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Social Norms, Morals and Self-interest as Determinants of Pro-environment Behaviours: The Case of Household Recycling

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Abstract This paper considers the role which selfish, moral and social incentives and pressures play in explaining the extent to which stated choices over pro-environment behaviours vary across individuals. The empirical context is choices over household waste contracts and recycling actions in Poland. A theoretical model is used to show how cost-based motives and the desire for a positive self and social image combine to determine the utility from alternative choices of recycling behaviour. We then describe a discrete choice experiment designed to empirically investigate the effects such drivers have on stated choices. A hybrid logit model is used to link statements over attitudes to recycling to choices, dealing with a potential endogeneity problem caused by the joint effects of un-observables on attitudes and choices. We find that a substantial share of our respondents prefer to sort their waste at home rather than in a central sorting facility. This preference is associated with a moral/intrinsic motivation, involving a belief that sorting at home is more thorough than central sorting.

Keywords Recycling · Motives of pro-environment behaviour · Social norms · Discrete choice experiment

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1 Introduction

What determines people's decisions to participate in "pro-environment" behaviours such as recycling or volunteering for a local conservation group? In the specific context of recycling, a considerable empirical literature (Iyer and Kashyap 2007; Nixon and Saphores 2009; Nigbur et al. 2010) points to factors such as the costs of alternative waste disposal options, the nature of facilities available for recycling, and the role of self-image and social pressures. However, certain aspects of households' motivation to recycle are apparently not yet fully understood.

A simple economic calculation would suggest that, unless the effort to sort waste into different categories for recycling (paper, cans, bottles, compostables etc.) saves money or generates other private benefits, then less home sorting would be preferred to more, as long as effort is costly. In a recent stated preference study of households in Poland, however, Czajkowski et al. (2014) found that a substantial share of respondents prefer to home sort into more categories as part of a municipal recycling programme, even when (1) this is costly to them (in terms of time and inconvenience) and (2) when the alternatives offered to individuals involved the same level of sorting, but performed by the municipal authority at a central waste handling facility instead. But why?

The data available to Czajkowski et al. (2014) did not permit them to explain statistically what kind of benefits caused some individuals to prefer waste collection contracts requiring higher levels of home sorting. This paper is an attempt to provide such explanations. In what follows, we present results from a new study using the same discrete choice experiment design as in Czajkowski et al. (2014), but with more attitudinal and de-briefing questions devoted to investigating why some people prefer at-home recycling compared with recycling in a central sorting facility. This allows us to jointly consider the relative effects of social pressures, individual moral motivations and the factors such as how troublesome or satisfying recycling is to respondents.

Due to possible self-selection bias, we cannot claim that our sample is representative of the population; nevertheless, it provides an interesting opportunity to study the underlying motives for household recycling. Like Czajkowski et al. (2014), we find that a substantial share of respondents prefer to sort themselves; in fact, 84 % prefer to sort into two categories rather than not sort at all, while 70 % prefer sorting into five categories compared with no sorting.[1] This contrasts with Bruvoll et al. (2002), who found that 72 % of their respondents preferred central facility sorting (assuming no extra costs). To our knowledge, our study is the first to look jointly at social pressures, moral motives and the costs of recycling actions from a stated preference, random utility perspective. This, as we argue below, seems a useful way of modelling people's choices over recycling.

Although we find that the preference to sort is motivated by a range of factors, we identify three broad, latent factors. These can be thought of as measures of three underlying psychological motives which determine both choices and responses to attitudinal statements. Broadly speaking, they capture, respectively, social pressures, moral norms, and personal inconvenience aspects. Intuitively, social pressures and moral norms may be hard to distinguish, and in fact, results on the relative influence of these two factors depend on the econometric model used (a hybrid multi-nomial logit or hybrid mixed logit model). Nevertheless, our main finding is that the willingness to pay to sort at home is associated with the latent variable representing moral or intrinsic norms, which is in turn associated with a belief that home sorting is in fact more thorough than central sorting.

[1] The results are based on the distribution of random taste parameters derived from a mixed logit model estimated on discrete choice experiment data.

In what follows, the existing empirical literature on the determinants of variations in recycling behaviour is briefly summarized, before a conceptual model is proposed. The next section explains the design of the empirical study, and the econometric approach taken. Results of the hybrid multinomial logit and hybrid mixed logit model are then presented, before we conclude.

2 What Does the Empirical Literature Tell Us About Decisions to Recycle?

Most of the empirical literature on recycling at the household level[2] within environmental economics has focused on the direct cost to households of engaging in recycling effort—such as the availability of curbside pick-up recycling rather than "bring" systems where consumers must transport recyclables to central collection points—and on the opportunity cost of *not* recycling, as reflected by the price paid for waste collection (Hong et al. 1993). This latter factor has received increasing attention as more municipalities and countries have introduced variable fees for solid waste collection over time (Reichenbach 2008). Recent US evidence shows a substantial effect on recycling effort from increasing the marginal cost of household rubbish disposal through a (higher) variable collection fee on the volume of waste that households generate (Huang et al. 2011).

Another influence on recycling behaviour is the "inconvenience factor", which can be thought of as a measure of the time, space and effort needed to be allocated by a household to achieve a given level of recycling activity. Jenkins et al. (2003) study 1049 households in 20 US metropolitan areas, looking at the influence of the availability of a curbside collection scheme for recyclables as one measure of this inconvenience factor. They find that for all materials (glass, newspaper, plastic bottles, aluminium, yard waste and newspapers), presence of curbside recycling schemes increases recycling effort, but that in no case is the unit price of waste collection a significant determinant of recycling effort. Kipperberg (2007) confirms the findings of Jenkins et al. using Norwegian data, estimating separate ordered logit models for five different categories of waste. Abbott et al. (2013) investigate the log of recycling volume per capita using data from English local authorities. They find that it is well explained by the quality of recycling infrastructure provided, and a "social norm", which they construct as a mean level of recycling in a reference group of local authorities. Kuo and Perrings (2010) show for 18 cities in Taiwan and Japan that actual recycling rates depend on the frequency of collection of both recyclables and rubbish intended for landfilling. Kipperberg and Larson (2012) show that some of the variation in stated preferences for waste management across households can be explained with the design characteristics of the recycling system employed in an area, and its financial cost to households. Refsgaard and Magnussen (2009) also found institutional features of waste management schemes at the municipality to be important factors for household behaviour and attitudes.

Another feature that has been shown to matter is income. Huhtala (2010) reports results from a contingent valuation study in Finland, which collected 1,131 responses to a questionnaire on WTP for alternative future waste management options for Helsinki. She found WTP for recycling to be decreasing in household income, which she attributes to the higher opportunity costs of time for high-income households. Basili et al. (2006) also found income to be an important determinant of WTP for waste management alternatives.

[2] Note that there is also an emerging literature which models recycling behaviour at the level of municipalities (organisations of local government responsible for household waste collection), looking for example at their willingness to set up curbside collection schemes (De Jaeger and Eyckmans 2008). Another literature looks at variations in recycling rates across countries (Mazzanti and Zoboli 2008).

Another strand of literature has investigated the extent to which indicators of social capital and community norms influence recycling behaviour. Kurz et al. (2007) show that a proxy for "sense of community" is closely related to engagement with recycling in Northern Ireland. Videras et al. (2012) find that, for a sample of over 2000 US households, intensity and strength of social ties, and pro-environment community norms, are linked to recycling behaviour: "…individuals who have strong connections with neighbours and who think most neighbours do things to help the environment are more likely to recycle" (p. 42). Knussen et al. (2004), in a study of stated intentions to participate in "bring" recycling schemes in Glasgow, Scotland, found that 29 % of the variation in intentions was explained by measures of attitudes, opportunities and what they refer to as subjective norms, in this case the degree to which respondents felt that their families and friends thought that recycling was a good thing.

A desire to conform to one's own ethical standards or a perceived sense of personal duty may also be important. Hage et al. (2009) study 2800 households in Sweden, and relate self-reported recycling activity (participation in a packaging waste recovery scheme) to measures of feelings of personal responsibility. They find that self-reported recycling rates are increasing in the degree of agreement with a statement "I recognize a moral obligation to recycle", and that recycling rates also rise the higher one perceives the degree of recycling by one's neighbours to be. Bruvoll et al. (2002), in a survey of 1162 Norwegian citizens, find that the most frequently cited motivation for home sorting of recyclables was "I should do what I want others to do", with "I want to think of myself as a responsible person" as the second most highly reported reason. Respondents to this study were also faced with the following question: "Assume that a recycling company can make use of your waste. New technology makes it possible to sort waste centrally so that the environmental effect will be the same. The company collects the unsorted waste from your home. Would you make use of the offer if this did not increase your expenses, or would you prefer to sort yourself?" 72 % of the respondents of Bruvoll et al. (2002) reported that they would make use of the offer, hence preferring separation of recyclables by others rather than by themselves.

In a paper very relevant to our own work, Brekke et al. (2010) consider the role of what they refer to as *duty orientation* (see also Brekke et al. 2003; Nyborg 2011). Duty-oriented individuals prefer to keep an image of themselves as socially responsible people. They may thus be willing to recycle even at a personal cost—provided that recycling is perceived as their personal responsibility. If in doubt whether they are in fact personally responsible for recycling, they may look to the behaviour of their peers; if so, their recycling actions can be increasing in the degree to which they believe others are also recycling (Nyborg et al. 2006). Brekke et al. (2010) test this hypothesis using data from a survey of glass recycling by Norwegian households. The survey includes information on whether individuals perceive recycling to be a moral responsibility, how common they thought recycling to be amongst their friends and family, how sure they were about this, and a dummy variable for self-reported glass recycling behaviour. The authors find that the feeling of personal responsibility is increasing in how common people thought recycling to be amongst friends and family; further, the more certain respondents were of this frequency estimate, the higher the feeling of personal responsibility. As perceived responsibility increases, glass recycling becomes more likely. Moreover, while the study indicated a direct effect of social sanctions (the fear of negative reactions from others) on recycling behaviour, the main effect of social sanctions appeared to arise indirectly, through their effect on feelings of personal responsibility. The Brekke et al. (2010) study did not, however, explore whether respondents preferred to sort themselves or to leave the sorting to others, the topic we will be turning to below.

3 Conceptual Framework

Before turning to the empirical study, let us take a moment to consider how factors like social pressure, moral motivation and effort could be expected to affect pro-environment behaviours such as recycling.

To fix ideas, consider an individual who cares about her private consumption c, a public good G, which we may think of as environmental quality, 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 (environmental quality). The budget constraint is given by

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

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

The above can be interpreted as assuming that income, consumption and recycling contributions are material only. A more general interpretation, allowing us to include recycling contributions in terms of time and/or inconvenience as well as money within this very simple framework, is that W measures generalized or full income, incorporating the individual's total available resources including time (Becker 1965). Similarly, c can represent generalized consumption (a monetary aggregate of private goods consumption and leisure). We can then interpret g as the individual's total environmental contribution, which may be produced through the use of time and/or money.[3]

Total supply of the public good depends on the contribution of every individual in society. However, assume that the society is large, and that the single individual's contribution is too small, relative to the total level of G, to make it possible for her to noticeably perceive the change in G due to her own contribution. She will thus, when making her choices, treat environmental quality G as if it were exogenously fixed.

Nevertheless, she may contribute to the environment due to image concerns (self-image and others' image 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, 2010; Nyborg 2011). Any deviation from the morally ideal behaviour yields a psychological loss, which may be thought of as cognitive dissonance. The morally ideal contribution g^* may be viewed as a measure of the individual's perceived moral responsibility for recycling. Note that if $g^* < W$, the individual finds it morally *inferior* to increase her contributions beyond a certain level, and doing so would then reduce her self-image. For example, she may find it unethical not to spend at least some resources

[3] More precisely, let all income be wage income. Let w be an exogenous wage rate, C be material consumption, L working time, l leisure, and T the exogenous total time available. Let recycling time be t and material recycling contributions m. The time constraint is then $T = L + l + t$, and the material budget constraint is $wL = C + m$. Combining these two, we get $wT = C + wl + m + wt$. Define $W = wT$ as full income, $c = C + wl$ as generalized consumption, and $g = (m + wt)/p$ as contributions in environmental units (where p measures how much input is needed to produce one unit of environmental improvement). Inserting for these definitions in the previous expression, we are back to the generalized budget equation (2).

to take good care of herself and her family; or, for home recycling efforts in particular, she may believe that central sorting would be equally or more socially beneficial and hence any contribution beyond that would be inefficient use of their time.

In addition to self-image, the individual may also care about others' image of her. Assume that believed judgement from 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. If no peers can observe her contribution, $b = 0$. Again, it is not necessarily the case that the ideal is as large as possible; if the individual thinks, for example, that her neighbours consider recycling foolish, she may be embarrassed, if observed recycling.

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, 2010; Nyborg 2011).

When deciding how much to contribute, the individual maximizes Eq. (1) with respect to g, given (2)–(4). This yields the following first order condition for an interior utility maximum:

$$g = \frac{ag^* + bg^{**} - 2pu'_c}{a + b} \tag{5}$$

where $u'_c = \partial u\,(c, G)/\partial c$ is the marginal utility of consumption.[4] That is, whether and how much the individual will 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 (a and b), and the loss of generalized consumption benefits (pu'_c, including monetary cost as well as costs in terms of time or inconvenience) caused by the marginal recycling contribution. If the moral and social motivations to recycle are always too weak compared to the private marginal cost of contributing $\left(pu'_c\right)$, the individual prefers not to recycle at all. That is, if $ag^* + bg^{**} < 2p\partial u\,(W, G)/\partial c$, the utility maximum is a corner solution, since g cannot take negative values and the first order condition (5) cannot hold.

The above framework does not specify whether the individual judges others (exerts social pressure on them). It is reasonable to assume, however, that within a peer group there is a close relationship between g^* and g^{**}: if the individual's peers are like her and share her moral ideal g^*, and if her beliefs are correct, then $g^* = g^{**}$. In that case, one cannot separate parameters a and b empirically based on observed behaviour [see Eq. (5)]. Thus, although internalized moral norms and social pressure may be conceptually different motives, they may be hard to distinguish in practice.

If the individual believes that her peers' view of the morally ideal recycling level is different from her own, however, she will have to trade off her desire for a good self-image against the desire to be judged favourably. If g^* increases marginally, all else fixed, the optimal contribution increases by $a/(a + b)$.[5] Similarly, if g^{**} increases marginally, all else fixed, the optimal contribution increases by $b/(a + b)$.

Consequently, if recycling is costly and/or burdensome, and you do not find intrinsic pleasure in it, a model like the one sketched above implies that you will recycle only if your preferences for image concerns are sufficiently strong, and, in addition, that your perception

[4] Recall that G is considered exogenous, implying $\partial G/\partial g = 0$ (from the individual's point of view).

[5] This can be seen by differentiation of eq.(5).

of the responsibility imposed on you by yourself and others is sufficiently strong.[6] All else equal, the model predicts that an individuals' contribution will be increasing in her view of the morally ideal contribution, and how much she cares about this; it will also be increasing in her belief about others' view of the ideal contribution, and how much she cares about their views; and it will be decreasing in her private marginal cost of contributing.

Although suppressed in the notation above, the exogenously fixed parameters and variables a, b, g^* and g^{**} may vary between individuals. Below, we estimate the effects of perceived moral responsibility and peer pressure on recycling choices. We do so via indices which represent individual's rating of the extent to which neighbours judge them with respect to their recycling behaviour and the importance to them of a positive self-image from recycling. With regard to the marginal cost $\left(pu_c'\right)$ we estimate the effects of changes in the financial cost to the household of waste collection contracts (which reduces freely disposable income) and the net effort or pleasure in recycling. Note that although the above model may be helpful in thinking about the relationship between moral responsibility, peer pressure and recycling behaviour, our estimated coefficients for moral responsibility and peer pressure do not correspond exactly to the parameters a and b, since g^* and g^{**} above were measured in environmental units, while our questionnaire responses indicate the level of agreement with verbal statements.

4 Design of the Empirical Study

4.1 Methodology: The Discrete Choice Experiment Approach

In this paper, we use a choice experiment approach to estimate the preferences of individuals for household recycling. Discrete choice experiments (DCE) have been widely applied in the environmental, health, food and transport economics literatures (Hanley et al. 2013; Carson and Czajkowski 2014). DCE are a stated preference method, where respondents make choices over goods or policy options described in terms of the attributes of these goods or policies, and the levels that they take. A price or cost attribute is usually included in the design to allow willingness to pay for changes in any non-price attribute to be calculated. As noted above, stated preference approaches to investigating the demand for recycling and waste management are numerous (Basili et al. 2006).

DCE are based on random utility theory, which states that the utility function can be disaggregated into deterministic and stochastic (random) components. Assumptions about the nature of this random component and the nature of preferences in terms of how they vary across respondents lead to a variety of econometric specifications. The main advantage of using the DCE approach here is that preferences and willingness to pay for different attributes of recycling schemes can be directly estimated, along with the impact of a number of potential determinants of recycling choice behaviour, such as selfish interest, social pressures and sense of moral duty.

4.2 Questionnaire Design

Polish law has required the sorting of municipal waste since the beginning of 2010. However, it is not specified in law exactly how this sorting should take place—whether household waste

[6] For related models, see Brekke et al. (2003), Bruvoll and Nyborg (2004), Nyborg et al. (2006) and Nyborg (2011).

should be collected in an already-sorted state (that is, sorted by the household), or collected un-sorted and then sorted centrally. The hypothetical scenario of our study coincided with government's plans to make each municipality (instead of private companies) responsible for waste management, by setting 'waste fees' for all households and hiring private companies to collect municipal waste from them.[7] The sorting method can be selected by each municipality independently, and collected at a range of frequencies.[8]

We used the following attributes to describe a set of hypothetical future alternative contracts for waste which were considered by respondents:

- The number of categories waste needs to be sorted into before it will be collected (1, 2, or 5 categories);
- The number of times each month that waste is collected from your property (1, 2, 4 times per month): frequency of collection has been shown to be important in other, comparable studies (Karousakis and Birol 2008);
- A cost to the household per month (25, 50, 75, 100 PLN—the bill they will face for waste collection).

An example choice card (translated) is presented in Fig. 1. The number of home sorting categories ranged from 1 (no sorting required), through 2 (recyclables, non-recyclables) to 5 (paper, glass, metals, plastic, other). The respondents were informed, however, that in every case the collected waste would undergo a central screening process, and due to regulatory requirements, even if it was collected unsorted it would still be sorted in a central professional sorting facility. Thus, irrespective of people's choices at the household level, a fixed quantity of recycling would be attained at the municipal level. However, no assurance was given about the quality of this central recycling effort: many of our respondents could thus believe that the care taken in and thus the effectiveness of recycling actions would be higher if recycling were done by households prior to collection. The survey also reminded people that sorting into more categories required more space in the household and more time and effort, and that a lower frequency of collecting waste requires that waste is stored on the respondent's property for longer. All levels of the attributes used in our study (including cost) were derived from observing the range of current practices of waste-collecting companies in 2013.

The study conducted here was a follow-up to Czajkowski et al. (2014) and so it used almost the same questionnaire and design,[9] supplemented with additional attitudinal questions aimed at uncovering the motives of respondents in making their recycling choices (see

[7] There is now substantial evidence that many of the biases identified in the stated preference studies are a result of the lack of incentive compatibility of the survey (Carson and Groves 2007; Carson et al. 2014), and in particular—the lack of perceived consequentiality of the survey, the importance of which has been demonstrated by both theoretical and empirical work (Nepal et al. 2009; Vossler and Evans 2009; Herriges et al. 2010; Broadbent 2012; Vossler et al. 2012; Vossler and Watson 2013). Our study aimed at being perceived as consequential. To this end, respondents were informed about the upcoming waste collection policy changes in the country and the necessity to decide upon a uniform waste collection scheme for entire municipality. The questions in the DCE part of the survey were thus framed from this perspective—collecting the respondents' preferences, which can influence future policy options. We acknowledge, however, that this leads to a potential difference between the theoretical model and our empirical application—note that the theoretical model focuses on individual's motivations while the empirical study scenario dealt with a new policy common for all: this could lead to some other strategy being optimal.

[8] The rationale for this change was to reduce the illegal trash dumping as well as impose more stringent recycling targets, in order to comply with EU Landfill Directive (1999/31; provide reductions in landfilling) and the EU Waste Framework Directive (2008/98; reaching minimum target levels of recycling).

[9] The experimental design of the original study, used also here, consisted of 6 choice-tasks each with 3 alternatives per respondent; there were 4 questionnaire versions (blocks). The design was optimized for median D-efficiency of a multinomial logit model using Bayesian priors (Ferrini and Scarpa 2007) and all prior estimates were assumed to be normally distributed, with their means derived from the MNL model

Choice Situation 1.	Alternative 1	Alternative 2	Alternative 3
Method of sorting in household	Into 5 categories	Into 2 categories	None
Frequency of collection	Once every 4 weeks	Once every 2 weeks	Once every week
Monthly cost for your household	75 PLN	50 PLN	100 PLN
Your choice:	☐	☐	☐

Fig. 1 Example of a choice card

Fig. 1 for details). Respondents were asked to indicate the extent to which they agreed or disagreed ("I definitely disagree", "I somewhat disagree", "I neither agree nor disagree", "I somewhat agree", "I definitely agree") with the following statements which correspond to our explanatory variables:

- *better*—"Sorting waste at home would be more thorough than at a central sorting facility";
- *troublesome*—"Sorting waste at home is troublesome";
- *satisfying*—"Sorting waste myself would give me a satisfaction";
- *careful*—"If I sort waste, I would do it carefully";
- *know*—"I know how to sort waste";
- *moral-duty*—"Sorting waste at home is my moral/ethical duty";
- *neighbours-judge*—"My neighbours will judge me unfavourably, if I don't sort waste at home";[10]
- *i-judge*—"I judge neighbours who don't sort waste at home unfavourably";
- *everyone-should*—"Sorting waste is something everyone should do on his own";
- *cost-saving*—"Sorting waste will allow to reduce my bills".

In addition, in what follows we use the respondents' socio-demographic characteristics to provide an insight into what observed variables can be related to their attitudes and motives. These variables include respondents' gender, age, household size and income, their responses to the questions about the extent to which they are satisfied with living in their town (*satisfied city*) and consider it clean (*clean city*) as well as their declarations about whether they ever participated in cleaning events (such as the Earth Day cleanup activities), if they currently sort their waste, and whether they have a home composting facility.

A mail survey of 8000 randomly-chosen households was undertaken in March 2013. The survey was targeted at the population of the two Polish towns of Józefów and Hrubieszów. These towns were selected because most inhabitants live in stand-alone houses, rather than in apartment buildings (since residents of apartment blocks typically do not have a direct influence on what recycling scheme is implemented for the entire building and because they

Footnote 9 continued
estimated on the dataset from the pilot survey, and standard deviations equal to 0.25 of each parameter mean (to reflect the relatively large uncertainty about the true parameters). We intentionally did not update the design using the information from the main wave of the study reported in Czajkowski et al. (2014) because we wanted to keep the design and the questionnaire as similar to the original as possible, to make the results comparable and only focus on exploring the attitudinal explanations to the observed results.

[10] Note that many of our actions as household recyclers might be observable. There are several aspects of recycling behaviour which your neighbours can observe. For example, how many different bins one puts out for collection—which is equivalent to how many fractions you sort your waste into—can be observed. Your neighbours can also see how frequently you put out your bins, and which company you have contracted with. They could possibly also observe trips you make to the local drop-off recycling centre.

are likely less concerned about collection frequency—the waste is stored in a common, designated space rather than on one's property). At the time of the study there were many different waste collection companies which differed with respect to how frequently they collected waste and to what degree they required household waste to be sorted. It was at each household's discretion whether to sign an agreement with one of the companies to collect their waste. The design of our survey was thus highly realistic, and reflected the actual decision problem which householders were faced with.

We received 418 usable questionnaires out of the 8000 questionnaires sent out, that is, a response rate of only 5.23 %. Even for a one-shot mail-out study, this is very low, and there may be good reason to expect that respondents with particularly strong opinions about waste policies are over-represented. Consequently, our analysis should not be interpreted as measuring the average citizen's views and values. Primarily, it is an attempt to understand what motivates those who, like in Czajkowski et al. (2014), prefer to sort themselves even at a cost. In addition, we believe that the data offers an interesting possibility to explore the relationships between attitudes, socio-demographic characteristics and choices, even though one should keep in mind that these relationships may possibly be influenced by self-selection into the sample.[11] We return to possible sample selection issues in the discussion section.

4.3 Econometric Approach

In order to analyse the links between respondents' attitudes, their socio-demographic characteristics and discrete choices, we apply the Hybrid Multinomial Logit (HMNL) model and the Hybrid Mixed Logit (HMXL) model. These combine the framework widely adopted for analysing DCE data, the multinomial logit or the mixed Logit (Revelt and Train 1998), with the Multiple Indicators and Multiple Causes (MIMIC) model (Jöreskog and Goldberger 1975).[12] We use these models to investigate the relative effects of economic, moral and social factors on preference heterogeneity.

Given that our attitudinal questions such as how much people think their neighbours will judge their actions are merely indications of the underlying factors which guide people's choices and attitudes towards recycling, we treat these psychological factors as latent variables, which provide a link between respondents' attitudinal responses and their stated preferences expressed in the DCE. The usual practice is to instead include stated attitudes as explanatory variables in the choice model directly,[13] or identify individual-specific factors explaining respondents' attitudes[14] and use these factors to explain their choices—but

[11] The respondents from Józefów were, on average, similar to those from Hrubieszów with respect to sex, age, household size and the number of children in a household. They were, however, (reportedly) wealthier and more often university educated. The data regarding socio-demographic characteristics of the population of the two towns targeted by our survey is not fully available. Using the available data (in some cases from larger administrative regions) we find that our sample had a larger share of females, respondents who were older, better educated, lived in larger households and were wealthier (particularly in Józefów). We do not therefore claim that the sample is representative for the populations of either of the two towns.

[12] Hybrid choice models are sometimes called Integrated Choice and Latent Variable (ICLV) models (Ben-Akiva et al. 2002). For example, Daziano and Bolduc (2013) include environmental concern as a behavioural variable in the context of a simple multinomial logit model to explain automobile choices. Hess and Beharry-Borg (2012) include pro-environmental attitude as a latent variable in a Latent Class model to explain preferences over rail travel.

[13] Note that it is likely that the indicators may then be endogenous, i.e. the errors in the measurement equations of respondents' attitudes could be correlated with errors in the discrete choice models (Louviere et al. 2005; Bahamonde-Birke and Ortúzar 2012) leading to inconsistent parameter estimators.

[14] In many cases there are many indicators describing one psychological factor, which may lead to a large number of estimable parameters in the model, collinearity and difficulty with the interpretation of results.

in a 2-step fashion. However, as noted in the next paragraph, there are problems with this approach. In contrast, our approach simultaneously identifies the links between psychological factors as well as attitudinal statements, and accounts for the relationships that are relevant for explaining choices (in the choice model). In addition, we introduce a socio-demographic component which takes respondents' observed characteristics into account by using them to explain variation in these latent psychological traits. In combination, this provides a better understanding of the variability in preferences for recycling across households in terms of the effects on these preferences of social norms, moral values and socio-economic characteristics such as household income.

From the econometric robustness point of view, our approach potentially deals with an endogeneity problem associated with a common set of un-observables co-determining both answers to attitudinal questions and choices, and with the potential co-linearity problem which arises if all attitudinal indicators (some possibly strongly correlated with each other) enter the discrete choice model simultaneously and independently (Daly et al. 2012). Instead, our approach identifies the main psychological factors (or traits) as latent variables which drive responses to attitudinal questions; and uses these latent variables to explain respondents' recycling choices, while at the same time allowing for links between the latent variables and respondents' socio-demographic characteristics. It is important to point out that the parameters in all components of our hybrid models (the measurement, structural, discrete choice components) are estimated simultaneously, thus improving statistical efficiency. The technical details of model structure and estimation are provided in the "Appendix".[15]

5 Results

Results from the attitudinal questions are shown in Fig. 2. In terms of attitudinal statements, 64 % of respondents agree that home sorting is more thorough than sorting at a central facility, slightly less than half agreed that "sorting waste at home is troublesome", whilst just over 50 % agreed that "sorting waste myself would give me a satisfaction". Over 80 % of the sample say that they know how to sort waste and that they would be doing it carefully. About 75 % agreed that sorting waste at home was their moral or ethical duty, with a similar fraction agreeing that "sorting waste is something everyone should do" (this is possibly a reflection of self-selection in our sample). Around 1/4 of people agreed with the statement "my neighbours will judge me unfavourably, if I don't sort waste at home", but just over 50 % agreed that they would also judge other people who do not sort at home.[16] Finally, about 2/3rds of respondents agreed that "sorting waste will allow me to reduce my future bills", which likely reflects their expectations about the effects of current actions on the future costs of waste collection and sorting. This data is used below to explain preference heterogeneity within the HMNL and the HMXL models.

As a point of departure, however, we start by estimating a simple multinomial logit (MNL) model to explain stated choices of waste management contract (Table 1). This shows that, on average, our respondents prefer to sort into more categories rather than fewer: sorting into 2 or 5 categories rather than no sorting both positively influence the probability of choosing a

[15] The software codes developed in Matlab used in this study are available at http://czaj.org and provided under *CC BY 4.0 license*.

[16] The different responses to these two questions do not necessarily mean that respondents are more judging than they expect their neighbours to be. Being judged by one's neighbours requires observability, which is implicit in the second question, but hardly in the first.

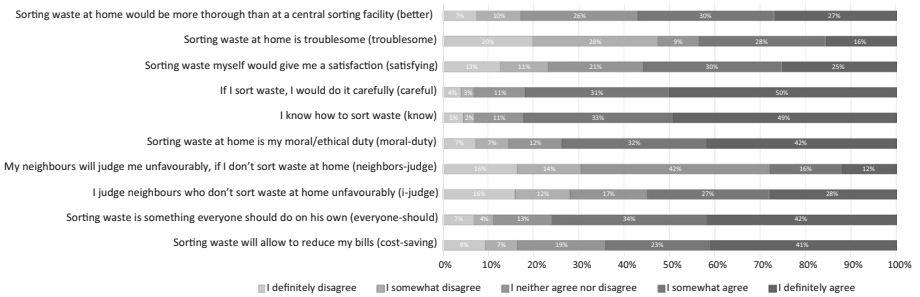

Fig. 2 Respondents' attitudes with respect to in-home sorting

Table 1 General preferences with respect to waste management contract characteristics—the results of the multinomial logit model

Variable	Coefficient (standard error)	WTP [PLN] (95 % CI)
*sort*2	0.6144***	15.66***
	(0.0978)	(11.18–20.14)
*sort*5	0.7314***	18.64***
	(0.0708)	(15.32–21.95)
*time*2	0.4630***	11.80***
	(0.1020)	(6.41–17.19)
*time*4	0.2601***	6.63***
	(0.0758)	(2.90–10.36)
cost	−0.0392***	–
	(0.0015)	
Model characteristics		
Log likelihood	−1398.35	
Log-likelihood (constants only)	−2026.50	
McFadden's pseudo R^2	0.3100	
AIC/*n*	1.5171	
n (observations)	1850	
k (parameters)	5	

***, **, * Significance at 1, 5, 10 % level

particular alternative (*ceteris paribus*). This result of a positive preference for (costly) home sorting mirrors that reported for a different data set in Czajkowski et al. (2014), and thus provides a good basis for exploring the paradox identified in that paper and discussed at the outset of this paper: that people prefer to sort themselves, even if it is costly and does not affect the overall level of recycling. On average, respondents prefer waste to be collected either twice or four times per month rather than only once per month, and prefer cheaper waste contracts to more expensive ones.

The results of the hybrid multinomial logit (HMNL) model are presented in Table 2, which is divided into three panels labelled "measurement equations", "structural equations" and "discrete choice model". The first panel includes the estimation results of the measurement component of the model. The Likert-scale responses to 10 attitudinal statements correspond-

ing to different motives for recycling were modelled using ordered a probit framework (see the "Appendix" for details). The first three columns present the estimated parameters corresponding to the latent variables—those underlying un-observed psychological factors which explain respondents' attitudes and choices. We found that the model with three factors outperformed specifications with fewer factors, while providing consistent and reasonable results in all three components. We allowed all latent variables to explain all measurement equations (i.e., we did not impose any *a priori* structure).[17] This measurement component of the model (the first part of Table 1) provides an understanding of the main factors (latent variables or LV) which underlie respondents' attitudes, and hence their responses to the questions illustrated in Fig. 2.

The first LV reflects social pressures as well as moral considerations and cost: LV1 is associated with being more likely (than the rest of the sample) to report that sorting is satisfying, saying that one would do it carefully, that one has a moral duty to do it, that sorting is something everyone should do themselves, that neighbours would judge one if one does not sort, and that one would judge one's own neighbours if *they* do not sort; also, that sorting will allow one to reduce bills (*cost-saving*). This last variable should be interpreted with care, however: the monetary cost of the waste handling contract is already accounted for in the discrete choice model (to be described below), so *cost-saving* should rather be taken to capture households' general beliefs about whether more home sorting will eventually lead to reduced waste bills. Interpreted this way, *cost-saving* may partly reflect respondents' beliefs about the social efficiency of home sorting.

LV2 seems surprisingly similar to LV1. Both are significantly and positively associated with finding sorting satisfying, being careful, finding sorting a moral duty, judging neighbours who do not sort, and believing that everybody should sort at home. In fact, for every single variable in the measurement equations, the coefficients for LV1 and LV2 have the same sign; they differ in terms of coefficients' size and statistical significance only. In particular, unlike LV1, LV2 is significantly associated with saying that home-sorting is better than central sorting, is not troublesome, and that one knows how to do it well; unlike LV1, the association is insignificant with regard to expecting judgement from one's neighbours or expecting cost-savings. The parameter on "I judge my neighbours badly if they do not recycle" is also much higher for LV1 than for LV2.

LV3 seems quite different from both LV1 and LV2. LV3 is associated with not believing home sorting is better than sorting in a central facility, with finding sorting troublesome and not satisfying, not knowing how to do it well, not being careful when sorting, not regarding it a moral duty, and neither judging one's neighbours badly nor expecting judgement from them.

One summary of this may be that LV1 and LV2 both capture norm-based motivation to sort. LV1 seems more strongly linked to extrinsic motives (social pressure, cost), while LV2 captures, to a greater extent, internalized motivation (moral duty, the belief that home sorting is in fact better than central sorting). LV3, on the other hand, appears to reflect the view that sorting at home is not a morally superior choice at all: it is not better, it is troublesome, and that it is not something everyone should do. Note, in particular, that only LV2 is associated with the belief that home sorting is better (more thorough) than sorting in a central facility. LV1 reflects a generally positive attitude towards sorting, without being significantly associated with a belief

[17] The last four columns present the estimates of the threshold parameters which are used to categorize a continuous (unobserved) index response into the 5 observed levels of disagreement / agreement. These thresholds parameters do not have a direct interpretation—overall their significance shows that the model performs well in predicting respondents' attitudinal Likert scale responses.

that home sorting is better. LV3 is significantly associated with a belief that home sorting is *not* better.

The next section of Table 2 presents the structural component of the model in which the latent variables are linked with respondents' observed socio-demographic characteristics. This makes it possible not only to identify latent traits which govern responses to the attitudinal questions, but also provides an insight into how likely these traits are for respondents with different socio-demographic characteristics. This shows that those with attitudes represented by LV1 are likely to belong to a smaller household, have higher income, have participated in cleaning the city (such as the Earth Day cleanup activities), currently sort their waste, and are less likely to have a home composting facility. Those with attitudes represented by LV2 are mostly female, come from a larger household, and have higher income. Finally, those with attitudes represented by LV3 are from the highest income group, do not currently sort, and do not have compost facilities. Respondents with strong LV2 and LV3 traits are more likely to state that they are less satisfied with living in their cities.

The third panel of Table 2 reports on the discrete choice component of the model. In this component, respondents' discrete choices across recycling contract alternatives are explained using the attribute levels which characterized these alternatives, along with the individual-specific latent variables. This provides an insight into how the preferences of respondents with a particular trait (latent variable) differ from the preferences of other respondents. These latent variables are specified as interactions with the attribute level parameters. Since the LVs are normalized with a mean 0 and standard deviation 1, the first column (reporting main effects) is very similar to the results provided by a stand-alone simple MNL model (Table 1).

Turning to the interactions, the following interesting pattern appears: the preference to sort into more categories—i.e., a positive and significant coefficient for *sort2* and *sort5*—is associated only with latent variable 2. For LV1 there is no significant relationship, while for LV3, there is a significant negative coefficient for sorting into five categories. In other words: wanting to sort appears to be associated with an internalized norm-based motivation, involving the belief that sorting at source is indeed better (more thorough) than sorting in a central facility.[18]

Next, we present results from the hybrid mixed logit (HMXL) model, which adds a representation of respondents' un-observed preference heterogeneity (Table 3).[19] This model offers a better fit than the equivalent MNL version in Table 2, as indicated by the lower score of the normalized Akaike Information Criterion, and formally supported by the results of the LR-test (test statistic 127.12, 5 d.f., p value < 0.0001).

Using this model, we see a pattern roughly similar to the above, although with some differences for individual questions. Again, only LV2 is associated with the belief that home sorting is better, while LV3 is associated with the belief that it is *not* better. In the measurement equations, LV1 is significantly associated with three questions only, all of them closely related to social approval: judging one's neighbours, expecting to be judged by them, and thinking that everyone should sort at home. LV2 is positively associated with neither of these; instead, LV2 is linked to several questions indicative of an intrinsically positive

[18] Further, LV2 is associated with a higher willingness to pay (*cost*). There are significant interaction effects for LV1 with *time*2 and *time*4, and a negative interaction with *cost*; that is, people with attitudes associated with LV1 generally want waste collected more often and are more cost-sensitive. LV3 is associated with wanting more frequent collection and lower price sensitivity.

[19] This heterogeneity shows up in the standard deviations of the random coefficients associated with the choice attributes—we see that there are significant standard deviation terms for *sort*5, *time*4 and *costs*.

Table 2 The results of the hybrid multinomial logit model (standard errors given in parentheses)

Measurement equations

	Latent variable 1	Latent variable 2	Latent variable 3	Threshold 1	Threshold 2	Threshold 3	Threshold 4
better	0.1421	0.3377***	−0.4747***	−1.6621***	−1.1141***	−0.2823	0.7479***
	(0.0863)	(0.0913)	(0.0795)	(0.1061)	(0.2385)	(0.2666)	(0.2824)
troublesome	−0.0865	−0.3943***	0.4166***	−1.0022***	−0.1634	0.2727	1.1744***
	(0.0887)	(0.0866)	(0.0799)	(0.0803)	(0.1376)	(0.1493)	(0.1698)
satisfying	0.3845***	0.7483***	−0.8450***	−1.7024***	−1.1389***	−0.3358	1.0362***
	(0.1263)	(0.1320)	(0.1120)	(0.1201)	(0.2590)	(0.2939)	(0.3312)
careful	0.5544***	0.6538***	−1.0174***	−2.7484***	−2.3434***	−1.4548**	0.1090
	(0.1363)	(0.1558)	(0.1283)	(0.1931)	(0.6016)	(0.6653)	(0.7098)
know	0.1963	0.4890***	−0.7939***	−2.2548***	−1.9738***	−1.2441***	0.1275
	(0.1067)	(0.1234)	(0.1078)	(0.1556)	(0.4045)	(0.4616)	(0.4967)
moral-duty	0.7323***	1.0450***	−1.5655***	−3.0341***	−2.1710**	−1.3656	0.5266
	(0.1852)	(0.2283)	(0.1914)	(0.2474)	(0.8616)	(0.9091)	(0.9944)
neighbours-judge	0.6597***	0.0381	−0.2806***	−1.2677***	−0.7147***	0.8024***	1.4796***
	(0.0996)	(0.1192)	(0.1060)	(0.0992)	(0.1792)	(0.2351)	(0.2567)
i-judge	1.0128***	0.4052**	−0.5693***	−1.5929***	−0.9911***	−0.3489	0.9858**
	(0.1581)	(0.1721)	(0.1323)	(0.1384)	(0.2831)	(0.3218)	(0.3874)
everyone-should	1.2728***	0.9478***	−1.5572***	−3.4727***	−2.8098**	−1.6101	0.5765
	(0.2181)	(0.2694)	(0.2085)	(0.3115)	(1.1728)	(1.2758)	(1.3997)
cost-saving	0.5264***	0.2180	−0.6293***	−1.6979***	−1.2678***	−0.5220	0.3270
	(0.0987)	(0.1225)	(0.0980)	(0.1136)	(0.2436)	(0.2788)	(0.2975)

Structural equations

	Latent variable 1	Latent variable 2	Latent variable 3
male	−0.0692	−0.2061***	0.0213
	(0.0780)	(0.0753)	(0.0788)
age	0.0906	0.1342	0.0504
	(0.0827)	(0.0862)	(0.0809)
household size	−0.1958**	0.2103**	0.1558
	(0.0820)	(0.0844)	(0.0890)
income	0.2691**	0.3630***	0.3774***
	(0.1071)	(0.0995)	(0.0883)
satisfied city	−0.1441	−0.4252***	−0.4838***
	(0.1233)	(0.1612)	(0.1405)
clean city	0.2026**	0.0892	0.0845
	(0.0808)	(0.0934)	(0.0883)
ever cleaned	−0.1055	−0.0397	−0.1427
	(0.0753)	(0.0840)	(0.0760)
currently sort	0.2021**	0.1487	−0.2135**
	(0.0816)	(0.0858)	(0.0837)
compost	−0.3476***	−0.1483	−0.3387***
	(0.0910)	(0.1016)	(0.0868)

Table 2 continued

Discrete choice model				
	Main effects	Interactions		
		Latent variable 1	Latent variable 2	Latent variable 3
sort2	0.8411***	0.0285	0.5488***	−0.3127
	(0.1482)	(0.1777)	(0.1835)	(0.1654)
sort5	0.8940***	−0.0429	1.1920***	−1.0160***
	(0.1242)	(0.2380)	(0.2119)	(0.1996)
time2	0.4007**	0.7296***	−0.1064	0.9879***
	(0.1804)	(0.2127)	(0.2513)	(0.2039)
time4	0.1101	0.9196***	0.1773	1.1531***
	(0.1395)	(0.2098)	(0.2570)	(0.1974)
cost	−0.0599***	−0.0126**	0.0284***	0.0138**
	(0.0036)	(0.0051)	(0.0047)	(0.0057)
Model characteristics				
Log-likelihood	−6300.87			
Log-likelihood (constants only)	−7841.45			
McFadden's pseudo-R^2	0.1965			
AIC/*n*	6.9469			
n (observations)	1850			
k (parameters)	117			

attitude to sorting (it is satisfying, not troublesome, one does it carefully and knows how to do it), and with the expectation *not* to be judged by others if not sorting. Somewhat surprisingly, LV2 is now not significantly linked to*moral duty*. Nevertheless, it seems fair to say that LV1 largely reflects concerns related to social approval, while LV2 appears to reflect an internalized positive attitude. LV3 again appears to represent the view that sorting at home is not socially useful (it is not better, troublesome, and not satisfying) and is thus no obligation: the negative associations with *moral duty* and *everyone-should* are strong and highly significant.

Looking at the discrete choice part of the HMXL model, a clear pattern emerges with respect to the three latent variables: wanting to sort (*sort2* and *sort5*) is associated with LV2 only. There is no significant relationship between LV1 and the preference to sort. For LV3, there is a strong and significant association with *not* wanting to sort.

In summary, we were able to identify three major factors (distinct latent variables) which on the one hand allow us to explain the variation in respondents' attitudinal responses, and on the other can be associated with significant differences in respondents preferences expressed in the discrete choice experiment. At the same time, these factors can be linked with respondents' socio-demographic characteristics. Whilst the associations between the latent variables on the one hand and attitudinal statements and preference parameter estimates are not causal, they indicate that the preference to home sort into more categories is associated with an underlying intrinsic, positive attitude to sorting at home, involving the belief that home sorting is more thorough than central sorting.

Table 3 The results of the hybrid mixed logit model (standard errors given in parentheses)

Measurement equations

	Latent variable 1	Latent variable 2	Latent variable 3	Threshold 1	Threshold 2	Threshold 3	Threshold 4
better	−0.0767	0.2742**	−0.5367***	−1.6859***	−1.1331***	−0.2910	0.7559***
	(0.1135)	(0.1246)	(0.0847)	(0.1097)	(0.1246)	(0.1565)	(0.1539)
troublesome	−0.0430	−0.2861**	0.4428***	−0.9905***	−0.1554	0.2776**	1.1669***
	(0.0952)	(0.1392)	(0.0821)	(0.0797)	(0.1135)	(0.1208)	(0.1580)
satisfying	0.2063	0.5648**	−1.0151***	−1.7320***	−1.1626***	−0.3528	1.0461***
	(0.1634)	(0.2548)	(0.1289)	(0.1344)	(0.2117)	(0.2518)	(0.3623)
careful	0.1052	0.7632***	−1.3457***	−3.0889***	−2.6165***	−1.6285***	0.1031
	(0.2150)	(0.2504)	(0.2045)	(0.2572)	(0.3228)	(0.3942)	(0.4861)
know	−0.1186	0.5356***	−0.8824***	−2.3872***	−2.0886***	−1.3146***	0.1210
	(0.1493)	(0.1659)	(0.1476)	(0.1740)	(0.3488)	(0.3611)	(0.4192)
moral-duty	0.2498	0.4953	−1.8310***	−3.0328***	−2.1755***	−1.3682***	0.5155
	(0.1945)	(0.3703)	(0.1905)	(0.2651)	(0.4502)	(0.4731)	(0.8362)
neighbours-judge	0.6556***	−0.5354***	−0.6231***	−1.4180***	−0.7844***	0.9265**	1.6727***
	(0.1925)	(0.1392)	(0.1263)	(0.1360)	(0.2036)	(0.3825)	(0.4121)
i-judge	1.5256***	−0.6229	−1.5186***	−2.2905***	−1.4214***	−0.4757	1.4660
	(0.3413)	(0.5000)	(0.2658)	(0.3312)	(0.1937)	(0.3931)	(0.8635)
everyone-should	0.6247***	0.3685	−1.8478***	−3.2105***	−2.6071***	−1.5150***	0.5421
	(0.2043)	(0.3539)	(0.1995)	(0.2615)	(0.5281)	(0.5459)	(1.0280)
cost-saving	0.1924	0.1066	−0.7166***	−1.6404***	−1.2210***	−0.4967**	0.3251
	(0.1007)	(0.1407)	(0.0837)	(0.1110)	(0.2211)	(0.2335)	(0.2616)

Structural equations

	Latent variable 1	Latent variable 2	Latent variable 3
male	−0.0793	−0.0802	0.0807
	(0.0855)	(0.0908)	(0.0582)
age	0.0038	−0.2101**	−0.1274
	(0.1036)	(0.0950)	(0.0683)
household size	−0.0363	0.2207**	0.1681**
	(0.0963)	(0.0995)	(0.0741)
income	0.5645***	0.2869	0.1246
	(0.1097)	(0.1607)	(0.0802)
satisfied city	−0.5305***	−0.2848	−0.2677**
	(0.1824)	(0.2182)	(0.1257)
clean city	0.2912***	0.2115	0.0761
	(0.1090)	(0.1305)	(0.0708)
ever cleaned	−0.2210**	−0.0939	−0.1187
	(0.0925)	(0.0993)	(0.0616)
currently sort	0.2103**	0.1414	−0.2344***
	(0.1040)	(0.1398)	(0.0667)
compost	−0.3904***	−0.0988	−0.1475**
	(0.1047)	(0.1066)	(0.0695)

Table 3 continued

Discrete choice model					
	Main effects		Interactions		
	Means	Standard deviations	Latent variable 1	Latent variable 2	Latent variable 3
*sort*2	1.1031***	0.0000	0.3603	0.6012**	−0.3724
	(0.1583)	(0.0000)	(0.2347)	(0.2772)	(0.2083)
*sort*5	1.4238***	1.7691***	0.2963	0.8735**	−1.1883***
	(0.1828)	(0.2135)	(0.3012)	(0.4423)	(0.2648)
*time*2	0.5070***	0.0000	1.3252***	0.2914	0.7786***
	(0.1861)	(0.0000)	(0.2698)	(0.2495)	(0.2374)
*time*4	0.1404	1.0813**	1.5616***	0.7680***	0.6271***
	(0.1745)	(0.4221)	(0.4344)	(0.2932)	(0.2212)
cost	−0.0776***	0.0521***	−0.0006	0.0026	0.0099**
	(0.0058)	(0.0054)	(0.0047)	(0.0056)	(0.0042)
Model characteristics					
Log-likelihood	−6237.31				
Log-likelihood (constants only)	−7841.45				
McFadden's pseudo-R^2	0.2046				
AIC/*n*	6.8843				
n (observations)	1850				
k (parameters)	122				

6 Discussion

Consider now the three latent variables identified above in light of the three types of motives emphasized in our theory model—social pressure, moral motivation, and private costs/effort. Although the following interpretations may be overly simplistic, let us provide some suggestions of the links between the theoretical and econometric analyses.

Our theory model corresponds to the standard *homo oeconomicus* model whenever $a = b = 0$. LV1 and LV2 both indicate the presence of norm-based motives inconsistent with *homo oeconomicus*. LV1 seems to pick up social approval-driven motives to sort, corresponding to $b > 0$ and $g^{**} > 0$ in the theory model. Similarly, LV2 indicates a mainly moral or intrinsic motivation to sort, corresponding to $a > 0$ and $g^* > 0$. Brekke et al. (2003) and Nyborg (2011) propose that g^*, the morally ideal contribution, is increasing in contributions' perceived social value; this seems nicely consistent with the fact that LV2 is associated with believing that sorting at home is more thorough than central sorting.

The interpretation of LV3 is somewhat less obvious. Since the monetary cost of waste contracts is already controlled in the discrete choice part of the econometric model (using the price attribute on the choice cards), LV3 does not reflect individual cost/effort motives in general. And even if LV3 is consistent with selfish motives, it cannot readily be interpreted as such. If one does not think home sorting is better than central sorting, and one finds sorting at home burdensome, then such an individual may not consider central sorting morally superior; in the language of the theory model, $g^* = 0$. As shown by Table 3, LV3 is associated with *not* believing sorting at home is better, and *not* feeling a moral duty. Even the strongest preference

for moral conduct—the highest possible a parameter—will not motivate you to sort if you so not find sorting morally superior, i.e., if $g^* = 0$. Consequently, LV3 appears to reflect a motivation *not* to sort at home which can be due either to *homo oeconomicus* preferences, or to a belief that home sorting is neither morally nor socially superior.

Respondents of the present study prefer, on average, to sort more at home, just like those of Czajkowski et al. (2014). These results contrast with Bruvoll et al. (2002), who found that the majority of their sample preferred sorting to be done by a central facility rather than doing it themselves. In light of the above, it is interesting to note that unlike the present study, Bruvoll et al. (2002) informed their respondents that "New technology makes it possible to sort waste centrally so that the environmental effect will be the same".[20] In addition, the different results may have arisen from a sample selection effect: the Norwegian respondents in Bruvoll et al. (2002) were questioned as part of an omnibus survey, whereas the participants in our survey were only questioned about recycling. Clearly, one's incentives to participate in a general survey are likely to be different to one's incentives to participate in a survey about an environmental issue, so that the sample selection process may have worked differently in the two studies. The response rate in Bruvoll et al. (2002) was considerably higher than ours, almost 60 %, which may support this explanation.

7 Conclusions

The motivation for this paper was to investigate the determinants of individuals' stated preferences for household recycling. In particular, our aim was to throw light on the previous result of Czajkowski et al. (2014), who found that their respondents preferred, on average, to sort at home rather than leaving it to a central waste handling facility even at a cost.

A conceptual model is used to show how three types of factors—economic factors affecting the net costs of recycling; personal moral sentiments; and social pressures—can all contribute to an individual's decision over how much to recycle. These factors have all been highlighted before in the literature, but this paper is, to our knowledge, the first to compare them within a stated preference, choice experiment setting using an integrated modelling approach.

The conceptual model is then applied to a case study of the preferences of a sample of Polish households for recycling, as reflected in their stated choices over alternative waste contracts. The main empirical findings are that, for this sample, many people "want to sort", preferring to sort their own household waste even when there is an alternative of getting a central facility to sort for them.

Due to possible sample selection effects, we cannot guarantee that these results are representative for the population at large. However, we find it interesting to explore the factors underlying the substantial norm-based motivation which appears to be present in our sample. We find considerable variation underlying the average effects, associated with indicators of social, moral and economic factors. The main result which emerges is that the willingness to pay for (and desire to participate in) higher levels of household recycling is mostly linked to a moral or intrinsic motivation, associated with the belief that sorting at home is in fact more thorough than sorting at a central facility.

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[20] Several other design features may have contributed to the different results: for example, our main questions were preceded by a couple of questions concerning local street cleanliness and local social engagement, which may have triggered a feeling that waste is something one should take care of oneself.

Appendix

Description of the Hybrid Attitudinal Questions Aimed at Discovering Respondents' Motivation

All hybrid choice models consist of three parts: a measurement component; a structural component; and a discrete choice component. Below we describe each part in turn.

Measurement Component

Often, psychological factors which influence individual behaviour cannot be measured in a direct way, unlike individual characteristics such as age and gender. Instead a researcher must use various indicator (measurement) questions in a survey, the responses to which could be expected to be determined by latent variables which are indicators of psychological traits or beliefs.

Modelling choices for the indicator equations depend on the particular application.[21] In this paper our indicators were measured on 5-point Likert scales—the measurement equations are therefore modelled using ordered probit models. Formally, for $\mathbf{I}_i$ ordered indicator variables the measurement component of the hybrid choice model can be specified as:

$$\mathbf{I}_i^* = \boldsymbol{\Gamma}'\mathbf{LV}_i + \boldsymbol{\eta}_i, \tag{6}$$

where $\boldsymbol{\Gamma}$ is a matrix of coefficients of individual specific latent variables $\mathbf{LV}_i$, and $\boldsymbol{\eta}_i$ denotes a vector of error terms assumed to come from a multivariate normal distribution with 0 means and identity covariance matrix. Under this specification, the relationship between I_{il} and I_{il}^* (for the l-th indicator variable which takes J possible, ordered values) becomes:

$$\begin{aligned}
I_{il} &= 1, \text{ if } && I_{il}^* < \alpha_{1l} \\
&\vdots \quad \vdots && \vdots \\
I_{il} &= k, \text{ if } \alpha_{k-1l} \leq I_{il}^* < \alpha_{kl}, \\
&\vdots \quad \vdots && \vdots \\
I_{il} &= J, \text{ if } && \alpha_{J-1l} \leq I_{il}^*
\end{aligned} \tag{7}$$

where the α's are the threshold parameters to be estimated for each indicator. This specification leads to the well-known ordered probit likelihood form for I_i:

$$P\left(I_i|\mathbf{LV}_i, \boldsymbol{\Gamma}, \boldsymbol{\alpha}\right) = \prod_{l=1}^{L}\left(P\left(I_{il}|\mathbf{LV}_i, \boldsymbol{\Gamma}_l, \alpha_l\right)\right) = \prod_{l=1}^{L}\left(\Phi\left(\alpha_{kl} - \boldsymbol{\Gamma}'_l\mathbf{LV}_i\right) - \Phi\left(\alpha_{k-1l} - \boldsymbol{\Gamma}'_l\mathbf{LV}_i\right)\right), \tag{8}$$

where $\Phi(\cdot)$ denotes the normal cdf, Γ_l and α_l are l-th row of the $\boldsymbol{\Gamma}$ matrix and the vector of thresholds parameters for *l-th* indicator variable, respectively.

[21] Many early hybrid choice model applications used a simple, linear regression even in cases where the dependent variable was clearly ordered (Daly et al. 2012).

Structural Component

We assume that the latent variables in (6) depend on some socio-demographic variables which are stacked in a vector $\mathbf{X}_i^{str}$. This relationship can be described by the following structural equations:

$$\mathbf{LV}_i = \mathbf{\Psi}'\mathbf{X}_i^{str} + \boldsymbol{\xi}_i, \tag{9}$$

with $\mathbf{\Psi}$ representing a matrix of coefficients and error terms $\boldsymbol{\xi}_i$ which are assumed to come from a multivariate normal distribution with 0 mean and a diagonal covariance matrix.

Discrete Choice Component

The theoretical foundation for the discrete choice model is random utility theory, which assumes that the utility a person derives depends on observed characteristics and unobserved idiosyncrasies, represented by a stochastic component (McFadden 1974). As a result, individual i's utility resulting from choosing the alternative j in choice set t can be expressed as:

$$V_{ijt} = \boldsymbol{\beta}_i' \boldsymbol{X}_{ijt} + e_{ijt}, \tag{10}$$

where the utility expression is a function of alternative attributes $\boldsymbol{X}_{ijt}$; the associated coefficients $\boldsymbol{\beta}_i$; and a stochastic component e_{ijt} allowing for factors not observed by the econometrician to affect individuals' utility and choices. Note that $\boldsymbol{\beta}_i$ are *individual*-specific, thus allowing for heterogeneous preferences amongst respondents and leading to a hybrid mixed logit model (HMXL).[22] Assuming that parameters are the same for all respondents implies homogenous preferences and leads to the hybrid multinomial logit model (HMNL).

In our HMNL and HMXL model we also assume that the random parameters $\boldsymbol{\beta}_i$ depend on latent variables $\mathbf{LV}_i$, related to respondents' beliefs and attitudes towards recycling. The functional form of this dependence is assumed to be of the form:

$$\boldsymbol{\beta}_i = \mathbf{\Lambda}'\mathbf{LV}_i + \boldsymbol{\beta}_i^*, \tag{11}$$

where $\mathbf{\Lambda}$ is a matrix of coefficients to estimate and $\boldsymbol{\beta}_i^*$ has a multivariate normal distribution with vector of means and covariance matrix to be estimated.[23]

As a result, the conditional probability of individual i's choices is given by:

$$P(y_i|\mathbf{X}_i, \boldsymbol{\beta}_i^*, \mathbf{LV}_i, \mathbf{\Lambda}) = \prod_{t=1}^{T_i} \frac{\exp\left(\boldsymbol{\beta}'_i \boldsymbol{X}_{ijt}\right)}{\sum_{k=1}^{C} \exp\left(\boldsymbol{\beta}'_i \boldsymbol{X}_{ikt}\right)} \tag{12}$$

Estimation and Identification of the Model

After combining Eqs. (8) and (12) we obtain the full-information likelihood for our HMNL or HMXL model, where for ease of exposition we stack the parameter vectors $\mathbf{\Lambda}$, $\mathbf{\Psi}$, $\mathbf{\Gamma}$ into the single vector $\boldsymbol{\Omega}$:

$$L_i = \int P\left(\mathbf{y}_i|\mathbf{X}_i, \mathbf{X}_i^{str}, \boldsymbol{\beta}_i^*, \boldsymbol{\xi}_i, \boldsymbol{\Omega}\right) P\left(\mathbf{I}_i|\mathbf{X}_i^{str}, \boldsymbol{\xi}_i, \boldsymbol{\Omega}\right) f\left(\boldsymbol{\beta}_i^*, \boldsymbol{\xi}_i|\boldsymbol{\theta}\right) d\left(\boldsymbol{\beta}_i^*, \boldsymbol{\xi}_i\right) \tag{13}$$

[22] Is it typically assumed that individual parameters follow a particular distribution (possibly multivariate distribution allowing for non-zero correlation of model parameters), rather than being separately estimated for each individual.

[23] Λ has number of columns equal to the number of latent variables and the number of rows equal to the number of attributes.

As random disturbances of $\boldsymbol{\beta}_i^*$ as well as error terms in structural equations $\boldsymbol{\xi}_i$ are not directly observed they must be integrated out of the conditional likelihood. This multidimensional integral can be approximated using a simulated maximum likelihood approach.

Identification

In order to make identification of hybrid choice models possible, the scale of a latent variable needs to be normalized (Daly et al. 2012). This can be done by normalizing the variances of the error terms in the structural equations or by normalizing some coefficients in the $\boldsymbol{\Gamma}$ matrix for each latent variable. Raveau et al. (2012) argue that normalizing variances leads to smaller bias, and this is the approach we adopt here. We normalize latent variables to have variance equal one ($LV_{ik}^{norm} = LV_{ik}/std\,(LV_k)$)[24] which leads to setting the k-th row of $\boldsymbol{\Psi}$ matrix to $\boldsymbol{\Psi}_k^{norm} = \boldsymbol{\Psi}_k/std\,(LV_k)$ and the standard deviation of k-th error term as $std\,(\xi_{ik}) = 1/std\,(LV_k)$.

Unfortunately it is not known if this condition is sufficient—the identification depends on the number of latent variables and measurement equations. To assure credibility of our results we followed Bollen and Davis (2009) to ensure the necessary conditions hold for identification of structural equation models. In addition, we tested our model by running simulations—we generated artificial datasets and validated our model by recovering the underlying parameters. Our model encountered no problems in identification and produces stable results.

References

Abbott A, Nandeibam S, O'Shea L (2013) Recycling: social norms and warm-glow revisited. Ecol Econ 90:10–18

Bahamonde-Birke FJ, Ortúzar JdD (2012) On the variability of hybrid discrete choice models. Transportmetr A Transp Sci 10(1):74–88

Basili M, Di Matteo M, Ferrini S (2006) Analysing demand for environmental quality: A willingness to pay/accept study in the province of Siena (Italy). Waste Manag 26(3):209–219

Becker GS (1965) A theory of the allocation of time. Econ J 75(299):493–517

Ben-Akiva M, McFadden D, Train K, Walker J, Bhat C, Bierlaire M, Bolduc D, Boersch-Supan A, Brownstone D, Bunch D, Daly A, De Palma A, Gopinath D, Karlstrom A, Munizaga M (2002) Hybrid choice models: progress and challenges. Mark Lett 13(3):163–175

Bollen KA, Davis WR (2009) Two rules of identification for structural equation models. Struct Equ Model Multidiscip J 16(3):523–536

Brekke KA, Kipperberg G, Nyborg K (2010) Social interaction in responsibility ascription: the case of household recycling. Land Econ 86(4):766–784

Brekke KA, Kverndokk S, Nyborg K (2003) An economic model of moral motivation. J Public Econ 87:1967–1983

Broadbent CD (2012) Hypothetical bias, consequentiality and choice experiments. Econ Bull 32(3):2490–2499

Bruvoll A, Halvorsen B, Nyborg K (2002) Households' recycling efforts. Resour Conserv Recycl 36(4):337–354

Bruvoll A, Nyborg K (2004) The cold shiver of not giving enough: on the social cost of recycling campaigns. Land Econ 80(4):539–549

Carson R, Groves T (2007) Incentive and informational properties of preference questions. Environ Resour Econ 37(1):181–210

Carson RT, Czajkowski M (2014) The discrete choice experiment approach to environmental contingent valuation. In: Hess S, Daly A (eds) Handbook of choice modelling. Edward Elgar, Northampton

Carson RT, Groves T, List JA (2014) Consequentiality: A theoretical and experimental exploration of a single binary choice. J Assoc Environ Resour Econ 1(1/2):171–207

[24] $std\,(LV_k)$ represents standard deviation of k-th latent variable. Since we earlier used $\mathbf{LV}_i$ to represent a vector of all latent variables for individual i, LV_{ik} is a value of the $k-$th LV for individual i.

Czajkowski M, Kądziela T, Hanley N (2014) We want to sort! Assessing households' preferences for sorting waste. Resour Energy Econ 36(1):290–306
Daly A, Hess S, Patruni B, Potoglou D, Rohr C (2012) Using ordered attitudinal indicators in a latent variable choice model: a study of the impact of security on rail travel behaviour. Transportation 39(2):267–297
Daziano RA, Bolduc D (2013) Incorporating pro-environmental preferences towards green automobile technologies through a Bayesian hybrid choice model. Transp A Transp Sci 9(1):74–106
De Jaeger S, Eyckmans J (2008) Assessing the effectiveness of voluntary solid waste reduction policies: methodology and a Flemish case study. Waste Manag 28(8):1449–1460
Ferrini S, Scarpa R (2007) Designs with a priori information for nonmarket valuation with choice experiments: a Monte Carlo study. J Environ Econ Manag 53(3):342–363
Hage O, Söderholm P, Berglund C (2009) Norms and economic motivation in household recycling: empirical evidence from Sweden. Resour Conserv Recycl 53(3):155–165
Hanley N, Shogren J, White B (2013) Introduction to environmental economics, 2nd edn. Oxford University Press, USA
Herriges J, Kling C, Liu C-C, Tobias J (2010) What are the consequences of consequentiality? J Environ Econ Manag 59(1):67–81
Hess S, Beharry-Borg N (2012) Accounting for latent attitudes in willingness-to-pay studies: the case of coastal water quality improvements in Tobago. Environ Resour Econ 52(1):109–131
Hong S, Adams RM, Love HA (1993) An economic analysis of household recycling of solid wastes: the case of Portland, Oregon. J Environ Econ Manag 25(2):136–146
Huang J-C, Halstead JM, Saunders SB (2011) Managing municipal solid waste with unit-based pricing: policy effects and responsiveness to pricing. Land Econ 87(4):645–660
Huhtala A (2010) Income effects and the inconvenience of private provision of public goods for bads: the case of recycling in Finland. Ecol Econ 69(8):1675–1681
Iyer ES, Kashyap RK (2007) Consumer recycling: role of incentives, information, and social class. J Consum Behav 6(1):32–47
Jenkins RR, Martinez SA, Palmer K, Podolsky MJ (2003) The determinants of household recycling: a material-specific analysis of recycling program features and unit pricing. J Environ Econ Manag 45(2):294–318
Jöreskog KG, Goldberger AS (1975) Estimation of a model with multiple indicators and multiple causes of a single latent variable. J Am Stat Assoc 70(351a):631–639
Karousakis K, Birol E (2008) Investigating household preferences for kerbside recycling services in London: a choice experiment approach. J Environ Manag 88(4):1099–1108
Kipperberg G (2007) A comparison of household recycling behaviors in Norway and the United States. Environ Resour Econ 36(2):215–235
Kipperberg G, Larson D (2012) Heterogeneous preferences for community recycling programs. Environ Resour Econ 53(4):577–604
Knussen C, Yule F, MacKenzie J, Wells M (2004) An analysis of intentions to recycle household waste: the roles of past behaviour, perceived habit, and perceived lack of facilities. J Environ Psychol 24(2):237–246
Kuo Y-L, Perrings C (2010) Wasting Time? Recycling incentives in urban Taiwan and Japan. Environ Resour Econ 47(3):423–437
Kurz T, Linden M, Sheehy N (2007) Attitudinal and community influences on participation in new curbside recycling initiatives in Northern Ireland. Environ Behav 39:367–391
Louviere J, Train K, Ben-Akiva M, Bhat C, Brownstone D, Cameron T, Carson R, Deshazo JR, Fiebig D, Greene W, Hensher D, Waldman D (2005) Recent progress on endogeneity in choice modeling. Mark Lett 16(3–4):255–265
Mazzanti M, Zoboli R (2008) Waste generation, waste disposal and policy effectiveness: evidence on decoupling from the European Union. Resour Conserv Recycl 52(10):1221–1234
McFadden D (1974) Conditional logit analysis of qualititative choice behaviour. In: Zarembka P (ed) Frontiers in econometrics. Academic Press, New York, pp 105–142
Nepal M, Berrens RP, Bohara AK (2009) Assessing perceived consequentiality: evidence from a contingent valuation survey on global climate change. Int J Ecol Econ Stat 14(P09):14–29
Nigbur D, Lyons E, Uzzell D (2010) Attitudes, norms, identity and environmental behaviour: Using an expanded theory of planned behaviour to predict participation in a kerbside recycling programme. Br J Soc Psychol 49(2):259–284
Nixon H, Saphores J-DM (2009) Information and the decision to recycle: results from a survey of US households. J Environ Plan Manag 52(2):257–277
Nyborg K (2011) I don't want to hear about it: rational ignorance among duty-oriented consumers. J Econ Behav Organ 79(3):263–274
Nyborg K, Howarth RB, Brekke KA (2006) Green consumers and public policy: on socially contingent moral motivation. Resour Energy Econ 28(4):351–366

Raveau S, Yáñez MF, Ortúzar J, Ortúzar JdD (2012) Practical and empirical identifiability of hybrid discrete choice models. Transp Res Part B Methodol 46(10):1374–1383
Refsgaard K, Magnussen K (2009) Household behaviour and attitudes with respect to recycling food waste—experiences from focus groups. J Environ Manag 90(2):760–771
Reichenbach J (2008) Status and prospects of pay-as-you-throw in Europe–a review of pilot research and implementation studies. Waste Manag 28(12):2809–2814
Revelt D, Train K (1998) Mixed logit with repeated choices: households' choices of appliance efficiency level. Rev Econ Stat 80(4):647–657
Videras J, Owen AL, Conover E, Wu S (2012) The influence of social relationships on pro-environment behaviors. J Environ Econ Manag 63(1):35–50
Vossler CA, Doyon M, Rondeau D (2012) Truth in consequentiality: theory and field evidence on discrete choice experiments. Am Econ J Microecon 4(4):145–171
Vossler CA, Evans MF (2009) Bridging the gap between the field and the lab: environmental goods, policy maker input, and consequentiality. J Environ Econ Manag 58(3):338–345
Vossler CA, Watson SB (2013) Understanding the consequences of consequentiality: testing the validity of stated preferences in the field. J Econ Behav Organ 86:137–147