Social information and waste disposal
Pre-Analysis Plan

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Abstract

We assess the impact of a social information program on the disposal of unsorted waste. We study a program implemented by an Italian multi-utility using an hybrid Pay-as-you-Throw collection system. Households are assigned a maximum number of solid waste units yearly and pay a fixed amount when the quantities are below such limit. For each unit exceeding the cap, customers pay per unit. We randomize customers into a treatment group which receives quarterly reports including information over the volume of unsorted waste compared to the average waste of similar customers living in the city, and a control group which receives nothing. Within the group of treated households receiving the report, half receives the standard report. The other half receives the report along with a clear reference to the disposal cap. This information allows treated customers to keep track of their performance against the cap, which is calculated on a yearly basis. We measure the main and heterogeneous treatment effects on the volume of unsorted waste and on the probability of passing the yearly threshold.

1 Introduction

This document outlines our pre-analysis plan for a field experiment on the impact of social information on waste disposal, to be conducted with customers of an utility operating in a city in the North-East of Italy. The document summarizes (i) our experiment and resulting data, (ii) our research questions and the plan of regressions, and (iii) power calculations.

At the time of writing this plan, we designed and launched the RCT. We accessed pre-experimental administrative data which we used to identify the study sample and randomize treatment assignment.
We intend to submit this Pre-Analysis Plan to the AEA RCT Registry.

2 Context, treatment, sample and randomization

Collection and disposal management of Municipal Solid Waste (MSW) in Italy is decentralized at the municipality level. Municipalities contract or are shareholders in disposal management firms under different waste collection and payment systems. The most common methods are: i. flat fees on MSW collection, where customers are charged a fee based on some characteristics, such as the size of the house and the number of household members; ii. Unit Pricing Systems or pay-as-you-throw programs, where waste is charged per unit disposed.
We study a program implemented by an Italian multi-utility in a Northern city using an hybrid Pay-as-you-Throw collection system. Households are assigned a maximum number of solid waste units yearly and pay a fixed amount when the quantities are below such limit. For each unit exceeding the cap, customers pay per unit. The value of the cap is determined by household characteristics: number of members and presence of young children or elderly with health problems[1]. Waste disposal is done in specific locations (collection points) spread throughout the city where users can dispose solid waste after being identified with a card. This allows us to measure these events precisely. In the same collection points differentiated waste, i.e. organic, paper, glass and plastic, is also collected in different containers, free of charge. We do not have individual level measures of differentiated waste disposal. There are about 4,000 (unsorted) waste collection points in the city area (405 Km^2), given about 54,150 resident households with a waste disposal contract.
Users can also access two waste collection centers where special waste (batteries, household appliances,

[1] There are six basic cap levels, corresponding to household size of 1, 2, 3, 4, 5 and 6 or more members. The corresponding levels (in liters per year) are 1080, 1380, 1560, 1740, 1920, 2100. When children are born or specific health problems are signalled, the utility increases the cap by about 1900 liters per year for each child or person with health problems.

bulky waste, etc) is collected and incentivized[2]. Access to waste collection centers and quantities of disposed waste are recorded at the user level.
We evaluate the impact of a social information campaign through the design and launch of "Opower-style" home waste reports. The report kicked-off in July 2020 and is delivered by post and email to customers every quarter, after the waste bill. The reference period of the report is the same of that reported in the bill. The report includes the following elements:

- *Static neighbor comparison:* one's own solid waste volume disposed in the reference period, expressed as total and in per capita-per day term (in liters), compared with total average waste of similar customers living in the city. Similar households are those with the same household size, hence with the same solid waste disposal cap.
- *Cumulative solid waste disposal:* Cumulative solid waste disposal since the beginning of the year.
- *Dynamic feedback:* comparison of own solid waste disposal over the months in the reporting period and same months of previous year;
- *Access to waste collection centers*: information on the cumulative number of accesses to the waste collection centers since the beginning of the year, along with the total number of accesses by other citizens during the year.
- *Make the difference:* this section underlines the importance of recycling in terms of reduction of CO2 emissions. The message is not customized.
- *Recycling tips:* tips on how to improve recycling and on its importance. They change for every report.

Figure 1 depicts the structure and the contents of the report.
To be eligible for the study sample, customers need to be single-contract residential users living in the city and endowed with the card for the solid waste disposal. The study sample includes more than 50,000 eligible customers with an active contract since (at least) January 2019.
The experimental design relies on the random assignment of two thirds of eligible customers to a treatment group which receives the report and one third to a control group, which does not. Within the group of treated households receiving the report, half receives the standard report as described above. The other half receives the report, as described above, along with a clear reference to the disposal cap, displayed in the cumulative solid waste disposal section. This information allows treated customers to keep track of

[2] Users weigh their disposed waste by major categories and obtain a proportional refund, ranging from 0.01 to 0.3 euro per kilogram, in the next bill.

their performance against the cap, which is calculated on a yearly basis. These customers also visualize an alert if the volume disposed in the quarter exceeds one fourth of the yearly cap assigned.
We follow a stratified individual level randomization procedure, to maximize ex-ante balance across the three experimental groups along a battery of important observable characteristics. Strata are obtained from the combination of the following variables:

- The disposal caps for unsorted waste in 2020
- The presence of any kind of benefit/deductible in terms of higher cap, due to the presence of children or health needs in the household (at the time of data extraction, i.e. April 2020)
- House size above the median
- Access to waste collection centres in 2019
- Having a valid e-mail access (hence possibly receiving the report by email vs by post)

We exclude strata with less than ten observations. We end up with 96 strata. Within each stratum, we sort customers by baseline unsorted waste disposal volume (in the period April 2019-March 2020) and assign adjacent customers to treatments and control group.

3 Research questions and analysis

The study addresses the following research questions. For each of them the specification, the test of hypothesis and the sample of analysis are indicated.

Research Question 1 *What is the impact of receiving the waste report on unsorted waste disposal and the probability of exceeding the yearly cap?*

We estimate the intention to treat effect (ITT) of receiving the report on unsorted waste disposal volume as follows:

$$y_{it} = \beta_1 Post_t + \beta_2 Prog_i * Post_t + h_t + g_i + \varepsilon_{it} \tag{1}$$

where y_{it} is customer i's volume of solid waste disposal in month t, normalized with respect to the control group waste disposal in the intervention period. $Prog_i$ is a treatment dummy which takes value of one for customers receiving the report, irrespective to the type of treatment, and zero otherwise, $Post$ is a dummy variable which becomes one after the delivery of the first report, i.e. July 2020. The regression

also includes month-by-year fixed effects, h_t, and household fixed effects g_i. Standard errors are clustered at the level of household, to allow for the presence of within customer correlation over time in the error term [1]. The exercise is carried out on the whole study sample.
As for the treatment effect on the probability of exceeding the yearly cap, we estimate a two-year (i.e. 2019 and 2020) panel with individual fixed effects. Similarly to model 2, the treatment effect is estimated through the interaction term $Prog_i * Post_t$, after controlling for $Post_t$. The outcome y_{it} is a dummy which is equal to one if the user exceeded the disposal threshold in the year.

Research Question 2 *What is the impact of being nudged about the unsorted waste disposal cap on unsorted waste disposal and the probability of exceeding the yearly cap?*

We assess the extent to which recalling the information on the yearly unsorted waste disposal cap, on the top of the standard report, influences waste disposal, with respect to receiving a standard report and no report. This is done by estimating the following model:

$$y_{it} = \beta_1 Post_t + \beta_2 Std\_Report_i * Post_t + \beta_3 Cap\_Report_i * Post_t + h_t + g_i + \varepsilon_{it} \tag{2}$$

where Std_Report_i and Cap_Report_i are dummies taking value of one if customers are assigned to the standard waste report or the report displaying the cap, respectively, and zero otherwise. The coefficients β_2 and β_3 reveal the effect of the receiving the report with and without cap indication, with respect to the control group not receiving it. By testing the hypothesis $\beta_2 = \beta_3$ we assess the extent to which the visualization of the disposal cap has any differential effect.

Research Question 3 *Is the impact of the waste report on unsorted waste disposal heterogeneous?*

We repeat the analysis in research questions 1 and 2 and look at the heterogenous treatment effects by adding the interaction of $Post$ and $Post * Treatment$ with the following baseline characteristics:

- Pre-treatment unsorted waste disposal above median
- Having passed the cap in the year preceding the launch of the treatment, i.e. in 2019
- The quarter the report refers to, which gives a measure of the distance from the cap and influences the salience of the information over the yearly cap

4 Data

All data used in the analysis are provided by our partner utility, after being anonymized.
As for general customer characteristics, we have access to:

- House size
- Household size (which typically determines the annual cap)
- Whether and when customers start benefiting from special conditions for their cap
- If the same utility also provides other services such as water, gas or electricity and whether customers receive consumption reports, similar to the one assessed in this project, on those resources

As for the main individual outcomes of the analysis, we have access to the following data at the customer level on a daily frequency:

- Number and volume of solid waste disposals and the collection point where they are disposed
- The date of delivery and the contents of the report seen by treated customers

The study period is expected to span from January 2019 to July 2021.

4.1 Sample Balance at Baseline

For each variable available at the time of treatment assignment, we conduct balance tests across treatment groups. We denote these variables as y_{i0} and for each of them we estimate the following equation:

$$y_{i0} = \beta_0 + \beta_2 Std\_Report_i + \beta_3 Cap\_Report_i + \varepsilon_{i0} \tag{3}$$

Balance is assessed by looking at the F-statistic of the test for joint significance of the treatment dummies. Table 1 reports, for a subset of variables employed for the construction of strata and the dimensions of heterogeneity available at the time of this writing, the mean and standard error in each treatment arm. The last column reports the p-value of the F-test of joint significance of the treatments in regression 3.

Tables and figures

Table 1: Summary statistics and balance

	Control		Standard report		Report with cap		
variables	Mean	SD	Mean	SD	Mean	SD	p-val of F-stat
N	18050		18051		18049		
UWD cap 2020	1348.371	242.232	1348.576	242.472	1348.479	242.341	0.997
Allowances in 2020	0.044	0.205	0.044	0.205	0.044	0.205	1
Above median house size	0.485	0.5	0.485	0.5	0.485	0.5	1
Pre-treat access to waste collection center	0.411	0.492	0.411	0.492	0.411	0.492	0.999
Has e-mail	0.376	0.484	0.376	0.484	0.376	0.484	1
Door-to-door collection	0.073	0.26	0.071	0.257	0.072	0.259	0.772
Pre-treat UWD	791.642	904.76	795.401	1007.858	792.205	913.731	0.925
Exceeded the cap in 2019	0.087	0.282	0.087	0.282	0.088	0.283	0.984

Note: This table reports customer level summary statistics (n. of observations, mean and standard deviation in each treatment arm). The last column reports the p-value of the F-test of joint significance of the treatments in regressions where the baseline characteristic is the outcome variable.

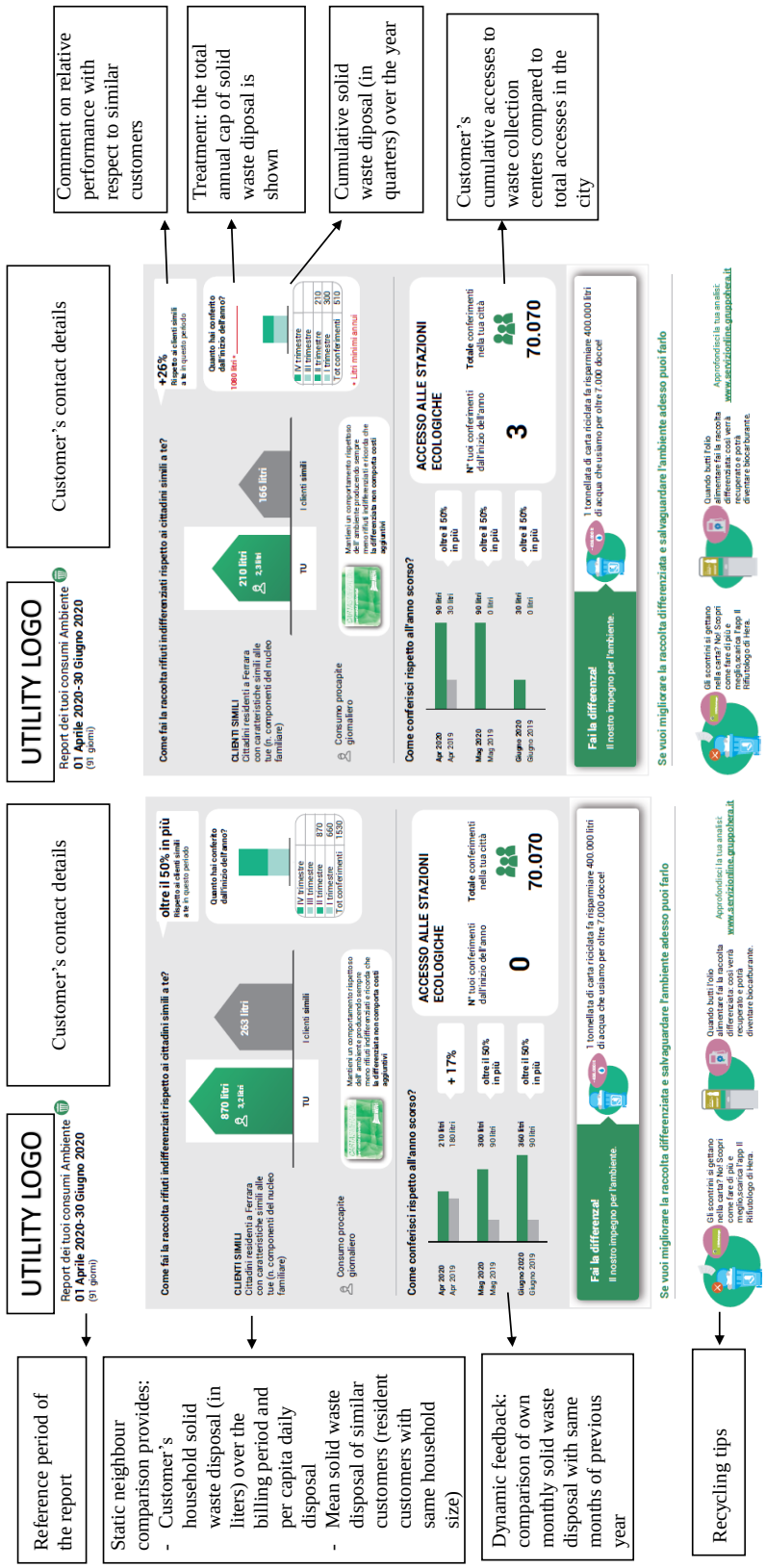

Figure 1: Waste report

References

[1] M. Bertrand, E. Duflo, and S. Mullainathan. How Much Should We Trust Differences-In-Differences Estimates? *The Quarterly Journal of Economics*, 119(1):249–275, Feb. 2004.