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Social norms and pro-environment behaviours: heterogeneous response to signals

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Abstract: Previous research on pro-environment behaviours demonstrated an effect of communicating social norms to subjects. In this paper, we extend this work by isolating the effects of information about (i) the absolute level (strength) of the norm (ii) its geographic proximity (iii) whether the norm is stated in relative terms. We also show how previous pro-environmental behaviours interact with social norm information. The context is a stated preference choice experiment on recycling behaviours by households in Poland. The main finding to emerge is that social norm effects on preferences seem to be very context-dependent; there is no evidence of generalizable effects which would be useful to policy designers.

Keywords: recycling, social norms, stated preferences, choice modelling

JEL codes: D04, D91, Q51, Q53

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1. Introduction

Increasing the willingness of citizens to recycle household waste is an objective for many governments, for example to reduce plastics pollution to the sea, as part of climate change policy, or in order to meet European Union targets for reductions in wastes disposed to landfill sites. Recycling efforts by households increase the supply of public good-type benefits, since more recycling of a given quantity of waste for disposal can lead to less water pollution and lower greenhouse gas emissions from landfill sites. The policy design problem is one of encouraging citizens to contribute to this public good. A large empirical literature, dating back to the mid-1990s (Hong et al. 1993), shows that peoples' recycling and waste disposal behaviours respond both to price incentives ("pay as you throw") for conventional waste disposal, and to changes in waste collection system which impact on the costs of effort to recycle (such as the requirement for households to source-separate wastes; or the deployment of kerb-side recycling pickups). Moreover, researchers including Bartelings and Sterner (1999) and Hage et al. (2009) have identified the importance of what the former refer to as "non-economic motives" for recycling behaviours: beliefs, ethical positions and a regard for the behaviour of others.

A wide literature of behavioural economics tells us that economic agents respond to many more influences than changes in relative prices and income (Chetty 2015; Nyborg et al. 2016). For environmental public goods in particular, Croson and Treich (2014) argue that "socio-psychological factors play an important role", and note that changes to the framing of decisions might be particularly important for pro-environment behaviours. One such aspect of the framing of choices is what people understand or believe about the behaviour of others, that is, about a social norm.

This paper contributes to the literature on social norms and pro-environment behaviours by investigating how preferences and willingness to pay (WTP) for higher levels of recycling within a household depend on the communication of social norms, in particular on the *strength* and *geographic proximity* of the social norm. We also investigate whether relative or absolute information is more effective at changing choices; and whether the size of social norm effects depends on the prior behaviour of the individual. These issues are important if governments wish to employ social norm-based nudges alongside prices and infrastructural improvements to help achieve recycling goals.

More specifically, the research questions we address are:

RQ1: Does stated willingness to pay for additional levels of recycling respond to information on a social norm?

RQ2: Does the size of this response depend on the "average performance level" encapsulated by the social norm?

RQ3: Does the size of response depend on the geographic proximity of the norm, namely whether it relates to behaviour in one's own city, or to average behaviour across the country in which one lives?

RQ4: Does information that allows the respondent to infer the relative magnitude of the norm matter?

RQ5: Does the size of any social norm effect depends on the individual's past behaviours with respect to recycling?

Our research design and subsequent analysis are based on a theoretical model of pro-environment behaviours presented in Czajkowski et al. (2017). This model is now briefly outlined, and we explain how it can be exploited to provide a basis for testing the research questions noted above (section 2). In section 3, previous literature on social norms and pro-environment behaviours is summarised, focussing on applications within economic analysis. Sections 4 and 5 describe the empirical context for our case study, the design of our experiment, and econometric analysis of results. The institutional context within which the case study is set proves to be particularly useful for testing the issues raised by our research questions. Discussion and conclusions follow in the final section.

2. A model of recycling behaviour

In this section, we summarise the model presented in Czajkowski et al. (2017), then explain how it can be used to derive predictions for each of the research questions noted above.

The model focusses on an individual who cares about her consumption c of a private good, a public good G, which we may think of as environmental quality (but in our context, is the total quantity of recycled material in a given area, e.g., a city), her own self-image as a morally responsible person S, and what she expects others' image of her to be, J:

$$U = u(c, G) + S + J, \tag{1}$$

where u is a quasi-concave and increasing function. Let $g \geq 0$ be the person's contribution to the public good: here, her recycling effort.

The budget constraint is given by

$$W = c + pg, \tag{2}$$

where W is the individual's income, and the price of consumption is normalized to one. The parameter p is an implicit price of contributions to the environment in terms of lost consumption; if recycling is a source of disutility, this corresponds to a higher p, and if sorting is intrinsically rewarding, this reduces p.

The total supply of the public good depends on the contribution of every individual in society (in our case study, we fix this as constant across all choice situations). However, each individual knows that their own effort is only a tiny contribution to the production of the public good, so that in this theoretical set-up, the individual assumes that G is exogenously determined and fixed from her viewpoint (as noted above, we choose an empirical context in which is this true). Despite this, the individual can still decide to contribute to the environment due to her desire to improve her own self-image and others' images of her. Assume that self-image is given by

$$S = -a\left(g - g^{*}\right)^{2}, \tag{3}$$

where a is a weakly positive constant, and $g^{*} \geq 0$ is i's view of the morally ideal contribution (see Brekke et al. 2003; Brekke et al. 2010; Nyborg, 2011). Any deviation from the morally ideal behaviour yields a psychological loss. The morally ideal contribution g^{*} may be viewed as a measure of the individual's perceived moral responsibility for recycling. However, of more importance for this paper is how utility depends on her perception of the actions of others, and how this compares to her own actions. That is, the individual may also care about others' image of her. Assume that her perception of the judgement of others is given by

$$J = -b\left(g - g^{**}\right)^{2} \tag{4}$$

where b is a weakly positive constant, and $g^{**} \geq 0$ is the individual's belief about *her peers'* view of the ideal contribution for a person like herself.[1]

[1] In the present paper, the ideal contributions g^{*} and g^{**} are taken to be exogenously given. However, note that in several previous papers, the morally ideal contribution has been assumed to be increasing in the social value of contributions (Brekke et al. 2003; Brekke et al. 2010; Nyborg 2011).

Czajkowski et al. (2017) then show that whether and how much the individual will choose to recycle depends on the extent to which she feels obliged to do so (g^{*} and g^{**}), the strength of her preference to conform to these duties (the preference parameters a and b), and the loss of generalized consumption benefits (including any monetary cost as well as costs in terms of time or inconvenience) caused by the marginal recycling contribution. They also show that if g^{**} (the social norm) increases marginally, all else fixed, the optimal contribution increases by $\{b/(a+b)\}$.

This is the key result for the present paper. To test the research questions above, we explore different ways in which g^{**} varies: higher or local levels of recycling behaviour by others (referred to here as the *size of the norm)* when the relevant peer group is all people living in one's one city; or the behaviour of those simply living within one's own country (a distinction referred to here as *geographic proximity*). Information that a given level of g^{**} (e.g., 50% of all people in the relevant peer group recycle) could have a different impact on one's desired contribution to the public good (the overall level of recycling) if a national peer group pressure is less influential than a more local peer group pressure, since the b parameter value (marginal disutility of being different to others) can depend on who those "others" are. That is, evidence for a *geographic proximity* effect would come from a comparison of b values when the context for the social norm is changed from "one's own city" to "the whole country" (Goldstein et al. 2008). A geographic proximity effect is also likely if one considers the sub-set of people conforming to a given behaviour who are likely to sanction me for breaking the norm: this subset is more likely to be composed of those living close to me than those living further away, even if the latter are members of a relevant peer group (Masclet et al. 2003).

A *size of norm* effect would occur if, for a given reference group (e.g., people living in own's own city), the social norm changes from 35% recycling to 70% recycling. Similarly, information which refers to a relative versus absolute level of recycling in a social norm can also be thought of as having a potentially different effect on how much she wants to recycle personally (through more sorting) if a relative norm has a different utility impact (different b) than an absolute norm – referred to from now as a *relative versus absolute norm* effect. In the case study described below, we generate a relative norm by relating recycling levels in one's own city relative to the national average. It is these differences in the b parameter, which we estimate by using different treatments within our sampling strategy, which allow us to investigate the effects of changing the nature of the social norm information as a policy nudge.

Finally, one's previous experience with recycling might determine how costly or pleasurable additional recycling would be in a new choice situation. A *past behaviour* effect would arise though variation across individuals in the parameter p above, since this shows how costly individuals perceive additional recycling effort to be.

3. Social norms, pro-environment behaviours and recycling

A social norm comprises both an awareness of the behaviour of some important reference group (a descriptive norm), and a desire to make one's own behaviour more like that of this reference group, due to a fear of social sanction (an injunctive norm).

Research on the effectiveness of social norms' in changing humans' behaviour had started in social psychology long before it was first applied in the behavioural economics (Cialdini et al. 1990; Schultz 1999). Interventions based on social norms proved to be effective in changing individuals' choices in some situations; at first in laboratory studies, then also in field experiments (Schultz et al. 2007; Shang and Croson 2009). There is also a very large literature on the role of social norms in public goods games (Sliwka 2007; Shang and Croson 2009). Social comparisons are also known to influence the supply of effort in teams (Gächter et al. 2012). The body of evidence on the role and influence of social norms on choices and behaviour is huge.

In empirical investigations on the influence of social norms on environmental behaviour, two main approaches are taken. The first communicates social norms as a "cue", a new reference point. This norm can take different forms. First, it can be a feedback on the level of action taken by neighbours, information about the number of people who take an action, or by suggesting what actions other people in a reference group undertake or support. A second approach is to ask people what they think the social norm is, and what their concerns are about others' perceptions of their own behaviour (this was the approach taken in Czajkowski et al, 2017).

The most famous examples of studies on role of social norms in the environmental area include large-scale applied microeconomic experiments, some based on hundreds of thousands of observations, which show that individuals informed or reminded about the behaviour of relevant others may reduce energy consumption (Schultz et al. 2007; Nolan et al. 2008; Allcott 2011; Ayres et al. 2013) or save water (Ferraro et al. 2011; Ferraro and Price 2013). Allcott (2011) uses data from an American electricity company to show that providing consumers with information on the average level of electricity use by their neighbours and allowing them to

compare their own use with this social norm reduced electricity consumption by 2% relative to a control group. Interestingly, this treatment effect did not seem to fade with time once treatment had ended (Allcott and Rogers 2014). Those people with electricity use much higher than the average cut consumption by the greatest fraction, whilst those with lower-than-average consumption did not increase electricity use. Ferraro and Price (2013) evaluate the effects of social comparison information on demand for water by residential customers in the USA. They found that such information had a bigger effect on consumption than simply asking people to reduce water use or telling them how to do so; and that the effects of social comparison information was greatest for those consumers who had relatively high water use. Finally, Goldstein et al. (2008) found that re-use rates of towels in hotel rooms fell when guests were given information on what proportion of other hotel guests re-used their towels (on environmental grounds), and that this effect was strongest when the information was (claimed to) relate to the exact room in which people were staying. Positive effects of social norms were also found in other domains such as conservation schemes targeted at foresters and farmers (Chen et al. 2009; Kuhfuss et al. 2015) .

Recycling is a form of pro-environmental behaviour, which can easily be classified as pro-social behaviour. It is individually costly, requiring the allocation of time, space, and effort (Bruvoll et al. 2002) – and results in provision of a public environmental good (Abbott, Nandeibam and O'Shea 2013). Nevertheless, when given the opportunity to recycle, some individuals engage in it without any monetary motivation (Berglund 2006; Briguglio et al. 2016). A positive willingness to pay for sorting was also found for population on Poles in a study by Czajkowski et al. (2014); whilst in a follow-up study, Czajkowski et al. (2017) show that this positive willingness to pay for a substantial group of respondents is motivated by belief in a social norm, namely their perception that their neighbours would judge them badly for not engaging in recycling efforts.

Using aggregate rather than individual data, Abbott et al. (2013) investigate the determinants of recycling volume per capita using data from English local authorities. They find that it is partly explained by a social norm, which they construct as the mean level of recycling in a reference group of local authorities (although it is not clear that individuals would be aware of this level: a problem we avoid in our study). Sidique et al. (2010) show that a perception that family and neighbours expect one to sort is a significant driver of recycling. Brekke et al. (2010) find empirical evidence from Norwegian households which supports a model of recycling where individuals are motivated by considering the gap between the

recycling actions of others and their own behaviour. Hage et al. (2009) use data from a survey of 2,800 Swedish households focussing on their self-reported levels of recycling for packaging waste. For paper, plastic and glass recycling, they find that self-reported recycling behaviour is increasing in agreement with a moral obligation to recycle and a Likert scale measuring concordance with the statement "important persons close to me want me to recycle". Note, however, that the authors do not externally vary the strength of this latter social norm, relying instead on variation in individual's agreement with the statement.

None of these papers on social norms and recycling directly manipulates relevant variable, that is information about the absolute size of the social norm, its geographic proximity, or investigates whether a relative or absolute norm produces a bigger effect on recycling choices. We use a micro data set based on a choice experiment to investigate these effects for a sample of households in Poland, in addition to investigating the impacts of past behaviour on the impacts of social norm information. The next section describes the design of this survey.

4. Case study: recycling by Polish households

To estimate peoples' preferences and willingness to pay for waste sorting a discrete choice experiment (DCE), based on the design first used by Czajkowski et al. (2014) and Czajkowski et al .(2017), was employed. The questionnaire consisted of five main sections: (1) introduction, (2) questions on current method of waste collection and opinions on waste management policy, (3) provision of descriptions related to recycling regulations and attributes in the choice scenarios, (4) the DCE component aimed at measuring preferences and willingness to pay for alternative waste collection schemes, (5) elicitation of attitudes to recycling and socio-demographic questions. In the beginning of the survey, subjects were informed that the results would be communicated to policy makers and could be used for designing changes to the solid municipal waste management policy, which were being considered at the time.

The study was conducted shortly after a new pro-environmental waste sorting policy had been introduced in Poland, whereby municipalities were required to meet new recycling targets at the level of the municipality, whilst households could choose which waste collection (and, by implication, which recycling) contract to enter in with a range of suppliers. Since recycling targets were established at the level of the municipality, we were able to hold contact the total level of recycling (supply of the public good) across all choice scenarios, since central waste sorting would be required to make sure the municipality target was achieved. Discussions were on-going at the time of the survey regarding whether the policy would be further revised.

The choice experiment consisted of 12 choice tasks which asked people about which waste collection contract they preferred, described in terms of the following attributes:

- *SORT* – described into how many categories a household would be required to sort waste into before it was collected. The levels of this attribute, the number of sorting categories, consisted of no sorting by the household, or sorting into 2, 3, or 5 categories of waste.
- *TIME* – the frequency of waste collection. The levels ranged from daily collection, through collection thrice, twice, once a week, to once every two weeks.
- *PRICE* – a monthly bill sent to respondent's household, which amounted to 25, 50, 75, and 100 PLN.

In each choice situation, one of the alternatives represented the current method of household waste collection and recycling (the status quo). Characteristics of this contract were determined by additional questions asked at the beginning of the survey. An example choice card is provided in Figure 1. In each choice situation, respondents were asked to choose the most preferred contract out of a set of four available options.

Figure 1: Example of a choice card (translation)

Situation 1.	Option 1	Option 2	Option 3	Current method of waste collection
Method of sorting in household	Sorting into 3 categories	Sorting into 2 categories	Sorting into 5 categories	
Frequency of waste collection	Once a week	Three times a week	Twice a week	
Monthly cost for your household	25 PLN	50 PLN	100 PLN	
Your choice:	□	□	□	□

Note that, relative to the earlier studies carried out by Czajkowski et al. (2014) and Czajkowski et al. (2017), there are different levels for the two waste attributes (sort and timing), whilst in the present case choices included a status quo (no change) option.

4.1. Information treatments for the social norm

Here, the social norm is given by what people are told in the survey about the level of recycling in their community, where "community" means either country or city, depending on the treatment. We avoided the unethical procedure of providing false information to respondents on the levels of recycling in Poland or their city (that is, we avoid using delusive deception).

Instead, we use factual information from a number of different reports and official data sources for national and city-wide information on different aspects of recycling and waste management. This allowed to vary the figure given to respondents across treatments, whilst avoiding what Croson and Treich (2014) refer to as "deceptive nudges". The figures provided refer to either the % of households sorting waste in a particular year, the % of household waste collected that is sorted, or the % of waste collected separately (that is, source-separated by households). These are not identical definitions of household recycling, but all refer to the same process of waste separation and collection in different years. That is, alternative definitions of the level of recycling all refer to how common participation in recycling is.

Each respondent was only provided with one of these pieces of information, apart from those in control group (treatment #8 below) who were not provided with any of this information. Treatment groups are set out below in Figure 2, and each respondent was randomly allocated to one of the eight treatments only. Treatments #1 to #3 included three levels of a national norm: low, medium, and high, which allows observing if the effect of provided national social norm information is increasing, that is, to test whether a *size of norm* effect is present in the data, where the relevant peer group is taken to be everyone living in Poland. Treatments #4, #5, #6 and #7 refer to differences in the size of norm presented in terms of the city where people live. Comparing the effects of varying the size of the city-norm with the size of the country-norm allow us to test the *geographic proximity effect.* Within these 4 city-group treatments, we also include variation according to whether people are told about how recycling levels in their city compare to the national figure for Poland. This allows a test of the *relative versus absolute norm effect*, by comparing T4 with T5, and T6 with T7. Finally, comparing preferences or WTP with T8 with another other treatment allows for a test of the presence of any social norm effect at all.

Figure 2: Treatment groups

- T1. "In 2011, **10%** of all municipal waste collected from households in Poland was sorted."
- T2. "In 2012, **44%** of households in Poland stated that they sort waste regularly."
- T3. "In 2012, **69%** of households in Poland declared that they sort waste."
- T4. "In 2011, **15%/11%/6%*** of all municipal waste collected from households in Cracow/Warsaw/Bialystok was collected selectively[2]."

[2] I.e., in a manner which separates recyclables from other wastes.

- T5. "In 2011, **15%/11%/6%*** of all municipal waste collected from households in Cracow/Warsaw/Bialystok was collected selectively. The average for Poland is **10%**."
- T6. "In 2011, **72%/65%/58%*** of households in Cracow/Warsaw/Bialystok declared that they sort waste."
- T7. "In 2011, **72%/65%/58%*** of households in Cracow/Warsaw/Bialystok declared that they sort waste. The average for Poland is **69%**."
- T8. No information on national or local levels of sorting of waste provided.

4.2. Survey administration

A survey questionnaire was administered via computer-assisted web interviewing (CAWI) technique to a random sample of households in three large cities in Poland during February 2014. The final sample consisted of 1,853 respondents, with approximately 600 respondents per city. The sample was quota-controlled with respect to gender and being a resident of the respective city.

4.3. Econometric approach

The discrete choice data is modelled using the random utility theory (McFadden 1974). It assumes that the utility an individual receives from an alternative he chooses depends on observed characteristics (attributes) and unobserved idiosyncrasies, which is represented by a stochastic component. Individual i's utility from choosing alternative j in situation t can be expressed as:

$$V_{ijt} = \mathbf{x}_{ijt}\boldsymbol{\beta}_i + e_{ijt}\,. \tag{5}$$

The utility expression is separable in the observed choice attributes $\mathbf{x}_{ijt}$ and e_{ijt} being the stochastic component allowing for unobservable factors that affect individuals' choices. The parameters $\boldsymbol{\beta}_i$ represent individual-specific taste parameters associated with marginal utilities of the choice attributes, allowing for heterogeneous preferences among the respondents. The multivariate (parametric) distribution of these parameters in the sample is $\boldsymbol{\beta}_i \sim f(\mathbf{b},\boldsymbol{\Sigma})$, where $\mathbf{b}$ is a vector of sample means and $\boldsymbol{\Sigma}$ is a variance-covariance matrix. A convenient way of accounting for preference differences associated with information treatments is $\boldsymbol{\beta}_i \sim f(\mathbf{b}+z_i\boldsymbol{\delta},\boldsymbol{\Sigma})$, where z is a binary indicator for treatment effects and $\boldsymbol{\delta}$ is a vector of its estimated attribute-specific effects.

To facilitate interpretation of the results we specify the model in WTP-space (Train and Weeks 2005; Scarpa et al. 2008):

$$U_{ij} = \beta_i^m \left(X_{ijt}^m + \mathbf{X}_{ijt}^{-m} \boldsymbol{\beta}_i^{-m} \right) + \varepsilon_{ij}, \tag{6}$$

where X_{ij}^m is the monetary attribute with respect to which all marginal rates of substitution are expressed, and $\mathbf{X}_{ij}^{-m}$ are all other attributes. In this specification, parameter estimates $\left(\boldsymbol{\beta}_i^{-m}\right)$ can readily be interpreted as marginal WTP for the non-monetary attributes.

Estimation of the MXL requires calculation of the k-dimensional integral for a likelihood function of individual i:

$$L_i = \int p\left(\mathbf{y}_i \mid \mathbf{X}_{ijt}, \beta_i^m, \boldsymbol{\beta}_i^{-m}\right) f\left(\beta_i^m, \boldsymbol{\beta}_i^{-m} \mid \Omega\right) d\left(\beta_i^m, \boldsymbol{\beta}_i^{-m}\right), \tag{7}$$

where $f\left(\beta_i^m, \boldsymbol{\beta}_i^{-m} \mid \Omega\right)$ is a density function of random parameters, which distributions depend on parameters to be estimated, Ω, and $p\left(\mathbf{y}_i \mid \mathbf{X}_{ijt}, \beta_i^m, \boldsymbol{\beta}_i^{-m}\right)$ is conditional probability of making choices, $\mathbf{y}_i$, given by:

$$p\left(\mathbf{y}_i \mid \mathbf{X}_{ijt}, \beta_i^m, \boldsymbol{\beta}_i^{-m}\right) = \prod_t \left(\sum_j y_{ijt} \frac{\exp\left(\beta_i^m \left(X_{ijt}^m + \mathbf{X}_{ijt}^{-m} \boldsymbol{\beta}_i^{-m}\right)\right)}{\sum_l \exp\left(\beta_i^m \left(X_{ilt}^m + \mathbf{X}_{ilt}^{-m} \boldsymbol{\beta}_i^{-m}\right)\right)} \right). \tag{8}$$

As the analytical formula for integral in (7) is usually not known it has to be approximated. Usually, researchers employ Maximum Simulated Likelihood (MSL) method, in which R random draws from distribution described by $f\left(\beta_i^m, \boldsymbol{\beta}_i^{-m} \mid \Omega\right)$ has to be generated for each individual, and then (7) can be approximated as:

$$L_i \approx \frac{1}{R} \sum_r p\left(\mathbf{y}_i \mid \mathbf{X}_{ijt}, \beta_{ir}^m, \boldsymbol{\beta}_{ir}^{-m}\right), \tag{9}$$

where additional index r, denotes r-th draw. To make the simulation sufficiently precise we used 10,000 scrambled Sobol draws (Czajkowski and Budziński 2017).

In the modelling, the cost variable was continuous and other attributes were dummy-coded. The parameters of alternative specific constants (ASC) and all other attributes, including the cost, were modelled as random and correlated. All parameters were assumed to follow

formal distributions with the exception of cost, which was assumed to be negative log-normally distributed.[3]

5. Results

Table 1 presents the choice modelling results. In the first column of data, we see parameter estimates on pooled data, where we do not distinguish among treatments. Since the model is estimated in the WTP space, parameters for each attribute level are interpreted as WTP for the given level, relative to a baseline. The coefficient on the status quo is negative and significant, likely implying people's dislike for the current policy. For the *sort* attribute, relative to the baseline of no sorting being necessary at home, subjects have a positive WTP for sorting waste into 2 or 3 categories, but negative for sorting waste into 5 categories. The abovementioned result is in line with Czajkowski et al. (2014) and Czajkowski et al. (2017). Regarding collection frequency, people are willing to pay extra to increase it above twice per month, with the highest WTP for collection 3 times per week. For all of these attributes and levels, there is significant preference heterogeneity, as indicated by the standard deviation parameter estimates in column 2.

[3] The models were estimated using a DCE package, which among other things can be used to estimate MXL models. The package has been developed in Matlab and is available at https://github.com/czaj/DCE. The code and data for estimating the specific models presented in this study are available from http://czaj.org/research/supplementary-materials.

Table 1: The results of the MXL model in WTP-space (EUR) representing consumers' general preferences for the number of in-home sorting categories and the frequency of collection in future waste collection contracts

	Mean	**St. Dev.**
Status quo (ASC)	-8.3915*** (0.1655)	8.7050*** (0.2174)
Sort in 2 categories (vs. no in-home sorting)	1.8741*** (0.1275)	2.5033*** (0.1494)
Sort in 3 categories (vs. no in-home sorting)	2.2385*** (0.1588)	3.8331*** (0.1292)
Sort in 5 categories (vs. no in-home sorting)	-0.6050*** (0.1908)	7.1482*** (0.2024)
Collect 1 time per week (vs. 1 time every 2 weeks)	2.0247*** (0.1397)	1.3394*** (0.1097)
Collect 2 times per week (vs. 1 time every 2 weeks)	2.6340*** (0.1241)	1.3239*** (0.1554)
Collect 3 times per week (vs. 1 time every 2 weeks)	3.0421*** (0.1306)	1.9406*** (0.1054)
Collect 7 times per week (vs. 1 time every 2 weeks)	2.2561*** (0.1559)	2.8147*** (0.1553)
- Monthly cost per household	-0.6914*** (0.0410)	1.1969*** (0.0454)
Model diagnostics		
LL at convergence	-17,067.37	
LL at constant(s) only	-28,054.48	
McFadden's pseudo-R^2	0.3916	
Ben-Akiva-Lerman's pseudo-R^2	0.5001	
AIC/*n*	1.5367	
BIC/*n*	1.5432	
n (observations)	22,236	
r (respondents)	1,853	
k (parameters)	18	

Notes: ***, ** and * indicate 1%, 5% and 10% significance levels, respectively. Parameter estimates represent WTP expressed in EUR per month per household. Standard errors provided in parentheses. All parameters were assumed to be normally distributed with the exception of the cost, which was assumed log-normally distributed (estimated coefficients of the underlying normal distribution provided).

Table 2 presents estimation results estimated separately for each treatment. T8 (control group) is a reference. We focus on the *sort* attribute, as it is relevant for environmental behaviour. The significance of the social norm information varies according to how this is presented, and what level of the attribute is considered.

For the *presence of a social norm effect*, we see that the low social norm in T1 (10% of Poles recycle) reduces WTP for sorting into more categories, but the higher absolute norm levels in T2 and T3 increase WTP for sorting into more categories. However, this effect can only be seen across some but not all of the attribute levels for *sort*. There is no increase in the size of the norm effect on WTP when comparing T2 (44% of Poles recycle) with T3 (69% of Poles recycle). Interestingly, there is a consistent, significant negative effect of norm information on preferences for the current waste collection system which respondents have access to (and thus WTP for moving away from this status quo) – seeT1, T2, and T3 relative to T8. For the other treatments negative, significant effects on WTP for the status quo come strongest in treatments with city level norms, i.e. T4 and T6. Provision of social norm information in T5, T6 and T7 increases WTP for sorting into 3 categories relative to no home sorting being required; for T6 and T7, this significant effect of the norm information extends to WTP for sorting into 5 categories, which implies a very high level of recycling compared to people's current situation. The most positive effects are observed in T7, so when a combination of high city level and high country level norm is presented to respondents.

Table 2: The results of the MXL model in WTP-space (EUR) representing consumers' general preferences for the number of in-home sorting categories and the frequency of collection in future waste collection contracts – main effects (no social norm information) and the effects of 7 treatments

	Baseline (T8)		Interactions						
	Mean	St. Dev.	T1	T2	T3	T4	T5	T6	T7
Status quo (ASC)	-7.9197*** (0.2322)	8.4668*** (0.1621)	-0.9953** (0.4110)	-0.8569*** (0.3088)	-0.6047* (0.3254)	-1.5414*** (0.3499)	0.3215 (0.3861)	-1.2877*** (0.3182)	0.1671 (0.2756)
Sort in 2 categories (vs. no in-home sorting)	2.0813*** (0.2557)	2.9258*** (0.1216)	-0.6924* (0.3776)	0.1243 (0.3339)	-0.1461 (0.3903)	-0.4280 (0.4239)	0.0495 (0.3795)	-0.4850 (0.3524)	0.1816 (0.3658)
Sort in 3 categories (vs. no in-home sorting)	1.3116*** (0.2882)	3.8736*** (0.1092)	0.2654 (0.4696)	1.4215*** (0.3703)	1.0845*** (0.4098)	0.8514 (0.5265)	1.7988*** (0.4493)	1.0742*** (0.3707)	1.8744*** (0.3892)
Sort in 5 categories (vs. no in-home sorting)	-0.7638** (0.3083)	7.4888*** (0.1424)	-0.5214 (0.5242)	-0.2972 (0.4464)	-0.0415 (0.5233)	-0.4501 (0.6366)	-0.1025 (0.5641)	1.2023*** (0.4362)	2.0994*** (0.3932)
Model diagnostics									
LL at convergence	-17,044.80								
LL at constant(s) only	-28,054.48								
McFadden's pseudo-R^2	0.3924								
Ben-Akiva-Lerman's pseudo-R^2	0.5003								
AIC/*n*	1.5378								
BIC/*n*	1.5569								
n (observations)	22,236								
r (respondents)	1,853								
k (parameters)	53								

Notes: ***, ** and * indicate 1%, 5% and 10% significance levels, respectively. Parameter estimates represent WTP expressed in EUR per month per household. Standard errors provided in parentheses. All parameters were assumed to be normally distributed with the exception of the cost, which was assumed log-normally distributed (estimated coefficients of the underlying normal distribution provided). The parameters of collection frequency and monthly cost per household were not treatment-specific. The model controls for scale (variance of the error term of utility function) differences between treatments. The frequency, cost and scale parameters were skipped for brevity – full results are available in the online supplement to this paper.

5.2. Size of norm effect

Table 3 presents the results of three models in which the effects of T2 and T3 are evaluated relative to T1, the effects of T6 are relative to T4, and the effects of T7 are relative to T5. Looking first at national level norm information, and thus comparing T1, T2 and T3, we see that there is only a small rise in the size of WTP for sorting into 2, 3 or 5 categories as the national-level social norm is increased. From Table 2 (columns 3, 4 and 5) we see that there is no consistent pattern emerging here: rising effects along absolute size of the norm would increases WTP for the interaction parameters for any of the sort levels, as one moves from T1 to T3. Such pattern does not appear in the data. Only WTP for sorting into 3 categories is affected by any level of the national social norm, and this effect size does not increase continuously as people are told that higher fractions (10%, 44%, 69%) of the national population recycles. However, we do see a higher WTP for sorting into 3 categories when the norm increases from 44% to 69%. For city-level norm information, thus comparing T4 with T6, or T5 with T7, there is again no evidence of a rise in WTP as the absolute level of the social norm is increased. Our overall conclusion is thus that we find very little evidence that the absolute magnitude of the social norm is important for WTP for this pro-environmental action. However, it is clear that there is very considerable preference heterogeneity for recycling in our data set – the standard deviation parameters for every level of the sort attribute are higher than the respective mean effects.

Table 3. The results of the MXL models in WTP-space (EUR) representing consumers' general preferences for the number of in-home sorting categories and the frequency of collection in future waste collection contracts – the effects of increasing size of the communicated norm

	Baseline (T1)		Interactions		Baseline (T4)		Interactions	Baseline (T5)		Interactions
	Mean	St. Dev.	T2	T3	Mean	St. Dev.	T6	Mean	St. Dev.	T7
Status quo (ASC)	-8.2760*** (0.2573)	8.4986*** (0.2493)	-1.6388*** (0.4298)	-0.4178 (0.4704)	-9.5120*** (0.2781)	8.3235*** (0.2671)	0.9321** (0.3641)	-8.1528*** (0.2483)	10.0165*** (0.3587)	0.3506 (0.3266)
Sort in 2 categories (vs. no in-home sorting)	1.4579*** (0.3625)	2.6777*** (0.1538)	1.2024** (0.4892)	0.6277 (0.6113)	1.5035*** (0.4383)	2.7933*** (0.3402)	-0.3866 (0.4950)	2.6247*** (0.3334)	2.6744*** (0.1451)	-0.3061 (0.4331)
Sort in 3 categories (vs. no in-home sorting)	1.4387*** (0.3131)	3.7019*** (0.1408)	1.2789*** (0.4546)	1.4421*** (0.4615)	1.7575*** (0.4226)	4.0650*** (0.2860)	0.5342 (0.5265)	3.0570*** (0.3156)	4.2509*** (0.1607)	-0.0184 (0.4292)
Sort in 5 categories (vs. no in-home sorting)	-1.4659*** (0.5168)	7.5485*** (0.3280)	0.0079 (0.7785)	-0.1694 (0.6672)	-0.0922 (0.5051)	6.5205*** (0.2829)	-0.8781 (0.5988)	-1.1439** (0.5553)	7.8180*** (0.4263)	0.6219 (0.6262)
Model diagnostics										
LL at convergence	-6,456.18				-4,146.72			-4,276.32		
LL at constant(s) only	-10,630.61				-6,938.19			-6,914.97		
McFadden's pseudo-R^2	0.3927				0.4023			0.3816		
Ben-Akiva-Lerman's pseudo-R^2	0.5000				0.4957			0.4990		
AIC/*n*	1.5417				1.5512			1.5476		
BIC/*n*	1.5651				1.5794			1.5750		
n (observations)	8,412				5,376			5,556		
r (respondents)	701				448			463		
k (parameters)	28				23			23		

Notes: ***, ** and * indicate 1%, 5% and 10% significance levels, respectively. Parameter estimates represent WTP expressed in EUR per month per household. Standard errors provided in parentheses. All parameters were assumed to be normally distributed with the exception of the cost, which was assumed log-normally distributed (estimated coefficients of the underlying normal distribution provided). The parameters of collection frequency and monthly cost per household were not treatment-specific. The model controls for scale (variance of the error term of utility function) differences between treatments. The frequency, cost and scale parameters were skipped for brevity – full results are available in the online supplement to this paper.

5.3. Geographic proximity

Following from Goldstein et al. (2008), we hypothesised that information on the behaviour of others in respondent's own city would have a stronger effect than information about the behaviours across the entire the nation. Unfortunately, with available information a very precise testing is beyond the reach of this study, we could not set the same % levels for the city population in T4, T5, T6, T7 and in T1, T2 and T3, without intentionally lying to respondents. However, one would expect that a comparison of the size of effect between T1 and T3, relative to respectively T4 and T6, would be revealing, as the lower and upper levels for the behaviour of "others" is rather similar, especially with a variation in city levels that should have eliminated such a discrepancy. We found that moving from a nation-level norm to a city-level norm gave significant reductions in WTP for the status quo recycling system. Comparing T1 to T4, a higher WTP for sorting into 5 categories occurs in the case of city-level information compared to national level information. Comparison between T3 and T6 reveals lower mean WTP for sorting into 2 or 3 categories in the later. There is thus no common pattern on the effect of social norm information on WTP for more recycling comparing city-level with national-level norm information.

Table 4: The results of the MXL models in WTP-space (EUR) representing consumers' general preferences for the number of in-home sorting categories and the frequency of collection in future waste collection contracts – the effects of using a country vs. local norm

	Baseline s (T1)		Interactions	Baseline (T3)		Interactions
	Mean	St. Dev.	T4	Mean	St. Dev.	T6
Status quo (ASC)	-9.4556*** (0.1994)	9.0595*** (0.4193)	-1.0057*** (0.2884)	-8.4271*** (0.2390)	8.2467*** (0.2999)	-0.8858*** (0.3345)
Sort in 2 categories (vs. no in-home sorting)	1.5409*** (0.2929)	2.6452*** (0.2361)	0.2497 (0.4731)	2.3294*** (0.3469)	3.2600*** (0.2402)	-1.1031** (0.4590)
Sort in 3 categories (vs. no in-home sorting)	1.9204*** (0.2674)	4.3779*** (0.2424)	0.0582 (0.3748)	2.8457*** (0.3013)	3.9147*** (0.1851)	-0.7397* (0.4399)
Sort in 5 categories (vs. no in-home sorting)	-2.6240*** (0.4416)	8.2089*** (0.4256)	1.6779*** (0.5376)	-0.7560* (0.4030)	6.7592*** (0.2861)	-0.2093 (0.5933)
Model diagnostics						
LL at convergence	-4,325.84			-4,155.37		
LL at constant(s) only	-7,145.69			-6,890.32		
McFadden's pseudo-R^2	0.3946			0.3969		
Ben-Akiva-Lerman's pseudo-R^2	0.4958			0.4974		
AIC/*n*	1.5554			1.5510		
BIC/*n*	1.5826			1.5791		
n (observations)	5,592			5,388		
r (respondents)	466			449		
k (parameters)	23			23		

Notes: ***, ** and * indicate 1%, 5% and 10% significance levels, respectively. Parameter estimates represent WTP expressed in EUR per month per household. Standard errors provided in parentheses. All parameters were assumed to be normally distributed with the exception of the cost, which was assumed log-normally distributed (estimated coefficients of the underlying normal distribution provided). The parameters of collection frequency and monthly cost per household were not treatment-specific. The model controls for scale (variance of the error term of utility function) differences between treatments. The frequency, cost and scale parameters were skipped for brevity – full results are available in the online supplement to this paper.

5.4. Relative versus absolute norm effect

In this instance, we compare WTP values in T4 with those in T5; and WTP values in T6 with those in T7. For example, in T4 respondents living in Cracow are told that 15% of all waste was collected selectively (i.e., in a manner which separates recyclables from other wastes); in T5 they are given this information and additionally information that the average for Poland is 10%. People in T5 can thus see that their city's mean level of recycling is relatively high compared to Poland as a whole. People in T4 cannot make this relative comparison. Similarly, we can compare WTP for a given level of sorting in T6 with WTP for that same level in T7. In T7 people in, for example, residents of Bialystok, learn that 58% of households in their own city said that they sorted waste, which is less than the Polish national figure of 69%. People in T6 do not get told this national figure.

From Table 5, we can see that we get no significant effects of T4 versus T5, but we do see a significant increase in WTP for sorting into 2 or 5 categories for T7 relative to T6. This provides some evidence of a stronger impact of relative-level social norm information compared to absolute-level information, but only when the information is about high social norm.

Table 5: The results of the MXL models in WTP-space (EUR) representing consumers' general preferences for the number of in-home sorting categories and the frequency of collection in future waste collection contracts – the effects of using an absolute vs. relative norm

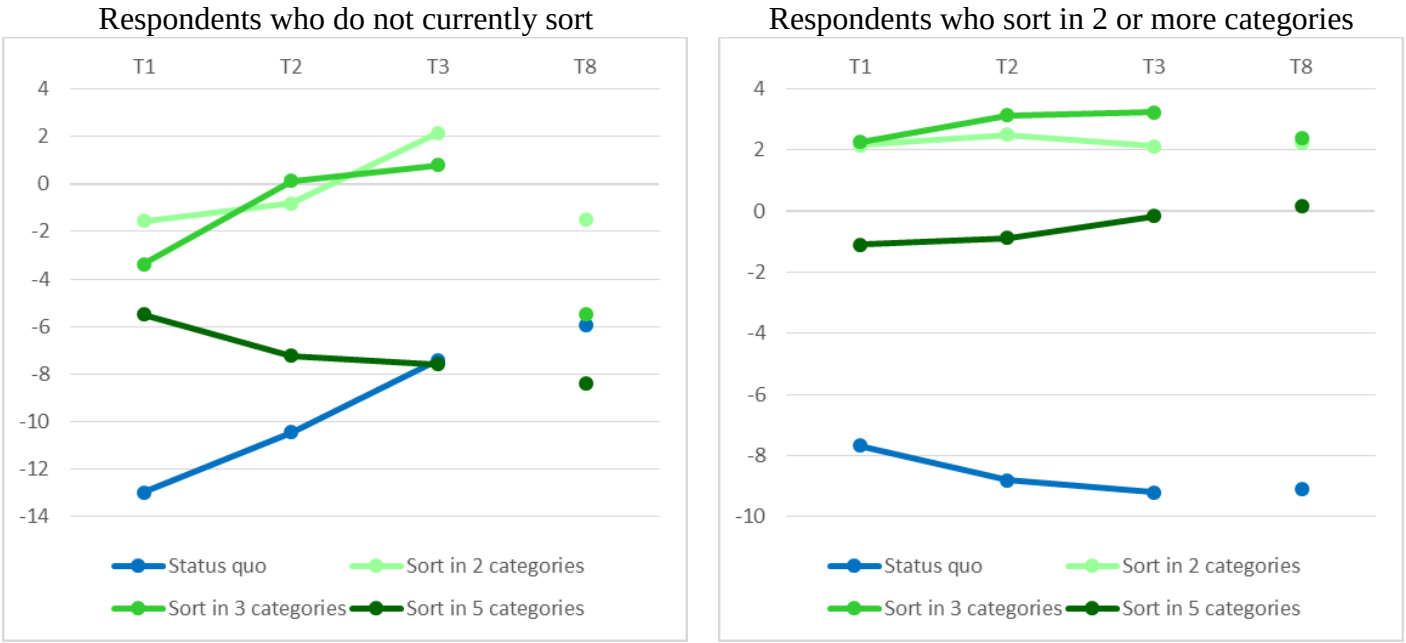
	Baseline (T4)		Interactions	Baseline (T6)		Interactions
	Mean	St. Dev.	T5	Mean	St. Dev.	T7
Status quo (ASC)	-8.2523*** (0.3313)	9.5668*** (0.3913)	0.2982 (0.3623)	-8.9953*** (0.3278)	8.3372*** (0.3587)	1.4523*** (0.4504)
Sort in 2 categories (vs. no in-home sorting)	1.6566*** (0.4360)	2.3933*** (0.1973)	0.5138 (0.4481)	0.9490** (0.3816)	2.4599*** (0.2584)	1.5124*** (0.4880)
Sort in 3 categories (vs. no in-home sorting)	2.4336*** (0.3461)	3.9580*** (0.2112)	0.2309 (0.4523)	2.2674*** (0.3754)	4.1709*** (0.1965)	0.5526 (0.4848)
Sort in 5 categories (vs. no in-home sorting)	-0.2959 (0.4411)	7.6330*** (0.4061)	-0.3333 (0.6834)	-1.1907** (0.5694)	7.0262*** (0.2922)	1.6749*** (0.6024)
Model diagnostics						
LL at convergence	-4,257.96			-4,161.87		
LL at constant(s) only	-6,966.88			-6,893.74		
McFadden's pseudo-R^2	0.3888			0.3963		
Ben-Akiva-Lerman's pseudo-R^2	0.4937			0.5023		
AIC/*n*	1.5750			1.5229		
BIC/*n*	1.6030			1.5505		
n (observations)	5,436			5,496		
r (respondents)	453			458		
k (parameters)	23			23		

Notes: ***, ** and * indicate 1%, 5% and 10% significance levels, respectively. Parameter estimates represent WTP expressed in EUR per month per household. Standard errors provided in parentheses. All parameters were assumed to be normally distributed with the exception of the cost, which was assumed log-normally distributed (estimated coefficients of the underlying normal distribution provided). The parameters of collection frequency and monthly cost per household were not treatment-specific. The model controls for scale (variance of the error term of utility function) differences between treatments. The frequency, cost and scale parameters were skipped for brevity – full results are available in the online supplement to this paper.

5.5. Impacts of past behaviour on social norm effects

To simplify we focus on country-level social norm information, and ignore those treatments that provide relative data on local-level recycling. That is, we focus on T1, T2 and T3, and divide the sample into groups (i) people who stated they currently do not sort waste into separate components, and (ii) people who say that they do currently separate their wastes for recycling. Table 6 presents estimation results using T8 as a reference for evaluating changes in T1-T3 (left), and T1 as a reference for evaluating changes in T2-T3 (right). The most important result is that social norm information has stronger effect on people who do not currently sort their waste. T1 and T2 results in significantly lower preferences for the status quo for those who do not currently sort, relative to those who do sort at present. Information set T2 increases preferences for sorting into 3 and 5 categories for those who do not currently sort, relative to T8 (no norm information). T3 increases preferences for sorting into 2 or 3 categories for those who do not currently sort, relative to T8. So past/current behaviour plays a role in moderating the effects of social norm information on respondents' preferences and WTP for recycling. This is illustrated in Figure 3.

Figure 3: Treatment-specific WTP (EUR) associated with new contract characteristics – sorting in 2, 3 or 5 categories (relative to no sorting) and the alternative specific constant associated with the status quo contract design – for respondents who currently do not sort (left) or who currently sort (right)



Notes: T8: no social norm information; T1, T2, T3: increasing levels of country sorting. The results are based on treatment-specific models available in the online supplement to the paper.

Table 6: The results of the MXL models in WTP-space (EUR) representing consumers' general preferences for the number of in-home sorting categories and the frequency of collection in future waste collection contracts – the effects of current/past behaviours

		Baseline (T8)		Interactions			Baseline (T1)		Interactions	
		Mean	St. Dev.	T1	T2	T3	Mean	St. Dev.	T2	T3
Currently do not sort	Status quo (ASC)	-8.7918*** (0.5497)	11.1174*** (0.5043)	-1.8976** (0.7778)	-3.6273*** (0.7467)	1.0636 (0.9759)	-10.2409*** (0.5562)	12.1237*** (1.1200)	-0.1977 (0.6611)	4.5077*** (1.0709)
	Sort in 2 categories (vs. no in-home sorting)	-1.4361** (0.6262)	3.2012*** (0.2667)	0.1033 (0.8072)	0.8753 (0.7833)	3.5889*** (1.2344)	-1.9287** (0.8795)	2.9803*** (0.3528)	1.7180* (1.0337)	4.4873*** (1.3423)
	Sort in 3 categories (vs. no in-home sorting)	-6.1126*** (0.9884)	4.8444*** (0.3763)	1.0081 (1.0857)	7.9245*** (1.1495)	6.6560*** (1.4838)	-3.9920*** (0.9089)	5.1718*** (0.3425)	4.2186*** (1.0365)	6.2719*** (1.4517)
	Sort in 5 categories (vs. no in-home sorting)	-5.4079*** (0.8625)	7.8365*** (0.6608)	-1.9067* (1.0136)	2.2698* (1.2455)	-1.5962 (1.2961)	-7.0385*** (1.3413)	7.6522*** (0.9519)	2.8319** (1.2736)	0.8994 (2.0966)
Currently sort in 2 categories or more	Status quo (ASC)	-9.0645*** (0.1851)	7.7120*** (0.1649)	1.3740*** (0.2320)	0.6870*** (0.2312)	0.1774 (0.2302)	-8.6539*** (0.1414)	7.9684*** (0.2376)	-0.8308*** (0.2063)	-0.1143 (0.2401)
	Sort in 2 categories (vs. no in-home sorting)	2.7699*** (0.1773)	2.2020*** (0.0855)	-0.6860** (0.2988)	0.3619 (0.2792)	-0.3291 (0.2668)	2.3262*** (0.2140)	2.3704*** (0.1540)	0.4880 (0.3074)	0.0690 (0.2938)
	Sort in 3 categories (vs. no in-home sorting)	2.4900*** (0.2380)	3.2423*** (0.0916)	0.5078 (0.3123)	0.4040 (0.3412)	0.5339* (0.3023)	2.8484*** (0.2228)	3.1845*** (0.1042)	0.4040 (0.3449)	0.0889 (0.3024)
	Sort in 5 categories (vs. no in-home sorting)	-0.0561 (0.2611)	7.2778*** (0.2499)	0.3737 (0.3681)	-0.0444 (0.3282)	0.2808 (0.5053)	-0.4311 (0.3864)	7.4093*** (0.2758)	0.6718 (0.4542)	0.6512 (0.4028)
Model diagnostics										
LL at convergence		-8,529.95					-6,422.55			
LL at constant(s) only		-14,186.69					-10,630.61			
McFadden's pseudo-R^2		0.3987					0.3958			
Ben-Akiva-Lerman's pseudo-R^2		0.5076					0.5023			
AIC/*n*		1.5186					1.5375			
BIC/*n*		1.5529					1.5743			
n (observations)		11,304					8,412			
r (respondents)		942					701			
k (parameters)		53					44			

Notes: ***, ** and * indicate 1%, 5% and 10% significance levels, respectively. Parameter estimates represent WTP expressed in EUR per month per household. Standard errors provided in parentheses. All parameters were assumed to be normally distributed with the exception of the cost, which was assumed log-normally distributed (estimated

coefficients of the underlying normal distribution provided). The parameters of collection frequency and monthly cost per household were not treatment-specific. The model controls for scale (variance of the error term of utility function) differences between treatments. The frequency, cost and scale parameters were skipped for brevity – full results are available in the online supplement to this paper.

6. Discussion and conclusions

The role of social norms as part of environmental policy, and as a means of better understanding people's behaviour, has become of increasing interest in the economics literature. This paper uses the choice experiment to collect individual level data and carry out tests of whether the way in which norm information is presented matters in terms of its predictable effects on choices. In particular, we focus on (i) the size of the norm (ii) its geographic proximity and (iii) whether absolute or relative norm information is presented. The research design randomly allocated respondents into one of eight treatments which capture this variation in social norm information. We also test for the interaction between norm effects and current/past environmental behaviours.

The interesting result that emerged is that social norm information does not always consistently or predictably enhance preference for recycling. For many of the treatments/level combinations, the insignificant norm effect is detected. The most consistent effect is a change of choices toward the status quo: presentation of social norm on average makes people more willing to pay for a modification in their current waste collection contract. There is some evidence that a higher absolute norm can increase WTP for more recycling. Little evidence emerged of a geographic proximity of the reference group effect. We do find that information which enables people to compare their city's recycling level to the national level of recycling has a bigger effect that where such comparative (relative norm) information is omitted. This effect is most prominent when two high norms are presented. It can be a result of comparison or a result of repetition of this high norm. Finally, we find that there is a huge effect of current/past recycling behaviour on the social norm, with the strongest social norm effect occurring for people who do not currently sort waste. This might be a result of relatively lower marginal cost of increasing sorting for households who are initially relatively less environmentally friendly. Similar result was earlier found for energy conservation programs based on social comparisons (Allcott 2011).

It should be pointed out that, due to a desire to avoid the need to mislead or lie to respondents, somewhat different definitions of "recycling" were employed in our treatments. T1-T3 (national level) it varies from "% of waste sorted" to "households who sort waste regularly" to ""% who declared they sort waste". These definitions are not quite the same, but we would argue that they are "close enough", whilst the only alternative was to lie to people. We do not think that this invalidates our results. It is also important to point out that in the context of our stated preference experiments, the extent to which an individual's behaviour,

which differs from a social norm is subject to a public sanction. Such public sanctions (e.g., reputation effects; shame) have been argued to be important for the effectiveness of a social norm on behaviour. Whilst deviating from the social norm imposes a utility penalty on individuals in our conceptual model (which could also be motivated by guilt aversion, as in Charness and Dufwenberg (2006), this self-sanction is not equivalent to a public sanction. It is also true that the ability of individuals to monitor the recycling behaviour of others is limited (you can watch me walk to the recycling bank with empty wine bottles, but you are unlikely to go through my recycling bin to see how full it is, or whether it is contaminated with non-recyclable material). If agents' behaviour is only imperfectly observed, then the ability to sanction behaviour which violates a social norm is compromised.

We propose a stated discrete choice method as a useful tool to predict the consequences of potential behavioural policies and information campaigns, before they are introduced. There is much scientific discussion on permanent and undesirable welfare implications of "nudging" in the field, which could possibly be avoided when pretested in such a survey. Of course, lab experiments can also be used to pre-test new policy instruments, but this typically comes at the cost of a much less diverse and representative sample of respondents than is the case with stated choice models. We were also able to investigate the effects of past environmental behaviours on a social norm-based nudge, and showed that there is indeed an effect of such past behaviours on how people respond to information. Social norm information had a stronger effect on people who do not currently sort their waste in our sample,

In conclusion, although social norm campaigns are very tempting as a solution to environmental problems due to their low cost and appeal to liberal paternalism, their effects cannot be generalised and thus are hard to predict for specific policy cases and specific targeted populations. We therefore recommend careful pretesting norm-based nudges before introducing them as a "routine" part of the policy tool-kit. Stated choice models are a useful way of carrying out such pre-tests.

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