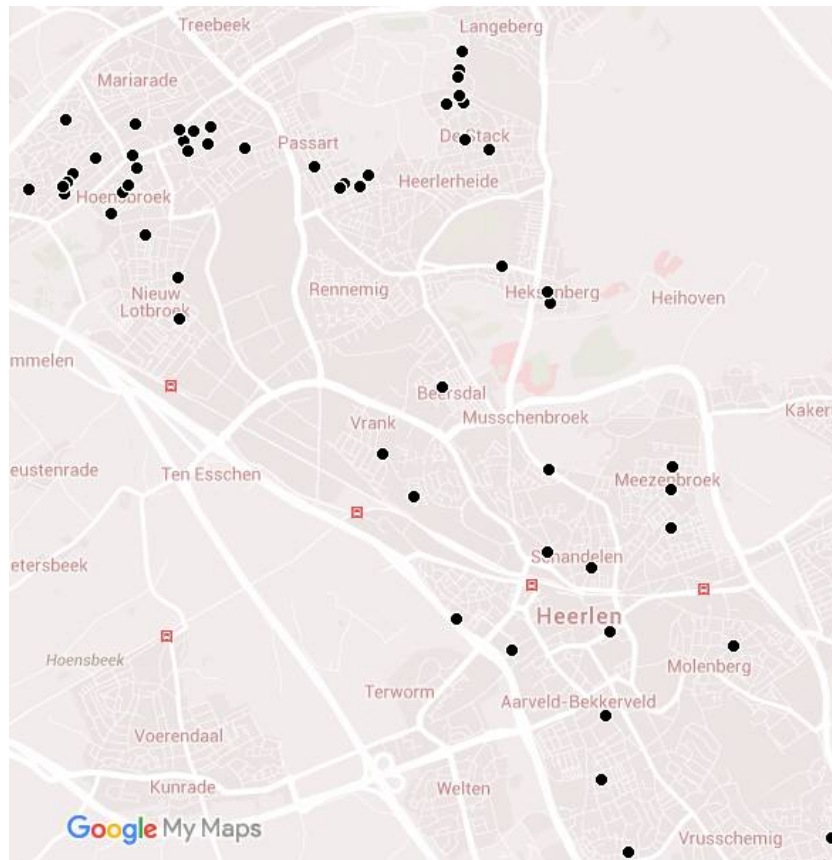
likely to be zero since the chance of getting caught for these items is close to zero, as we discuss below. A substantial part of offending is likely to be occasional in nature because illegal disposal of garbage has been found to be highly contagious (Dur and Vollaard 2015).

### *Law enforcement*

About one and a half years prior to the experiment, the city of Heerlen selected 31 garbage bag disposal locations and 25 glass and paper disposal locations as 'hot spots', based on a qualitative assessment of the prevalence of illegal garbage disposal. The 56 hot spots are spread over the city, although a fair share is concentrated in the Hoensbroek neighborhood to the north (see Figure 2). As of mid-April 2012, almost 1.5 years before the experiment, the same two uniformed officers enforce the garbage disposal laws on each business day, year-round, at these hot spot locations. They alternate a morning round and an afternoon round along the 56 container locations on a weekly basis. The officers primarily search for name and address identifiers in illegally dumped garbage bags; catching an offender in the act is very rare (only 2 percent of fines). The probability of detecting households that illegally dispose large household items such as discarded furniture is very close to zero: for the period that we have the officers' records, not a single fine related to discarded household items. Once an address label is found in a bag, the officers visit the home of the suspect, and question him or her. If the suspect confirms wrongdoing, or at least is not able to provide a coherent explanation for the detected bag, he or she receives a fine to the value of 90 euros. The officers search about 25 percent of illegally disposed garbage bags (based on data that we discuss in Section 3). They do not search all bags, because the locations are regularly cleaned and they visit a container location only once per day. In addition, they occasionally miss a round due to sick leave or a day off. On average they find evidence leading to a suspect in 20 percent of searches, implying an average probability of detection of 5 percent ( $0.25 \cdot 0.20$ ). In other words, on average, a household that consistently puts one garbage bag next to a container on a weekly basis will be caught every 5 months. Obviously, if a household is only an occasional offender, then the expected average duration until one is caught is much longer. For each illegally disposed garbage bag the expected penalty is 4.50 euros ( $0.05 \cdot 90$ ) on average. That is a lot more than the 1 euro saved for not using the container for legal disposal of a garbage bag. One explanation for the prevalence of illegal disposal is that the

penalty for illegal disposal is not salient. After all, the officers are only present in a street for a short time and at times that most people are at work. In addition, the fine arrives in the mail two weeks after the home visit: unless the offender shares this information with others, no one else is likely to know about the penalty. An alternative, but less plausible, explanation for illegal disposal is that the perceived costs of operating the container are very high.

Figure 2. *Map of the area including the 56 container locations*



### 3. Identifying the behavioral response

#### *Treatment*

In the treatment condition, the officers put bright orange self-adhesive warning labels on illegally disposed garbage bags for a period of five weeks (September 9-October 11, 2013) at a random subset of the 56 locations. On the label it said: "Found by law enforcement. Fine: minimally 90 euros" (see Figure 3). The bright labels make the existing law enforcement activities much more visible to the residents, with a minimum of effort. Everything else remained unchanged.

Figure 3. *The self-adhesive warning label*



*Note.* Warning labels were only put on illegally disposed garbage bags, not on other types of garbage. The message reads: 'Found by law enforcement. Fine: minimally 90 euros.'

To keep the labels visible to the public, the officers put searched garbage bags into new, slightly larger garbage bags and left them at the container location where they were found.<sup>8</sup> This routine was introduced in the baseline period (four weeks), continued during the treatment (five weeks) and after the treatment (five weeks). Apart from the labeling of garbage bags, a similar routine was followed at locations in the control group. In the past, the officers would put garbage into the container after inspection. Obviously, the old routine would render the new policy of making law enforcement more salient using labels on garbage bags infeasible.<sup>9</sup> The daily cleaning by the Department of Sanitation puts a limit on the duration that the warning labels are visible, something we return to later in this section.

#### *Behavioral mechanism*

The treatment may increase the deterrent effect of existing law enforcement activities, either because beliefs about the expected penalty are adjusted upwards or because potential offenders become more attentive to law enforcement. In both cases, the effect may not be limited to the moment of observing

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<sup>8</sup> Shortly after the start of the study, before the intervention started, the substitute garbage bags were found to be of too low quality and were replaced with transparent plastic wraps.

<sup>9</sup> The change in routine might have made law enforcement activities more salient at all locations, possibly limiting the effect of the warning labels. Since we do not have experimental variation in this routine, we cannot examine how it affected illegal disposal.

the warning label. Shaming can be excluded as a mechanism because the plain grey garbage bags cannot be linked to an offender other than by the investigative efforts of the officers (this also holds when the officers put searched bags in transparent plastic wraps, see footnote 8).

The treatment may not only have favorable effects on behavior, however. First, the warning labels may indicate that law enforcement is largely toothless. At visited treatment locations, warning labels are ubiquitous but fines remain rare. In addition, some 75 percent of illegally disposed garbage bags are not searched by the officers and, hence, not labelled. Hence, the treatment may also lead to a downward adjustment of the perceived chance of getting fined. For this perception to take hold, residents should have sufficiently high priors about the probability to be caught. This seems unlikely given the cost-benefit considerations sketched earlier.

Second, the warning labels may signal that the officers have visited the container location, and that they will return the following day at the earliest. This may create an opportunity for illegal disposal that goes undetected. For this to be true, residents should know that the officers only visit a location once per day. This is not obvious since the officers alternate a morning and an afternoon round on a weekly basis. In addition, the resident should take the risk that the officers return earlier than the service workers from the Department of Sanitation who clean the location of all garbage, and that they get fined after all. Taken together, we do not expect that the treatment enables residents to outmanoeuvre the enforcement officers.

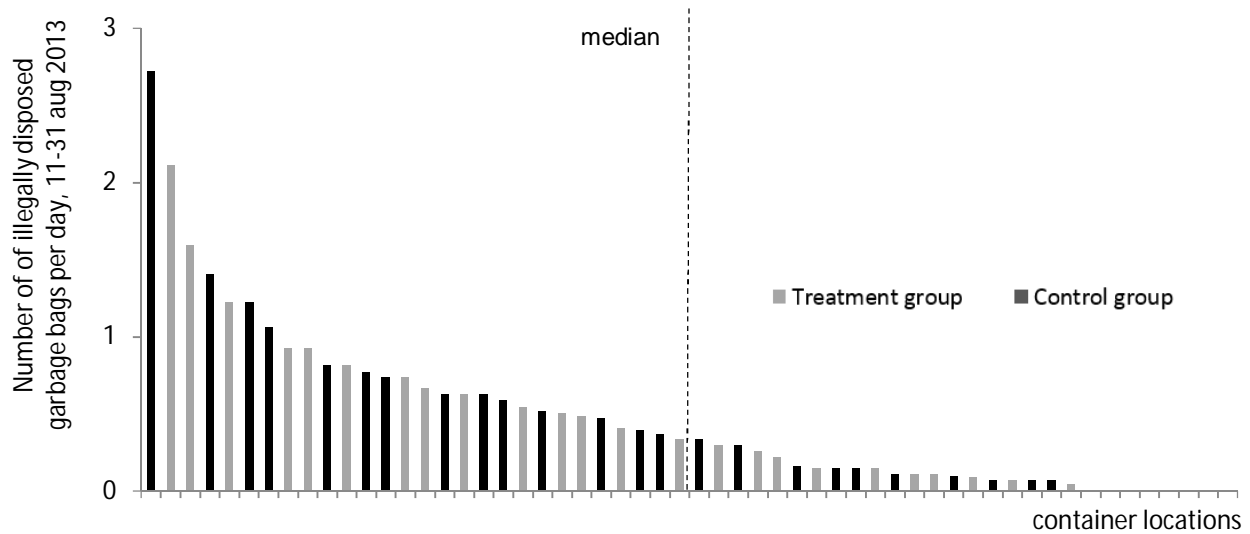
Third, the labels may signal that breaking the law is common, creating a bad example that residents may follow (Dur and Vollaard 2015). The bad examples were already there, however, and they are now turned into a warning, making this adverse effect on behavior unlikely. Moreover, if the treatment has a deterrent effect, the volume of illegally disposed garbage goes down, which reduces the invitation for illegal disposal.

Fourth, as with any increase in the perceived penalty, the treatment may increase the tendency to change tactics in order to evade law enforcement. In this case, more residents may take care not to leave name and address identifiers in illegally disposed garbage bags, thus reducing the rate at which officers find evidence leading to a suspect. Our data show that detection rates in the treatment group are indeed lower in the treatment period relative to the baseline period and do not change

much in the control group, but this could also be the result of selection rather than a change in behavior. If it is behavior, then our estimated effect on illegal disposal is somewhat smaller than it would have been in the absence of evasion.

To conclude, these four possible adverse effects may drive down the treatment effect, but we have reason to believe that the adverse effects are likely to be limited.

Figure 4. *Average daily number of illegally disposed garbage bags per location, pre-treatment period*



### Randomization

We assigned container locations to treatment based on matched pair randomization. We ranked locations based on the aggregate volume of illegally disposed garbage bags during the first three weeks of the data collection (August 11-31, 2013). Out of each of the 28 pairs of container locations, we randomly selected one for the treatment group. We focus on garbage bags, because the treatment is exclusively targeted at this type of illegally disposed garbage. The randomization was conducted one week before the start of the treatment to allow time for instruction of the officers. Figure 4 shows the pre-treatment values for each of the locations. For illustrative purposes, the figure shows the number of illegally disposed garbage bags per day rather than the summed volume.<sup>10</sup> Even though all these locations were once characterized as ‘hot spots’, illegal disposal is obviously quite low at a number of locations. This is of consequence for our study, since treatment intensity is going

<sup>10</sup> See the sensitivity analysis for how we transform the volume of garbage bags into the number of bags.

to be relatively low at these locations. Labeling is only possible in the presence of illegally disposed garbage bags after all. For this reason, in the empirical analysis we explore heterogeneity in the treatment effect by pre-treatment levels of illegal disposal.

### *Data collection*

Service workers of the Department of Sanitation record the volume of illegally disposed garbage when they clean up the areas around the containers between 7.30 am and 2.30 pm.<sup>11</sup> They distinguish four types of illegally disposed garbage: garbage bags (46 percent of the total volume of illegally disposed garbage), discarded household items (38 percent) and paper and glass (17 percent). The service workers were trained to estimate the volume of garbage (in cubic meters), rather than to count the number of items. The workers also record whether a container is out of order, which rarely happens. Out of concern for privacy, the municipality did not provide data on the recorded use of the garbage bag disposal containers.

Our primary outcome measure is the volume of illegally disposed garbage bags. In the sensitivity analysis, we also present results for the number of garbage bags – after transforming the volume of bags back into the approximate number of bags – and for discarded household items.

The law enforcement officers provided us with their records, including the number of searched bags and the number of fines. The officers' data allowed us to compute the search rate and detection rate that we discussed previously.

### *Randomization check*

Table 1 summarizes the baseline characteristics of the treatment and control locations in our sample. The matched pair randomization guaranteed balance between the treatment and control locations with respect to the presence of illegally disposed garbage bags. On average, 0.04 m<sup>3</sup> of garbage bags are illegally disposed per day at the 28 treatment locations, and a similar volume at the control locations (equal to the equivalent of 2 to 3 bags per location per week on average). The difference is minimal and not statistically significantly different from zero. The volume of illegally disposed

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<sup>11</sup> Our data are unbalanced: 27 out of the 56 locations are not only serviced on business days but also a sixth time on Saturday. In the sensitivity analysis, we collapse the data by week and show that this does not affect the results.



household items is also similar between the two groups. The rare occurrence of containers that are out of order is slightly higher at control locations than at treatment locations, but the difference is not statistically significant. The number of searched bags is higher in treatment than in control locations. The higher number of searched bags at treatment locations is primarily due to a strong one-off increase at three locations in week 3. The number of illegally disposed bags at a location, and also the number of searched bags, is characterized by wild fluctuations. Given the high standard deviation of the number of searched bags, the difference between treatment and control is not statistically significant. Excluding week 3, the means for the two groups are virtually identical. Similarly, the number of detected offenders, which is a direct function of the number of searched bags, is higher in treatment locations than in control location, but the difference is not statistically significant either.

Table 1. *Baseline characteristics and randomization check*

	Treatment locations	Control locations	P-value difference
Illegally disposed garbage bags (m <sup>3</sup> )	0.04 (0.10)	0.04 (0.09)	0.41
Illegally disposed household items (m <sup>3</sup> )	0.06 (0.19)	0.05 (0.14)	0.21
Container out of order†	0.01 (0.11)	0.02 (0.14)	0.24
Number of searched bags	0.13 (0.65)	0.08 (0.69)	0.17
Number of detected offenders	0.02 (0.02)	0.01 (0.01)	0.35
Number of locations	28	28	
Number of observations	571	616	

*Note.* Observations by container location and day. Standard deviation between parentheses. Baseline period is August 11-September 7, 2013. (†) Defined as the number of times a container was found to be out of order per location per day.

#### *Treatment compliance*

The law enforcement records show that labelling of garbage bags started in the first week of the treatment and continued for five weeks (calendar weeks 37-41 in 2013). Given the regular cleaning activities by service workers, not all garbage bags disposed at treatment locations were labelled. As

discussed previously, on average some 75 percent of illegally disposed bags were not searched.<sup>12</sup> At treatment locations, a bag not searched meant a bag not labelled. In other words, the officers complied with the treatment, but treatment intensity was low given their routines. The percentage searched varied greatly by week, however, and so did the percentage of bags labelled at treatment locations. The number of bags that could be labelled was much lower in even weeks than in odd weeks, in line with the alternating afternoon and morning rounds of the officers. In even weeks, 90 percent of bags were not labeled; in odd weeks 60 percent. The cause of the variation in treatment intensity is the daily cleaning between 7.30 am and 2.30 pm. Cleaning limits the duration that the warning labels are visible, which also affects the morning round, but it prevents application of the treatment altogether if there are no illegally disposed bags, which is common to afternoon rounds. We return to this issue in the next section.

The data show that law enforcement routines other than the labelling remained unchanged during the experiment. The officers always visited all 56 locations on a daily round. Weekly variation in the percentage of bags searched and in the detection rate was similar between the treatment and control group. More generally, we find that law enforcement did not go into overdrive during the experiment. The monthly number of fines for illegal disposal of garbage during August-October 2013 varied between 26 and 31, which is within the usual range, albeit somewhat higher than in earlier months because the officers did not take long vacations during the experiment.

#### 4. Estimation results

To estimate the effect of the treatment on the volume of illegally disposed garbage bags, we estimate the following equation:

$$(1) \quad G_{i,t} = \alpha T_i P_t + \sigma_i + \lambda_t + \varepsilon_{i,t}$$

where  $G_{i,t}$  is the volume of illegally disposed garbage bags at location  $i$  in day  $t$ .  $T_i$  denotes the treatment group and  $P_t$  the treatment period; the product of  $T_i$  and  $P_t$  is 1 for the treatment group during the treatment period and 0 otherwise.  $\alpha$  is the parameter of interest: the absolute change in

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<sup>12</sup> Table 1 shows that on average 0.04 m<sup>3</sup> of garbage bags were illegally disposed per location per day, which is equal to 0.22 m<sup>3</sup> per week. This is equal to a little more than two garbage bags. Given an average number of searched bags of about 0.5 per week, the percentage of bags searched is 25 percent.

the volume of illegally disposed garbage as a result of the treatment. We include container location fixed effects,  $\sigma_i$ , and day fixed effects,  $\lambda_t$ . The error term  $\varepsilon_{i,t}$  is clustered at the level of container locations.

Table 2. *The effect of warning labels on illegal disposal of garbage bags*

Dependent variable: volume of illegally disposed garbage bags	(1) Overall	(2) By am/pm round	(3) By pre-treatment level	(4) By type of location
Treatment	-0.48 (0.74)			
Treatment * a.m. round		-0.87 (0.90)		
Treatment * p.m. round		0.10 (0.85)		
Treatment * cleanest locations			-0.71 (0.76)	
Treatment * messiest locations			-0.08 (1.02)	
Treatment * garbage bag disposal locations				-2.22 (1.03)**
Treatment * glass/paper disposal locations				1.31 (0.99)

*Note.* All coefficients \*100. Observations by container location and day. Number of observations is 2,867. Between parentheses standard errors clustered by container locations. Not shown are estimation results for location-fixed effects and day-fixed effects. Further, column (2) includes the interaction between the indicator variable for morning rounds and the treatment period; column (3) the interaction between the indicator variable for an above-median baseline level of illegal disposal and the treatment period; column (4) the interaction between the indicator variable for the type of location and the treatment period. \*  $p < 0.10$ ; \*\*  $p < 0.05$ ; \*\*\*  $p < 0.01$ .

Table 2 shows the estimation results based on equation (1). On average, we find a negative effect of the treatment, but it is imprecisely estimated (column 1). The point estimate suggests a 12 percent reduction in illegal disposal.

In column (2), we explore how weekly variation in treatment intensity affects the results. As discussed in the previous section, treatment intensity was about four times higher in odd weeks than in even weeks (40 percent versus 10 percent of bags searched and labelled), depending on whether the officers did their round at a time of day that many locations still were to be cleaned or had been cleaned already. Since the variation in treatment intensity is orthogonal to illegal disposal of garbage, we allow the treatment effect to vary between odd weeks (with morning rounds) and even

weeks (with afternoon rounds).<sup>13</sup> Our estimate for the morning rounds, when treatment intensity is relatively high, is negative, almost twice as high as the default estimate, but highly imprecise. The estimate for the afternoon rounds is small, positive and also insignificant. The two coefficients are not statistically significantly different.

In column (3), we explore how the treatment response depends on the rate of illegal disposal at a location, which we know to vary greatly. The type of households – and their response to the treatment – may differ across locations. For instance, relatively messy locations may be used by people who are not easily deterred by penalties. Besides different location-specific characteristics, a difference in the treatment response between the two groups may be due to the greater visibility of warning labels at locations with lots of illegally disposed garbage. Obviously, the number of bags labelled by the enforcement officers is strongly positively correlated with the number of illegally disposed bags. Another reason to allow the treatment response to differ depending on baseline levels of disposal is that equation (1) imposes a similar absolute change in the level of disposal across all locations, clean or messy. In the randomization, we blocked on the baseline level of illegal garbage disposal, allowing us to explore heterogeneity in the treatment effect along this dimension. We divide the sample into two groups: one group with below-median pre-treatment levels of illegal disposal and another group with above-median levels.

Illegal disposal went down by 70 percent on average at locations that were cleanest in the baseline period, but the estimate is again highly imprecise. It went down by an estimated 1 percent at locations that were messiest in the baseline period. The effect for the latter subsample is also imprecisely estimated.<sup>14</sup> The two coefficients are not statistically significantly different.

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<sup>13</sup> The regression equation also includes the interaction between an indicator for the morning round and treatment period  $P_t$ . We follow a similar approach in columns (3) and (4). See the notes below Table 2.

<sup>14</sup> It should be noted that the ranking of locations from clean to messy is not fully stable. The ranking is based on a four-week baseline period. Based on the estimation results of the specification in column (3) of Table 2, we find evidence for reversion to the mean. The interaction term between the group of clean locations and the treatment period is positive and highly statistically significant (not shown). This effect is limited, however: the estimated coefficient of the interaction term (multiplied by 100) is 3 compared to a difference in the mean volume of illegal disposal between the two groups of 13.

In the last column of Table 2, we allow the treatment response to differ between the two types of garbage disposal locations. The estimate for locations with garbage bag disposal containers is negative and statistically significant; the estimate for locations with glass/paper disposal containers is, unexpectedly, positive but statistically insignificant. The difference between the two coefficients is statistically significant at the 1 percent level. A coefficient of -2.22 implies an average reduction of 60 percent in illegal disposal at locations with garbage bag disposal containers.

The major difference in the behavioral effect between the two types of locations was not anticipated. We can provide four reasons for this difference. First, since glass and paper containers are further away from homes, the warning labels are less conspicuous, making exposure to the treatment weaker. Second, the type of offender may differ. While the residents going to a glass and paper container with a garbage bag are lawbreakers by definition, such need not be the case at the other type of locations. Third, at locations with garbage bag containers people can easily switch to the legal option by putting the bag in the container rather than next to it, whereas at glass and paper containers the only way of doing the right thing is to not dispose the garbage bag at that location. In other words, the costs of the legal alternative are lower at locations where we find a large treatment effect. Fourth, visibility of the warning labels is also lower at glass/paper containers because they are also cleaned on Saturdays, whereas most garbage bag disposal containers are cleaned on business days only.

To conclude, the estimation results reported in Table 2 point towards lower rates of illegal disposal in response to the treatment, particularly for weeks with a relatively high treatment intensity and at container locations that were relatively clean in the baseline period, but we miss the statistical power to identify a precisely estimated effect. We only find a precisely estimated negative effect for locations with garbage bag disposal containers.

#### *Post-treatment period*

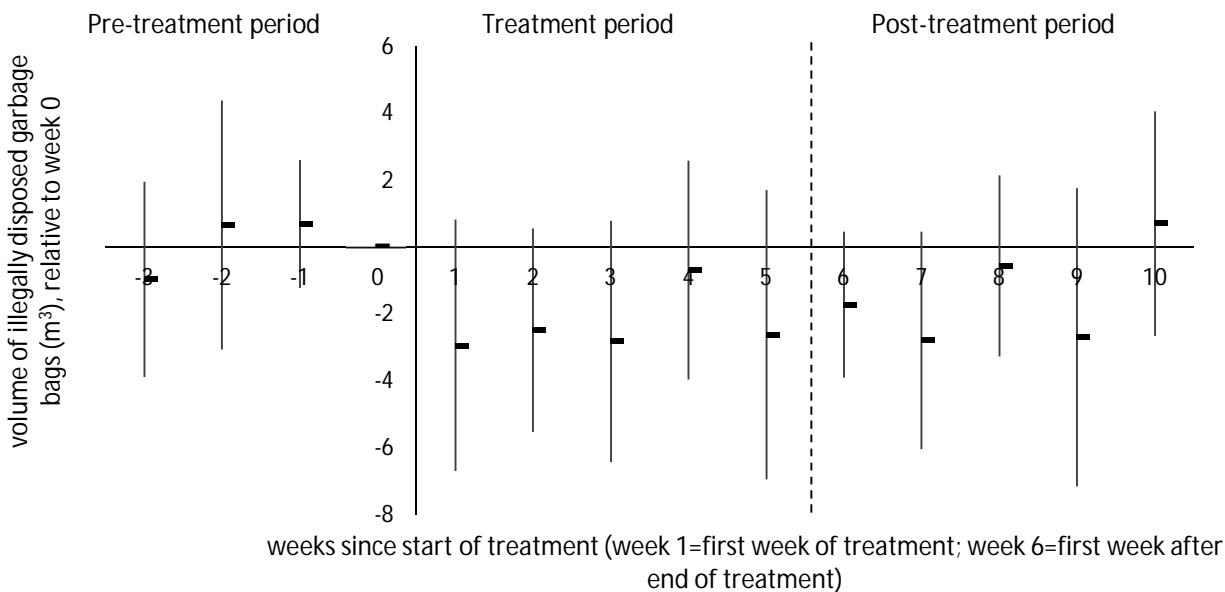
After the end of the treatment, the officers continued their routine of leaving searched bags next to the container at all 56 locations for another five weeks. The treatment effect may carry over to those weeks, since residents may have updated their beliefs about the expected penalty as a result of the treatment, as argued in Section 3.

For an analysis of the behavioral response after the end of the treatment, we focus on illegal disposal at the subsample of locations with garbage bag disposal containers. If the treatment had a persistent effect on behavior at all, chances are we can detect it at these locations. To graphically illustrate how behavior evolved, we estimate the difference in illegally disposed garbage between the control and treatment container locations for each week before, during, and after the experiment. We estimate the difference between treatment and control locations for weekly rather than daily time intervals to reduce noise in our estimates. We estimate the following equation:

$$(2) G_{i,t} = \sum_{t=1}^Z W_{i,t} \alpha_t + \sigma_i + \lambda_t + \varepsilon_{i,t}$$

where  $W_{i,t}$  is a vector of weekly indicator variables which are 1 for container locations in the treatment group and 0 for container locations in the control group; vector  $\alpha_t$  represents the parameters of interest. Other than replacing the treatment indicator by this vector of indicator variables, equation (2) is identical to equation (1).

Figure 5. *Difference in volume of illegally disposed garbage bags between treatment and control locations relative to last week of baseline period (garbage bag disposal container locations only)*



*Note.* The figure plots coefficients  $\alpha_t$  from estimation of equation (2). All estimates \*100. The bars show the 95 percent confidence intervals. Number of observations 2,125.

Figure 5 shows the estimation results based on equation (2). The coefficients show the estimated difference in the weekly volume of illegally disposed garbage bags between the control and treatment

group. All coefficients are estimated relative to the last week of the baseline period, which is set to zero. The estimated coefficients for the pre-treatment period (weeks -3 to 0) show that the treatment and control group do not have a different trend in illegal disposal, one of the assumptions underlying our empirical approach. As soon as the treatment starts (week 1), the volume of illegally disposed garbage bags drops sharply at the treatment locations relative to the control locations. In line with the estimation results reported in Column (4) of Table 2, the average difference during the treatment period (week 1-5) is about -2.2.

Figure 5 also shows the difference in treatment response between even and odd weeks that we discussed earlier (see also column (2) in Table 2). This pattern continues into the post-treatment period and even becomes slightly more pronounced. This is surprising because the number of labelled garbage bags no longer varies after the end of the treatment: it is now always zero in even and odd weeks. Treatment intensity does not vary any longer; the treatment has ended. The most likely explanation is that the warning labels made residents at treatment locations sensitive to signs of searched bags. After a search, the officers rolled a bag into transparent plastic and left this package next to the container. In other words, searched bags left at the container location may have become another signal for law enforcement activity. This goes for the treatment group, where this package used to be accompanied with the bright warning label, not for the control group, where a searched bag may not be identified as such. For this to be true, a sizeable number of residents at treatment locations should have become familiar with the treatment over the course of five weeks, which is not unlikely. This could explain why the difference in illegal disposal of garbage remains significantly lower at treatment locations than at control locations in odd weeks after the end of the treatment.

### *Sensitivity analysis*

In the sensitivity analysis, we report results for both the average treatment effect and the conditional average treatment effects for garbage bag disposal locations and glass/paper disposal locations.

Our main outcome variable, illegal disposal of garbage bags, is essentially a count variable truncated at zero. Garbage bags are of uniform size and tend to be filled to the brim. Strong bunching around multiples of 0.1 m<sup>3</sup> in the volume of garbage bags suggests that the service workers take this as the approximate volume of a garbage bag. This is in line with Robin (2004), who estimates that the

approximate volume of a full garbage bag is equal to 0.09 m<sup>3</sup>. When we transform our outcome variable into count data based on this assumption and estimate a negative binomial regression model, we get qualitatively similar results.<sup>15</sup> The point estimate in row (2) of Table 4 suggests a drop in illegal disposal of about 40 percent at garbage bag disposal locations, which is somewhat smaller than in our default specification.

As discussed in Section 3, all locations are serviced on business days, but only a subset of locations are also serviced on Saturdays. This results in an unbalanced panel. To test the robustness of our findings, we collapse the data by week and use the summed volume of illegally disposed garbage as our outcome variable. The results are presented in row (3) of Table 4 and are – in percentage terms – similar to those in the default specification.

Next, we examine whether the estimated treatment effect is affected by spillover effects. Residents may displace illegal disposal of garbage from treated locations to locations that they believe to be untreated. Displacement is not without its costs, think of a longer walking distance to another location, but it has the possible benefit of avoiding detection. Spillovers may also be positive. Upon noticing the warning labels, residents may believe that the officers also visit locations that are actually untreated.

We counted the number of treatment locations and untreated locations that were within walking distance (250 meters). Untreated locations include the 28 control locations within our sample and the 302 other locations not included in our sample. We assume that spillover effects are most likely to occur at nearby locations. As it turns out, we are not in the best possible position to learn about spillovers. The reason is that we hardly have any locations *without* one or more untreated locations within walking distance. What we do have is a decent number of locations, both in the treatment and in the control group, with only untreated locations nearby. This subsample of locations is unlikely to be affected by spillover effects given the absence of treatment locations within walking distance. We also have a fair number of locations with a mixture of treated and untreated locations nearby. This makes for an interesting comparison group, because spillover effects, if at all present,

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<sup>15</sup> In line with Allison and Waterman (2002), we estimate an unconditional negative binomial regression estimator with binary variables to represent the fixed effects.



are likely to affect these locations. We present the results for the two subsamples in row (4) and (5) of Table 4. We find the estimated treatment effect to be considerably larger for the group with a mixture of treated and untreated locations nearby compared to the group with only untreated locations nearby. This suggests the presence of negative spillovers. Displacement leads to a greater volume of illegally disposed garbage at control locations after all, increasing the difference between the treatment and control group. The two estimates are not statistically significantly different, however, rendering the evidence for negative spillover effects suggestive.

Table 4. *Sensitivity analysis*

Dependent variable: illegal disposal of garbage bags	Average treatment effect	Conditional average treatment effect	
		garbage bag disposal locations	glass/paper disposal locations
1. Default	-0.48 (0.74)	-2.22 (1.03)**	1.31 (0.99)
2. Number of garbage bags (incidence rate ratio)	-0.04 (0.18)	-0.44 (0.27)*	0.33 (0.25)
3. Collapse to weekly data	-2.84 (3.89)	-11.17 (5.17)**	7.15 (5.86)
4. Subsample: only untreated locations nearby	-0.48 (0.88)	-1.43 (1.66)	0.24 (0.75)
5. Subsample: combination of untreated and treated locations nearby	-1.12 (1.24)	-2.82 (1.25)**	4.23 (2.12)*
6. Volume of discarded household items	-1.48 (1.21)	-1.10 (1.47)	-1.82 (1.77)
7. Control for bags searched	-0.52 (0.75)	-2.29 (1.02)**	1.26 (1.01)

*Note.* Observations by container location and day (by week in row 3). All coefficients \* 100 (except row 2). Number of observations 2,867 (504 in row 3; 1,408 in row 4; 1,120 in row 5). Between parentheses standard errors clustered by container locations. Not shown are estimation results for container location-fixed effects, day-fixed effects (or week-fixed effects in row 3), and the interaction between an indicator for the type of container and the treatment period. \*  $p < 0.10$ ; \*\*  $p < 0.05$ ; \*\*\*  $p < 0.01$ .

So far, we focused on illegal disposal of garbage bags only. The treatment may also prevent illegal disposal of other types of garbage for two reasons. First, a smaller volume of illegally disposed garbage has been shown to limit the overall tendency for illegal disposal (Dur and Vollaard 2015). Second, the perceived penalty for illegal disposal of other garbage may go up, even though the

chance of getting caught for anything else than garbage bags is remote. Hence, as an additional test, we also present results for the volume of illegally disposed household items. This is another sizeable part of illegally disposed garbage that is present at both types of container locations. The results are presented in row (6) of Table 4. All our estimates are negative, but not statistically significantly different from zero.

Other than labelling garbage bags in treatment locations, the routines of the officers were similar between treatment and control locations. To examine whether the officers did not become more zealous at treatment locations, we use the (absolute) number of bags searched as an indicator of law enforcement activity during the experiment. When we include this variable as a covariate in equation (1), we get very similar results (row 7).

## **5. Concluding remarks**

The economic analysis of crime has mainly focused on how the probability of conviction and the severity of punishment jointly affect an individual's inclination to commit crime. Typically, potential offenders are assumed to be aware of these parameters and to incorporate them in their decision making. Not all potential offenders may hold correct beliefs, however (Durlauf and Nagin 2011). Moreover, even when beliefs are correct, the level and likelihood of penalties may not always play a dominant role in decision-making, because people cannot attend to everything at once (Bordalo et al. 2013). In such situations, it may pay off to make enforcement policy more salient, as suggested by Jolls et al. (1998). By doing so, potential offenders may adjust their beliefs about the likelihood of conviction and the severity of punishment upwards. Such a policy also increases the likelihood that potential offenders take these factors into consideration before committing an illegal act.

We put this idea to the test in a context where we can be fairly confident that people underestimate the consequences of breaking the law. We have studied illegal dumping of garbage bags by citizens in residential areas in a city in the Netherlands. In the baseline, chances of getting caught for illegal dumping are about 5 percent and the fine is 90 euro, implying an expected penalty of about 4.50 euro. The cost of the legal alternative (putting the garbage bag into the container) is just 1 euro and a bit of effort. In cooperation with local law enforcement, we set up a field experiment that made enforcement activity more salient by putting bright orange warning labels on illegally disposed

garbage bags. We find sizeable responses to the treatment, but only at garbage bag disposal locations, not at locations for disposal of glass and paper. While these heterogeneous treatment effects are unexpected (and so should be taken as tentative evidence), they are easy to rationalize. We also find some indications for displacement of illegal dumping from treated to untreated locations.

Our paper is a first attempt at proof of concept. It would be worthwhile to replicate our experiment in similar or different settings. It should be noted, however, that interventions like the one studied may have unfavorable effects. If potential offenders believe that enforcement policy is more severe than it actually is, then making the actual severity more salient may backfire and result in more rather than less illegal behavior.

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