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Does pro-environmental behaviour affect carbon emissions?

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HIGHLIGHTS

- CO_2 emission in relation to residential heating, electricity and transport activities was explored.
- Pro-environmental behaviour does not necessarily contribute to CO_2 mitigation.
- Brown and Supergreen consumers have similar CO_2 emission level.
- Sociostructural factors can offset the motivation-driven pro-environmental behavior.

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ABSTRACT

The primary focus of this research is to explore the effect of pro-environmental behaviour on CO_2 emissions in relation to heating, electricity and transport activities in the residential sector. Changing such behaviour has considerable potential for conserving energy and is an important target of environmental policies which are designed to decrease energy consumption. It is hypothesized that people who consciously act in a pro-environmental way do not necessarily have lower CO_2 emissions more than those who do not undertake environmental activities. Data about residential energy use is based on a survey carried out in Hungary in 2010 with a sample of 1012 people. Latent cluster analysis (LCA) was conducted based on data about the reported pro-environmental behavior in the survey and four clusters were identified. Relevant sociostructural and structural factors were also inverstigated.

Results of the data analysis show that no significant difference is found between the impacts of environmentally aware and environmentally unaware consumers, i.e. both 'Brown' and 'Supergreen' consumers consume approximately the same amount of energy and produce approximately the same amount of carbon emissions because the motivation-driven activities of 'Supergreens' are offset by structural factors.

1. Introduction

Since many European countries are heavily energy dependent and about one-third of a country's carbon emissions stem from transport and the energy used in households (e.g. IEA, 2007; DEFRA, 2005), the need to encourage low-carbon activities in everyday life and reduce demand for fossil fuels has become the focus of energy and climate-related policies.

The success of such climate and greenhouse gas (GHG)-related policies are found to be highly dependent on the nature of different environmental activities and the positioning and communication of green products (Csutora and Zsóka, 2010; Litvine and Wüstenhagen, 2011). Raising awareness in the residential sector about using renewable energies and reducing energy consumption are both challenging goals. Energy-saving behaviour in private homes has been particularly well-addressed by research and surveys from the field of environmental psychology, as well as in environmental economics, with similar conclusions (e.g. Csutora et al., 2009; Thøgersen and Gronhoj, 2010; Sanne, 2002; Kerekes and Luda, 2011): in order for consumer behaviour to significantly change, both the socio-economic system and sociostructural factors need also to be modified.

The primary focus of the research described in this paper was to explore patterns of CO_2 emissions arising from residential energy use in Hungary, since there is considerable potential for energy conservation in this area. This paper presents a latent cluster analysis of a group of Hungarian consumers in order to explore the effect of pro-environmental behaviour on energy

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saving and investigates the influence of related socio-demographic and structural characteristics.

The structure of the paper proceeds as follows. Section 2 discusses the theoretical background behind measuring pro-environmental behavior. In Section 3 the research goals and hypothesis are described. Section 4 presents the methodological approach which was used in the research to estimate the CO_2 emisssions of households. Section 5 presents the results of the survey and Latent cluster analysis. Finally, in Section 6 the discussion and main conclusions are drawn.

2. Measuring the effect of pro-environmental behaviour

How people chose to adopt one pro-environmental behaviour but not another is the result of a personal decision-making process with strong interference from an individual′s attitude and values, prevailing social norms and assessment of personal costs (Diekmann and Preisendörfer, 1992; Blake, 1999; Stern, 2000). It was recognized even in the 1990s that there is a discrepancy between environmental attitudes and pro-environmental behaviour which can be attributed to the cost of a certain pro-environmental behaviour. Put simply, people usually choose to behave in the way that is the least costly, as expressed in money, time or effort (Diekmann and Preisendörfer, 1992). This finding was confirmed by Kaiser and Wilson (2004) who used the theory of goal-directed performance to characterize behaviour driven by personal effort.

Investigations into what factors trigger pro-environmental behaviour are still underway. Much research has highlighted the failure of environmental policies and has flagged up the idea that there is no linear correlation between reported environmental awareness and knowledge and actual pro-environmental behaviour, or in other words, claimed that there is a barrier between knowledge about environmental issues and pro-environmental action. This is the so-called ‘awareness gap’ which was identified in the 1980s by many sociologists, psychologists and environmental scientists (Rajecki, 1982; Burgess et al., 1998; Ajzen and Fishbein, 1980) and has been examined at both the individual and company level (Zsóka, 2005). Environmental policies usually focus on raising awareness though environmental education but even early research clearly indicated that education is only one single contributor to pro-environmental behaviour, although it is a very important factor (Owens, 2000; Marjainé Szerényi et al., 2011). Pro-environmental behaviour is rather driven by a complex system of internal and external factors (Stern et al., 1993; Kollmuss and Agyeman, 2002).

Stern (2000) identifies two types of pro-environmental behaviour which he classifies according to the purpose of the behaviour; namely, ‘impact’ and ‘intent-oriented’ behaviour. The first focuses on the identification of major human activities which contribute to the human impact on environment, which are regarded as the by-products of human lifestyles. Intent-oriented behaviour emphasizes the importance of an individual′s beliefs and values in shaping pro-environmental behaviour leading to the development of the so-called value-belief-norm (VBN) theory of environmentalism. This theory suggests that values (egoistic, altruistic and biospheric values), beliefs (NEP, adverse consequences, acceptance of responsibility) and personal norms influence what environmental activities a person engages in (Stern et al., 1995; Stern, 2000). Since then, in environmental psychology the importance of these values for explaining pro-environmental behaviour has been stressed and studied in depth (e.g. de Groot and Steg, 2010; Whitmarsh and O′Neill, 2010). Stern (2000) also highlights the necessity of research into the discrepancy between environmental intent and impact through the following example: many people in the USA still believe that spray cans are harmful to the ozone layer and choose not to use them, even though such ozone layer damage-causing substances have not been used as propellants in the spray cans for many years (Stern, 2000).

Several studies have focused on the relationship between pro-environmental behavior and energy saving in households. Thøgersen and Gronhoj (2010) found that neither motivational nor structural factors independently influence the electricity saving of Danish households. However, they found that sociostructural factors (such as home size and family composition) have a significant effect on a household′s electricity consumption, especially through the quantity of electric devices they own and use. Differences in electricity-saving behavior according to gender have also been reported; women report to doing more to save electricity than men, a situation which may be attributed to the fact that women undertake more domestic chores. Interestingly, men are more likely to copy the behaviour of the other members of the household than women. Motivational drivers are related to self-efficacy and outcome expectations (Thøgersen and Gronhoj, 2010). Wang et al. (2011) conducted empirical research in China on the relationship between the willingness and actual behaviour of Beijing residents to save electricity and concluded that economic benefits, comfort and convenience and information are important factors which affect a household′s electricity-saving behavior, but the role of environmental awareness in electricity saving is limited. Sardianou (2007) came to the conclusion that income and family size are important variables for explaining energy conservation preferences, and that age and expenditure on energy seem to be negatively correlated to adopting energy-saving behaviours. The authors also concluded that environmentally-conscious respondents are those people who are likely to make efforts to save energy. Shiro Hori et al. (2013) carried out a survey of energy-saving behavior across five major Asian cities. Their results show that awareness of global warming, environmental behavior and social interaction had a relatively significant role in shaping behaviour, and that income and age also had a weak positive effect.

A lot of surveys have been conducted recently about energy-saving behaviors and regardless of the exact focus of the research they have come to similar conclusions concerning the limited role of environmental awareness in energy-saving behavior. Some of them also focused on the relationship between actual energy use and pro-environmental behavior (Gatersleben et al., 2002; Poortinga et al., 2003; Csutora, 2012). Gatersleben et al. (2002) conducted a representative survey among Dutch households which revealed that respondents who claim that they are more pro-environmental do not use less energy. The amount of energy a person uses seems to be more closely related to income and household size than pro-environmental behavior, which is more connected to attitudinal factors (Gatersleben et al., 2002). Poortinga et al. (2003) investigates the relationships between values, general environmental concerns, specific environmental beliefs and household energy use. The authors find that environmental behaviors, as defined from an intent-oriented perspective, were related to attitudinal variables. In contrast, environmental behaviors defined from an impact-oriented perspective were not related to such variables. Household energy use appeared to be especially closely related to socio-demographic variables such as household size and income which influence an individual′s ability to perform specific behaviors (Poortinga et al., 2003). Csutora (2012) introduced the notion of a ‘Behaviour-Impact Gap’ (BIG) problem which appears to exist beyond the gap between pro-environmental behavior and the actual environmental impacts of consumers. Her research indicated that there were no significant differences in the ecological footprint of green and brown consumers. This finding draws attention to the fact that individual pro-environmental behaviour does not always reduce the environmental impacts of consumption, which opens the way to an interesting field of research for environmental economics (Csutora, 2012).

3. Research goal and hypothesis

This study contributes to research about the behavior-impact gap problem (Csutora, 2012) by focusing on energy saving behavior in the residential sector. Several studies have been designed to reveal the factors which influence the energy saving behavior of households (Thøgersen and Gronhoj, 2010; Wang et al., 2011; Shiro Hori et al., 2013) but only a few of them have investigated the relationship between pro-environmental behavior and actual energy consumption (Gatersleben et al., 2002; Poortinga et al., 2003). This study focuses on profiling consumers according to their pro-environmental behavior and measures actual impacts on energy use (in terms of carbon emissions) between different groups of consumers. Csutora (2012) has also investigated the different environmental impact of green and brown consumers based on pro-environmental behavior in terms of overall ecological footprint. She found that there is no statistically significant difference between the overall ecological footprint of green consumers and brown consumers. Pro-environmental behavior was associated with only a small reduction in ecological footprint in specific areas (Csutora, 2012). The ecological footprint methodology provides a general overview of the environmental impact of human consumption through aggregating different areas such as the environmental impact of food, energy consumption and the impact of international trade etc. and fails to assist with the setting of focused policy targets. There is therefore a need to investigate energy consumption behavior more in detail so that it may better serve policy goals. Although the studies of Gatersleben et al. (2002) and Csutora (2012) helped to define the gap between behavior and actual impact, this study takes a step forward in measuring the extent of this gap by presenting the results of latent cluster analysis based on pro-environmental behavior which is directly connected to the actual impact of the energy use of households. In addition, socio-demographic and structural attributes are also investigated based on previous research (Thøgersen and Gronhoj, 2010). The aim of the research presented herein is to identify social clusters whose members may be said to be acting in a (non) environmentally-friendly way, to investigate the environmental impact of their energy use in terms of CO_2 emissions and finally, to profile these clusters through using their socio-demographic and structural characteristics. This allows the testing of the following hypothesis: people who consciously act in a pro-environmental way (green consumers) are responsible for a similar level of CO_2 emissions to those created by people who do not undertake environmental activities (brown consumers). Confirmation of this hypothesis would serve to strengthen the contention that the positive impact of motivational drivers is offset by structural and socio-demographic factors and would have significant implications for policymakers regarding their efforts to reduce residential energy use. Changing attitudes is indeed a very important (but not the final) step towards creating a low carbon society. Linking pro-environmental behavior to the carbon emitted through energy use enables the revision of current policy efforts and places the emphasis on undertaking action which has major environmental impact.

4. Methodological approach

4.1. Pro-environmental behaviour, socio-demographic and structural variables measured in the survey

For measuring current pro-environmental behaviour the traditional methodology used by Eurobarometer was followed. This involves listing activities with both lower and higher environmental impact. The existence of pro-environmental behaviour was measured using 8 items which included all the important environmental activities highlighted by DEFRA (2008) as headline behaviours (energy and water use, waste behaviour, transport-related activity and shopping choices) to which respondents could only give binary – yes/no – answers (see Table 4). DEFRA (2008) has compared the environmental impacts of these different pro-environmental behaviours (expressed in kg of CO_2 emissions) and has identified the current take up of these behaviours in the UK. Reducing transport-related activities (especially using cars and air transport) has the most significant impact on CO_2 mitigation. Making energy savings and cutting back on consumption of food (especially meat) are of great significance as well but have lower impact. Recycling activities have a mid-level impact and the least effective activities of all involve buying energy efficient products, reducing the amount of water used and buying local food (DEFRA, 2008).

Recycling does not have a great impact on protecting the environment but is considered to be a very important component of pro-environmental behaviour. It is regarded as a ‘catalyst’ behaviour (Austin et al., 2011) which is assumed to positively effect the adaptation of other pro-environmental behaviours. Thøgersen (1999) examined the role of recycling in decreasing the amount of packaging waste in Danish households and concluded that it had a positive influence (also known as a positive spill over effect in the literature). On the other hand, other authors (Wenke, 1993; Tucker and Douglas, 2006) emphasize the fact that recycling may lead to negative spill over effects by providing people with an excuse to avoid undertaking more impactful actions such as reducing their household waste.

Relevant socio-demographic and structural variables were selected based on an overview of literature. The dataset used in this paper was related to a larger project and, accordingly, other potentially interesting variables and approaches that were present in other studies cannot be explored in this paper. In Table 1 the variables and description selected for the analysis are summarized.

4.2. Survey method

To determine the total CO_2 emissions of households, a survey-based approach was utilised in which data were collected about the direct and indirect fuel consumption of households, including their use of heating, transport activities and electricity.

This empirical research is based on a representative survey of 1012 respondents carried out in the first half of 2010 in Hungary. Data were collected about the expenditure, consumption patterns, environmental attitudes and life satisfaction of consumers. Personal (face-to-face) interviewing was undertaken by a surveying company (TARKI) which used a representative probability sample representative of the population aged 18 or older in terms of gender, education, type of settlement, and educational background. The random walk technique was used to select the dwelling and personal interviews were conducted with one member of each selected household using the Leslie Kish key method.

Questions about energy consumption focused on respondents' monthly or annually energy expenses for heating and electricity, since it was assumed that the respondents would identify these expenditures more accurately than they would be able to report on physical units of energy consumed. Besides providing details about their expenditure, the types of heating used and their share of total energy use were also investigated (respondents could choose as many heating sources as were relevant from the following list: LP-gas, district heating and coal and renewable energy sources (directly produced by households, e.g. PV, solar, geothermal)). Expenditures for heating were first converted into physical units (GJ) using the average price for a unit of energy

Table 1
Selected socio-demographic and structural variables.

Variables	Description
Socio-demographics	• *Gender* (1=Male; 2=Female) • *Age* (years) • *Household monthly net income* (categorical; 1 to 5 scale) • *Education* (categorical, 1: eight years of primary school or less, 2: technical college, skilled worker, 3: High school diploma or higher accredited qualification, 4: University degree) • *Household size* (number of family members including respondent)
Structural variables	• *Type of house* (categorical; 1: apartment house, 2:new estate, 3: Terraced house, 4: Detached and Semi-detached house, 5: Farmhouse) • *Number of rooms* • *Size of house* (square meters) • *Energy efficiency* (quantity of electrical devices, scale: 0–8 devices) • *Car ownership* (binary, yes/no) • *Travel to workplace* (categorical; car or other vehicle including bicycle, public transportation, motorcycle, by foot) • *Free time travel* (Binary; yes/no, Do you typically spend your free time travelling?)

(KSH, 2012) and CO_2 emissions were then calculated according to IPCC (2006) estimates about stationary combustion sources in the residential sector. Expenditure on electricity was first converted to TW h, then disaggregated by the different source (for electricity generation in different power plants) and finally also converted into CO_2 emissions according to IPCC estimates.

For transportation, details about the distances travelled by passenger car, coach and train and the hours spent using air transport and public transport were collected. Transportation data were converted firstly to passenger kilometres for vehicles. CO_2 emissions are based on IPCC (2006) estimates of mobile combustion values.

4.3. Statistical analysis

To investigate how reported environmental behaviours are connected to each other and how they are connected to actual environmental impacts in terms of CO_2, social clusters were identified with the use of a latent class model.

Latent cluster analysis (LCA) is an analytical method which can be used to determine subgroups or classes of observations that are similar to each other along multiple observed variables using model-based, posterior membership probabilities (in opposition to traditional cluster analysis, which uses ad hoc distance definitions to create clusters). LCA also includes a K-category latent variable, with each category representing a cluster containing a homogeneous group of persons (cases). Moreover, a latent class model enables the user to cluster dichotomous as well as categorical and continuous variables. Model estimations were carried out using Latent Gold 4.5 software (Vermunt and Magidson, 2005).

In the analysis consecutive cluster models are compared on the basis of different model parameters. The indicator variables were the eight types of environmental activities which respondents undertook during the last month for environmental reasons. All eight items were coded in a binary manner: either 0 (=have not done) or 1 (=have done). Selection of the model with the best data fit was done using the following model parameters: likelihood-ratio (L^2) and its p-value, the Bayesian Information Criterion (BIC) and the number of parameters (Npar).

The L^2 likelihood-ratio statistic shows the amount of association between the variables that remains unexplained by the model. The p-value of L^2 also measures the fit of the model and it assumes that the L^2 parameter follows a chi-square distribution (consequently, a p-value of greater than 0.05 is desired for an adequate fit). The Bayesian Information Criteria takes the number of parameters into account to compare the models; a smaller BIC indicates a better fit. Finally, the model with the fewest number of parameters (Npar) (i.e. the most parsimonious model) is selected (Vermunt and Magidson, 2005).

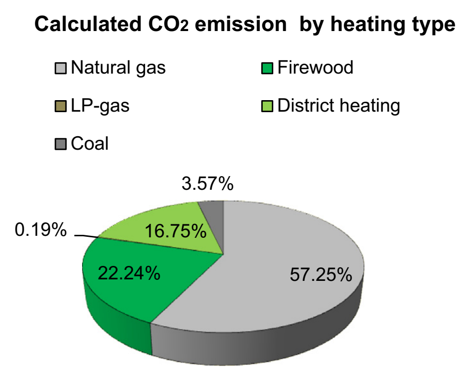

Fig. 1. CO_2 emission by heating type.

Because a number of variables were modelled and the data for individual response categories was in some cases sparse, the p-value by bootstrap of L^2 (n=500 iterations) was also estimated. This relaxes the assumption that the L^2 statistic should follow a chi-square distribution. Because these were nested models we also used a conditional bootstrap option (n=500 iterations) for computing the difference in the log-likelihood statistics between the two models (-2LL Diff) to see if adding another cluster significantly improved the model fit. In our final model, we examined the bivariate residuals to assess how well the model explained the correlation between each of the variables.

5. Results

5.1. CO_2 emissions from residential energy use

Fig. 1 shows energy consumption and CO_2 emissions by method of heating, according to the results of the survey. Having several sources of heating (e.g. having piped gas and a fireplace in the house which is fed with wood or coal) is very typical of Hungarian homes. Gas heating is available almost everywhere in the country but its dominant role as a heat supply system has created political dependencies for the country. District heating is widespread, especially in new estates in Hungary, and it is not usually combined with the use of any other energy resources. 50% of respondents reported that they used natural gas, 38% wood, 20% district heating, 6% coal and 3% LP-gas (numbers do not sum up to 100% because of cases of combined use). Other sources of energy such as renewable energy technologies were being used in 6 cases so these data were excluded from the statistical analysis.

Firewood has a significant share in the residential sector both in terms of provision of energy (36.74%) and CO_2 emissions (22.24%). Statistics indicate a remarkable rise in the consumption of firewood in Hungary over the last two decades; in 1996 it accounted only for 17% of the domestic energy mix but by 2008 this had risen to 27% (KSH database, 2012). This trend might be an indicator of illegal tree felling. According to estimates there is a significant difference between officially reported statistics about sales of wood and the actual firewood consumption of Hungarians. The actual firewood consumption as calculated by data from household panel surveys is approximately four times higher than reported in national statistical databases (Szajkó et al., 2009). According to EU Directive 2009/28/EC, the emissions which stem from renewable sources such as biomass should be accounted for at zero.[1] The IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories report (2002) also gives some attention to non-traded fuels, especially to firewood, and notes how inaccurate indirect estimations of its consumption may be. During the calculations made for this piece of research, emissions from firewood combustion were reduced by 30% from the original level because it was assumed that 30% of the firewood consumed is illegally-traded and is presumably not taken from areas where sustainable forest management is practiced.

Hungary is not an electricity-intensive country on a per capita basis. For instance, in 2008 electricity consumption per capita (all sectors included) amounted to about 4092 kW h, which is considerably lower than the European average of about 6000 kW h per capita (the world average is about 3000 kW h) (IEA, 2007). The Hungarian household sector is responsible for about 25.78% of all electricity consumed in Hungary. Using electricity for heating purposes is not common. However, electricity consumption has also increased by 25–28% in the residential sector over the past 15 years, mainly due to the increasing use of electrical devices in households. The share of renewable energy resources in the energy mix is still negligible, except for biomass which is mainly used in heat and CHP power stations. In Hungary electricity is generated primarily from natural gas (38%) and nuclear power (37%), and secondly from coal and oil (18%). The share of wind power, hydropower, biomass and other renewable energy resources is still not significant in the electrical energy mix (these sources combined account for 6.51% of total energy) (MAVIR, 2008). Although the share of coal and oil is significantly lower, nuclear energy has a relatively large share of the energy mix and is hindering a switch to renewable energy technologies. However, it creates the lowest specific CO_2 emissions per GW h (see Fig. 2).

In the questionnaire, household transport activities were divided into the categories of passenger car, railway, coach and air transport and urban public transportation (including tram, bus and underground). According to the related responses 795 kgCO_2/capita is emitted annually on average for transport, of which almost two thirds is produced from the use of passenger cars. In Hungary, 63% of domestic passenger km/s are travelled using passenger cars, 9% by railway transport, 13% by coach, 6% by air transport, and 9% by urban public transport (KSH database, 2012).

[1] EU Directive 2009/28/EC on the promotion of the use of energy from renewable sources in Annex V: “Emissions from the fuel in use shall be taken to be zero for biofuels and bioliquids”. The manual of the EU Air Emission Account (2009) says that “Countries are requested to separately report emissions of CO_2 from biomass (wood and wood waste, charcoal, bio-alcohol, black liquor, landfill gas, household waste, etc.) used as fuel. The emissions of CO_2 from biomass are not included in the total CO_2 emissions in greenhouse gas emissions inventories reported to the UNFCCC, they are reported only as a memo item. For the purposes of air emissions accounts these emissions should be reported separately from non-biomass CO_2”.

Fig. 3 depicts the calculated carbon emissions of different types of passenger transport in terms of domestic passenger km/s based on survey results.

In official statistics data usually are recorded according to the location of combustion and not the purpose. For the currently-described analysis all CO_2 emissions related to residential fuel use which could be consciously controlled by consumers were accounted for according to the reason for their consumption. Table 2 presents a summary of the emissions that occurred as a consequence of the domestic consumption of fuels by Hungarians.

Adding up the mean values and dividing by the sample gives a total of 2591 kgCO_2/capita emitted from residential activities, the major components of which are heating, transport and electricity (53.8%, 30.7% and 15.5%, respectively).

5.2. Results of latent cluster analysis

Survey results show some correspondence with findings reported in DEFRA (2008); the most popular environmental activities of respondents include recycling (18.67%), using public transport (17.98%), undertaking energy reduction activities (17.79%) and water reduction measures (15.34%). Recycling and energy reduction are the most commonly-undertaken pro-environmental behaviours of respondents according to DEFRA (2008); this fact was also confirmed by the Hungarian results.

In the analysis, different groups of people may be identified based on their reported environmental activities from the past (i.e. based on the 8 survey items). Latent cluster model was applied to classify respondents into clusters.

The latent cluster analyses (LCA) included 1005 cases and models which estimated 1-class through 5-class solutions and were compared (Table 3) using the four main criteria; L^2, its p-value, BIC and number of parameters estimated.

The best model is a 4-cluster model with values of L^2 of 243.78, a p-value of 0.13, BIC of 8368.90 and Npar of 35. The 4-class model was also assessed using an L^2 bootstrap procedure to estimate the p-value ($p=0.13$). From this, four statistically significant clusters were identified that show four profiles on the basis of environmental behaviour (Table 4). The profile output table contains the size of each cluster (for each one, the numbers sum to 100%). The body of the table consists of marginal conditional probabilities that show the relationship of the clusters identified to the indicator variables, and within each variable the probabilities sum to 1 (Vermunt and Magidson, 2005).

A total of 27.66% of all respondents were assigned to Cluster 1, 36.22% to Cluster 2, 24.08% to Cluster 3, and 12.04% to Cluster 4. The four clusters seem to generally differentiate respondents' environmental behaviour very well. Cluster 4 contains the most environmentally active people; these individuals carry out the most environmental activities and there is a greater probability that they will undertake all environmental activities except for reducing their consumption of water. People from this group are from now on called the ‘Supergreens’. Cluster 3 members have a lower probability of undertaking environmental activities than Cluster 4, excluding cutting back on consumption of water and energy. Members of this cluster seem to be very keen on saving energy, so these people are called the ‘Energy savers’. Respondents in Cluster 1 seem to be at the first stage of taking up environmentally friendly behaviours such as using greener methods of travelling or recycling and they have a medium, high or low probability of doing the rest of the activities (‘Beginners’). Cluster 2 (which accounts for more than the one third of the sample) represents so-called ‘Brown’ consumers, who were not willing to act in an environmentally-friendly way in any field of activity.

As reported above, recycling is the most prevalent form of environmental activity and it does seem to be a trigger behaviour, since it is done by many Browns and Beginners.

Statistical relationships were investigated between the CO_2 emissions of electricity use, heating and transport activities and pro-environmental behaviours for each of the four clusters. Fig. 4 depicts the mean values for $kgCO_2$ per capita emissions stemming from transport, heating and electricity use of the residential sector according to the four clusters.

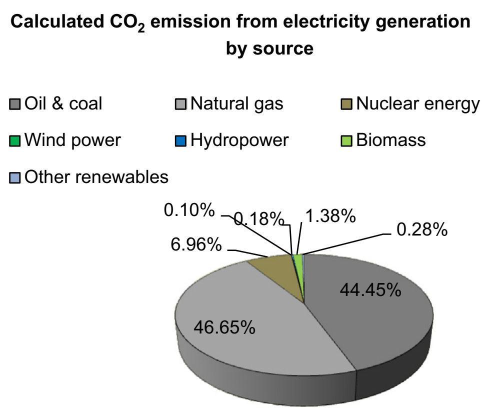

Fig. 2. Calculated CO_2 emission from electricity generation by source.

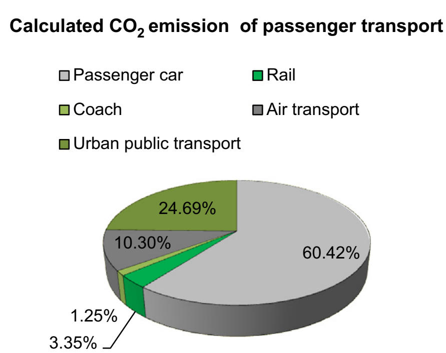

Fig. 3. Calculated CO_2 emission of passenger transport types.

The differences in medians among clusters were tested with a series of Mann–Whitney non-parametric tests (see Table 5). The total CO_2 emissions from the total energy consumption of the clusters Supergreens (3467 $kgCO_2$/cap) and Browns (3289 $kgCO_2$/cap) differ significantly from each other ($p=0.010$), which can be attributed to the use of urban public transport; Supergreens use this mode of transport significantly more often. Surprisingly, Energy savers have statistically significantly higher total CO_2 emissions (3959 $kgCO_2$/cap) than all other clusters; Beginners (3578 $kgCO_2$/cap) have slightly lower per capita emissions. Although the clusters basically do not show any difference according to electricity consumption, Browns along with Supergreens consume the most electrical energy (13% and 12% of total kgCO2/cap emission, respectively). Energy savers use the least electricity (9%) and their consumption is statistically different from that of the Supergreens. Overall CO_2 emissions from heating are not statistically different between clusters, although Browns emit the lowest and Supergreens the most; 1977 and 2066 $kgCO_2$/cap, respectively. Structurally, 60% of total carbon emissions for Browns and Supergreens are produced through their use of heating, and 55% for Beginners and 52% for Energy savers. Browns emit the least CO_2 due to their lower demands for transportation (881 $kgCO_2$/cap, 27% of total emissions). Energy savers use significantly less natural gas for heating than Browns or Supergreens do. While Energy savers cut back on their use of electricity and heating, they use cars more heavily (1190 $kgCO_2$/cap) than other clusters do and their carbon emissions from transportation are 1.7 times higher (1547 $kgCO_2$/cap) which accounts for 39% of their total emissions. Supergreens, according to their answers to survey questions, use their cars the least and use public transportation more (974 $kgCO_2$/cap, 28% of total emissions).

In order to test what relationship exists between clusters and socio-demographic and structural characteristics, Mann–Whitney non-parametric tests were conducted. Table 5 and Table A1 in

Table 3
Latent class model selection.

	LL	BIC(LL)	Npar	L^2	df	*p*-Value	Class. Err.
1-Cluster	−4364.09	8783.486	8	845.0104	247	1.90E−66	0
2-Cluster	−4136.14	8389.79	17	389.0997	238	2.20E−09	0,1235
3-Cluster	−4092.44	8364.613	26	301.7086	229	0.00089	0,1742
4-Cluster	−4063.48	8368.906	35	243.7869	220	0.13	0,2391
5-Cluster	−4045.78	8395.717	44	208.3826	211	0.54	0,2562

Table 2
Direct and indirect CO_2 emissions from residential use of different fuels ($kgCO_2$/capita).

	Frequency	Percent within sample (%)	$kgCO_2$/cap		$kgCO_2$/cap
			Mean (divided by frequency)	Std. deviation	Mean (divided by sample = 1012)
CO_2 emissions from households for heating activities					
Natural gas	505	50	1600	1354	798
Firewood	380	38	826	2364	310
LP-gas	26	3	104	140	3
Coal	56	6	899	731	50
District heating	206	20	1148	775	234
CO_2 emissions from households from transport activities					
Passenger cars	586	58	830	1815	481
Rail	302	30	89	196	27
Coach	440	43	23	55	10
Air transport	53	5	1566	3268	82
Urban public transport	359	35	554	565	196
CO_2 emissions from electricity					
Electricity generation	975	96	416	349	401
Total CO_2 emissions					**2 591**

Table 4
The size of latent clusters and the profile output.

			Cluster 1: Beginners	Cluster 2: Browns	Cluster 3: Energy savers	Cluster 4: Supergreens
	Cluster Size		27.66%	36.22%	24.08%	12.04%
1.	Has chosen more environmentally friendly ways of travelling (on foot, bicycle or public transport)	0	0.53	0.88	0.70	0.06
		1	0.47	0.12	0.30	0.94
2.	Has reduced their consumption of disposable items (plastic bags, certain kind of packaging, etc.)	0	0.78	1.00	0.71	0.42
		1	0.22	0.00	0.29	0.58
3.	Has separated most of their waste for recycling	0	0.51	0.82	0.67	0.21
		1	0.49	0.18	0.33	0.79
4.	Has cut down their water consumption (e. g. not leaving water running when washing the dishes or taking a shower, etc.)	0	0.90	0.97	0.19	0.30
		1	0.10	0.03	0.81	0.70
5.	Has cut down their energy consumption (e. g. turning down air conditioning or heating, not leaving appliances on stand-by, buying energy saving light bulbs, buying energy efficient appliances, etc.)	0	0.74	0.94	0.29	0.20
		1	0.26	0.06	0.71	0.80
6.	Has bought environmentally friendly products marked with an environmental label	0	0.89	1.00	0.88	0.72
		1	0.11	0.00	0.12	0.28
7.	Has chosen locally-produced products or groceries	0	0.69	1.00	0.86	0.37
		1	0.31	0.00	0.14	0.63
8.	Has used car less	0	0.91	0.99	0.92	0.64
		1	0.09	0.01	0.08	0.36

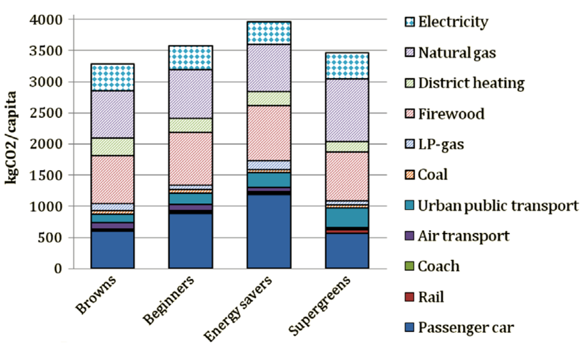

Fig. 4. $kgCO_2$/capita emissions from energy consumption by cluster.

Appendix A show the socio-demographic and structural features of each cluster: gender, age, education, monthly net household income, household size, type of house, number of rooms, the size of the house, energy efficiency, car ownership, the method of travelling to the workplace and free time spent travelling.

In contrast to the work of Thøgersen and Gronhoj (2010), gender, age and household size do not seem to be related to pro-environmental behaviour or energy use. As discussed above, education can play an influential role in forming pro-environmental behaviour; i.e. better qualified people tend to act in a more environmentally-friendly way, although the relationship between education and pro-environmental behaviour should not be over-generalised and cannot be considered linear. Almost all the clusters differ from each other according to educational background; the most qualified people are Supergreens, of whom about 24% hold university degrees (in this group the fewest respondents from all the groups (14%) have had only 8 years of primary schooling). Brown consumers are on average least educated and there is a significant difference between almost all clusters except for Supergreens and Beginners in terms of education.

As might be expected, Supergreens have the highest average monthly net income while Browns are the poorest, on average. Energy savers have a similar income level to Supergreens and Beginners. The financial states of respondents are also underpinned by other features such as the size and type of their houses and number of rooms. 'Supergreens' possess the largest houses with the greatest number of rooms and the majority of them live in detached or semi-detached houses. Only 19% of the respondents of this cluster live in new estates where people of lower incomes typically reside. Energy savers have similar housing situations to Supergreens; 61% of them live in detached or semi-detached houses, but the size of their homes, along with the number of rooms differentiates them from Supergreens. Brown consumers differ significantly from Supergreens and Energy savers regarding the features of their houses.

'Energy efficiency' measures the quantity of electrical devices and appliances a respondent has (refrigerator, freezer, air-conditioner, washing machine, computers, etc.). This factor also differentiates clusters; Supergreens tend to have the most household devices of all clusters, which explains their higher consumption of electricity.

The most significant difference can be observed with ownership of cars and the way respondents travel to their places of work. Although more Supergreens have cars than other clusters, they still prefer to use alternative ways of travelling to work. Browns and Energy savers use their cars the most, presumably on a daily basis, for travelling to their workplaces. Browns spend their free time travelling the least of all clusters, but in other cases this variable does not seem to be strongly related to pro-environmental behaviour.

6. Discussion and conclusions

The main finding of this study is that undertaking environmental activities does not necessarily result in tangible overall decreases in environmental impact or CO_2 mitigation.

Four main profiles were identified on the basis of the environmental actions taken by respondents. Two clusters describe people who undertake energy-saving behaviour; Energy savers and Supergreens. Respondents from the latter cluster undertake a range of environmental activities, including reducing their energy consumption and travelling in more environmentally friendly ways instead of using cars. In accordance with these statements, this cluster has the lowest carbon emissions for car use. However, their emissions due to energy consumption for heating and electricity are, on average, similar to those of Browns. Moreover, in some cases they exceed them.

It is notable that there is a trade-off between using natural gas and firewood for heating in Hungary. Since wood is a relatively inexpensive form of heating and has been promoted by EU Directives as a renewable source of energy it has become more and more popular over the last decade and now constitutes an

Table 5
Results of Mann–Whitney U pairwise test by cluster.

	Browns vs Supergreens	Browns vs Energy savers	Browns vs Beginners	Energy savers vs Supergreens	Energy savers vs Beginners	Supergreens vs Beginners
CO_2 emissions by electricity, heating and transport activities						
Electricity	0.200	0.291	0.693	0.034**	0.504	0.112
Natural gas	0.866	0.047**	0.203	0.060*	0.452	0.186
District heating	0.464	0.816	0.000**	0.499	0.001**	0.117
Firewood	0.711	0.322	0.941	0.744	0.471	0.805
LP-gas	0.837	0.209	0.407	0.667	0.429	1.000
Coal	0.401	0.879	0.681	0.234	0.763	0.186
Urban public transport	0.01**	0.598	0.826	0.052*	0.493	0.006**
Air transport	0.291	0.359	0.703	0.355	0.335	0.265
Coach	0.070*	0.627	0.141	0.133	0.281	0.485
Rail	0.31	0.985	0.126	0.251	0.071*	0.657
Passenger car	0.512	0.005**	0.833	0.003**	0.013**	0.364
Socio-demographic and structural variables						
Gender	0.355	0.384	0.738	0.822	0.261	0.257
Age	0.416	0.409	0.251	0.963	0.764	0.794
Education	0.000**	0.043**	0.000**	0.014**	0.088*	0.248
Household net income	0.001**	0.019**	0.014**	0.113	0.786	0.186
Household size	0.144	0.135	0.585	0.774	0.293	0.252
Type of house	0.061*	0.076*	0.140	0.620	0.730	0.464
Number of rooms	0.000**	0.075*	0.033**	0.004**	0.811	0.005**
Size of house	0.000**	0.045**	0.831	0.035**	0.090*	0.001**
Energy efficiency	0.000**	0.000**	0.000**	0.013**	0.867	0.016**
Car ownership	0.000**	0.000**	0.005**	0.046**	0.345	0.005**
Travel to workplace	0.011**	0.672	0.104	0.006**	0.050**	0.185
Free time travel	0.708	0.139	0.008**	0.455	0.302	0.111

* p-level < 0.10.
** p-level < 0.05.

Table A1
Socio-demographic and structural variables by cluster.

	Beginners	Browns	Energy savers	Supergreens
Gender (woman, in %)	53	54	57	59
Age	44.33	46.24	44.64	44.39
Education				
8 years of primary school or less	17%	30%	24%	14%
Technical college, skilled worker	41%	39%	43%	45%
High school diploma or higher accredited qualification	26%	20%	14%	17%
University degree	16%	11%	18%	24%
Household net income (thousand HUF/month)	211.05	189.11	206.54	241.59
Type of settlement				
Capital	17%	17%	17%	20%
Suburbia	6%	4%	11%	10%
City	52%	50%	41%	48%
Village, farm	25%	29%	30%	22%
Type of house				
Apartment house	3%	8%	5%	4%
New estate	29%	26%	21%	19%
Terraced house	11%	6%	5%	7%
Detached and Semi-detached house	44%	51%	61%	61%
Farmhouse	14%	8%	8%	8%
Number of rooms	2.62	2.49	2.60	2.86
1	5%	6%	5%	1%
2	44%	53%	47%	39%
3	39%	31%	36%	36%
Over 4	11%	10%	12%	24%
Size of house (m^2)	75.73	76.86	78.52	84.96
Energy efficiency				
0–2	9%	17%	9%	3%
3–5	56%	59%	58%	55%
6–8	35%	24%	33%	43%
Do you have a passenger car?				
Yes	55%	44%	60%	70%
Work place travel				
Car	27%	35%	37%	19%
Free time spent travelling (yes, %)	50	39	45	41

important heating source, which may substitute for natural gas. In some cases respondents reported that they owned mixed-fuel boilers which can combine wood burning with gas heating systems. Energy savers use the most firewood in their heating mix. The use of coal and LP-gas no longer prevails in Hungary. District heating is the only form of heating which creates indirect CO_2 emissions, since combustion occurs in heat and CHP plants and not at the location of the end user. Having this form of heating means that a customer is locked-in from an infrastructural perspective (i.e. these consumers are not usually able to switch to using other energy sources, regardless of their wishes).

Energy-saving behaviour is one of the most popular environmental activities although it is difficult to specify the reasons for this (is it driven by environmental concern or a desire to reduce costs?). This survey indicated that Energy savers generally have lower incomes. It is also remarkable that Energy savers appear willing to cut back on direct consumption of energy but they pollute significantly more through their use of passenger cars.

The central hypothesis of this research, that “people who consciously act in a pro-environmental way do not necessarily impact CO_2 emissions more than those who do not undertake environmental activities” is partly confirmed; there were no significant differences found between groups in terms of electricity use or heating activities—only with transport activities. This finding has implications for environmental and energy policy-making.

There are two main approaches in the literature to reducing consumption and environmental load; voluntarism and structural approaches. Voluntarism can be increased through awareness-raising campaigns, education-related drives and increasing the willingness to live an environmentally-friendly lifestyle. Socio-structural approaches address the living conditions and circumstances that lock consumers into living unsustainable lifestyles and include factors such as working conditions, size of homes, family sizes, etc. (Sanne, 2002; Thøgersen and Gronhoj, 2010). Whilst studies emphasize that both approaches are needed to increase *pro-environmental behaviour*, fewer studies have paid attention to identifying how the approaches and behaviour changes *actually impact* the environment. Thus, the second finding of this research is striking: that there may actually be no difference between environmentally-conscious and environmentally indifferent individuals in terms of their energy-related CO_2 emissions. Browns and Supergreens emit almost the same amount of carbon because the voluntarism of Supergreens is offset by structural factors which, at the same time, reduce the consumption and carbon emissions of Browns. The finding indicates that pro-environmental behaviours are limited in impact and may be dominated by structural factors. Interestingly, this situation appears in the case of heating and electricity but not with transportation. There has been a remarkable increase in private car use in almost all European countries which is one of the main reasons for the increase in carbon emissions due to transportation (EUROSTAT, 2010). Supergreens appear to be using cars less, although they are more likely to own them than respondents from other clusters, and they are more likely to choose alternative ways of travelling to their workplaces than other respondents. This indicates that motivational factors can make a real difference in terms of CO_2 emissions. The consumption of energy for heating and electricity seem to be influenced rather by socio-structural factors, such as income, size of home and quantity of electric devices.

These inferences are important enough to merit attention in future research and draw the attention of policy-makers and NGOs. The message is to focus on the real environmental impact of environmentally-friendly behaviour rather than examine the frequency of its occurrence. The cost of marginal environmental action can overcome its benefits in the long term. There is a lack of public understanding about the impact of environmental action which may lead to redundant efforts being made, a limit in the environmental benefits that are achieved and the demoralization of consumers.

The findings described in this paper have relevant implications for environmental and energy policies. For policy makers, the findings presented in this paper suggest that, besides introducing policy measures that encourage environmentally friendly and energy-saving behaviour (especially in the transport sector), there is a need for instruments that also tackle socio-structural factors to be designed, not only those that address the promotion of pro-environmental behaviour.

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Appendix A

See Table A1.

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