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Complementarity vs substitutability in waste management behaviors

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Abstract

Both the economic and psychological literature suggests that household waste reduction and recycling behaviors are driven by different motivators. In this article, we investigate whether any relationship exists between waste reduction and recycling efforts and, in this case, if they turn out to be complements or substitutes in individuals' preferences. Our theoretical results, supported by empirical evidence for England, suggest that waste policies and environmental motivations may affect recycling and waste reduction both directly and indirectly, through their reciprocal interactions.

Keywords: Recycling; Waste Reduction; Warm-Glow; Complementarity; Substitutability.
JEL Codes: D10; Q53; Q58.

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Abstract

Both the economic and psychological literature suggests that household waste reduction and recycling behaviors are driven by different motivators. In this article, we investigate whether any relationship exists between waste reduction and recycling efforts and, in this case, if they turn out to be complements or substitutes in individuals' preferences. Our theoretical results, supported by empirical evidence for England, suggest that waste policies and environmental motivations may affect recycling and waste reduction both directly and indirectly, through their reciprocal interactions.

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1 Introduction

Municipal solid waste is the most visible and pernicious by-product of the consumer-based lifestyle which characterizes many of the world's economies (Hoornweg and Bhada-Tata, 2012). Despite the increasing awareness of the external effects of waste production/disposal and the multiplicity of policy initiatives undertaken by governments and international organizations, waste volumes are increasing as a result of higher incomes and urbanization rates, increased consumption of goods and services, and more intensive use of packaging materials.

In response to the challenges posed by growing waste levels, minimization of waste production has been identified as a key policy option towards a sustainable waste management strategy[1]. Focusing attention on the European Union, whilst significant improvements in recycling performance have been realized in recent years[2], the same does not hold for reduction of municipal waste. According to the European Environmental Agency, though waste prevention is at the top of the waste hierarchy (EU 2008 Waste Framework Directive), between 2001 and 2010 only eleven countries cut their generation of municipal waste per capita, whilst twenty-one countries increased their production (EEA, 2013)[3]. These results suggest that policy efforts at EU and national level have provided stronger incentives towards increasing recycling than towards waste reduction (Mazzanti and Zoboli, 2009; Cecere *et al.*, 2014).

[1]Waste minimization is defined as "measures or techniques... that reduce the amount of wastes generated. Examples of waste minimisation are environmentally-sound recycling and source reduction practices". (Source: http://www.eionet.europa.eu/gemet/en/concept/5022/ accessed 03/12/2014).

[2]Between 2001 and 2011, recycling and composting of municipal waste increased from 27% to 40% in the EU-27, while landfilling reduced from 56% to 37% (Eurostat, 2013).

[3]In the UK, for instance, waste arising from households fell by 2 per cent between 2010 and 2012. Nevertheless, this could be the result of a fall in average household expenditure over the same period, which dropped by nearly 4 per cent in 2012 compared to 2010 (DEFRA, 2015), suggesting that no decoupling is taking place.

In particular, given larger costs and difficulties of implementing waste prevention interventions and the observed sluggishness of waste reduction policies in terms of implementation, an interesting question arises concerning the potential impact of existing recycling policies in driving waste reduction. Intuitively, two opposite situations may arise. On the one hand, incentives to encourage recycling may have positive effects on waste reduction, by affecting people's cultural learning of new preferences about a pro-environmental lifestyle (Bowles and Polania-Reyes, 2012). On the other hand, they may have negative effects due to a sort of multi-tasking effect (*à la* Holmstrom and Milgrom, 1991), so that the individual devotes less effort to waste reduction in response to incentives aimed at increasing recycling efforts. In the first case a relationship of complementarity between the two waste management behaviors may be expected; at the opposite, in the second case a relationship of substitutability is more likely to exist.

In this paper we aim at analyzing these potential interrelationships by explicitly considering, theoretically and empirically, the possibility that recycling decisions interact with reduction decisions, reinforcing or weakening each other. By admitting the possibility that recycling and reduction efforts may be complements or substitutes in individuals' preferences, we introduce additional, and to our knowledge not investigated yet, potential channels through which policies and behavioral drivers can affect the different dimensions characterizing waste related behaviors.

A relevant strand of economic literature has already investigated potential effects of waste policies on recycling and reduction decisions. In several works, the analysis is devoted to assessing whether the provision of convenient recycling options and/or the introduction of waste disposal fee have positive effects in terms of increased households' recycling effort[4]. For example, user fees or pay-as-you-throw (PAYT) schemes, which charge residents for the quantity of waste thrown away for collection, are suggested to have a direct, negative effect on the amount of waste production, although this effect is not confirmed by all studies (Bel and Gradus, 2014). By increasing households' costs of discarding additional waste relative to the cost of recycling, PAYT instruments can generate also positive incentives on recycling efforts (as shown, for instance, by Hong *et al.*, 1993, and Hong, 1999 for households in Oregon and Korea, respectively, Ferrara and Missios, 2005 for Canada and Kipperberg, 2007 for Norway), even though this evidence is not supported by other studies (Fullerton and Kinnaman, 1996, Kinnaman and Fullerton, 2000 for the US). This can be justified by considering that unit pricing provides only an indirect incentive to recycling (Jenkins *et al.*, 2003)[5].

Previous contributions, however, have focused on the impact of waste policies on waste related efforts

[4]Jenkins et al. (2003) provide a thorough review of existing empirical studies exploring the impact of unit pricing and curbside recycling policies on households' recycling effort.

[5]For the US, however, Reschovsky and Stone (1994) find that recycling rate increases when PAYT schemes are adopted jointly with curbside recycling programs. Similar results are obtained by Morris and Holthausen (1994), who simulate the introduction of unit disposal fees without changing the opportunity cost of recycling, and conclude that the percentage of recycled material can even be reduced.

Regarding the different impact of waste disposal fees in different national contexts, Kipperberg (2007, p. 225) concludes that "[. . .] an emerging insight is that user fees work in several societies, including in Norway, whereas their effectiveness in the United States is yet to be fully established".

taken as separate behaviors, without considering the existence of potential interrelationships between them. We innovate with respect to the literature above, since we aim at investigating not only the direct impact of (both recycling and waste reduction) policies, but also their indirect impact passing through the potential complementarity/substitutability relationship between the two waste efforts.

More specifically, we are particularly interested in assessing the indirect effect of recycling policies on waste reduction behaviors, given the persistence of difficulties and delays in the implementation of waste minimization policies. As noted above, in the EU, waste reduction policies are still lacking, and in several Member States waste collection and disposal costs continue to be financed through flat charges or municipal taxes not related to the amount of generated waste[6]. In this respect, the choice of England as case study for our empirical investigation is particularly relevant, as in this country current legislation forbids local authorities from introducing PAYT schemes[7], implying that they have to rely on other instruments to stimulate waste reduction efforts. In this context, recycling policies play an important role in the waste management system; this suggests the opportunity of investigating potential indirect effects due to the presence of complementarity or substitutability between recycling and reduction efforts. On the other hand, given the importance of other drivers behind individual pro-environmental behaviors, as testified by a wide literature on this subject, it is worthy to explore the impact of different, non monetary motivators of waste disposal decisions.

Our analysis then builds upon the literature that focuses on the potential determinants of different waste behaviors. One of the main conclusions from this literature is that recycling and waste reduction represent different dimensions of waste management behaviors, and then require different strategies and specific incentive mechanisms. According to Ebreo and Vining (2001), for instance, waste reduction is not strongly correlated to recycling behavior: whilst individual concerns for the future are related to recycling behaviors, the same predictors are not effective in stimulating waste-reduction behaviors, which at the opposite are related to internal values and general concerns about the environment. Tonglet *et al.* (2004) find a significant correlation between reduction behaviors and some recycling factors (i.e. consequences of recycling and outcomes of recycling), even though the correlation with recycling intentions and attitudes does not turn out to be significant. An extensive analysis of different motivators for waste management behaviors is provided also by Barr (2007), that identifies three groups of predictors: environmental values, situational variables and psychological factors. On the basis of this taxonomy, the author investigates the determinants of recycling, reuse and reduction behaviors, concluding that different determinants explain each of them. According to Barr, recycling is mainly a normative behavior, as it is likely to be affected by individual awareness of the social norm, while waste reduction behavior reflects personal environmental

[6]According to Hogg et al. (2012), in the EU, only Austria, Finland and Ireland have PAYT schemes in place in all municipalities. Reschovsky and Stone (1994) have identified some concerns about PAYT schemes, related, for instance, to difficulties in setting rates, potential incentives to illegal dumping, high administrative costs and the regressive impact that variable fees could have on low income residents. All these factors contribute to explain their difficult implementation and scarce popularity.

[7]Localism Act 2012; see Holmes et al. (2014).

values.

Finally, we draw on a second strand of literature that explores the influence of non-monetary incentives on individual waste management decisions (Berglund, 2006; Brekke *et al.*, 2003, 2010; Hage *et al.*, 2009; Halvorsen, 2008). Viscusi *et al.* (2011), for instance, empirically investigate the role of social norms in affecting recycling of plastic water bottles in US, finding that the social norm variable, reflecting the individual's potential guilt with respect to neighbors' attitudes in case of not recycling, turns out to be not statistically significant. Kinnaman (2006) suggests that recycling is increased by warm-glow incentives more than by unit-based pricing, to the point that households may even be willing to pay for the opportunity to recycle. With respect to waste reduction, Cecere *et al.* (2014) test how motivations affect food waste reduction, finding that warm-glow decreases the likelihood of producing more waste. Finally, Abbott *et al.* (2013) examine (theoretically and empirically) how social norms and warm-glow affect the link between the quality of recycling facilities and recycling effort, showing that social norms significantly affect recycling decisions and warm-glow does not.

Our paper adds to these contributions by considering that recycling and reduction efforts may interact in the individual utility function, when we evaluate the impact of policy as well as other behavioral and environmental factors on them. To empirically test the hypothesized interactions between waste behaviors, we adopt structural equation modeling (SEM), which allows us to estimate the magnitude of both direct and indirect effects among the involved variables. In particular, the use of such technique is required in order to verify the existence of a reciprocal causation effect between recycling and waste reduction behaviors.

The paper is organized as follows. Section 2 presents the theoretical model and lays out the main research hypotheses to be tested empirically. Section 3 introduces the data, while Section 4 presents the empirical specifications and estimation results. Section 5 concludes.

2 Theoretical model and testable implications

We model a setting featuring a single agent[8]. Individual utility increases with the effort exerted by the agent in waste recycling and reduction, labelled, respectively, as e_{REC} and e_{RED}. In other words, we are assuming the existence of a "warm-glow" effect[9], summarized by the function $v(e_{REC}, e_{RED})$, increasing in the two arguments. The intensity of individual "warm glow" is measured by the marginal utility of waste related efforts, assumed to be decreasing, as it is standard, in the two efforts, namely $\frac{\partial^2 v}{\partial e^2_{REC}} < 0$ and $\frac{\partial^2 v}{\partial e^2_{RED}} < 0$.

Pro-environmental behaviors are likely to be modified when individuals are aware of the existence of a social norm. Social norms entail both knowledge of shared social expectations and individual readiness

[8]This is coherent with the unit of analysis of the dataset adopted in the empirical part, that is at individual level.

[9]As noted in Section 1, the relevance of warm-glow perceived both in recycling and waste reduction behaviors has been widely emphasized in the literature (Kinnaman, 2006; Viscusi *et al.*, 2011; Cecere *et al.*, 2014)

to comply with these expectations (Kaiser and Fuhrer, 2003), that are motivated by the desire for social approval or by the fear of losing approval. We can expect that the agent's utility will be affected by the judgement of her peers and that it will increase with the social approval coming from adherence to the social norm. However, peer approval can affect the agent's utility only if the individual behavior is visible. Whilst recycling behavior is visible to "neighbors' eyes"[10], reduction behavior is much less visible to individuals (Barr, 2007; Cecere *et al.*, 2014). According to Bortoleto (2014), for instance, waste reduction decisions such as to not buy, reuse and repair something are activities performed privately by individuals and they cannot be influenced by social norms. Another good example is home composting which, in general, occurs out of view (McKenzie-Mohr, 2013). Accordingly, we restrict our analysis of the effects of social norm and peer approval on recycling efforts. More specifically, in our model, we assume that utility from peer approval depends on the relationship between individual recycling effort and the social norm (sn). Peer approval is defined as the difference between recycling effort and the social norm, namely $pa = e_{REC} - sn$. We consider social norm as exogenous, i.e. the individual does not perceive the impact of her choices on sn as significant (Azar, 2004; Abbott *et al.*, 2013 and Czajkowski *et al.*, 2015), and increasing with recycling policy. Indeed, we can expect that better recycling facilities, making recycling easier to individuals, can increase peers' average recycling effort, moving therefore the social norm upwards. Accordingly utility from peer approval is given by the function $\pi = \pi\left(e_{REC} - sn\right)$, where an increase in recycling effort implies a higher utility, given the social norm, and a higher social norm implies a lower utility, given the effort level. We assume the standard property of decreasing marginal utility also with reference to peer approval.

Finally, the utility function depends also on a measure of leisure (l), as it will be clarified below.

All previous assumptions can be summed up in the following utility function:

$$U = l + v\left(e_{REC}, e_{RED}\right) + \pi\left(e_{REC} - sn\right). \tag{1}$$

The assumed separability in (1) is coherent with the focus of our analysis. Although it may lead to losses in generality it has the crucial merit to allow us to obtain readable insights concerning complementarity/substitutability across efforts. Also notice that, following Andreoni (1990; p. 465), we assume the individual is "...motivated to give only by warm-glow, hence is *purely egoistic*": accordingly, environmental quality does not enter directly in (1). It follows also that the individual does not perceive her individual efforts' contribution as significant in determining overall environmental quality, and/or that the utility derived directly from such contribution is negligible.

The individual maximizes (1) subject to a constraint expressed in terms of available time. Specifically,

[10]For curbside recycling, for instance, "engagement in the behavior is visible every time someone puts their container at the curbside" (McKenzie-Mohr, 2013; p. 78).

we assume weak separability between consumption, on one side, and leisure and waste related efforts, on the other[11]. As a result, we take consumption (and chosen labour supply) as exogenous, and focus on the allocation of non labour time among "pure" leisure and waste related efforts. Our budget constraint can therefore be written as follows[12]:

$$E = L + p_{REC}e_{REC} + p_{RED}e_{RED} \tag{2}$$

where E is total available effort for non-labour activities, i.e. total time *minus* time devoted to work, and depends on socioeconomic features and labour market conditions. Specifically, individuals with a higher wage or, more generally, with a larger opportunity cost of time, will have a smaller E (i.e. they will choose more consumption and less non-labour time). The parameters p_{REC} and p_{RED} measure the time related "opportunity cost" of recycling and reduction efforts, respectively. These opportunity costs are affected by waste policies; in particular, p_{REC} can be affected by curbside policies, whilst p_{RED} can be influenced by specific reduction related policies (e.g. composting enhancing interventions). Finally, L is "pure" leisure time. A more parsimonious version of (2) is:

$$1 = l + w_{REC}e_{REC} + w_{RED}e_{RED} \tag{3}$$

where $l = \frac{L}{E}$, $w_{REC} = \frac{p_{REC}}{E}$ and $w_{RED} = \frac{p_{RED}}{E}$. As a result, the constraint in (3) requires that the fraction of non labour time spent in leisure plus the fraction spent in exerting efforts related to recycling and waste reduction activities, sum up to 1 (i.e. 100% of non labour time). In (3), w_{REC} (w_{RED}) is smaller if recycling (reduction) effort is made easier by better policies, as this would imply that a smaller fraction of non labour time is needed to perform each unit of effort; also, w_{REC} and w_{RED} are larger for improved labour market conditions, as in the latter case, E is smaller.

Substituting for l from (3) into (1), we get to the following first order conditions with respect to effort levels:

$$\frac{\partial v}{\partial e_{REC}} + \frac{\partial \pi}{\partial pa} = w_{REC} \tag{4}$$

$$\frac{\partial v}{\partial e_{RED}} = w_{RED} \tag{5}$$

A first straightforward outcome from (4) and (5) can be derived in terms of the impact of the intensity of individual "warm glow" , as measured by $\frac{\partial v}{\partial e_{REC}}$ and $\frac{\partial v}{\partial e_{RED}}$ for recycling and reduction efforts, respectively. More specifically, from (4) we can conclude that, *ceteris paribus*, a larger $\frac{\partial v}{\partial e_{REC}}$ will imply a larger equilibrium level for e_{REC}. A similar conclusion can be derived from (5). Therefore, any factor increasing "warm glow" intensity related to recycling or reduction activities will imply a larger

[11] On the issue of weak separability see, among others, Cherchye et al. (2015).

[12] Being (1) strictly increasing in the effort levels and leisure, we limit our attention to the case in which the budget constraint holds with equality.

corresponding effort level.

From (4) and (5), we can also conclude that waste reduction and recycling efforts decrease, respectively, with their opportunity costs[13]. On the other hand, the sign of $\frac{de_{REC}}{dw_{RED}}$ and $\frac{de_{RED}}{dw_{REC}}$ is positive (negative) if $\frac{\partial^2 v}{\partial e_{REC} \partial e_{RED}} < (>) 0$. Quite interestingly, a decrease in recycling opportunity costs, e.g. resulting from an improvement in recycling policy, implies larger (smaller) waste reduction effort when waste recycling and reduction are complements (substitutes) in the utility function. The same clearly holds when assessing the impact of a change in w_{RED} on e_{REC}. In other terms, explicitly allowing for the marginal utility of one effort type to be affected by changes in the other effort, we are introducing a sort of "multidimensional" warm-glow effect in our theoretical setting. Whether the two efforts turn out to be complements or substitutes in the individual utility function is an empirical matter and it will be tested in the following (Section 4).

Focusing on the impact of recycling policy through peer approval, notice that a better recycling policy, by increasing the social norm, leads *ceteris paribus* to an increase in recycling effort[14]. We can therefore conclude that when recycling is made easier, then the recycling effort is positively affected both directly (through reduced opportunity costs) and indirectly (through peer approval).

Finally, any increase in recycling effort related to changes in the social norm will imply a larger (smaller) waste reduction if the two efforts are complements (substitutes) We can then conclude that social norm appears to be another channel through which recycling policies may affect recycling as well as waste reduction behaviors, through the multidimensionality of warm-glow.

On the basis of previous theoretical analysis, we can set out the following consequential research hypotheses that will be tested in the empirical part of the article:

H1: a potential complementarity/substitutability relationship between waste reduction and recycling behaviors may exist;

H2: *better recycling policies may imply larger (smaller) waste reduction if H1 holds.*

3 Data

Our empirical investigation is based on data coming from the Survey of Public Attitudes and Behaviors toward the Environment[15], conducted in England in 2009 and consisting of 2,009 observations (Thornton, 2009). The survey reports either the opinion or the stated actual behavior of the respondent (or both) on

[13] All details on comparative statics are in Appendix A1. We limit our attention to interior solutions.

[14] As the marginal utility decreases with peer approval, i.e. $\frac{\partial^2 \pi}{\partial pa^2} < 0$, given the effort level, a larger sn, implying a lower pa, leads to a larger marginal utility from peer approval and, therefore, provides incentives to increase effort.

[15] This Survey is commissioned by the Department for Environment, Food and Rural Affairs (Defra), together with the Energy Saving Trust. Data for 2009 was collected in February/March of the same year using face to face interviews in respondents' homes. Respondents have been selected using "Census output areas" (small and homogeneous areas including 125-150 households) as sampling units to minimize potential interviewers' biases. Output areas are stratified by socio-economic variables to ensure a representative sample of different areas in England. Further details are provided in Thornton (2009).

a wide range of environmentally relevant daily activities, including energy and water use, recycling habits and waste production, food purchasing/consumption, and travel. Besides information about individual activities that may have an environmental impact, the survey includes a number of questions to gauge the respondents' knowledge of various environmental issues as carbon offsetting, biodiversity, use of green spaces as well as the degree of involvement in volunteering for environmental organizations. This dataset appears then as particularly suitable for the purposes of our analysis[16].

To derive the latent constructs used in the empirical model, we have selected the variables[17] listed in Table 1. Correlations for the selected variables (Table 2) reveal that indicators are related to each other and provide some initial evidence of the associations among the latent constructs: in particular, the strongest relations characterize variables in the waste behaviors dimension.

Finally, some socioeconomic and demographic variables that the literature identifies as potentially affecting everyday waste disposal decisions have been included in the final model as control variables (for descriptive statistics see Table A1 in the Appendix).

Turning to variables forming waste behaviors, we have two items specifically related to recycling actions (frequency of recycling items - *recbeh1* - and number of recycled materials - *recmat*), and one that can be interpreted as more related to a reuse behavior (frequency of taking his/her own shopping bag - *shopbag*). Concerning waste reduction actions, we have other variables related to the choice of minimizing the amount of packaging (frequency of deciding not to buy something because of too much packaging - *notbuy*) and food waste (level of effort in minimizing the amount of uneaten food thrown away - *eff_food*), as well as choices about food and green waste composting at home (frequency of composting - *comp*). In particular, the inclusion of the variable measuring the individual level of effort in reducing the amount of food waste is coherent with the recent focus of the European Commission, which identifies food waste prevention as one of the major priorities in the Resource Efficiency Roadmap, due to its impacts on the environment, greenhouse gas emissions and global food security (European Commission, 2011).

Table 1. Descriptive statistics of observed indicator items - HERE

Table 2. Correlation Matrix for Selected Variables - HERE

To evaluate the impact of reduced opportunity costs on the two waste related behaviors, we consider some factors that can affect them.

[16]The 2009 release is the latest available year for this Survey. As previous releases do not provide the same information, we cannot extend our analysis to consider different years. To the best of our knowledge, datasets adopted in other works which investigate waste behaviors are built up on the basis of *ad hoc* questionnaries, making it very difficult to compare our results for England with other national contexts.

[17]Variables adopted in the analysis are based on individuals' self-reports. In some cases, original variables have been recoded to assign higher values to greener attitudes and behaviors; we have merged some response categories that were very close and only rarely reported by respondents.

A first potential factor is given by waste related policies. Whilst for recycling behaviors specific curbside policies can be identified following the adoption of several Directives at the EU level (Nicolli and Mazzanti, 2011), waste reduction policies are still underdeveloped and targets on waste reduction are very recent. Further, user fees or PAYT schemes, based on the quantity of waste set out for collection, are forbidden by existing legislation in the UK. Not surprisingly, then, in the survey we do not have information about the adoption of policies specifically addressed to stimulate individuals' waste reduction efforts by reducing the relative opportunity cost. At the opposite, we can assume recycling opportunity costs to be affected by the existence of specific recycling policies, for which we use a variable indicating the presence of recycling facilities in the area of residence (*rec_bank*). This type of information is commonly adopted as a proxy for recycling policies, as curbside policy is considered as a key instrument for policymakers to affect households' recycling decisions, also through the activation of the social norm to recycle (see, for instance, Abbott *et al.*, 2013).

Coherently with our theoretical model, we can presume that the opportunity cost of waste reduction and recycling efforts may be affected by individual labor market characteristics, that may influence the opportunity cost of time devoted to waste management efforts. To capture this aspect, we have considered the respondent's social grade (*socgrade*), which provides an indication of individuals' socioeconomic position based on occupation, as a proxy for the household's employment status and purchasing power. Social grade is a classification produced by the ONS (UK Office for National Statistics), based on four categories[18]. Information about social grade is useful in the absence of reliable information about the level of household income, which can be affected by problems of under-(or mis-)reporting (see, for instance, Hurst *et al.*, 2014; Johns and Slemrod, 2010; Pedace and Bates 2000)[19].

We assume that the individual perception of the relevance of the social norm can be captured by the degree of agreement with the statement "*People have a duty to recycle*" (*recduty*); in other terms, by considering that recycling duty represents a social norm, the stronger the level of agreement with this duty the higher the relevance for the individual of attaining peer approval through adherence to the norm, the stronger the incentives towards increasing recycling decisions[20].

Coherently with our theoretical background, the intensity of individual warm-glow affects the level of waste related efforts. Such intensity can be influenced by personal environmental awareness and consciousness. In this perspective, we have assumed that individual environmental values can be represented

[18]AB: Higher and intermediate managerial, administrative, professional occupations; C1: Supervisory, clerical and junior managerial, administrative, professional occupations; C2: Skilled manual occupations; DE: Semi-skilled and unskilled manual occupations, unemployed and lowest grade occupations. For details, see http://www.ons.gov.uk/census. The social grade classification is commonly adopted in the literature as a proxy of the occupational status and the labor market situation of the respondents; see, for instance, Calvet and Comon (2003), Hibbs (1982) and Moodie et al. (2009).

[19]In the DEFRA Survey, the income variable is characterized by an extremely high number of missing values; this would reduce the validity of the results.

[20]Previous contributions in the literature consider recycling as a duty able to activate a social norm, as individuals comply with it to receive approval by the community "because they want to be seen as responsible" (Halvorsen, 2012; p.20). In this paper, we refer to social norm as what a particular society approves or disapproves of and that can be described as an "ought norm" (as in Reno, Cialdini, and Kallgren, 1993).

by five observed items: the degree of consciousness about the potential impacts of food production and disposal (level of agreement with the statement "Food production contributes to climate change" - *kn-food*), the individual environmental feeling (attitude towards the environment - *envfeel*) and the level of knowledge of the most serious environmental problems (level of knowledge about climate change - *knclim*; level of knowledge about global warming - *kngwarm;* level of knowledge about carbon footprint - *kncfoot*). The choice of including variables related to general environmental knowledge is in line with the literature recognizing the significant role it plays in shaping waste management decisions (see, for instance, Barr, 2007 and the concept of "abstract knowledge for action" proposed by Schahn and Holzer, 1990). We have considered also one specific item as affecting solely waste reduction: the level of agreement with the statement "'Waste not want not' sums up my general approach to life" (*wastenot*). This variable describes the attitude of individuals who plan carefully the quantity of goods they buy and who do their best to use those goods rather than throwing them away. We presume that these individuals perceive higher utility in reducing waste[21].

4 Empirical analysis and results

In order to examine empirically the relations developed in the theoretical model we use structural equation modeling (SEM). This modeling technique, which consists of series of multiple regression equations fitted simultaneously, appears to be particularly suited to test our research hypotheses due to the possibility of estimating the magnitude of the effects (direct and indirect) that independent variables (either observed or latent) have on dependent variables (either observed or latent). The use of SEM is further suggested by the existence of a reciprocal causation effect between the two waste related behaviors in our theoretical model (and accordingly between their residuals).

As explained in Appendix A2, the structural equation model consists of a measurement model, that links observed endogenous (exogenous) variables and their latent endogenous (exogenous) variables, and a structural model, which specifies the causal relations among latent variables. The measurement and the structural portions of the model tested in this paper are shown separately, for the sake of clarity[22].

Path diagram in Figure 1 depicts the causal relations between unobserved latent factors (in ovals) and their respective observed indicators (in rectangles). As shown by the Figure, three variables have been selected to indicate each of the two waste related behaviors (*RECBEH, REDBEH*), five variables express environmental values (*ENVVAL*), whilst recycling policy (*RECPOL*), social grade (*SOCGRADE*), social norm (*SOCNOR*) and waste reduction attitude (*REDATT*) are represented by only one measure (Bollen,

[21]For instance, people may prefer using over-ripe bananas to make banana cake rather than throwing them away.

[22]Analytical details are provided in Appendix A2. The model is estimated by using the LISREL 9.1 software. Since we have categorical variables, we adopt the Robust Maximum Likelihood estimation method.

1989)[23].

Figure 1. The measurement (CFA) model - HERE

As suggested by several authors (among others, Mueller and Hancock, 2008; Brown and Moore, 2014), the validity of the measurement model has been preliminarily tested through a confirmatory factor analysis (CFA)[24]. Figure 1 displays standardized factor loadings linking observed items and their latent constructs. Standardized loadings, which are statistically significant even though rather small in some cases, reveal that *recbeh1* (frequency of recycling) and *comp* (frequency of composting food and/or garden waste) are the most valid indicators for recycling and reduction behaviors respectively, while *kngwarm* (level of knowledge of global warming) is the most valid measure for environmental values. Construct reliability has been evaluated by calculating a composite reliability indicator on the basis of information on the standardized loadings and error variances. Composite reliability is equal to 0.7 (*RECBEH*), 0.6 (*REDBEH*) and 0.8 (*ENVVAL*). As values greater than 0.6 are generally considered as desirable (Diamantopoulos and Siguaw, 2000), we can conclude that our indicators provide reliable measurement of latent constructs[25].

Figure 2 shows the complete structural model, that is used to estimate the path coefficients and to assess the validity of causal structures among latent constructs. Coherently with the literature, the purpose of SEM analysis is to determine the extent to which a theoretical model is supported by sample data (Schumacker and Lomax, 2012). Accordingly, we test the relationships among constructs as hypothesized on the basis of our theoretical model.

Hence, we assume a direct influence of environmental values (*ENVVAL*), as affecting the intensity of individual warm-glow, on both waste behaviors (*REDBEH* and *RECBEH*); we consider the effect of waste reduction specific attitudes (*REDATT*) on *REDBEH* for model specification reasons. We also evaluate the direct relation between social grade (*SOCGRADE*), as affecting waste reduction and recycling opportunity costs, and each waste behavior (*REDBEH* and *RECBEH*) and the impact of recycling policy (*RECPOL*), as affecting recycling opportunity costs, on both recycling behavior (*RECBEH*) and social norm (*SOCNOR*), which in turns affects *RECBEH*. Finally, in order to investigate if the two waste behaviors are complements or substitutes, we hypothesize a mutual causal influence between *RECBEH* and *REDBEH*, each variable affecting the other.

[23] For a discussion about the use of single-item measures see Fuchs and Diamantopoulos (2009) and the references they provide.

[24] The final model presents the following measures of good fit: Standardized Root Mean Square Residual (SRMR) = 0.034, Root Mean Square Error of Approximation (RMSEA) = 0.053 with CI_{90} : (0.047 ; 0.059), Comparative Fit Index (CFI) = 0.997, Normed Fit Index (NFI) = 0.991, NonNormed Fit Index (NNFI) = 0.994, Adjusted Goodness-of-Fit Index (AGFI) = 0.947 (for threshold values and a description of the fit indices see Appendix A2).

[25] The latent variable for *RECBEH* includes an item that can be related to a reuse behavior (*shopbag*). Nevertheless, its inclusion in the recycling behavior dimension significantly increases the reliability of the latent construct. At the opposite, including *shopbag* in the *REDBEH* variable leads to a reduction of the reliability values for both waste related behaviors.

The complete model has a relatively good fit: SRMR = 0.054; RMSEA = 0.069 with CI_{90} : (0.064; 0.075); CFI = 0.991, NFI = 0.985, NNFI = 0.984, GFI = 0.960, AGFI = 0.920 [26].

Figure 2. The structural model (1) - HERE

Figure 2 reveals that some of the hypothesized causal effects between latent variables are not significant (dashed arrows); in particular, environmental values do not seem to have a significant effect on recycling effort, while the occupational status, summarized by social grade, do not significantly affect neither recycling nor waste reduction behaviors. This result is in line with previous findings related to the effect of income on waste behaviors, according to which ambiguous effects are the result of different forces pushing in opposite directions: on the one hand, a higher opportunity cost of time for high-income earners can lead to the adoption of less environmentally friendly behaviors, but, on the other hand, high income individuals can afford to pay for a better environment (see Abbott *et al.*, 2013 and the references herein provided).

To interpret results and improve estimation, we have estimated again the model by removing non-significant paths[27]. The final model is displayed in Figure 3.

Figure 3. The structural model (2) - HERE

As highlighted by Figure 3, the paths estimating the reciprocal direct effects of recycling and reduction behaviors are significant in both directions of influence, supporting the hypothesized interaction between the two waste related behaviors (*research hypothesis H1*). Furthermore, the positive sign of standardized coefficients[28] suggests that the two waste behaviors tend to strengthen each other, revealing that the two efforts can be complements in the utility function. This result may seem to contradict some previous studies suggesting that, in some cases, the availability of the option to recycle increases consumption of certain types of products, such as office paper or bathroom paper towels (e.g. Catlin and Wang, 2012). However, the substitutability relation implicitly proposed in these studies is related only to very specific individual recycling/reduction decisions, involving well identified types of material or product. At the opposite, our analysis is based on a more general recycling/reduction behavior, involving different choices over a plurality of items. Hence, it can be reasonable to suppose that individuals motivated to recycle will be more prone to reduce waste because they are more sensible to waste problems.

[26] Chi-square = 148.53, df = 60; we report chi-square values although, as noted by the literature, the chi-square test of model fit can lead to wrong conclusions about outcomes of the analysis, being sensitive to sample size (i.e. when sample size increases, generally above 200, the statistic tends to indicate a significant probability level).

[27] After the elimination of non-significant relations, the model fit is slightly improved: SRMR = 0.056; RMSEA = 0.067 with CI_{90} : (0.061; 0.073); CFI = 0.992, NFI = 0.986, NNFI = 0.987, GFI = 0.962, AGFI = 0.929.

[28] For a given sample, only standardized coefficients can be meaningfully interpreted as the latent variable metrics are arbitrary (Mueller and Hancock, 2008; p.507).

From the path diagram we can also note that a better recycling policy increasing recycling provisions has a positive influence on the adoption of recycling behaviors, as it is common in the literature (e.g. Guagnano *et al.*, 1994; Abbott, 2013). Nevertheless, it has also a positive effect on the perceived stringency of the social norm, which in turn positively affects recycling decisions. These relations suggest that, besides having a direct effect, recycling policy can have also an indirect, stimulating effect on recycling behaviors mediated by its impact on social norm. On the other hand, given the existence of a complementarity relation between recycling and reduction efforts, we cannot exclude that recycling policy may have also an indirect effect on reduction decisions through its impact on the social norm.

In order to uncover the overall effect that recycling policies may have on reduction efforts, given mediated influences, we calculate the total effects summarized by the different paths[29]. As Table 3 shows, an improvement in recycling policy has a significant and positive impact (equal to 0.19) on reduction effort (*research hypothesis H2*).

Table 3. Total effects of exogenous latent variables on endogenous latent variables (standardized values) - HERE

According to our empirical outcomes, waste reduction decisions are positively affected by the latent construct expressing environmental values, whilst, as noted above, the same values turn out to have a non-significant direct effect on recycling behavior, confirming previous achievements in the literature (for instance, Barr, 2007). Nevertheless, given the complementarity relation between waste behaviors, environmental values can have a positive indirect effect also on recycling effort. By looking again at Table 3, we note that the coefficient expressing the total effect of environmental values on recycling behavior is equal to 0.25.

The analysis of total effects provides some arguments potentially relevant for policy: even though recycling policies act as a stimulus for individual recycling behaviors and indirectly (as far as the complementarity relation is confirmed) for reduction choices, results about total effects reveal that their impact on individual waste reduction is quite low, however much less than the effect environmental values have on reduction behavior itself. This contrasts with recent policy efforts at the EU level, that have been targeted towards improving waste disposal management and increasing recycling facilities, and contributes to explain why policy interventions have brought about only minor changes in terms of reduced waste generation. Our results further suggest that investing in environmental education and increasing pro-environmental attitudes of individuals may be an effective instrument to stimulate waste reduction.

[29] Path analysis allows for a decomposition of the effects of one variable on another into direct, indirect and total effects. Direct effects are the influences of one variable on another that are not mediated by any other variable. Indirect effects are mediated by at least one other variable and the total effects are the sum of direct and indirect effects (Bollen, 1989; p. 376).

The stability of our empirical results has been assessed including some socio-demographic controls as additional explanatory variables in the model. Specifically, the age of respondents, their gender and education, the household size, the presence of children in the household are likely to affect waste management decisions and have been supposed to have a direct influence on them.

Although path diagram is not reported here to save space (output is available upon request), all the relationships investigated in Figure 3 remain statistically significant when we control for socio-demographic variables. Estimated coefficients of control variables are displayed in Table 4. The variable for gender is significant and the estimated coefficient is negatively signed on recycling, suggesting that men tend to recycle less than women. Individuals in older age groups appear to recycle more, whilst age is not significant in explaining reduction actions; the higher recycling effort of elderly people is generally explained by considering that in several cases they are retired and therefore tend to have more time to sort products out for recycling or re-use (Tonglet *et al.*, 2004). More educated people appear to reduce more waste, whilst both the presence of children and the number of people in the household are insignificant on waste behaviors.

Table 4. Effect of socio-demographic control variables – standardized values (unstandardized values in parentheses) - HERE

5 Concluding remarks

This paper analyzes potential interactions between individuals' waste reduction and recycling activities, focusing on the effects that different drivers may have, both directly and indirectly, on the two waste related behaviors. Although waste reduction is at the top of the waste hierarchy, it is still not a specific policy target. On the contrary, policy attention has been mainly devoted to recycling.

The central question of our work is what kind of effects may be induced by recycling policies on individuals' decisions to reduce waste. Our theoretical analysis suggests that policies oriented at reducing the opportunity cost of recycling may have positive or negative effects also on waste reduction. The existence of a multidimensional warm-glow may arise: increasing one of the two efforts increases or decreases the marginal utility of the other, depending on the existence of a complementarity or substitutability relationship.

In the empirical part of the paper we test this relationship, using England as a case study. Of course, our empirical conclusions depend on the adopted dataset, so that an obvious, though intriguing, extension is to verify the robustness of these results to changes in the geographical coverage of the dataset used. We find positive and significant reciprocal linkages between recycling and reduction behaviors, disclosing the existence of complementarity between the two waste related efforts. Total effects of recycling policies on waste behaviors provide particularly interesting insights. In fact, given the complementarity relation, policies oriented at facilitating recycling have indirect positive effects also on waste reduction. Waste reduction turns out to be also affected by personal environmental values; this latter effect is larger than the (indirect) impact of recycling policies. Furthermore, environmental values, through the complementarity relationship, also positively impact on recycling. If it is true that complementarity and not substitutability emerges between the two waste management behaviors, it is also true that different drivers do not have the same strength in affecting waste reduction and recycling. These considerations help explaining the moderate impact of recycling policies on waste reduction. Government educational and informative programs aimed at increasing individuals' awareness about environment and waste problems may be much more effective in stimulating waste reduction in order to achieve long-term sustainability targets.

Appendix

Table A1. Descriptive statistics of socio-demographic variables - HERE

A1 - Theoretical results

We first derive concavity conditions in order for (4) and (5) to be necessary and sufficient for an interior optimum. Define the Hessian determinant as follows: $|H| = \begin{vmatrix} H_{11} & H_{12} \\ H_{12} & H_{22} \end{vmatrix}$ where: $H_{11} = \frac{\partial^2 v}{\partial e_{REC}^2} + \frac{\partial^2 \pi}{\partial pa^2}$, $H_{22} = \frac{\partial^2 v}{\partial e_{RED}^2}$, and $H_{12} = H_{21} = \frac{\partial^2 v}{\partial e_{REC} \partial e_{RED}}$. Concavity requires $H_{11} = \frac{\partial^2 v}{\partial e_{REC}^2} + \frac{\partial^2 \pi}{\partial pa^2} < 0$, which always holds in our setting, and $|H| = \left(\frac{\partial^2 v}{\partial e_{REC}^2} + \frac{\partial^2 \pi}{\partial pa^2} \right) \frac{\partial^2 v}{\partial e_{RED}^2} - \left(\frac{\partial^2 v}{\partial e_{REC} \partial e_{RED}} \right)^2 > 0$; we assume the latter to be the case. From (4) and (5), we can derive the following signs for comparative statics:

$$sgn\left(\frac{de_{REC}}{dw_{REC}}\right) = sgn\left(\frac{\partial^2 v}{\partial e_{RED}^2}\right) < 0,$$

and

$$sgn\left(\frac{de_{RED}}{dw_{RED}}\right) = sgn\left(\frac{\partial^2 v}{\partial e_{REC}^2}\right) < 0,$$

as $\frac{\partial^2 v}{\partial e_{REC}^2} < 0$ and $\frac{\partial^2 v}{\partial e_{RED}^2} < 0$. Also, it is easily shown that:

$$sgn\left(\frac{de_{RED}}{dw_{REC}}\right) = sgn\left(\frac{de_{REC}}{dw_{RED}}\right) = sgn\left(-\frac{\partial^2 v}{\partial e_{REC} \partial e_{RED}}\right).$$

As a consequence, we can conclude that $\frac{de_{RED}}{dw_{REC}} \gtreqless 0$ and $\frac{de_{REC}}{dw_{RED}} \gtreqless 0$ if $\frac{\partial^2 v}{\partial e_{REC} \partial e_{RED}} \lesseqgtr 0$. Turning to the impact of the social norm related to waste recycling through peer approval, comparative statics implies, again from (4) and (5):

$$sgn\left(\frac{de_{REC}}{dsn}\right) = sgn\left(\frac{\partial^2\pi}{\partial pa^2}\frac{\partial^2 v}{\partial e_{RED}^2}\right) > 0,$$

and

$$sgn\left(\frac{de_{RED}}{dsn}\right) = sgn\left(-\frac{\partial^2\pi}{\partial pa^2}\frac{\partial^2 v}{\partial e_{REC}\partial e_{RED}}\right).$$

We can therefore conclude that the sign of $\frac{de_{RED}}{dsn}$ depends on $\frac{\partial^2 v}{\partial e_{REC}\partial e_{RED}}$. More specifically, $\frac{de_{RED}}{dsn} \gtreqless 0$ if $\frac{\partial^2 v}{\partial e_{REC}\partial e_{RED}} \gtreqless 0$.

A2 - Technical Appendix on Structural Equation Models

The structural equation model consists of three types of relationships (Jöreskog and Sörbom, 1996)[30]. The first measurement model specifies the relation between observed endogenous variables and latent endogenous variables:

$$\mathbf{y} = \mathbf{\Lambda}_y\boldsymbol{\eta} + \boldsymbol{\varepsilon}$$

where $\mathbf{y}$ is a $p \times 1$ vector of observed endogenous (or dependent) variables, $\mathbf{\Lambda}_y$ is a $p \times m$ (m is the number of latent variables η) matrix of regression coefficients for the effects of the latent variables on the observed variables, $\boldsymbol{\eta}$ is a $m \times 1$ vector of latent dependent variables and $\boldsymbol{\varepsilon}$ is a $p \times 1$ vector of error terms. The second measurement model specifies the relation between observed exogenous variables and latent exogenous variables:

$$\mathbf{x} = \mathbf{\Lambda}_x\boldsymbol{\xi} + \boldsymbol{\delta}$$

where $\mathbf{x}$ is a $q \times 1$ vector of observed independent variables, $\mathbf{\Lambda}_x$ is a $q \times n$ (n is the number of latent variables ξ) matrix of regression coefficients, $\boldsymbol{\xi}$ is a $n \times 1$ vector of latent independent variables and $\boldsymbol{\delta}$ is a $q \times 1$ vector of measurement errors.

While measurement models identify the relations between each latent variable and the manifest variables that cause it, the structural model specifies the causal relations that exist among the latent variables:

$$\boldsymbol{\eta} = \mathbf{B}\boldsymbol{\eta} + \mathbf{\Gamma}\boldsymbol{\xi} + \boldsymbol{\zeta}$$

where $\mathbf{B}$ is a $m \times m$ matrix of coefficients for the latent endogenous variables, $\mathbf{\Gamma}$ is a $m \times n$ coefficient matrix for the latent exogenous variables, $\boldsymbol{\zeta}$ is a vector of errors.

[30] For a detailed description see, for instance, Bollen (1989).

Given the model specification, the fit can be assessed by adopting many indices (absolute, parsimonious and incremental indices; for details see, among others, Mueller and Hancock, 2008). Absolute indices evaluate the overall discrepancy between observed and implied covariance matrices; examples are the standardized root mean square residual (SRMR) and the goodness-of-fit index (GFI). Parsimonious indices take into account model's complexity; for instance, the root mean square error of approximation (RMSEA) and the adjusted goodness-of-fit index (AGFI). Finally, incremental indices assess absolute or parsimonious fit relative to a baseline model: the most widely used are the comparative fit index (CFI), the normed fit index (NFI), and the non-normed fit index (NNFI). Although there are no well-established guidelines for determining what constitutes an adequate fit, to evaluate if the model matches the observed data the literature proposes some rule of thumb criteria for goodness-of-fit indices. In the following, we provide threshold values for the measures adopted in the text: for SRMR a value lower than 0.08 suggests good model fit; for the RMSEA acceptable fit corresponds to 0.05–0.08 and good fit to 0–0.05; for the CFI and NNFI an acceptable fit is in the range 0.95–0.97 and good fit in the range 0.97–1; values of NFI $\geq$ 0.95, GFI and AGFI $\geq$ 0.90 are indicative of a good fit to the data (Hu and Bentler, 1999).

To evaluate the reliability of latent constructs, it is possible to adopt several composite reliability indicators. We have adopted the indicator suggested, among others, by Diamantopoulos and Siguaw (2000), calculated on the basis of standardized loadings and error variances; as already noted in the text, values ideally greater than 0.6 suggest reliable measurement of the construct.

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Figures and Tables

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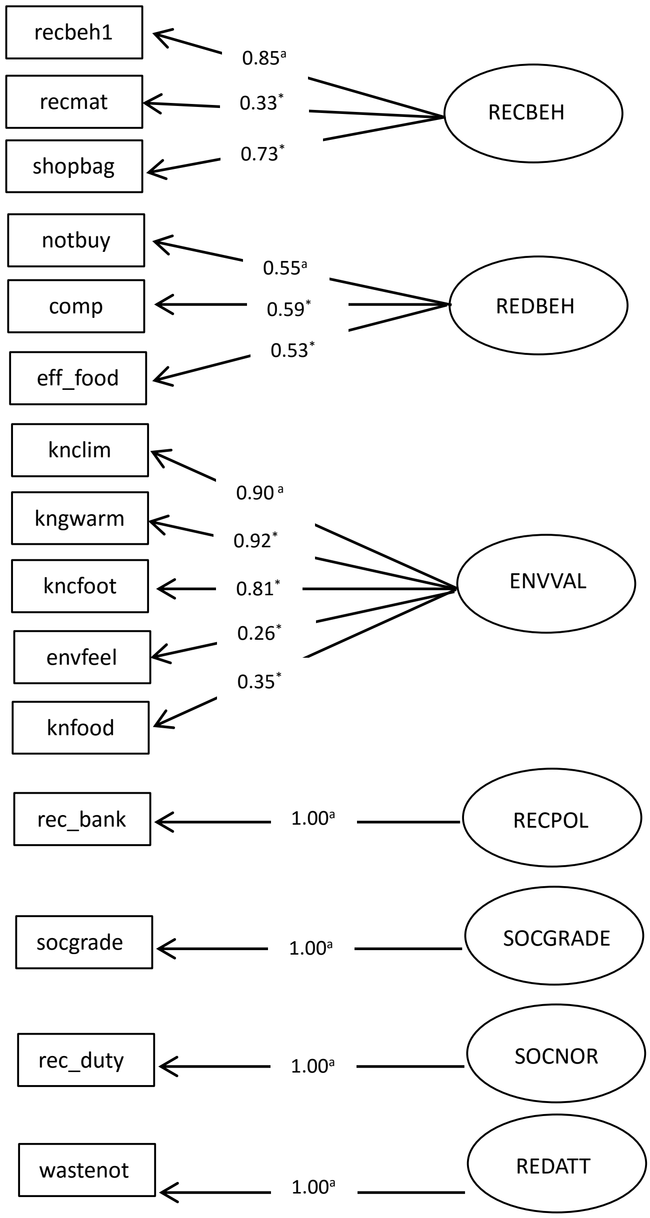
Table 1 - Descriptive statistics of observed indicator items

Construct	Variable	Description	Obs	Mean	St. Dev.
RECBEH					
	RECBEH1	Takes value 3 if the individual declares that s/he *always/very often* recycles items rather than throw them away, 2 if s/he does it *quite often/sometimes/occasionally*, 1 *never*.	2002	2.726	0.512
	RECMAT	Counts the number of materials/items the individual can put outside for a council recycling or composting collection (it ranges from 1 to 9).	1793	1.955	0.930
	SHOPBAG	Takes value 3 if the individual declares that s/he *always/very often* take her/his own shopping bag when shopping, 2 if s/he does it *quite often/sometimes/occasionally*, 1 *never*.	1974	2.629	0.655
REDBEH					
	NOTBUY	Takes value 3 if the individual declares that s/he *always/very often* decide not to buy something because it has too much packaging, 2 if s/he does it *quite often/sometimes/occasionally*, 1 *never*.	1906	1.677	0.723
	COMP	Takes value 3 if the individual declares that s/he *always/very often* compost her/his household's food and/or garden waste, 2 if s/he does it *quite often/sometimes/occasionally*, 1 *never*.	2005	2.446	0.597
	EFF_FOOD	Takes value 3 if the individual declares that s/he goes *a great deal/ a fair amount* of effort in order to minimize the amount of uneaten food thrown away, 2 if s/he goes *a little/not very much* of effort, 1 *not at all*.	1985	2.770	0.463
ENVVAL					
	KNCLIM	Takes value 3 if the individual knows *a lot/ a fair amount* about climate change, 2 *just a little*, 1 *nothing (have only heard of the name/have never heard of it)*.	2004	2.562	0.597
	KNGWARM	Takes value 3 if the individual knows *a lot/ a fair amount* about global warming, 2 *just a little*, 1 *nothing (have only heard of the name/have never heard of it)*.	2005	2.610	0.567
	KNCFOOT	Takes value 3 if the individual knows *a lot/ a fair amount* about carbon footprint, 2 *just a little*, 1 *nothing (have only heard of the name/have never heard of it)*.	1983	2.322	0.748
	ENVFEEL	Takes value 3 if the individual *would like to do a lot more to help the environment,* 2 if s/he *would like to do a bit more to help the environment*, 1 if s/he is *happy with what s/he does* for the environment.	2005	1.616	0.626
	KNFOOD	Takes value 3 if the individual *strongly agrees/ tends to agree* with the statement "Food production contributes to climate change", 2 if s/he *neither agrees nor disagrees*, 1 *tends to disagree/strongly disagrees*.	2009	1.346	0.818
RECPOL					
	REC_BANK	Takes value 1 if there is a bottle bank or recycling bank in the area of residence, 0 otherwise.	1895	0.883	0.321
SOCGRADE					
	SOCGRADE	Takes value 4 if the individual belongs to categories AB, 3 if s/he belongs to C1, 2 if s/he belongs to C2, 1 if s/he belongs to DE.	2009	2.459	1.125
SOCNOR					
	RECDUTY	Takes value 3 if the individual *strongly agrees/ tends to agree* with the statement "People have a duty to recycle", 2 if s/he *neither agrees nor disagrees*, 1 *tends to disagree/strongly disagrees*.	2005	2.838	0.478
REDATT					
	WASTENOT	Takes value 3 if the individual *strongly agrees/ tends to agree* with the statement "`Waste not want not' sums up my general approach to life", 2 if s/he *neither agrees nor disagrees*, 1 *tends to disagree/strongly disagrees*.	1959	2.649	0.636

Table 2 - Correlation Matrix for Selected Variables

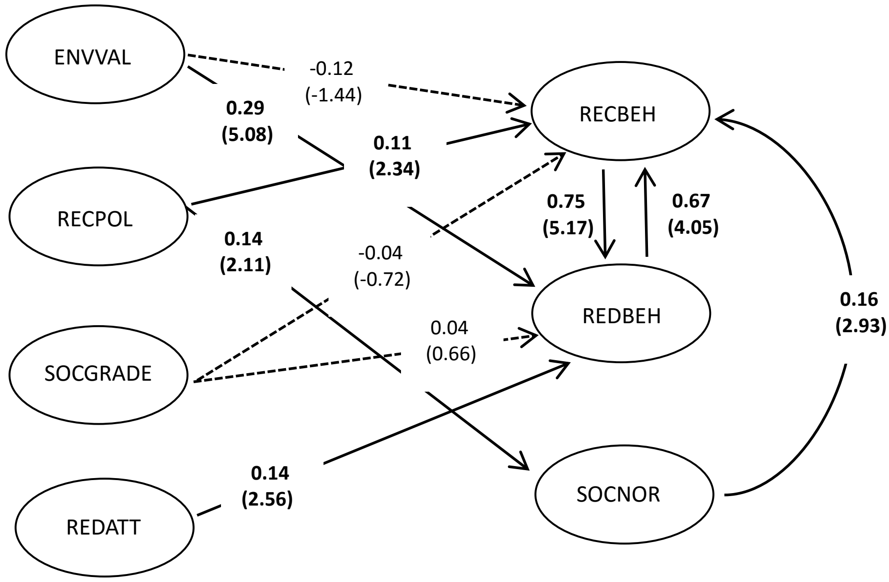
Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1 recbeh1														
2 recmat	0.325													
3 shopbag	0.395	0.183												
4 notbuy	0.299	0.025	0.277											
5 comp	0.355	0.089	0.351	0.352										
6 eff_food	0.313	0.171	0.285	0.255	0.316									
7 recduty	0.375	0.176	0.275	0.204	0.188	0.245								
8 rec_bank	0.209	0.144	0.249	0.186	0.202	0.209	0.138							
9 knclim	0.230	0.148	0.216	0.302	0.267	0.327	0.198	0.257						
10 kngwarm	0.180	0.106	0.185	0.294	0.194	0.242	0.215	0.204	0.830					
11 kncfoot	0.185	0.102	0.171	0.279	0.230	0.212	0.156	0.210	0.711	0.747				
12 envfeel	-0.005	-0.080	-0.024	0.178	0.009	0.106	0.210	0.129	0.229	0.253	0.211			
13 knfood	0.058	0.035	0.029	0.234	0.194	0.192	0.245	0.140	0.302	0.276	0.308	0.263		
14 wastenot	0.251	0.050	0.269	0.154	0.215	0.254	0.311	0.056	0.061	0.087	0.074	-0.107	0.057	
15 socgrade	0.100	0.086	0.219	0.126	0.158	0.202	0.122	0.320	0.325	0.285	0.345	0.171	0.180	0.051

Figure 1 – The measurement (CFA) model



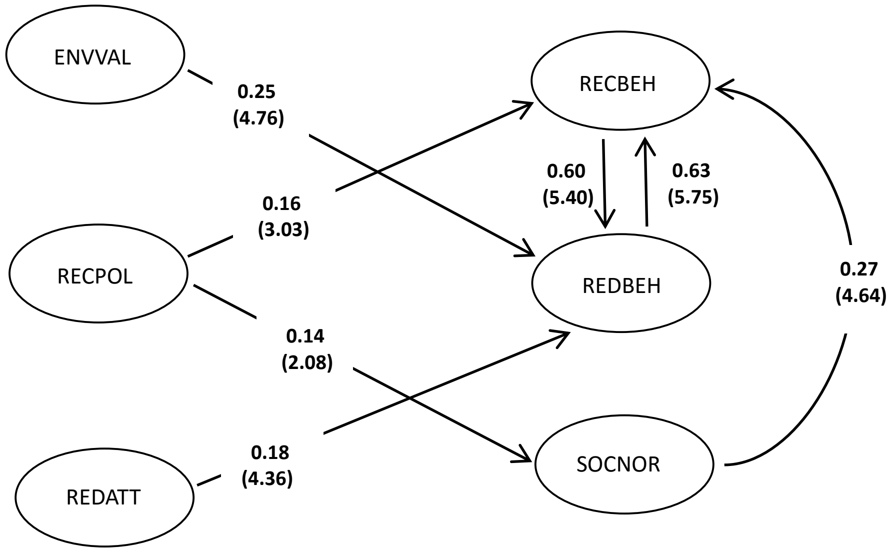
Note: [a] Reference variable for the latent construct. Unstandardized factor loading fixed to 1; no standard error computed. Perfect reliability is assumed for latent variables with one indicator.
* $p < .001$

Figure 2 – The structural model (1)



Note: Standardized coefficients (t-values in parenthesis). Statistically significant estimates in bold.

Figure 3 – The structural model (2)



Note: Standardized coefficients (t-values in parenthesis).

Table 3 - Total effects of exogenous latent variables on endogenous latent variables (standardized values)

	Environmental Values	Recycling Policy
Recycling Behavior	0.25	0.32
Reduction Behavior	0.40	0.19

Table 4 – Effect of socio-demographic control variables – standardized values (unstandardized values in parentheses)

Indep. var.	RECBEH	REDBEH
Male	-0.16 (- 0.09**)	0.01 (0.00)
Age	0.30 (0.17***)	-0.02 (-0.00)
Child	0.14 (0.07)	-0.12 (-0.06)
Npeople	0.01 (0.05)	0.01 (0.00)
Edu	-0.08 (-0.04)	0.13 (0.03**)

Table A1 - Descriptive statistics of socio-demographic variables

Variable	Description	Mean	St. Dev.
MALE	Gender of the respondent: 1 if respondent is male, 0 otherwise (dummy).	0.493	0.500
AGE	Age of the respondent (4 categories).	2.576	1.018
CHILD	Presence of children under 16 in the household: 1 if present, 0 otherwise (dummy).	0.293	0.455
NPEOPLE	Number of people living in the household, adults and children (continuous).	2.591	1.231
EDU	Highest academic qualification obtained by the respondent (6 categories).	2.484	2.160
N. OBS		2009	