Encouraging Household Waste Separation: Can Social Comparison Help?

EDUARDO CARDADEIRO [a,b], CATARINA ROSETA-PALMA [c], TITO LANEIRO [b]

[a] CICEE – Research Center in Economics & Business Sciences, Lisbon, Portugal, [b] Universidade Autónoma de Lisboa, Lisbon, Portugal, [c] ISCTE - Instituto Universitário de Lisboa, Lisbon, Portugal

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ABSTRACT

As more people move to urban areas, larger flows of solid waste are generated, bringing about significant challenges in municipal solid waste management. Implications of management failure can be serious for human health and for the environment, and landfills are not a sustainable solution. European legislation makes it clear that business-as-usual is not good enough and sets ambitious targets for the coming years. In Portugal, waste separation at source is far below the desired levels, highlighting the need for policy change. Other authors have attempted to stimulate resource conservation, especially for water and electricity, using social-comparison nudges. In this paper, we describe a similar field experiment for waste, developed in 6 parishes ("freguesias") in the north of Portugal; treatment households received a message comparing their parish's per capita deposition of sorted waste in existing collection bins to that of a neighboring parish or to higher environmental targets. Finally results, however, are contradictory.

Keywords: Social comparison; Waste recycling; Field experiment

I. Introduction

The management of municipal solid waste is one of the thorniest issues in many urban areas, as increasing quantities of waste generate higher service costs and make it ever harder to achieve safe disposal. Inadequate waste management can have serious implications not only for human health but also for the environment, yet collecting unsorted waste and sending it to landfills is a clearly unsustainable solution (UNEP, 2015). Still, it is often said that in natural systems there is no such thing as waste, and this view underpins the circular economy strategies that have gained recognition in recent years. In the European Union, the Waste Framework Directive (2008/98/EC) defined a waste hierarchy, where prevention takes top spot, yet suitable disposal got most of the policy attention in practice, although it is the very last option in the hierarchy.

Both the Circular Action Plans (COM/2015/0614, COM/2020/98) and the European Green Deal (COM/2019/640) acknowledge waste as a resource flow that must be integrated to ensure higher resource-use efficiency. Current EU policy enshrines various targets, such as: 70% of packaging waste must be recycled by 2030 (2018/852), with flow-specific targets; the re-use and the recycling of municipal waste must be increased to a minimum of 65 % by weight, by 2035 (2018/851); and an upper bound of 10% is placed on landfilled waste, out of the total amount of municipal waste generated by weight, by 2035 (2018/850). While municipal waste generation per capita shows no sign of decreasing, recycling rates have been flat or even decreasing, namely for plastic packaging[1]. Portugal has been one of the laggards, with 56% landfilled waste[2] and recycling rates of 30.4% for overall municipal waste and 38.1% for plastic packaging in 2021.

To improve recycling performance and minimize landfill disposal, it is critical to guarantee the proper separation of waste streams where they arise, e.g. within households. This diminishes the contamination of materials, thereby producing more useful and valuable resources (Knickmeyer, 2020). Many different policies have been tried to support waste separation at home, but the reality is that significant challenges remain. Various authors have detailed the factors behind individual waste-separation choices. Barr et al. (2001) propose a framework where environmental values influence behavioral intention and subsequent action, although situational and psychological variables affect both intention and action. For recycling[3], the authors find that in Exeter, UK, norms, such as knowing that people recycle and viewing this as the accepted behavior, are fundamental determinants of household choices. A more recent survey (Knickmeyer, 2020) organizes relevant factors differently, distinguishing between socio-demographic factors, psychological factors (including environmental concern), economic and legal factors, noting that comparative feedback to households can be effective. Another systematic review (Zhang, 2023) presents micro and macro factors separately, including variables such as demographics, norms, attitudes, emotions and knowledge in the former category and policies, economy, culture, and markets in the latter. The author proposes that waste-separation policy design use the 4C marketing mix theory (customer needs, cost, convenience, and communication). The difference between factors pertaining to individuals (micro) and to households (meso) can also be ascertained (Macklin et al., 2023). Most studies agree that recycling behavior is multifaceted, depending on a variety of factors (see also Hage et al., 2009; Oluwadipe et al., 2022; Varotto & Spagnolli, 2017), but social norms are always found to play a leading role.

Blake (1999) attempts to address the difference in attitude and behavior, explaining the gap found in this process. This model points out that most models of pro-environmental behavior are limited, because they do not take into account individual,

[1] https://ec.europa.eu/eurostat/web/circular-economy/monitoring-framework
[2] https://ec.europa.eu/eurostat/web/circular-economy/monitoring-framework
[3] Technically, people do not recycle at home, only separate waste flows to prepare them for recycling or composting. Nonetheless, several authors use "recycling" to describe the desired household behavior so we occasionally use this term.

social and institutional constraints, assuming that human beings are rational and make systematic use of available information. According to Kollmuss and Agyeman (2002), although Blake's model is very useful, as it combines external and internal factors and describes them in some detail, it does not take into account social factors, such as family pressures and cultural norms, nor does it explore psychological factors in greater depth, such as the lack of time for certain behaviors.

Another model to take into consideration is the ABC Model (Attitude, Behavior, Context) which is considered relevant in the attempt to develop a meaningful and integrated model to explain environmental behavior and attitude and behavior restrictions. It is also relevant for overcoming the internalist-externalist dichotomy found in social psychology literature (Jackson, 2005). In the language of the ABC model, behavior (B - behavior) is "an interactive product of variables from the sphere of personal attitudes (A - attitude) and contextual factors (C - context)" (Stren, 2000, p. 415). Attitude variables (A) can include a variety of specific personal beliefs, norms, values, and pre-dispositions to act in certain ways. However, contextual factors (C) can potentially include a wide variety of influences, such as: monetary incentives and costs, physical capacities and constraints, institutional and legal factors, public policy support, interpersonal influences (social group pressures, loyalty, and participation in environmental groups).

As for monetary incentives, while they have long been used to promote resource efficiency in areas such as energy or water consumption, the same cannot be said for waste. The costs associated with waste management systems are often difficult to recover from households, especially if the goal is to do so in a way that provides adequate waste reduction and separation incentives. Pay-as-you-throw (PAYT) schemes can be successful but are infrequent, perhaps because they bring about potentially undesirable outcomes, namely increased illegal dumping and crowding out effects (Abbott et al., 2013; Knickmeyer, 2020; Thøgersen, 2003). Deposit refund schemes, on the other hand, can be effective but are often expensive to implement. In regions where household pay waste fees, they are commonly disconnected from outcomes - in Portugal, for example, fees depend on household water consumption, since water meters are ubiquitous. Given the relatively low waste separation rates in the country, the search for better policies is paramount. In this study, we develop a field experiment in two Portuguese municipalities, by sending social comparison information to households in some parishes while controlling the total amount of waste generated per parish ("freguesia") before and after the interventions. As in many other places, most waste production and separation information in Portugal is not available at the household level, so a parish-level assessment is provided. This type of intervention has seldom been carried out, as noted in the literature review below, so we expect our contribution to be useful to other locations.

The next section summarizes existing studies on the application of non-monetary behavioral incentives to household waste separation. Section III presents the case study area and the methodology, while Section IV discusses the results.

II. Nudges for Household Waste Management

When the concept of nudges was proposed (Thaler & Sunstein, 2009), the idea of providing tips to change people's behavior through more thoughtful choice framing seemed to have significant potential to contribute novel solutions to common environmental problems. One fruitful approach led to researchers partnering with utilities in water (Ferraro et al., 2011; Ferraro & Price, 2013) and energy (Allcott, 2011), to send tailored messages to a sample of customers comparing their consumption levels with those of their neighbors. These initial field experiments found that effects on resource consumption were significant, which was considered especially beneficial given the low price-elasticity of demand for these goods. Applications to waste management have not been as popular. Carlsson et al. (2021) distinguish "pure" nudges that appeal to doing the right thing from "green nudges" that aim to diminish negative environmental externalities. In their empirical review of the latter, only 4 peer-reviewed papers (out of around 40) cover the waste sector, two of which focus specifically on recycling. Likewise, when Wee et al. (2021) present 37 more recent peer-reviewed papers on nudging to promote pro-environmental behavior, only seven are waste-related and a single one considers recycling participation, albeit in a university context (the remainder cover food waste, paper usage and reducing waste on the floor). Of the different nudges that have attempted to increase waste separation, few are field experiments. Nonetheless, some authors find significant results with nudges such as clear trash bags, duty-orientation messages, positive injunctive norms and providing comparative feedback (Akbulut-Yuksel & Boulatoff, 2021; Brekke et al., 2010; Dupré & Meineri, 2016; Salazar et al., 2021).

The important role of social norms to enhance waste separation by households is highlighted in a study that uses real collection data for English local authorities (Abbott et al., 2013, p. 16). The authors note that: "in the context of household recycling it may be more attractive to policymakers to rely on social norms rather than other measures to guide behavior", even if the positive effect of other people's recycling seems to be stronger through peer groups (age, ethnicity) than locality alone. In Sweden, Hage et al. (2009) use results from a questionnaire to also emphasize the role of beliefs about other's behavior on separation of packaging materials, especially for paper and plastic packaging.

In terms of methodology, few papers present field experiments such as ours. The exception is Milford et al. (2015), which describes a Norwegian study that included the provision of social comparison feedback to households as well as advice for recycling and waste reduction. The households who received the treatment letters on recycling did increase their recycling rates by a significant 2% compared with the control households, an effect that was strongest for those who had a prior lower-than-median recycling. Finally, Zhang and Wang (2020) use data from the Chinese General Social Survey to show that compared to other cities, in the pilot cities "implementing a waste separation program which makes waste sorting and recycling more visible to local inhabitants helps to stimulate the emergence of a social norm to sort and recycle" (p. 6), with significant

effects on their propensity to voluntarily sort their waste even after long periods of time (in this case, 13 years).

III. Case study description

Keeping in mind the goal of studying the impact of a non-financial stimulus (i.e. a nudge) to improve household's waste segregation, we designed a field experiment consisting in sending social comparison information regarding the recycling behavior pattern of one parish's population in relation to the neighbouring parish (message type 1) or in relation to the recycling behavior that would be consistent with waste management environmental targets (message type 2).

Three parishes were selected in each of two municipalities in the north of Portugal – Viana do Castelo and Barcelos. In each municipality, the population of one parish received type 1 messages and another parish received type 2 messages, while a third parish was used as the control group. Overall, we used four intervention and two control parishes, during the intervention period that started on the 10th of April 2022 (date of first message) and ended on the 4th of August 2022 (date of last message). We collected data on the quantities of materials deposited by households in street recycling containers (see Figure 1 below) from the 1st of September 2021 to the 31st of August 2022 (12 months). The bins are color-coded as follows: glass (green bins), paper and cardboard (blue bins) and plastic and metal packaging (yellow bins).

Figure 1
Street recycling containers

A. Selection of the intervention and control parishes

The selection of the parishes for the field experiment required special attention from the research team, in areas such as data availability, stakeholder engagement and control for undesired factors affecting household waste-sorting behavior in the intervention areas during the research project. First of all, from the 308 municipalities in Portugal, only few had already implemented an information system that provided data on quantities per

container emptying – the "360 waste" system – namely those located in the area managed by the waste management entity RESULIMA, where Viana do Castelo e Barcelos belong. RESULIMA's top management got enthusiastic with the project from the first moment and provided institutional, logistic and technical support for parish selection and data extraction. The research team also made sure that the Presidents of the Parish Councils supported the project before selecting their parishes for intervention, because it is an important condition to appropriately deliver both physical and digital supports with the intervention messages.

Additionally, the selected parishes should be as homogeneous as possible regarding socio-economic factors that could influence household waste-sorting behavior. Selecting contiguous parishes favors that homogeneity in demographic and economic activity variables. The selection of small parishes allowed a better control of the field work, the ability to individually deliver messages to each household, greater tracking of recyclable waste flows and the capacity for segregating messages type 1 and type 2 to neighboring parishes with minimal risk of cross messaging. The selection of the field experiment areas also met the condition that throughout the study period there were no changes in the waste management service, neither by the introduction of additional (or new) containers or relocation of the existing ones, nor by changing the collection methods and routines. Furthermore, in the same period there was no other campaign focused on households' waste in the region that could introduce noise into the controlled messages of this experiment.

Taking all these concerns into consideration, in the municipality of Viana do Castelo the parishes of Amonde and Outeiro were selected for intervention and Perre as control parish, while in the municipality of Barcelos, parishes Coussorado and Panque were the intervention ones and Aborim the control. Basic parish characterization data is presented in Table 1.

Table 1: Risk - Characterization of the selected parishes.
Notes: * Conventional dwellings of usual residence (no.). Source: INE Census 2021.

Municipality		All parishes' range		Selected parishes		
Viana do Castelo		Min	Max	Amonde	Outeiro	Perre
Population	85,784	231	25,158	231	1,060	2,772
Age group	0-14 y	7%	14%	7%	10%	11%
	15-24 y	7%	12%	7%	11%	8%
	25-64 y	42%	58%	52%	49%	54%
	>= 65 y	18%	44%	33%	30%	27%
Households*	32,993	96	10,451	96	342	964
Barcelos		Min	Max	Aborim	Cossourado	Panque
Population	116,766	692	12,828	827	758	631
Age group	0-14 y	9%	15%	13%	12%	12%
	15-24 y	10%	15%	11%	11%	11%
	25-64 y	50%	60%	55%	54%	57%
	>= 65 y	14%	27%	21%	22%	20%
Households*	40,173	214	4,961	299	274	214

B. Message selection and planning

Within this kind of field experiment, the messages sent to households play a threefold role: (1) they are supposed to constitute an initial "call for action" stimulus – making the receiver sensitive to the need of doing something differently; (2) they also play the important role of informing the receiver on how to change behavior, as the success of the initial stimulus will only result in different behavior if household members know what to do; finally, (3) they provide feedback throughout the intervention period – retro-feeding the action (eventually) adopted after the initial information – thereby reinforcing the initial stimulus and providing an incentive to do better. In order to maximize this incentive, the feedback messages should be as individualized as possible. However, in the context of households without a door-to-door collection system, there is no information on each household's segregation of recyclable materials. Selecting small parishes was one way of minimizing this drawback, as feedback on the parish quantities was provided throughout the field experiment period.

It was planned to send four messages from the 10th of April to the 4th of August, incorporating in each message the information on recyclable quantities observed until the previous week, to provide the intended feedback.

Messages were conveyed through physical pamphlets delivered by the Parish Council (the President himself in some cases) to every household, posters at selected public locations in each parish (i.e. the church entrance) and electronic support at parishes' websites and social networks. A specific script was also introduced in the existing waste recycling call line ("Linha da Reciclagem"), to make sure that any inhabitant from the intervention parishes who called the line to clarify any doubts would receive the appropriate message. To leverage the impact of the messages, the project was debated at the local radio broadcast station and was announced in local newspapers. Previous contacts were also made with local priests.

Messages type 1 were sent to Amonde and Panque, comparing the monthly per capita recyclable quantities of the former with their neighbors' at Outeiro (which are higher) and of the latter with those of Cousorado. Messages type 2 were sent to Outeiro and Cousorado, comparing their quantities to the per capita "reference" of 6kg/month. The initial pamphlets are presented in Figure 2.

The design of the pamphlets presented a challenge to balance scientific accuracy, simple wording, short and positive sentences, visual impact, and institutional information. The association to past waste recycling campaigns was also considered. Municipalities and parishes' institutional logos were introduced to reinforce the credibility of the message and reduce the risk of discarding by households.

Messages were adjusted to the data on recyclables collected in the parish but keeping the same principles and visual appearance. For example, the third message to Amonde: "Amonde inhabitants increased recycling by 40% to 2.0 kg per capita month. They reduced the gap to Outeiro parish".

Figure 2
Initial pamphlets, delivered on the 10th of April.

Message type 1

Message type 2

Type 1 initial message for Amonde: "Each Amonde inhabitant recycles 1.8kg a month. In the neighboring Outeiro parish, they recycle 3.0kg a month. From waste to resources – when everyone does their job, we all win. What shall we do? Easy. Recycle everything, everywhere!"
Type 2 initial message for Outeiro: "Each Outeiro inhabitant recycles 3.0kg a month. To clean the planet and reach our environmental targets we must recycle 6.0kg a month. From waste to resources – when everyone does their job, we all win. What shall we do? Easy. Recycle everything, everywhere."

C. Data collected

The information system "360 waste" is a dynamic route-planning system that gathers daily information of every truck route, for every container, date, time, fullness level and quantities collected[4]. The data for the 37 containers located in the six selected parishes (Table 2) was periodically extracted from the system database and sent to the research team for analysis and validation. Any doubt was immediately clarified with Resulima's technical team.

During the experiment thousands of data points were processed, corresponding to 3,535 container emptying events, collecting 227.3 tons of recyclables, of which 58% were

[4] Quantities are weighted when the truck empties at the end of the route and allocated to each container collected based on its dimension and the fullness level estimated by the appropriately trained driver at the moment of container emptying. This estimate is introduced in the system at that moment using the driver's terminal on the truck.

glass, 20% paper & cardboard and 22% plastic & metal (Table 3).

Table 2 – Recycling containers monitored.

Containers (no.)		**Parish**		
		Amonde	Outeiro	Perre
Glass	(green)	3	6	7
Paper & Cardboard	(blue)	3	6	7
Plastic & Metal	(yellow)	3	6	7
		Aborim	Cossourado	Panque
Glass	(green)	5	9	7
Paper & Cardboard	(blue)	5	9	7
Plastic & Metal	(yellow)	5	9	7

Table 3 – Container emptying events.

Containers (no.)		**Parish**		
		Amonde	Outeiro	Perre
Glass	(green)	8	73	173
Paper & Cardboard	(blue)	38	257	669
Plastic & Metal	(yellow)	51	288	728
		Aborim	Cossourado	Panque
Glass	(green)	61	66	20
Paper & Cardboard	(blue)	233	234	84
Plastic & Metal	(yellow)	229	229	94

As the intended data analysis methodology consisted in comparing per capita recycling quantities before and after message stimulus, data on quantities collected in the first emptying after the initial message was not considered, because part of the flow could not have been influenced by that message. As the collection period is not rigid, this analysis was made for each of the containers. Data is presented on Table 4.

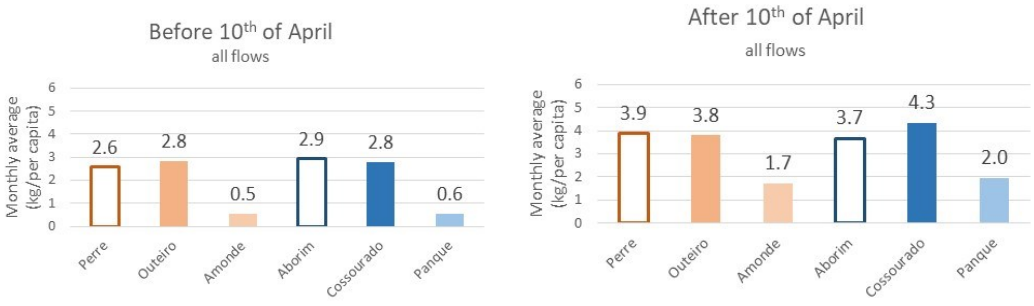
Table 4 – Descriptive statistics on quantities collected from 1st Sept 2021 to 31st Aug 2022.

Quantities collected		**Parish**								
		Amonde			Outeiro			Perre		
		Q	*avg*	*cv*	*Q*	*avg*	*cv*	*Q*	*avg*	*cv*
Glass	(green)	3,373	422	0.22	25,753	353	0.35	59,609	345	0.43
Paper & Cardboard	(blue)	815	21	0.54	7,380	29	0.40	20,436	31	0.40
Plastic & Metal	(yellow)	1,162	23	0.50	10,034	35	0.34	23,857	33	0.45
		Aborim			Cossourado			Panque		
		Q	*avg*	*cv*	*Q*	*avg*	*cv*	*Q*	*avg*	*cv*
Glass	(green)	17,846	293	0.30	20,525	311	0.35	6,168	308	0.35
Paper & Cardboard	(blue)	7,008	30	0.34	6,825	29	0.37	2,154	26	0.48
Plastic & Metal	(yellow)	6,314	28	0.27	5,851	26	0.33	2,190	23	0.34

IV. Results and Discussion

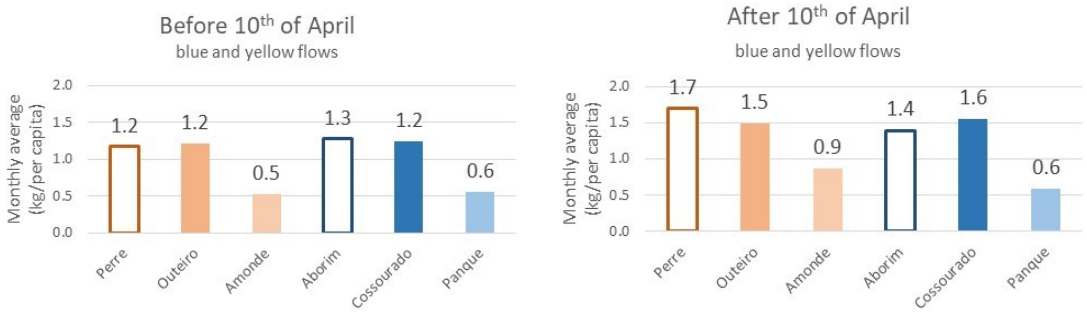
Average monthly per capita quantities of recyclables before the intervention showed that Outeiro and Cossourado were in line with the correspondent control parish, while Amonde and Panque were far behind. The figures for these latter parishes are biased by the fact that no data on glass quantities was used for this calculation, because the number of valid observations was too small to calculate the monthly average. The average for the period after the first stimulus was clearly higher for all parishes (Figure 3), possibly reflecting an increasing tendency for household recycling in Portuguese society. The huge increase observed in Amonde and Panque (over 200%) is explained by the inclusion of glass quantities in the calculation, which does not allow for any relevant comparison.

Figure 3
Monthly per capita quantities before and after the first stimulus.



Average monthly quantities increased 50% at the control parish in the municipality of Viana do Castelo, but only 25% at the control parish in the municipality of Barcelos, a significant difference that could be explained by each municipality's specific factor and would not (by itself) compromise the experiment objectives. However, when comparing the evolution of the quantities at these parishes with the quantities of Outeiro (in Viana do Castelo) and Cossourado (in Barcelos) one faces contradictory signals. Quantities at Outeiro increased 34%, less than at the corresponding control parish, suggesting the type 2 messages stimulus might have had a negative impact, while quantities at Cossourado observed an increment of 55%, more than the corresponding control parish, suggesting precisely the opposite.

Figure 4
Monthly per capita quantities before and after the first stimulus (without glass).



Type 1 messages' effects could not be tested due to the lack of relevant information for glass in Amonde and Panque. Therefore, we considered recycling quantities for the other two waste flows aggregated. As glass accounts for 58% of the collected quantities, removing glass would also avoid any specific effect of this flow.

Regarding the effects of type 1 messages, if compared the increments at Amonde with those at Perre it might appear that the effects were negative, the results obtained when comparing Panque with Aborim (Table 5). Without glass quantities, consistently with the results on the effects of type 2 messages, outcomes are contradictory.

Table 5 – Pre/pos stimulus incremental quantities, without glass.

Quantities increment		**Parish**		
		Amonde	Outeiro	Perre
Paper & Cardboard + Plastic & metal	(blue) + (yellow)	45%	23%	65%
		Aborim	Cossourado	Panque
Paper & Cardboard + Plastic & metal	(blue) + (yellow)	9%	25%	6%

Likewise, the analysis of the relative effects of type 1 messages compared to type 2 is inconclusive. The comparison of quantity increments at Amonde with those at Outeiro would suggest a higher impact of messages type 1, but the conclusion would be the opposite based on the comparison of the results at Cossourado with Panque.

Different time cuts were explored to distinguish the pre-stimulus from the post-stimulus period, namely using the date of the second message (16th of May), but in all circumstances contradictory and, therefore, inconclusive results were found. There was, therefore, no evidence that the messages' stimulation for increasing household waste sorting at the four intervention parishes produced any effective results. That might have happened for several reasons.

One hypothesis to explain these results is the positioning of recycling bins. The literature suggests that it is easier to take up recycling when these are closer to the consumer. Still, when access to recycling facilities is very difficult or very easy, it doesn't matter whether people have pro-recycling attitudes or not, since in the first case, hardly anyone recycles and in the second, most people do (Jackson, 2005).

We can also take into account that the same message can have different effects depending on the generation it is trying to reach, as mentioned in the peer-group analysis described in Abbott et al. (2013). Vacari et al. (2017) note that generations include people born during a certain period and whose paths have similarities. According to generational theory, the members of each generation are different from those of another in terms of their characteristics, values, beliefs, interests and expectations (Strauss & Howe, 1997). Some well-known segmentation approaches employ descriptive variables such as demographic and geographic methods, along with psychographic approaches that attempt to go beyond the surface of consumers in order to understand purchase motivation, among other behavioral issues. For Izagirre-Olaizola et al. (2015), motivation is significantly associated with ecological behavior. For instance, younger people recycle driven generally by altruistic factors, namely consumer perceptions in which the

individual recognizes their needs and desires, as well as knowledge about the environment.

Messages not reaching the population (or not doing so intelligibly) is another one of the possible explanations for the lack of clear results, despite all the care in messages' conception and all the communication channels used to convey them. Furthermore, the comparison of parish population behavior with the neighbor parish population (messages type 1) or with a reference "good" behavior (messages type 2), might not constitute a strong enough call to action stimulus if each inhabitant does not have a strong feeling of belonging to their parish community. In this case, even assuming the message reached the population in proper condition, it might not have sparked a concrete individual action.

An additional, related, reason might be associated with the impossibility of providing feedback that is adjusted individually (or, at least, as is common for other field experiments, at household level), thereby breaking the link between the feedback provided during the experiment and the stimulus for action. This makes it especially challenging for social comparison nudges to be effective in improving waste management, since most locations do not collect household data, unlike what is common in water or electricity, where meters are ubiquitous.

Nonetheless, the research team made use of all possible means in the field, as well as the technical knowledge of experienced waste management personnel and top managers, and it was composed of researchers from economics and psychology, who brought the knowledge to design and implement the experiment. There is probably not much room for improvement in the real context of Portuguese waste management. Improved recycling outcomes may require a more structured change in the way waste collection services are organized and how the whole industry functions, namely adjusting economic incentives.

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