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Andrea Martinangeli and Mariangela Zoli

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Department of Economics
School of Business, Economics and Law at University of Gothenburg
Vasagatan 1, PO Box 640, SE 405 30 Göteborg, Sweden
+46 31 786 0000, +46 31 786 1326 (fax)
www.handels.gu.se info@handels.gu.se

Exploring Environmentally Significant Behaviors in a Multidimensional Perspective

Andrea Martinangeli*
University of Gothenburg

Mariangela Zoli†
Università di Roma "Tor Vergata"

Abstract

This paper contributes to the recent literature exploring the determinants of individual environmental behaviors. Contrary to many previous studies, which consider single items as proxies of individuals' overall environmental responsibility, we adopt a multidimensional perspective and derive composite indicators measuring individual performance on a set of distinct environmental dimensions. These indicators are then used to provide a more comprehensive picture of the complex mechanisms behind the formation of environmentally responsible behaviors. In addition to commonly investigated variables, we consider a richer set of determinants of green behaviors, finding that the level of public environmental protection expenditure, lifestyle satisfaction, individual worldviews and participation of different types of social actors all significantly affect the degree of environmental responsibility. Our empirical analysis is based on data from the British "Survey of Public Attitudes and Behaviours toward the Environment" for 2009.

JEL classification: A130; H130; Q530; Z130.
Keywords: public environmental expenditure; green behaviors; multidimensional analysis.

*Department of Economics, School of Business, Economics and Law at the University of Gothenburg, Sweden - Email: andrea.martinangeli@economics.gu.se

†SEFEMEQ Department - Faculty of Economics - Via Columbia, 2 - 00133 Rome, Italy - Tel. +39 06 72595925 - Fax +39 06 2040219 - Email: zoli@sefemeq.uniroma2.it

1 Introduction

The strengthening of environmental problems as a major policy issue reflects the growing concern about the effects of human activities on the environment. Since the United Nations Conference on Environment and Development in Rio de Janeiro (1992) and even more after the World Summit on Sustainable Development in Johannesburg (2002), sustainable consumption and production have been considered as one of the key challenges to be tackled to ensure the sustainability of global development strategies. Government policies aimed at changing consumption patterns, however, seem to have poorly performed with respect to the intended targets (see, for instance, the report on Sustainable Consumption and Production in Europe, ETC/CSP, 2011), and despite the efficiency and production improvements, environmental impacts from household consumption schemes are rising. Even though several causes for these shortcomings can be identified, it clearly emerges that a deep understanding of factors behind the formation of individual environmentally responsible behaviors is essential in order to increase the effectiveness of public intervention. In the absence of a clear knowledge of the variety of factors that may affect individual behavior, environmental policies risk being unsuccessful, leading to unrealistically high expectations from some policy outcomes or even to the adoption of ineffective policy instruments.

In order to improve existing knowledge about the determinants of sustainable behavior patterns, in this work we investigate the role played by several socio-psychological and socio-economic characteristics in affecting individual attitudes and actions toward the environment.

Differently from the bulk of previous studies, we depart from the idea of treating environmental behavior as a single item and adopt a multidimensional perspective. Specifically, we identify six distinct dimensions through which individuals perceive and interact with the environment; for each of them, the main determinants of environmental behaviors are explored. Further, environmental behaviors are sequentially linked on the basis of the number of dimensions on which individuals can be considered as environmentally responsible, obtaining a measure of overall, or "inter-dimensional", environmental responsibility, whose determinants are hence investigated. The empirical analysis is based on a large survey of English households (the Survey of Public Attitudes and Behaviours toward the Environment; Defra, 2010), which provides unique information on environmental behaviors.

Our work rests on the literature examining the relationship between people's environmental responsibility and their economic and social backgrounds. Owen and Videras (2006), for instance, focus on the impact of civic cooperation, environmental attitudes and behavioral intentions on willingness to sacrifice economic growth and income for the sake of the environment, while Torgler and Garcia-Valiñas (2007) analyze how some socio-economic variables determine individual willingness to pay for the prevention of environmental damage. On the same line, Shen and Saijo (2007) consider the determinants of environmental concern in Shanghai, and Welsh and Kühling (2009) those of pro-environmental consumption in the region of Hanover, Germany; Darby and Obara (2005) and Wang et al. (2011) explore consumer behaviors and attitudes towards the disposal of e-waste recycling in Cardiff, Wales, and Beijing, China, respectively, while Martinsson et al. (2011) assess the relative importance of socio-economic factors and environmental attitudes on households' energy saving. In these studies, however, only one dimension of environmental behaviors at a time is considered; in other words, a single, unidimensional variable is taken as representative of overall individual environmental behavior, which is instead clearly multifaceted (Stern, 2000).

By adopting a multidimensional perspective, our results highlight that relying on several distinct dimensions of environmental behaviors provides a more comprehensive picture of their manifold aspects. Further, we can show that, by investigating separately the main determinants of each environmental domain, many useful policy suggestions may be drawn, allowing policy makers to better address their intervention.

The rest of the paper is organized as follows: Section 2 describes the data used for the analysis, Section 3 derives individual environmental responsibility indicators, while Section 4 introduces the models used for the empirical analysis. Section 5 presents the main results and Section 6 concludes.

2 The Data

The data used in our analysis are taken from the 2009 Survey of Public Attitudes and Behaviours toward the Environment[1], 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 behavior of the respondent (or both) on a wide range of environmentally relevant daily activities, these grouped into a number of issues which include: energy and water use in the home, purchasing behaviors, recycling habits and waste production and reuse, food purchasing/consumption and food waste, and travel. Furthermore, a number of questions are included 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 in environmental organizations. This dataset appears then as particularly suitable for the investigation of individual environmental behaviors and attitudes from a multidimensional perspective.

Unfortunately, to the best of our knowledge, there are no other datasets providing comparable information. While this clearly prevents us from comparing results for England with those for other countries, it does not reduce the validity of the adopted methodology. As it will become clearer in the following, the role played by variables in explaining each dimension of environmental behavior depends on the correlation between the considered variable and that dimension. It implies that synthetic indicators of pro-environmental behaviors in different countries could be different according to the specific weight of underlying variables. Far from being a limitation, exploiting correlations among data allows us to capture country-specific habits and cultural patterns that should be taken into account when environmental behaviors are investigated.

To best exploit the information conveyed by the variables in the Survey for the purposes of our investigation, their original codification has required in several cases a significant reorganization (i.e. merging, recoding and splitting) so as to ensure that a lower value corresponds to a less environmentally responsible action or opinion.

To perform the multidimensional analysis presented in the next Section we have retained

[1]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.

79 recoded variables from the dataset, of which a complete list is provided in Table 1.

3 The Construction of Environmental Responsibility Indicators

People's everyday actions are directly or indirectly responsible for many environmental problems. Transport, food and water consumption, waste disposal, and the use of energy in the household are all dimensions of individual behaviors that can have negative environmental effects. People tend to behave differently on each dimension according to their situational constraints, personal beliefs and knowledge. Adopting an environmentally responsible consumption, which avoids the use of products that may be harmful to the environment and reduces the amount of household waste, for instance, may be easier for wealthy people living in urban areas, because the products are often more expensive and not always available in regular stores (Nordlund and Garvill, 2002). Acknowledging that different factors can determine the individual performance on different environmental dimensions (what we can call "intra-dimensional" responsibility), we can conclude that environmental behavior should be better described in terms of distinct domains. Such considerations suggest the adoption of a multidimensional perspective to investigate individual environmental performance.

In order to conduct our research, a preliminary stage implies the construction of synthetic indicators measuring individual environmental performance in different domains. These indicators allows us to examine the differences in how people behave within each dimension and the relationships among the dimensions themselves, thus obtaining a much clearer picture of the mechanisms behind the formation of environmentally responsible behaviors. We have thus chosen to group the 79 retained variables into six, well identified sets, each describing a different environmental domain as suggested by common experience, by the Defra questionnaire itself, and by the correlational structure of the data[2].

[2]To reduce the multidimensionality of a dataset, researchers can choose on the basis of their personal expertise or may let some statistical method suggest the most appropriate solution of data reduction. In this analysis we have performed an *exploratory* Non Linear Principal Components Analysis (NLPCA) on the raw variables in the dataset to uncover the underlying structure of the data. The use of such a statistical technique has the advantage of avoiding to force pre-established relationships between variables, since latent structures are uncovered by exploiting correlations among data (Linting, 2007). Results from this exploratory analysis suggest

Table 1: Variables used to build the six human-environment interaction dimensions.

AWARENESS

- Knowledge on climate change
- Knowledge on global warming
- Knowledge on carbon footprint
- Knowledge on CO2 emissions
- Knowledge on biodiversity
- Overpopulation
- Limited amount of resources
- Present environmental situation
- Global awareness
- Agreement contribution of food production to climate change
- Understanding of contribution of food production to climate change

ATTITUDE

- Guilt
- Government should deal with: environment
- Level of distress at throwing food
- Attitude toward saving energy
- Attitude towards recycling
- Attitude towards water usage
- Attitude towards the environmental crisis
- Attitude towards changing habits for the sake of the environment
- Attitude towards the future effects of climate change
- Attitude - worth being responsible only if profitable
- Is willing to pay more taxes for the sake of the environment
- Concerned with the loss in local biodiversity
- Attitude towards waste and greed
- Attitude - resignation
- Priority of the environment relative to personal habits
- Is skeptical that his personal behavior is affecting the environment
- Concerned with the loss in local biodiversity
- Attitude - pride in local environmentÕs quality
- Attitude - priority of water saving
- Concerned with the public sector wasting energy
- Concerned with people wasting
- Stated overall attitude towards the environment

INVOLVEMENT

- Volunteered in conservation groups
- Buys plants who encourage wildlife for his/her garden
- Lifestyle and the environment (stated)
- Advices other people on ways they could help the environment
- Tries to persuade people to adopt a sustainable way of life
- Suggests environment-oriented improvements at work
- Buys local products
- Active in environmental protection (stated)
- Made donations to the Royal Society for the Protection of Birds (stated)

ENERGY & MOBILITY

- Cuts gas and electricity usage at home
- Buys energy efficient appliances
- Would turn the thermostat down by 1¡+
- Cuts usage of hot water at home
- Cut usage of hot water at home (actual)
- Installing solid wall insulation
- Installing draught exclusion
- Installing solar panels for electricity
- Installing solar water heating
- Installing a condensing boiler
- Switching to public transportation instead of driving
- Switching to an electric/LPG/hybrid car
- Buying or driving a more fuel efficient vehicle

FOOD & WATER

- Cuts on the use of water at home
- Cuts on the use of water at home (actual)
- Is committed to wasting less food
- Buying fresh locally produced, seasonal food
- Grows his/her own fruit/vegetables
- Installing water butt to collect rain
- Buys fish from sustainable sources
- Usually boils only as much water as needed
- Usually boils only as much water as needed (actual)
- Quantity of uneaten food usually thrown away
- Level of effort to minimize food waste

WASTE & RECYCLING

- Recycling rather than throwing away
- Checking if packaging is recyclable before buying
- Refuses too buy because of too much packaging
- Reusing items like bottles, bags, etc
- Using a non disposable shopper
- Composting
- Recycling rather than throwing away (effective)
- Refuses too buy because of too much packaging (effective)
- Reusing items like bottles, bags, etc (effective)
- Using a non disposable shopper (effective)
- Composting waste (effective)
- Recycling site coherence
- Curbside recycling coherence

The six group of variables can be identified as *Awareness* (AW), *Attitude* (ATT), *Involvement* (INV), *Energy and Mobility* (EM), *Food and Water* (FW), and *Waste and Recycling* (WR). Interestingly, it can be noticed that while the first two groups represent *"pre-behavioral"* factors, the remaining four describe "*actual behaviors*" *strictu sensu*. Variables included in each group are shown in Table 1.

For each group, composite indicators of individual performance are derived by aggregating variables through a Non Linear Principal Component Analysis (NLPCA). The use of the non linear version of PCA is required by the (categorical and Likert-type) nature of the variables under analysis. Similarly to its linear version, NLPCA reduces a multiplicity of variables to a smaller number of orthogonal linear combinations (called *principal components*), preserving the original structure of the data[3]. It is nonetheless better suited to handle ordinal and categorical variables, since qualitative items are transformed into quantitative variables through an optimal scaling process which retains the original variance among the data as much as possible. The quantification depends on the type of variables to be treated. Given the nature of our variables, we adopt an ordinal scaling, ensuring that the original categories are quantified so as to maintain their ordered relationship. The transformed variables are then analyzed with a linear PCA model, where correlations between the quantified variables and each component are maximized in such a way that each component can be viewed as a new variable measuring some latent information conveyed by the data. Principal components can be ordered according to the amount of the original variance they explain (expressed by their eigenvalues): the first component accounts for the largest proportion of the total variability in the data, the second component for the next largest amount not accounted for by the first, and so on for higher order components.

By applying NLPCA, each individual is assigned an object score[4] for each component, defined as the sum over his/her standardized scores on the original variables, weighted by the

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that six dimensions provide a good statistical fit, giving also the need of interpreting each component as a distinct dimension of environmental behavior.

[3]The k^{th} principal component is defined as:
$Z_k = a_{k1}X_1 + a_{k2}X_2 + ... + a_{kq}X_q$
where a_{kj} is the weight assigned to variable j on component k (Nardo *et al.*, 2005).

[4]The object score for individual i on component k will be: $s_i(Z_k) = \Sigma_j x_{ij}(r(X_j, Z_k))$
where x_{ij} is the standardized score of individual i on variable j, where $r(X_j, Z_k)$ is the loading of variable j on component k, which express the correlation between the variable and the component.

corresponding variable's loading on the same component (Nardo *et al.*, 2005). Object scores can be interpreted as the performance of the individual on the new variables (the components).

To perform a distinct analysis on each environmental domain, we run six NLPCAs (one for each set of variables) and retain the first principal component on each group as synthetic indicator of environmental responsibility on that particular domain. Component scores can be used to order individuals on the basis of their level of proenvironmental behavior. For each indicator, individuals with lower scores can be considered as less environmentally responsible[5]. Table 2 reports the amount of variance explained by the first component in each environmental dimension.

As it will be shown in the next Section, it is precisely by using these indicators that we will investigate the determinants of individual environmental behaviors.

Table 2: % of total variance explained by the first component for each environmental dimension

Environmental dimension	**% of variance explained**
Awareness	33,922
Attitude	31,660
Involvement	26,876
Energy & Mobility	22,805
Food & Water	26,462
Waste & Recycle	27,222

4 The empirical analysis

To a have a better understanding of factors affecting pro-environmental behaviors and attitudes, we first analyze the indicators derived in the previous Section through a series of linear regression estimations[6].

[5]This can be explained by recalling that lower scores imply that individuals are performing relatively worse on several items included in the considered dimension. For example, as all the variables included in EM provide information about people's energy consumption and transportation behaviors, the first component extracted from the NLPCA on the EM variables provide us with a distribution of scores, each of them summarizing the *overall* level of individual responsibility emerging from his/her performance on all the single variables.

[6]Due to the fact that the response variables measure different aspects of the same issue, it might seem plausible to allow the disturbances being mutually correlated. In our case, however, as the explanatory variables

The model for individual i living in region j will then be:

$$\begin{cases} AW_{ij} = \beta_{aw} X_j + \gamma_{aw} W_{ij} + u_{ij} \\ ATT_{ij} = \beta_{att} X_j + \gamma_{att} W_{ij} + v_{ij} \\ INV_{ij} = \beta_{inv} X_j + \gamma_{inv} W_{ij} + \omega_{ij} \\ EM_{ij} = \beta_{em} X_j + \gamma_{em} W_{ij} + \zeta_{ij} \\ FW_{ij} = \beta_{fw} X_j + \gamma_{fw} W_{ij} + \eta_{ij} \\ WR_{ij} = \beta_{wr} X_j + \gamma_{wr} W_{ij} + \varepsilon_{ij} \end{cases} \tag{1}$$

where each equation ties the individual's score on each environmental dimension to a set of individual (W) and regional (X) covariates. Table 3 reports the estimated coefficients for the model.

The choice of the explanatory variables to be included in the model has been driven by the purposes of our analysis. Specifically, our focus here is on the influence that some institutional, socio-economic and socio-psychological factors may have in explaining individual attitudes and actions toward the environment.

With regard to socio-demographic variables, we follow the existing empirical literature on the issue (see, for instance Diamantopoulos et al., 2003, and the literature review therein provided) and choose to include the respondent's sex, age, education[7] (five dummies, "no education" excluded), the number of children in the household, four dummies indicating the respondent's marital status (divorced, engaged, widowed and single (excluded)) and his/her area of residence (three dummies: city (excluded), town or village). Along with these, we include two dummies indicating whether the respondent usually reads broadsheet newspapers (excluded) or tabloids as additional controls for the education level.

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are the same in all equations, parameter estimates are identical either by estimating each equation separately with Ordinary Least Squares or by estimating all equations simultaneously with Seemingly Unrelated Regression (Greene, 2012; p.295). We hence chose to proceed with six separate OLS regressions, and to correct the estimated standard errors for clustering of the observations according to the region of residence.

[7]The DEFRA dataset does not contain any indication on the number of years of education each respondent completed, but rather a set of dummy variables indicating the group to which the highest level of education of the individual pertains. Since both formal (high school, college, MA, etc.) and informal education (namely vocational and other professional qualifications) have their own sets of dummies, to make them useful for our analysis it has been necessary to recode and aggregate them into five dummy variables, covering from total absence (Education 0, excluded category) to the highest level (Education 4 - PhD, MSc, Ma, etc..).

The respondents' financial situation is summarized by a set of six dummy variables corresponding to the social grade classes into which British households are classified[8]. As additional control for the respondent's financial status, we include three dummies indicating whether his/her house is mortgaged, rented, or owned (excluded). The respondent's ethnicity has been excluded from the analysis, as it does not affect individual environmental behaviors.

Our interest in investigating these socio-demographic aspects is motivated by the lack of homogeneous results with regards to their impact on environmental behaviors. In particular, the influence of gender and age on the environmental performance seems to be unclear. As far as gender differences are concerned, most studies suggest that, compared to men, women generally show greater participation in pro-environmental behavior and activism (Zelezny *et al.*, 2000), even though they appear more likely to engage in "private" pro-environment behaviors within the household (e.g., recycling, buying/eating organic) and less likely to engage in pro-environment "public" behaviors (e.g., volunteer time, attend public meetings; see Hunter *et al.*, 2004). Other authors conclude that males have higher knowledge about green issues than females (see Table 1 in Diamantopoulos, 2003) and that men tend to be more concerned with environmental quality because of their higher propensity to get involved in local politics and organized groups (McEvoy, 1972, quoted in Van Liere and Dunlap,1980).

Another debated relationship is that between environmental performance and age. Two forces make the issue difficult to interpret: the so called "age-effect" and "cohort-effect" (Cutler, Kaufman and Glenn, 1975; Glenn, 1980; Inglehart, 1990). The *age effect* makes older individuals adverse to any change in the *status-quo* that could undermine the social resources they accumulated during lifetime (Hornback, 1974 quoted in Mohai and Twight, 1987) and less prone to take pro-environmental actions given that they won't benefit of an improved environment (Whitehead, 1991; Carlsson and Johannson-Stenman, 2000). The latter effect denotes instead the shifting of people's attitudes due to inter-generational differences in the exposure to external events during youth (Vlosky and Vlosky, 1999): increased information on environmental deterioration and its effects on, e.g., health and biodiversity could be behind

[8]Social grade classifies households according to the type of occupation of the chief income earner, where A corresponds to "higher managerial, administrative and professionals" and E to "state pensioners, casual and lowest grade workers, unemployed with state benefits only" (see http://www.nrs.co.uk/lifestyle.html). The income variable has been left out of the analysis due to the extremely high number of missing values (nearly 45% of the sample).

the increased environmentalism of later generations (Van Liere and Dunlap, 1980). Nord *et al.* (1998) show that age and environmentalism are tightly, strongly and positively related, while, on the other hand, Harris (1991) and Furman (1998) find only a weak relationship between age and environmental concern.

Given the existence of contradictory results, our analysis aims at showing that some results appear less paradoxical if we examine each dimension of environmental behaviors separately.

In addition to socio-demographic variables, we also consider other possible determinants of environmental behaviors, more related to personal values and motivations, which are at yet relatively unexplored by previous literature.

Besides the satisfaction with his/her own financial position, already investigated by Torgler and García-Valiñas (2007), we suggest that individual inclinations to adopt an environmentally responsible lifestyle can be affected also by the respondent's stated level of satisfaction with his/her current lifestyle, as well as the respondent's expectation about life and material conditions in the future (three dummies: Pessimist, Optimist, Neutral excluded)[9].

Further, we suppose that individuals' environmental performance might be influenced by what they expect others to do. We thus include information on whether the individual feels the need of behavioral reinforcement from three different socio-economic actors: the Government, the business sector, and his/her closest entourage and the society in general[10]. The idea is that respondents with different levels of environmental performance might need reinforcement in their environmental behaviors by the active involvement of distinct societal segments.

Finally, to account for the institutional context in which individuals' green behavior is performed, we consider the level of regional public expenditure for the protection of the environment. More specifically, the inclusion of this variable serves the purpose of investigating whether institutional concern towards environmental quality, as proxied by higher levels of public expenditure devoted to environmental issues, affects the individual environmental performance and in which direction. Data are drawn from the Public Expenditure Statistical Analyses for

[9]The three dummies *pessimist*, *neutral*, *optimist* are extracted by answers to the question: "*Do you think the general economic condition of the UK in the next 12 months will improve, stay the same or get worse?*".

[10]This information is extracted from the level of agreement to the questions: "*If the Government did more to tackle climate change I would do more too*", "*If Business did more to tackle climate change I would do more too*", and "*It's not worth me doing things to help the environment if other don' t do the same".*

the year 2008/2009 (PESA, 2010), issued by the HM-Treasury, which report public expenditure levels in each of the nine British Government Regions. To control for the amount of people living in each region and for pollution levels, regional population figures and pollution levels (regional per capita levels of Particulate Matter - PM10 - for the year 2008 have been included in the model.

Throughout the analysis, we assume that public expenditure will plausibly influence people's behavior immediately. On the contrary, the existence of feedback effects can be ruled out by considering that political reaction to shifts in people's behaviors tends to be lagged by at least one or more periods, following electoral cycles, and because of the rigidity of the political agenda (see, for instance, Ercolani and Pavoni (2008), that use cross-sectional individual data to exclude the presence of endogeneities in their assessment of the substitutability or complementarity between public and private consumption). Moreover, using cross-sectional data shields our analysis from the effect of shifts in the quality of environmental information provided by the media on individual behaviors[11].

As a further investigation, the same covariates are then used to explain what determines the probability of being simultaneously "responsible" on a plurality of dimensions. This part of the analysis rests on the consideration that an individual exhibiting a green behavior on one dimension will likely also be environment-friendly on one or more additional dimensions. This will be especially true if environmental responsibility can be viewed as the product of the interaction of circumstances and underlying personal characteristics.

In addition to constituting a robustness check for the results from previous model, this further analysis also allows us to derive additional insights on the level of individual responsibility. If it is true, in fact, that a higher score on Energy and Mobility, for instance, informs us that one individual is more responsible (in energy consumption and transportation behaviors) than another one with a lower score on the same dimension, it tells us nothing of their accumulation of different environmental responsibilities. It could well be possible for Energy and Mobility to be the only dimension on which the first individual proves responsible, while on the opposite the second one could be responsible on all dimensions *except* on Energy and Mobility. Then,

[11]Due to problems of multicollinearity with the level of public environmental expenditure, regional Gross Value Added (GVA) could not be included in the analysis.

it could be interesting to compare them using a measure of "inter-dimensional" responsibility. To this end, we build a new categorical variable taking values according to the number of environmental dimensions on which the respondent behaves responsibly. In other words, it takes value "0" for an individual with low scores on all the environmental areas, "1" for an individual responsible on one dimension only, "2" for one that is responsible on two, and so on and so forth up to "6".

In order to discern environmentally responsible from irresponsible individuals, a threshold value for individual scores on each dimension needs to be set. Given the nature of the problem, a univocal and informed decision is hard to make. The most immediately evident candidate is the mean of each score distribution, which equals to zero by construction, and which identifies those respondents who overall behave neutrally on the considered dimension. Such a choice identifies individuals with a positive score as environmentally responsible, and we assign them the value "1" in a dimension-specific responsibility binary variable. The categorical variable (indicating our inter-dimensional responsibility) is then obtained by summing up on these dummies for each individual.

To identify the main determinants of this measure of interdimensional environmental responsibility, an Ordered Probit model is estimated, where the derived categorical variable is used as dependent variable[12].

5 Discussion of the results

Results from regression analysis are presented in Table 3, while Table 6 shows the results obtained from the estimation of the Ordered Probit model.

From Table 3, it emerges that women tend to be more environmentally responsible than men on four out of the six dimensions here considered. Men are in fact found more responsible than women on Energy and Mobility and on Awareness, confirming the idea that they are likely to have a greater awareness of environmental issues (Diamantopoulos, 2003). In general, however, men are less prone to display pro-environmental attitudes, to actively engage in activities

[12]The same analysis based on the quantiles of the *logistic* distribution yields very similar results.

Table 3: OLS regressions for the determinants of environmental indicators

VARIABLES	AW	ATT	INV	EM	FW	WR
Male	0.19943**	-0.12000***	-0.15419**	0.09550**	-0.12859**	-0.22661***
Age	0.02946**	0.03392***	0.03298***	0.06025***	0.02347***	0.02608***
Age sq	-0.00031**	-0.00023***	-0.00031***	-0.00056***	-0.00012*	-0.00023***
Engaged	-0.09504	0.04311	0.03725	0.23629***	0.27681***	0.17070*
Divorced	0.01200	0.19648*	0.10260	0.24667**	0.18613**	0.14601
Widowed	-0.11622	-0.01951	0.02365	0.10910	0.17529	0.13009
Town	0.01337	0.01722	-0.01423	-0.04739	-0.00923	-0.02301
Village	0.27377**	0.22313**	0.06116	0.02709	0.01609	0.11735
One child	-0.16020*	-0.05481	-0.08736	-0.02797	-0.07925	-0.16468*
Two children	-0.03316	-0.13070	-0.13156**	-0.00165	-0.24553**	-0.16147**
Three children +	0.19239	-0.04206	0.23361	0.12286	-0.04985	-0.07334
Education 1	0.63618***	0.41467***	0.39634***	0.44964***	0.29929***	0.30626***
Education 2	0.25360**	0.13445**	0.16102***	0.24379***	0.24495***	0.12996**
Education 3	0.38842***	0.23487***	0.31599***	0.28383***	0.20781**	0.23701***
Education 4	0.55021***	0.33303***	0.31245***	0.36530***	0.20356**	0.25548***
Tabloid	-0.13360	-0.14663**	-0.04270	-0.09178*	-0.08090	-0.11217***
SocGr: A	0.15063	0.15159	-0.17002*	0.26780**	0.09111	0.22697
SocGr: B	0.23683**	0.12870	-0.03286	0.10594	0.03041	0.14041
SocGr: C1	0.03808	0.07193	0.00482	0.18112*	0.05237	0.09653
SocGr: C2	-0.05334	0.05680	-0.13612	0.04394	0.03247	-0.01505
SocGr: D	-0.13000	-0.03950	-0.13714	-0.08652	-0.10096	-0.06344
Mortgage	-0.12175*	-0.08757	-0.08507	0.01227	-0.16088***	-0.03407
Rent	-0.08204*	-0.05732	-0.13929**	-0.55814***	-0.28504***	-0.30791***
Economic satisfaction	0.13611**	0.08334	0.04084	0.03410	0.04795**	-0.05378
Lifestyle satisfaction	-0.00890	0.03356**	0.05610***	0.00837	0.02847***	0.03082***
Optimist	0.11558	0.10920**	0.08228	0.10721	0.05301	0.01880
Pessimist	0.13178***	0.13469***	-0.03473	0.03244	-0.00463	0.11470*
Social reinforcement	-0.15939**	-0.45833***	-0.20856***	-0.22228***	-0.32511***	-0.30503***
Institutional reinforcement	0.13282	0.19586**	0.24741***	0.07170**	0.13490**	0.07182
Business reinforcement	0.07142	0.23391***	0.19705**	0.13329**	0.13156*	0.18302**
Pc.P.Envir.Expenditure	0.03410***	0.03956***	0.01007**	0.03736***	0.03879***	0.03314***
Pc.P.Envir.Expenditure sq	-0.00011***	-0.00012***	-0.00003**	-0.00012***	-0.00013***	-0.00010***
Pc.Particulate Matter	-0.51533***	-0.36905*	0.24569**	-0.57565***	-0.40642*	0.07079
Pc.Particulate Matter sq	0.03627***	0.02451	-0.02373**	0.03463***	0.01741	-0.01413
Reg.population	-0.09159***	-0.07457**	0.03741**	-0.13935***	-0.07229**	0.03921
Constant	-1.62480***	-3.25819***	-2.91255***	-2.34697**	-2.40227***	-3.79121**
R-squared	0.18792	0.20802	0.11856	0.31727	0.22491	0.20637

‡ Observations are clustered by regions

‡‡ Full name of variables:

SocGr, Social Grade

Pc.P.Envir.Expenditure (sq), Per Capita Public Environmental Expenditure (squared)

Pc.Particulate Matter (sq), Per Capita Particulate Matter (squared)

Reg.population, Regional Population

devoted to the protection of the environment, or to adopt more responsible habits for food and water consumption and waste production and management.

For what concerns the relationship between environmental responsibility and age, the former is found to be a concave function of the latter with highly significant coefficients on both the linear and the quadratic terms on all dimensions but one (Food and Water, for which the quadratic term is only significant at the 90% level). Turning points are located roughly between 45 and 55 years, with the exception of Attitude, on which the turning point is shifted much further, at around 74 years, and Food and Water behaviors, 96 years.[13]. The quadratic relationship suggests the prevalence of the "cohort effect" identified by the literature: the peak in environmental responsibility can be found in correspondence to people who were born or grew up between the sixties and the early seventies, while younger and older individuals show on average a lower degree of "greenness". This pattern can be explained by considering that for the earliest cohorts, access to information on environmental threats and pollution during youth was extremely limited, while environmental problems climbed to the top of the media agenda during the sixties (McEvoy, 1972), and then dropped during the following decades (Heberlein, 1981).

As far as marital status, area of residence, education level and social grade are concerned, results are substantially in line with previous findings, even though they impact differently on different dimensions. Quite significantly, for instance, living in rural areas does not affect environmental actions, but it positively influences green awareness and attitude.

A somewhat surprising result arises by looking at the household composition. Contrary to what we would expect (and to the "parent effect" suggested by Dupont, 2004), the presence of at least one child in the household does not increase the probability of a greener behavior. On the opposite, a negative and significant effect of one child on Awareness and Waste and Recycling, and of two children on Food and Water and Waste and Recycling can be clearly detected.

As far as worldview and social motivation are considered, the contribution of individual economic satisfaction is positive and significant on the Awareness and Food-and-Water Consumption dimensions only. On the opposite, individuals' satisfaction with their lifestyle exerts a

[13]More discussion on tipping points is provided at the end of this Section.

positive and significant effect on four dimensions out of six[14]. Notably, no significant effect can be detected on Awareness, which is instead the dimension on which we find the most significant effect of economic satisfaction.

It can be supposed that the two variables are sequentially linked, with economic satisfaction preceding and being a (not nearly sufficient) condition to achieve lifestyle satisfaction[15]. Thus, as we can see economic satisfaction as the driver and precondition for *pre*-behavioral responsibility, and behavioral responsibility as being instead triggered by the achievement of lifestyle satisfaction, this result is confirming the sequentiality of these two types of environmental performance. Further, we find a significant and positive impact of economic satisfaction on Food/Water.

Other interesting insights are provided by results for individual worldview. While pessimists and optimists can be hardly distinguished from the neutrals (our reference group) on the basis of their environmental behaviors, they jointly exhibit a higher propensity for a better attitude towards, and higher knowledge of, the environment. As neither of the these categories have an impact on actual behaviors, apart from a positive effect of pessimism on waste production and management, these results suggest that worldviews might be primarily a determinant of pre-behavioral factors.

Concerning the sector of the society the individual needs reinforcement from to increase his/her responsibility (Business sector, Government and general Others, intended both as closest entourage and society in general), we notice that those claiming they would do more to help the environment should the institutions and the business sector be more active too, are found to be more responsible than those who don't claim as much on five out of our six dimensions. On the contrary, needing reinforcement from the society is associated to a lower degree of environmental responsibility.

This can be partly explained by considering the specific role played by these actors themselves. Government and business sector can actually enable people to adopt more responsible

[14]Both these results have proven robust to the separate inclusion of these two variables and to the exclusion of Social Grade from the analysis.

[15]What should be kept well in mind is that financial satisfaction is here not necessarily a synonym of high income or social grade. A person might be satisfied with his/her own financial situation (and state it in a survey) without being for this reason "rich".

habits through, for instance, the provision of public goods and services (e.g. improved public transportation or easier access to locally distributed renewable energy). Concerned people claiming they would do even more to help the environment if the institutions and/or business were willing to do the same, hence, are probably actually stating that they would do more *if the institutions and/or business gave them the opportunity to do so*[16]. On the opposite, the society (intended as the group of individuals living more or less in proximity to the respondent) is generally incapable of providing such services on its own (with the exception of some formal or informal local organized groups).

As a confirmation of previous result concerning the need of reinforcement from the Government, our estimates show that public environmental protection expenditure is capable of triggering positive responses at the individual level, at least up to a certain point. A concave and highly significant effect can in fact be clearly detected on all our six indicators, meaning that as the level of public environmental protection expenditure increases, individual behaviors get greener at first, but start declining above a certain level. In other words, after an initial positive effect, public environmental expenditure seems to "crowd out" private efforts towards more responsible behaviors. The level of public environmental protection expenditure in the nine British regions for the year 2008-2009 is reported in Table 4, while tipping points are reported in Table 5.

These results complement existing knowledge on 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's (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).

[16]It is worth nothing for a household to put aside materials for recycling if those dealing with their collection and disposal, whether public or private company, treat all waste as undifferentiated.

Table 4: Public environmental expenditure (2008-2009)

Region	**Pounds/head**
West Midlands	122
East Midlands	128
Yorkshire and the Humber	130
North East	131
South East	131
East Anglia	136
London	151
South West	172
North West	218

Our conclusions are consistent with this view: the concave relationship suggests that high levels of public environmental expenditure might be felt as shifting control over pro-environmental decisions from the individual to the external regulatory intervention, thus crowding out individual responsibility.

On the opposite, for lower levels of environmental expenditure, we see that institutional concern towards environmental quality accompanies individuals towards higher levels of environmental performance, suggesting thus a reinforcing effect of the interventions on individuals' environmental morale. This is also in line with recent contributions proposing social norms as relevant factors in redirecting people's behaviors (see, for instance, Schultz *et al.*, 2007; Nolan et al., 2008, and Allcott and Mullainathan, 2010 for field experiments), if we interpret public expenditure for the environment as an expression of the social disposition towards the topic.

By looking at tipping points for different dimensions (Table 5), and comparing them with their actual level of environmental expenditure, it is clear that for most of British regions the most plausible pattern is the one implying "complementarity" (or crowding-in) between public expenditure and private environmental actions, i.e. government concerns and individual behaviors seem to reinforce each other.

However, the quadratic (concave) relationships between age or public environmental protection expenditure and our environmental indicators deserves further discussion. Due to the proximity of the quadratic term to zero, we cannot rule out the possibility that the non-linear relationships found are due to an *a-priori* imposition of non-linearity in the estimated equations.

Following Bernard *et al.* (2011), to check the validity of our results we rely on robust

inference on tipping points, which are defined by the ratio $\delta = -\beta_1/2\beta_2$, where β_1 and β_2 are the coefficients on the linear and quadratic term respectively. Specifically, we use Fieller's (1940, 1954) method to build confidence intervals for their estimated values and, in addition to checking for their interpretability, we use the confidence sets themselves as warning signals for the values of β_2 being null[17] (see Bernard *et al.*, 2011 for computational and theoretical details).

Table 5 reports the estimated tipping points for age and public environmental protection expenditure for all estimated equations, as well as confidence intervals built using both the Delta and Fieller's method. Although Fieller confidence intervals are wider than standard Delta ones, they will nevertheless contain the true value with the correct 95% probability. As we can see, all Fieller confidence intervals are bounded and acceptably narrow for most of our estimates, with the exception of the effect of public environmental expenditure on Involvement and age on Food and Water, raising doubts on the actual concavity of their relationships. Where the widths of the Fieller and Delta confidence intervals are quite close and by and large overlapping, we have evidence of strong identification of the estimated model.

As a last step of our investigation, we can conclude that the picture emerging from the indicator of inter-dimensional environmental responsibility complements the previous analysis in most respects, although some interesting specificities characterizing the different dimensions of environmental behavior clearly cannot be recognized by adopting an aggregate perspective. As far as the impact of gender is considered, for instance, we can notice that men are found to have a lower probability of being environmentally responsible (i.e. scoring "6" on the overall responsibility indicator), confirming that women have generally a greener behavior than men.

Finally, it is worth underlining the fact that needing institutional reinforcement and business sector reinforcement unequivocally shifts probability mass onto the higher extreme of the inter-dimensional indicator, while needing social reinforcement, on the opposite, increases the

[17]Problems with traditional confidence intervals built using the Delta method arise when the ratio defining tipping points is weakly identified. Since this occurs when the *true* β_2 is near zero, a significant estimate of this parameter does not necessarily guarantee identification. Should this be the case, Delta confidence intervals will not be level-correct, i.e. will not contain the true level of the parameter with probability $1 - \alpha$, while at the same time appearing quite narrow.

Fieller's confidence intervals are instead robust to such weak identification: specifically, the Fieller confidence interval set will be unbounded when β_2 is zero. Thus, finding bounded and reasonably narrow *Fieller* confidence intervals for our tipping points will constitute evidence against the possibility of the quadratic parameter being in reality equal to zero, and in favor of the interpretability of tipping values.

Table 5: Tipping points and confidence intervals (years and Pounds/head).

Variable	Tipping point	Fieller CI $\alpha = 0.05$	Delta method CI $\alpha = 0.05$
Awareness			
Public Environmental Protection Expenditure	157.74	[138.091;179.901]	[154.48; 161.015]
Age	48	[15.37;136.36]	[40.58; 55.59]
Attitude			
Public Environmental Protection Expenditure	160.81	[116.543;218.63]	[154.736; 166.897]
Age	74	[53.08;106.83]	[63.08; 85.47]
Involvement			
Public Environmental Protection Expenditure	161.665	[41.025; 535.439]	[150.763; 172.568]
Age	53	[26.81;101.34]	[48.15; 58.23]
Energy and Mobility			
Public Environmental Protection Expenditure	160.13	[119.928; 211.006]	[154.105; 166.155]
Age	54	[39.29; 75.03]	[49.23; 59.06]
Food and Water			
Public Environmental Protection Expenditure	154.76	[102.173; 228.32]	[147.134; 162.399]
Age	96	[43.92; 1011.91]	[37.72; 154.52]
Waste and Recycle			
Public Environmental Protection Expenditure	162.82	[99.713; 256.888]	[152.735; 172.924]
Age	57	[25.64; 134.27]	[49.1; 66.7]

probability that the individual will score zero on all the single responsibility indicators, which constitutes one of the new findings of our analysis.

Table 6: Ordered Probit model

VARIABLES	
Male	-0.10606**
Age	0.04663***
Age sq	-0.00040***
Engaged	0.20219**
Divorced	0.30335***
Widowed	0.11639
Town	-0.03466
Village	0.28580***
One child	-0.09396
Two children	-0.17294**
Three children +	-0.08962
Education 1	0.65603***
Education 2	0.31768***
Education 3	0.46306***
Education 4	0.53382***
Tabloid	-0.11283*
SocGr: A	0.19264
SocGr: B	0.17401
SocGr: C1	0.08343
SocGr: C2	-0.04104
SocGr: D	-0.19346
Mortgage	-0.18120**
Rent	-0.41964***
Economic satisfaction	0.06012
Lifestyle satisfaction	0.03483***
Optimist	0.13683
Pessimist	0.08694**
Social reinforcement	-0.37455***
Institutional reinforcement	0.26455***
Business reinforcement	0.25345***
Pc.P.Envir.Expenditure	0.05384***
Pc.P.Envir.Expenditure sq	-0.00017***
Pc.Particulate Matter	-0.57773***
Pc.Particulate Matter sq	0.03587***
Reg.population	-0.11531***

6 Conclusions

Ever since environmental issues have entered the worldwide political and scientific agenda, a growing literature has explored the human-environment relationship. Several studies, in particular, focus on the contribution of individual characteristics in shaping environmental preferences and behaviors. For some of the investigated determinants it is not possible to find a set of commonly accepted conclusions about their effect on individual proenvironmental behavior, as different studies yield different and at times contrasting outcomes. In this work we have shown that this result can be partly due to the widespread use of unidimensional indicators of individual environmental behaviors, which as such convey limited information on only part of a multidimensional phenomenon.

The investigation here presented, relying on synthetic indicators of individual environmental performance which summarize a multiplicity of variables, provides a richer picture of individual environmental behaviors and attitudes. Our results show that different dimensions of environmental behavior are differently affected by individual characteristics, thus emphasizing the complexity of the processes behind the formation of environmental preferences and actions. Especially, we provide evidence of the fact that individual characteristics interact with distinct dimensions of environmental responsibility through effects of different magnitude and sign. The long lived dispute on whether it is women or men that are more concerned with the protection of the environment, for instance, appears as misdirected, given that women and men tend to have different levels of environmental responsibility on different dimensions.

In addition to socio-demographic variables, we have included other determinants of environmental behaviors previously not fully explored. The inclusion of regional public expenditure for the protection of the environment, for instance, have shown that *institutional* environmental behaviors should be considered as a relevant determinant shaping individual's environmental responsibility. This is also confirmed by looking at the actors on which individuals rely to direct their environmental behavior. It emerged that those who would be more responsible should the Business sector and the Institutions be "greener" too are more inclined to behave responsibly, while people referring to "the Society" appear instead as characterized by a weaker environmental commitment. We can conclude, moreover, that if it is true that the respondent's "financial satisfaction" is relevant in predicting greener levels of Awareness and Attitude, it is

lifestyle satisfaction that counts more in affecting actual behaviors.

The analysis here presented can have relevant implications from a policy perspective. In a world in which the provision of economic incentives to people in order to raise the environmental sustainability standards of their day-to-day behaviors and attitudes will sooner or later become a priority of policy designers worldwide, knowing what effect different socio-economic characteristics have on the various human-environment dimensions is crucial to build *targeted* policies.

A multidimensional approach provides the bases for assessing whether policies aimed on one specific group (as identified by a common characteristic) or on one particular environmental dimension will also affect its behavior on other dimensions. Especially, knowing whether this "collateral" effect will be positive or negative constitutes a major advantage in order to maximize the intended outcome of policies, while contextually limiting any other unwanted and perverse effects. Moreover, given that an important aspect emerging from the analysis is that public environmental expenditure does indeed constitute a determinant for an increased environmental responsibility, also public environmental expenditure levels should be accounted for in the policy-design processes.

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