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Alessio D'Amato, Susanna Mancinelli, Mariangela Zoli

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Two Shades of (Warm) Glow: multidimensional intrinsic motivation, waste reduction and recycling*

Alessio D'Amato† Susanna Mancinelli‡ Mariangela Zoli§

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Abstract

Although waste minimization is considered a priority to face the waste problem, EU targets on waste prevention are very recent and most policy interventions have been oriented towards increasing recycling rates. As a result, significant improvements in recycling performance have been attained, but there is still no clear evidence of increased waste prevention. A possible explanation of different trends in waste minimization and recycling rates may be found in the existence of interactions between the two waste related behaviors as well as between policies and households' personal motivations. The aim of the paper is to investigate both theoretically and empirically the impact of waste policies on recycling and prevention decisions of individuals. In the theoretical analysis, we model the role played by policies, intrinsic and extrinsic motivations in affecting waste decisions by explicitly allowing for complementarities or substitutabilities between recycling and waste reduction efforts in the utility function. Theoretical results suggest that policies, social norms and intrinsic motivations may affect recycling and prevention both directly and indirectly, through their reciprocal interactions. Theoretical predictions are then tested in a structural equation model, by using data for England from the Survey of Public Attitudes and Behaviours toward the Environment (Defra, 2010). Our empirical investigation shows that waste prevention and recycling activities reinforce each other, supporting the existence of complementarities between them. Nevertheless, when we consider also indirect effects among the involved variables, our results suggest that recycling policies may be not very effective in stimulating waste prevention whilst policy measures acting through intrinsic motivations may have stronger impacts.

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†Università di Roma Tor Vergata, Italy.

‡Università di Ferrara, Italy

§Corresponding author. Università di Roma Tor Vergata, Italy. Email: zoli@sefemeq.uniroma2.it.

1 Introduction

Municipal solid waste (MSW) 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, global waste volumes are increasing rapidly as a result of higher incomes and urbanization rates, increased consumption of goods and services, and more intensive use of packaging materials[1].

In response to the challenges posed by the growing waste levels, minimization of waste production has been identified as a key policy option towards a sustainable waste management strategy[2]. Waste prevention is, for instance, at the top of the "waste hierarchy" introduced by the EU Waste Framework Directive in 2008 (Article 4), being the most desirable action to be promoted compared to recycling, re-use and recovery, and especially to landfilling (which at the opposite is considered as the last resort and should be reduced). To move up the waste hierarchy, Member States are required to establish national waste prevention programmes and to set out appropriate specific targets to assess their progress (Article 29). More recently, also the Roadmap to a Resource Efficient Europe (COM(2011) 571) has recognized the importance of waste minimization and has highlighted the need of introducing specific incentives for waste prevention and recycling.

Whilst significant improvements in recycling performance have been realized in the EU in latest years[3], the amounts of municipal waste generated are still not decreasing. According to the European Environmental Agency, municipal waste prevention can be assessed by analyzing trends in the amounts of municipal waste generated. On the basis of this indicator, there is no clear evidence of improved waste prevention in 32 European countries between 2001 and 2010. [4]. Besides larger costs and difficulties of implementing

[1]According to World Bank projections, global MSW generation levels are expected to increase from current 1.3 billion tonnes per year to approximately 2.2 billion tonnes per year by 2025, corresponding to an increase in per capita waste generation rates from 1.2 to 1.42 kg per person per day (Hoornweg and Bhada-Tata, 2012)

[2]Waste minimization is considered a priority action in order to face the waste problem by the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal, the Organization for Economic Co-operation and Development (OECD), the European Environment Agency (EEA) as well as the United States Environment Protection Agency (EPA), for instance (The Secretariat of the Basel Convention, 2012).

[3]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).

[4]Specifically, twenty-one countries increased their production of municipal waste per capita in 2010 compared to 2001, whereas eleven countries cut their waste generation in the same period. The same figures for the years 2001 and 2008 (according to which twenty-six countries recorded an increase and six countries a decrease in their waste production),

actions resulting in waste reduction, this suggests that policy efforts at EU and national level have provided stronger incentives towards increasing recycling than towards waste prevention (Cecere et al., 2013; Mazzanti and Zoboli, 2009).

We provide a possible argument explaining why improvements in recycling rates have not been accompanied by comparable achievements in waste minimization can be related to the existence of potential interrelationships between individuals' recycling and waste prevention behaviors. In fact, waste policies can have two different effects on waste management behaviors. The first one may be positive, since policy intervention and incentives to recycling may have the effect of stimulating a pro-environmental lifestyle. This, in turn, may have positive effects on waste reduction as well. On the other hand, waste policies may not affect (or they can even negatively affect) individual waste behaviors, since a sort of multi-tasking effect (à la Holmstrom and Milgrom, 1991) may prevail: if the agent is encouraged to recycling (by both incentives and controls), less effort may be devoted to the less incentivized activity, that is waste reduction (if the latter features marginal costs which are increasing in the amount of recycling and/or lacks proper incentives). This may imply a crowding-out effect of recycling activities over waste minimization efforts. Moreover, waste policies can feature crowding-in or crowding-out effects also through their impacts on other determinants of individuals' pro-environmental behaviors, as psychological and social factors.

In this paper we aim at investigating both theoretically and empirically the impact of waste policies on recycling and prevention decisions of individuals, by explicitly accounting for potential interactions (complementarity vs substitutability) between the two waste-related behaviors and taking into account all the involved drivers. We also account for the possibility that waste policies affect individual waste management behaviors directly as well as indirectly, through their impacts on other determinants of individuals' behaviors.

This paper draws on the wide literature that investigates the determinants of individual waste behaviors. Indeed, waste disposal decisions of households have received huge research attention in several disciplines and from different perspectives, ranging from economics, environmental psychology, sociology and engineering. The early literature exploring households participation in recycling programmes dates back to the early 1970s: in this initial stage, research was focused on socio-demographic characteristics and economic rewards to stimulate recycling behaviors. Afterwards, a deeper analysis of social and psychological motivators for personal recycling behavior has been carried out (Hornik et al., 1995), investigating a multiplicity of

however, suggest that the reduction in municipal waste generation per capita may be the result of the economic downturn started in 2008 (EEA, 2013).

reasons for recycling behaviors, including barriers, motivations, values and beliefs. As noted by Miafodzyeva and Brandt (2012), the investigated variables vary greatly among different studies and thus it is difficult to formulate general statements from the results, even though it is clear that recycling behavior and other environmental behaviors are complex and diverse. Barr (2007) argues that three groups of independent variables can be identified as affecting the relationship between household attitude and environmental behaviors: environmental values, situational variables and psychological factors. On the basis of this taxonomy, the author investigates the determinants of three waste management behaviors (recycling, reuse and reduction), by adopting the Theory of Reasoned Action (TRA) as conceptual framework for examining the relationship between environmental intentions and behaviors. One of the main result of the study is that different waste management strategies must be considered as different behaviors, because different predictors explain each of them. Furthermore, whilst recycling behavior can be encouraged quite easily, reduction and reuse behaviors are less simple to stimulate, being affected by strong environmental values, good knowledge of environmental policy issues and other factors that require innovative policy measures. However, Barr's analysis does not consider potential linkages between recycling and waste minimization activities. The relevance of the relationship between attitudes and recycling behaviors is recognized also by Schwab et al. (2012), even though they highlight the need to examine the direct effects of others' behavior on individual attitudes and behaviors. According to this study, accounting for the social context in which attitudes and behaviors are formed and expressed allows for a better comprehension of recycling behaviors.

Very recently also the economic literature started to explore the influence of intrinsic and extrinsic motivations on individual waste disposal decisions. Viscusi et al. (2011) empirically investigate the role of social norms in reinforcing proenvironmental behaviors, where social norms are defined in terms of what is "normatively appropriate". Their analysis aims at assessing both the role of personal norms (that a person imposes on others), and external norms that people perceive as imposed on them by others. Their findings (relating to recycling of plastic water bottles in US) show that whilst the variable for the internal private value is significant, the social norm variable, reflecting the individual's potential guilt with respect to neighbors' attitudes if one does not recycle, turns out to be not statistically significant. This suggests external pressure cannot be considered as an effective way to drive changes in recycling. Cecere et al. (2013) test how motivations affect waste related behavior when people face the collective management of waste (focusing on food waste), finding that extrinsic motivations increase the likelihood of producing more waste and, more generally, that the nature of social preferences matters. The authors also show relevant implications of their analysis for the policy makers to achieve waste reduction results.

Abbott et al. (2013) perform an analysis which is close to our own: they examine (theoretically and empirically) how social norms and warm-glow affect the link between the quality of recycling facilities and the recycling effort, showing that a social norm for recycling exists. The issue of the existence of a "warm glow" in determining pro social behaviour is strictly related to the public-private dynamics in the provision of public goods (see Pollitt and Shaorshadze, 2011 for a review): if individuals are “warm-glow givers", their intrinsic motivation for contributing to public goods may be reduced by the provision of monetary incentives (the so-called “crowding out hypothesis"). This view has been empirically supported by Gneezy and Rustichini (2000) finding that “compensating" people for socially desirable actions could in fact be counterproductive, leading to lower levels of voluntarily provided goods. It has also been argued that public instruments devoted to reducing demand for environmentally damaging activities (e.g. tradable permits, Pigouvian taxes) may exert a crowding-out effect on individual's environmental moral due to the shift of individual locus of control to the institutions (Frey, 1999; Frey and Stutzer, 2006). All the above considerations suggest that waste related behavior is likely to depend on personal motivations that might interact with existing policies as well as with personal characteristics.

We innovate with respect to the existing literature as, to the best of our knowledge, our paper is the first attempt to explicitly consider, theoretically and empirically, the possibility that recycling decisions interact with reduction decisions, reinforcing or weakening each other, and which explore how waste policy might affect individual disposal decisions both directly and indirectly through the potential interaction between recycling and reduction behaviors.

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

2 The Model

We model a setting featuring n individuals. As we assume that none of the individuals perceives her own impact on the choice of other individuals, we will focus, without loss of generality, on a single individual. Individual utility depends on the following variables: it increases with environmental quality, which is labelled as G and is assumed to increase directly with the effort exerted by the individual in waste recycling and in waste reduction, implying the existence of a "warm glow" effect. Recycling and waste prevention efforts are labelled, respectively, as e_R and e_M. Utility also increases with leisure time (l), and with the degree of peer approval from recycling (pa), that will be discussed below. The utility funtion can therefore be written as follows:

$$U(l, G, e_R, e_M, pa); \tag{1}$$

All standard assumptions concerning decreasing marginal utility are satisfied. Also, and importantly, as our model is devoted to the investigation of the consequences of complementarities and/or substitutabilities between the two waste related behaviors, i.e. the effort levels, we assume that cross derivatives between all other variables than e_R and e_M are equal to 0, so that, for example, $\frac{\partial^2 U}{\partial l \partial G} = 0$ etc. On the other hand, we leave $\frac{\partial^2 U}{\partial e_R \partial e_M}$ free to vary.

We label the individual contribution to the public good as $g(e_R, e_M)$, which is assumed to be increasing in the effort levels, as it is reasonable. As a result,

$$G = G_{-i} + g(.)$$

where G_{-i} labels the contribution by all other individuals. Coherently with the existing literature, this is taken as exogenous, that is, the individual does not perceive her effort choices as significant in determining the effort and public good related choices of other individuals.

We assume that peer approval depends (negatively) on the level of the social norm sn and (positively) on the recycling effort. The sn variable is taken as exogenous, i.e. the individual does not perceive the impact of its choices on the social norm, but we assume that it increases with recycling policies, to capture a possible crowding-out effect. More specifically:

$$pa = pa\left(e_R - sn\right).$$

As a result, an increase in the social norm decreases *ceteris paribus* peer approval while the recycling effort increases it (Abbott et al., 2013). The function pa is assumed to be increasing in δ. This is coherent with the behavioral literature focusing on waste behaviors, which underlines the peculiar features of waste with respect to other issues involving a strong behavioral component (e.g. tipping, Azar, 2004).

Our individual maximizes (1) subject to the following "budget" constraint

$$E = l + f(w_R e_R, w_M e_M) \tag{2}$$

where $f'(.) > 0$; w_R is a measure of the "opportunity cost" of recycling while w_M is the opportunity cost of waste prevention.

We assume that w_R is decreasing in recycling policy strictness and in specific knowledge related to recycling. Specific knowledge has to be intended as the degree of knowledge of the individual concerning the specific methodologies and techniques that can be adopted to recycle. Policy strictness is addressed in broad way, so that an increase in policy strictness might take the form of a stricter waste related taxation (e.g. a larger landfill tax, increasing the opportunity cost of not recycling), of a larger subsidy to recycling or to reuse, as well as of better waste related facilities. The opportunity cost of waste prevention, w_M, is defined in a similar way, although, in the absence of specific waste prevention policies at households level[5], the interpretation of its links with recycling policy are less straightforward. In other words, we cannot say whether a better recycling policy increases or decreases the opportunity cost of waste prevention. Finally, E is total available effort for non-labour activities, i.e. total time *minus* time devoted to work. As a result, the constraint in (2) requires that available effort time (that is, total time minus labour time) equals time spent in leisure plus time/effort spent in recycling and waste minimization activities. If we substitute for l from (2) into (1) we get to the following maximization problem:

$$\max_{e_R,e_M} U(E - f(w_R e_R, w_M e_M), G, e_R, e_M, pa\,(e_R - sn)) \tag{3}$$

To simplify matters, we put additional structure on the model, by assuming also that $f(w_R e_R, w_M e_M) = w_R e_R + w_M e_M$ and $g(e_R, e_M) = e_R + \alpha e_M$. The parameter α (with $\alpha > 1$) measures the degree of individual consciousness of the superiority of waste prevention over recycling activities as a strategy to improve environmental quality; this assumption is coherent with the relevance recognized by policy makers to minimization strategies as the most preferred waste management option in the long run. We interpret α as an indicator of intrinsic motivations to waste reduction (see also the discussion in Section 3).

Finally, we assume a linear shape for $pa(\delta)$, namely $pa(\delta) = e_R - sn$.

Additional simplying assumptions are needed to improve results interpretion: namely, we assume that utility is linear in G and l. Albeit these assumptions are expected to affect our theoretical conclusions, they are invaluable in terms of readability of results.

Based on these assumptions, the individual chooses effort levels in order to maximize (3). First order conditions imply:

$$\frac{\partial U}{\partial G} + \frac{\partial U}{\partial e_R} + \frac{\partial U}{\partial pa} = \frac{\partial U}{\partial l} w_R \tag{4}$$

$$\frac{\partial U}{\partial G}\alpha + \frac{\partial U}{\partial e_M} = \frac{\partial U}{\partial l} w_M \tag{5}$$

Define the Hessian determinant as follows:

$$|H| = \begin{vmatrix} H_{11} & H_{12} \\ H_{12} & H_{22} \end{vmatrix}.$$

[5] Waste reduction policies at the household level are still underdeveloped at the EU level, despite the relevance recognized by policy makers to waste minimization efforts.

where: $H_{11} = \frac{\partial^2 U}{\partial e_R^2} + \frac{\partial^2 U}{\partial pa^2}$, $H_{22} = \frac{\partial^2 U}{\partial e_M^2}$, and $H_{12} = H_{21} = \frac{\partial^2 U}{\partial e^R \partial e^M}$.

Concavity requires $H_{11} < 0$, which always holds under our assumptions concerning decreasing marginal utility, and

$$|H| = \left(\frac{\partial^2 U}{\partial e_R^2} + \frac{\partial^2 U}{\partial pa^2}\right)\frac{\partial^2 U}{\partial e_M^2} - \left(\frac{\partial^2 U}{\partial e^R \partial e^M}\right)^2 > 0;$$

we assume the latter to be the case.

From (4) and (5), we can make some comparative statics.

Looking at the impact of the recycling opportunity cost, we have that:

$$\frac{de_R}{dw_R} = \frac{\begin{vmatrix} \frac{\partial U}{\partial l} & H_{12} \\ 0 & H_{22} \end{vmatrix}}{|H|} = \frac{\frac{\partial U}{\partial l}\frac{\partial^2 U}{\partial e_M^2}}{|H|} < 0$$

$$sgn\left(\frac{de_R}{dw_R}\right) = sgn\left(\frac{\partial U}{\partial l}\frac{\partial^2 U}{\partial e_M^2}\right) < 0$$

It implies that a lower opportunity cost of recycling activities (induced by an improvement in specific recycling knowledge and/or in recycling policy) unambigously leads to a larger effort in recycling.

Turining to the impact of w_R on e_M, we get:

$$\frac{de_M}{dw_R} = \frac{\begin{vmatrix} \frac{\partial^2 U}{\partial e_R^2} + \frac{\partial^2 U}{\partial pa^2} & \frac{\partial U}{\partial l} \\ \frac{\partial^2 U}{\partial e^R \partial e^M} & 0 \end{vmatrix}}{|H|}$$

so that

$$sgn\left(\frac{de_M}{dw_R}\right) = sgn\left(-\frac{\partial^2 U}{\partial e^R \partial e^M}\frac{\partial U}{\partial l}\right)$$

As a consequence: $\frac{de_M}{dw_R} \gtreqless 0$ if $\frac{\partial^2 U}{\partial e^R \partial e^M} \lesseqgtr 0$, meaning that an improvement in specific recycling knowledge and/or in recycling policy implies a larger (lower) effort in waste prevention when recycling and prevention efforts are complements (substitutes) in the utility function.

These considerations suggest the potential existence of multidimensional "warm glow" impacts. In other words, the marginal utility of one effort type can increase or decrease in reaction to changes in the other effort, depending on the existence of potential complementarities or substitutabilities in the utility function.

Before moving to other relevant comparative statics results, notice that an equivalent analysis concerning w_M would not be very informative theoretically; indeed, as argued before, no straight conclusion is possible in terms of the changes in w_M resulting from changes in the recycling policy. Related impacts are therefore mostly an empirical issue.

Other relevant comparative statics refer to the impact of α and the indirect impact of policy and specific knowledge through peer approval. Comparative statics lead us to the following:

$$sgn\left(\frac{de_R}{d\alpha}\right) = sgn\left(\frac{\partial^2 U}{\partial e^R \partial e^M}\frac{\partial U}{\partial G}\right)$$

so that $\frac{de_R}{d\alpha}$ has the same sign as $\frac{\partial^2 U}{\partial e^R \partial e^M}$; as a result, a larger intrinsic motivation for waste prevention will imply a larger effort in recycling if the two efforts are complements ($\frac{\partial^2 U}{\partial e^R \partial e^M} > 0$). Turning to the impact on waste reduction:

$$sgn\left(\frac{de_M}{d\alpha}\right) = sgn\left(-\frac{\partial U}{\partial G}\right)\left(\frac{\partial^2 U}{\partial e_R^2} + \frac{\partial^2 U}{\partial pa^2}\right) > 0$$

so that a larger α always leads to a larger effort in waste prevention.

Focusing next on the impact of the social norm sn, we get:

$$\frac{de_R}{dsn} = \frac{\partial^2 U}{\partial e_M^2}\frac{\partial^2 U}{\partial pa^2} > 0$$

and

$$\frac{de_M}{dsn} = -\frac{\partial^2 U}{\partial e^R \partial e^M}\frac{\partial^2 U}{\partial pa^2}$$

A stricter policy or, more generally, a more ambitious social norm impacts the recycling effort level (through peer approval) in a positive way, while the impact on minimization effort depends again on complementarity/substitutability between efforts in the utility function. If the two efforts are complements, a larger prevention effort emerges as a result of a stricter social norm; we cannot however exclude that social norm can have "perverse" effects on prevention (or even no effect at all).

The supposed direct relationships emerging from the theoretical model are summed up by the conceptual path in Fig. 1.

3 The data

Our empirical estimation is based on data provided by the 2009 Survey of Public Attitudes and Behaviours toward the Environment[6], which is representative of the population in England (Thornton, 2009). Consisting of 2,009 observations, the survey reports either the opinion or the stated actual

[6] This Survey is commissioned by the Department for Environment, Food and Rural Affairs (Defra), together with the Energy Saving Trust. The data for 2009 release was collected in February/March of the same year.

behavior of the respondent (or both) on a wide range of environmentally relevant daily activities. These activities are grouped according to a number of issues including energy and water use, purchasing behaviors, recycling habits and waste production and reuse, food purchasing/consumption and food waste, 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, and attitudes towards, 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.To the best of our knowledge, there are no other datasets providing comparable information.

To derive the latent dependent variables used in the empirical model, we have selected the following variables as indicators of:

1. waste disposal behaviors:

- How frequently do you recycle items (*recbeh1*)
- How frequently do you compost your household's food and/or garden waste (*recbeh2*)
- How frequently do you take your own shopping bag when shopping (*recbeh3*)
- How frequently do you decide not to buy something because too much packaging (*minbeh1*)
- How much uneaten food would you say you generally end up throwing away (*foodmin*)
- How much effort do you and your household go to in order to minimise the amount of uneaten food thrown away (*eff_food*)

2. intrinsic motivation:

- Level of knowledge about climate change (*knclim*)
- Level of knowledge about global warming (*kngwarm*)
- Level of knowledge about carbon footprint (*kncfoot*)
- To what extent throwing uneaten food away bother you personally (*fw_ bother*)
- Attitude towards own lifestyle and the environment (*envfeel*)

3. recycling opportunity cost:

- Presence of bottle bank or recycling bank where taking bottles, cans or paper to recycle (*rec_ bank*)
- Level of knowledge about the type of materials that can be put for a council recycling or composting collection (*sp_ kn*)

4. peer approval:

- Degree of agreement with the statement “People have a duty to recycle” (*peer_ app*).

Descriptive statistics for the selected variables are reported in Table 1[7].

As far as waste behaviors are concerned, we have used answers to questions where respondents are asked to consider their current behaviour in relation to different types of recycling/reusing, composting[8] and prevention decisions.

To evaluate the impact of waste policy on recycling and reduction behaviors, we use a variable indicating the presence of kerbside facilities in the area of residence[9]. This type of information is commonly adopted as a proxy for waste policies, as kerbside policy is considered as a key instrument for policymakers to affect households’ recycling decisions through the activation of the social norm to recycle and the increased individuals’ perception of competence and autonomy in carrying out recycling activities (Abbott et al., 2013).

In addition to kerbside facilities, specific knowledge about the types of materials that can be recycled is considered as a factor reducing the opportunity cost of recycling effort. As indicator of specific recycling knowledge we have constructed a variable that expresses the number of items the respondent can put outside for council recycling or composting collection.

Coherently with our theoretical model, we suppose that the recycling opportunity cost is affected by waste disposal decisions both directly and indirectly through its effects on the social appraisal the individual enjoys by complying with the social norm. Peer approval can be defined as the external rewards that derive to the individual from his/her pro-social behavior (Cecere et al., 2013). In this work, we assume that peer approval can be captured by the degree of agreement with the statement "People have a duty to recycle", by considering that the recycling duty represents a social

[7] Original variables have been recorded in order to assign higher values to greener attitudes and behaviors.

[8] Among recycling behaviors we have considered also composting. This is coherent with the definition provided by the waste hierarchy, according to which recycling includes "turning waste into a new substance or product, includes composting if it meets quality protocols" (see for instance https://www.gov.uk/waste-legislation-and-regulations, last accessed 06/26/2014).

[9] Expressed by the answer to the question: "Is there a bottle bank or recycling bank in your area where you can take things like bottles, cans or paper to recycle?".

norm and that the stronger the level of agreement with this duty the higher the attainment of peer approval coming from adherence to this norm.

Whilst recycling is visible to "neighbours' eyes" and can then be stimulated by social rewards (extrinsic motivations), waste reduction is a private action which is unlikely to be observable by others. Accordingly, we can expect that "more private" motivations can induce waste prevention. As a proxy for intrinsic motivations to waste minimization we have considered two variables related to the individual attitude towards the environment (expressed by the degree of bother the individual feels when throwing uneaten food away, and personal feeling about the current lifestyle in relation to the environment), and three variables expressing individual knowledge of environmental problems. This is in line with the literature recognizing that environmental knowledge can play a significant part in shaping waste management decisions (see, for istance, Barr, 2007 and the concept of "abstract knowledge for action" proposed by Schahn and Holzer, 1990).

4 Empirical analysis and results

In order to test whether the theoretical results obtained in Section 2 can be confirmed empirically, 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 theoretical model 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) (Hershberger et al., 2003). The measurement model specifies how latent variables depend upon the observed variables, whereas the structural equation model specifies the causal relationships among the latent variables and describes the causal effects. Both models are specified by the researcher by choosing and constraining the model's parameters as fixed, constrained and free.

The use of structural equation modeling is further suggested by the existence of a reciprocal causation effect between the two waste behaviors in our model (and accordingly between their residuals). Reciprocal causation between variables requires the specification of a nonrecursive model, for which the use of a full information technique (such a LISREL model) can be particularly useful.

As commonly done by several authors (Anderson and Gerbing, 1988; Medsker et al., 1994; Zattoni et al., 2012), we followed a two-stage procedure, where, in the first step, we have tested the validity of the measurement models through a confirmatory factor analysis (CFA). In the second step, the complete structural equation model was used to estimate the path coefficients and test for the relationships between constructs.

Following Jöreskog and Sörbom (1996), the structural equation model consists of three types of relationships. 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. In our specification, recycling and minimization behavior as well as peer approval are latent endogenous variables ($\boldsymbol{\eta}$); the measurement model then identifies the relations between each latent variable and the manifest variables that causes them[10].

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. In our case, intrinsic motivations (alpha) and recycling opportunity cost are specified as latent independent variables explained by their observed independent constructs.

Finally, 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.

As it is shown in Figures 2 and 3, latent variables (both dependent and independent) are graphically represented by ovals, whilst observed (endogenous and exogenous) variables are included in rectangles.

Since the variables used in the analysis are ordinal, we adopt the Weighted Least-Squares (WLS) method based on polychoric correlations and their asymptotic covariance matrix.

Coherently with the suggested relationships provided by our theoretical model, two different specifications have been tested: in the first specification, to account for the existence of a potential direct influence of variables

[10] For a detailed description see Bollen (1989).

affecting recycling opportunity cost on waste reduction effort, we have explicitly considered the path between the two variables. As Figure 2 displays, however, the direct relationship between "reduction in recycling opportunity cost" and minimization behavior is not significant (t-value = -1.70); nevertheless, we can expect that indirect effects on waste prevention efforts through impacts on other variables may take place. The exclusion of the path between "reduction in recycling opportunity cost" and minimization behavior leads to the second model specification. Figure 3 shows the estimated relationships and their standardized coefficients for the second specification[11].

The model specification is acceptable (RMSEA = 0.00, SRMR = 0.085); the goodness of fit indices values are as follows: Goodness of Fit Index (GFI) = 0.9842, Adjusted Goodness of Fit Index (AGFI) = 0.9767.

By looking at the structural model in order to assess the validity of causal structures among latent variables, it can be noted that a lower opportunity cost of recycling (positively affected by better knowledge of recycling opportunities and the presence of kerbside facilities) has a positive direct effect on recycling behaviors and on peer approval, which in turn positively affects recycling decisions. These relations suggest the possibility that waste policy can have also an indirect effect on recycling behaviors through its impact on peer approval, implying that no crowding out of environmental policies and extrinsic motivations takes place in our specifications[12].

Intrinsic motivations for prevention (explained by the level of knowledge of environmental issues and the individual green attitude) positively affect waste minimization, confirming previous results in the literature (Barr, 2007).

According to our estimations, there are positive and significant reciprocal linkages between recycling and minimization behaviors. These results suggest that the two waste behaviors tend to reinforce each other, supporting the view that the two waste related efforts are complements in the utility function. The existence of a complementarity relation can then imply that even though waste/recycling policy doesn't affect directly prevention efforts, they may be stimulated indirectly through their positive impact on recycling.

In order to uncover the overall effect that each variable may have on the others, we calculate the total effects summarized by the different paths[13]. As

[11] Compared to the first model, the second specification yields gains of goodness of fit indicators.

[12] This partly confirms results obtained by Cecere et al. (2013) at the EU level.

[13] 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 ones that are mediated by at least one other variable and the total effects are the sum of direct and indirect effects (Bollen, 1989; p. 376).

Table 2 shows, a reduction in the recycling opportunity cost has a positive and significant impact on prevention effort, even though the coefficient is very low. At the opposite, intrinsic motivations have a strong impact not only on minimization behaviors (as noted before) but on recycling efforts as well (and the value of the coefficient is much higher than the coefficient between w_R and minimization behavior).

Results about total effects hence suggest that we cannot rely too much on recycling policies to boost waste minimization, as they do not affect individual prevention efforts directly and have only a low indirect impact. 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 much more effective in stimulating waste prevention and in order to achieve long-term sustainability targets.

5 Conclusion

This paper analyzes potential interactions between individuals' waste prevention and recycling activities, focusing on the effects that different drivers may have, both directly and indirectly, on the two waste related behaviors.

Although waste prevention 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. It is particularly intriguing then to investigate the effects that recycling policies may have on individuals' decisions to reduce waste.

A question to which we have looked for an answer is what kind of effects may be induced by recycling policies on individuals' decisions to reduce waste.

In fact, if, on the one hand, incentives and facilities to encourage recycling may have positive effects on waste reduction too, by stimulating a pro-environmental lifestyle, on the other hand they may have negative effects generating a trade-off between the two behaviors.

Our theoretical analysis shows that policies oriented at reducing the opportunity cost of recycling may have positive (negative) effects also on waste reduction if the two efforts are complements (substitutes) in the individual utility function. The existence of a multidimensional "warm glow" may arise: increasing one of the two efforts increases (decreases) the marginal utility of the other, depending on the existence of a complementarity or substitutability relationship.

The existence of complementarities (or substitutabilities) between the two efforts determines also positive (negative) indirect effects of intrinsic motivations on recycling behavior as well as of social norms on waste minimization decisions.

In the empirical part of the paper we investigate our theoretical predictions, by specifying the role played by policies, personal beliefs and social norms in determining individual waste-related actions.

Our results suggest that recycling policies do not directly affect waste reduction decisions. Instead, there are positive and significant reciprocal linkages between recycling and minimization behaviors, disclosing the existence of a relationship of complementarity between the two waste related efforts. This implies that in our case study recycling policies indirectly stimulate waste prevention, through their positive impact on recycling. The same relationship of complementarity between the two efforts allows us to consider the direct and indirect effects of intrinsic motivations and social norms on both behaviours. What emerges by the calculus of the total effects summarized by the different paths is of great interest.

In fact, given the complementarity relation between the two behaviors, policies oriented at incentivizing and facilitating recycling have indirect positive effects also on waste prevention, nevertheless their impact is very low.

At the opposite, intrinsic motivations that have a strong direct impact on waste minimization, have also a strong indirect impact on recycling. Endogenous motives that induce individuals to comply with waste minimization positively influence also recycling.

If it is true that complementarity and not substitutability emerges between the two waste management behaviors, it is also true that the different drivers of the diverse behaviors do not necessarily have the same strength on both waste minimization and recycling. Multidimensional warm glow is more relevant in explaining the indirect effect of intrinsic motivations on recycling than it is in determining the indirect effect of waste policy on waste prevention.

These considerations help explaining the moderate impact of policy interventions aimed at improving waste disposal management on waste reduction. Government campaigns aimed at increasing individuals' awareness about the waste problem may be much more effective in stimulating waste prevention in order to achieve long-term sustainability targets.

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Table 1 - Descriptive statistics

Variable	Description	Obs	Mean	St. Dev.	Min	Max
RECBEH1	The variable takes value 1 if the individual declares that s/he *always* recycles items rather than throw them away, 2 if s/he does it *quite often*, 4 *sometimes*, 5 *occasionally*, 6 *never* (7 *DK*, 8 *NA*).	2009	1.925	1.367	1	8
RECBEH2	The variable takes value 1 if the individual declares that s/he *always* compost her/his household's food and/or garden waste, 2 if s/he does it *quite often*, 4 *sometimes*, 5 *occasionally*, 6 *never*.	2009	4.197	2.495	1	8
RECBEH3	The variable takes value 1 if the individual declares that s/he *always* take her/his own shopping bag when shopping, 2 if s/he does it *quite often*, 4 *sometimes*, 5 *occasionally*, 6 *never*.	2009	2.238	1.847	1	8
MINBEH1	The variable takes value 1 if the individual declares that s/he *always* decide not to buy something because it has too much packaging, 2 if s/he does it *quite often*, 4 *sometimes*, 5 *occasionally*, 6 *never*.	2009	4.780	1.700	1	8
FOODMIN	The variable takes value 1 if the individual declares that s/he throws away *quite a lot* uneaten food, 2 if s/he throws away *a reasonable amount*, 3 *some*, 4 *a small amount*, 5 *hardly any*, 6 *none*.	2009	4.348	1.030	1	7
EFF_FOOD	The variable takes value 1 if the individual declares that s/he goes *a great deal* of effort in order to minimize the amount of uneaten food thrown away, 2 if s/he goes *a fair amount* of effort, 3 *a little*, 4 *not very much*, 5 *not at all*.	2009	1.970	1.060	1	6
	INTRINSIC MOTIVATIONS					
KNCLIM	Takes value 1 if the individual knows *a lot* about climate change, 2 *a fair amount*, 3 *just a little*, 4 *nothing - have only heard of the name*, 5 *nothing - have never heard of it*.	2009	2.312	.835	1	6
KNGWARM	Takes value 1 if the individual knows *a lot* about global warming, 2 *a fair amount*, 3 *just a little*, 4 *nothing - have only heard of the name*, 5 *nothing - have never heard of it*.	2009	2.232	.820	1	6
KNCFOOT	Takes value 1 if the individual knows *a lot* about carbon footprint, 2 *a fair amount*, 3 *just a little*, 4 *nothing - have only heard of the name*, 5 *nothing - have never heard of it*.	2009	2.655	1.099	1	6
FW_BOTHER	Takes value 1 if the individual bothers *a great deal* when s/he has to throw uneaten food away,.2 if s/he bothers *a fair amount*, 3 *a little*, 4 *not very much*, 5 *not at all*.	2009	2.376	1.330	1	6
ENVFEEL	Takes value 1 if the individual feels *happy with what s/he does at the moment* for the environment, 2 if s/he *would like to do a bit more to help the environment*, 3 if s/he *would like to do a lot more to help the environment*.	2009	1.621	.635	1	4
	RECYCLING OPPORTUNITY COST					
REC_BANK	Takes value 1 if there is a bottle bank or recycling bank in the area of residence, 0 otherwise.	2009	1.223	.536	1	3
SP_KN	Counts the number of materials/items the individual can put outside for a council recycling or composting collection.	2009	5.661	2.061	1	9
	PEER APPROVAL					
RECDUTY	Takes value 100 if the individual *strongly agrees* with the statement "People have a duty to recycle", 50 if s/he *tends to agree*, 0 *neither agrees nor disagrees*, -50 *tends to disagree,* -100 *strongly disagrees*.	2009	48.35	446.5	1	6

Table 2 - Total effects (second model specification)

Total Effects of KSI on ETA

	rec_oppc	alpha
recbeh	0.231	0.206
	(0.043)	(0.037)
	5.364	5.596
minbeh	0.084	0.223
	(0.021)	(0.029)
	4.001	7.705
pa	0.295	- -
	(0.063)	
	4.701	

Total Effects of ETA on ETA

	recbeh	minbeh	pa
recbeh	0.510	1.395	0.117
	(0.181)	(0.358)	(0.036)
	2.816	3.890	3.224
minbeh	0.552	0.510	0.043
	(0.164)	(0.181)	(0.015)
	3.374	2.816	2.936
pa	- -	- -	- -

Figure 1 - Conceptual path

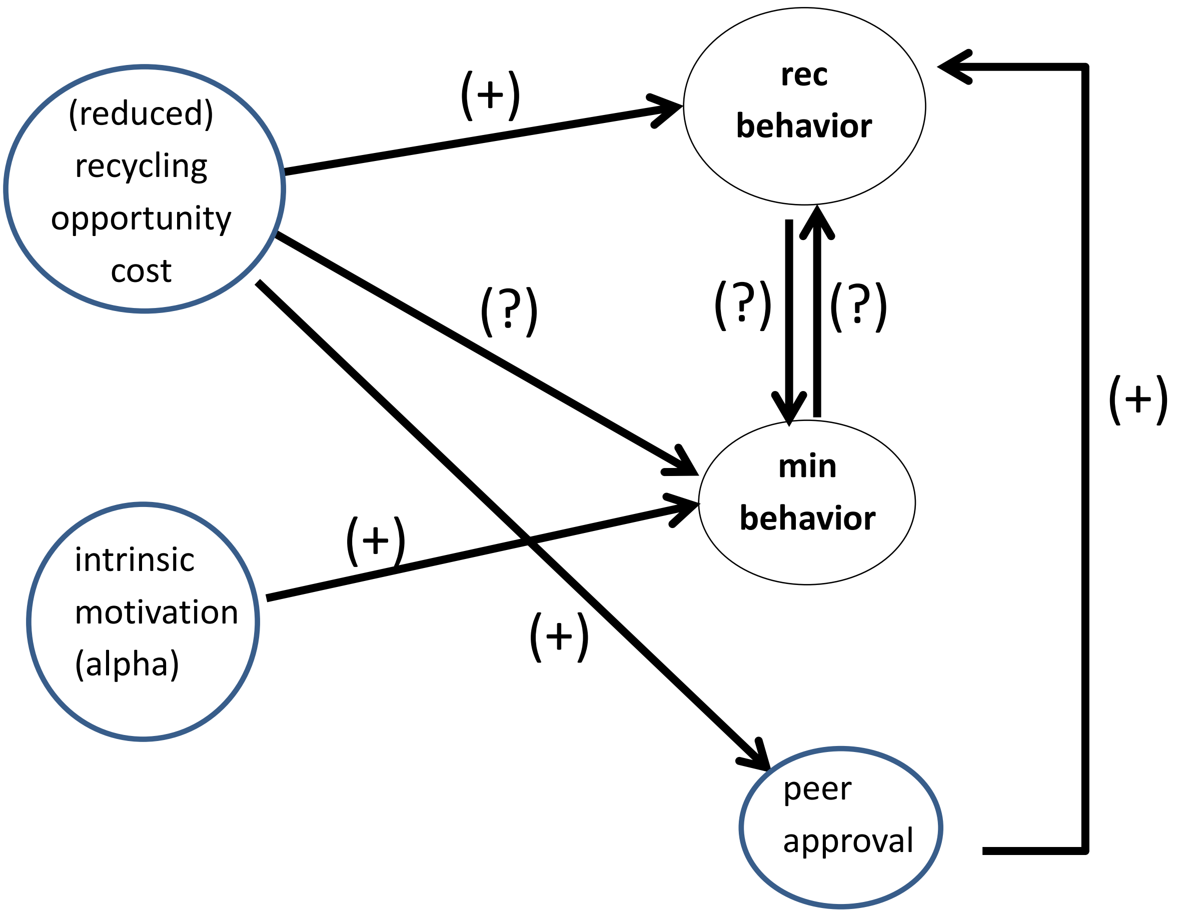

Figure 2 – Estimated path diagram (standardized solution) – First specification

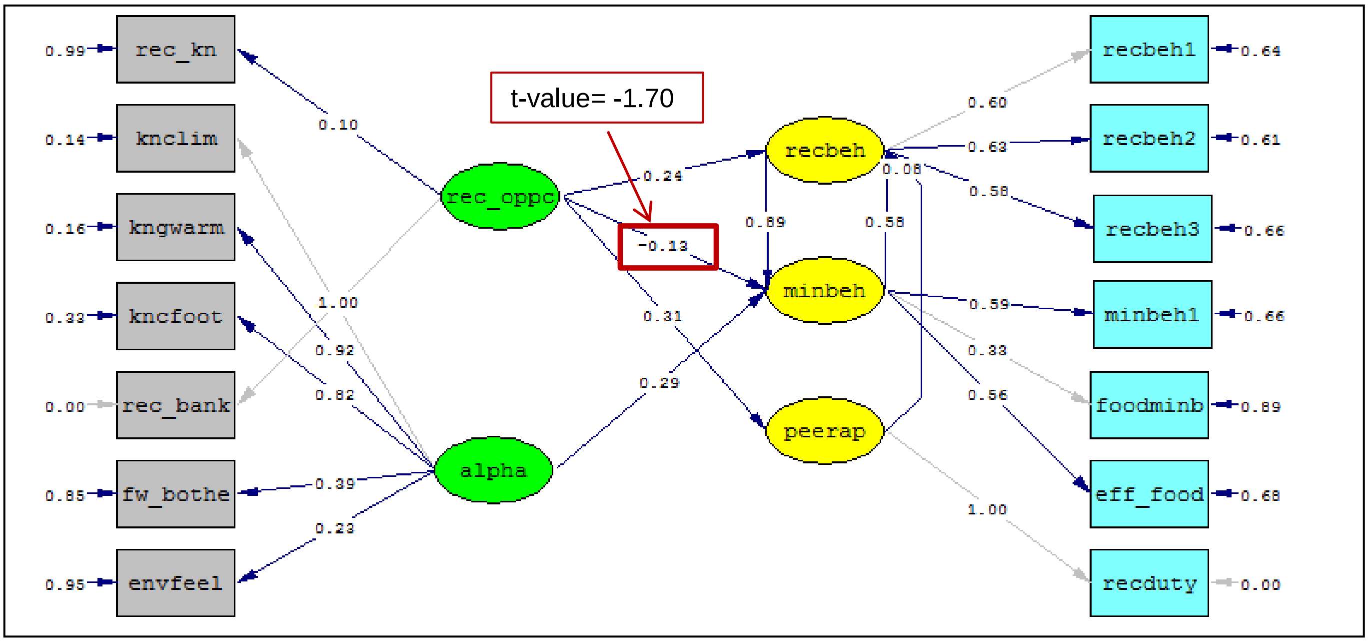

Figure 3 – Estimated path diagram (standardized solution) – Second specification