

Do Proenvironmental Attitudes Affect Household
Level Energy-Efficiency?
Evidence from Eight European Countries

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Submitted to
Central European University Department of Economics and Business

In partial fulfilment of the requirements for the degree of Master of Arts in
Economic Policy in Global Markets

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Budapest, Hungary
2020

Abstract

Energy consumption in Europe has been increasing for the past couple of years, while concerns about related environmental issues are mounting. The EU has already missed its 2020 Energy Efficiency Directive and without additional efforts it will not be able to meet its 2030 target. The author of this paper argues that proenvironmental attitudes and values can partially help this process by motivating the residential sector to increase its energy-efficiency, hence reducing their overall energy demand. To investigate the significance of the relationship an Attitude Index (ATI) is regressed on three separate energy-efficiency indicators. The estimates indicate that households with higher ATI are significantly more likely to adopt energy-efficient lightbulbs, purchase efficient appliances and use environmentally friendly transport. Considering the limitations of the study, the results indicate that promoting environmental awareness can help to reduce the residential sectors` energy demand.

Acknowledgements

I would like to thank my supervisor Professor Gábor Békés for the consultations and advices he provided me during the thesis writing process.

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1. Introduction

The European Commission (2012) set out its Energy Efficiency Directive to reach its 20% energy efficiency target by 2020, which would have required Member States to reduce their national energy sales by 1.5% annually. This battle has been already lost, due to the increase in final energy consumption between 2014 and 2017 and only a small decrease in 2018 (Simon, 2019). In 2018, the original Directive has been amended to set out a 2030 energy efficiency target of at least 32.5% (European Commission, 2019). To keep this target Member States and the EU must introduce appropriate measures to incentivise its population to adopt energy-efficiency measures.

According to Eurostat (2019), in 2017 the European residential sector accounted for 27% of final energy consumption 24% of which was electricity usage and 11.2% was related to oil and petroleum products. Lighting and appliances alone accounted for 14.4% of total energy consumption, which was the third largest consumer after space- and water heating. Although investment costs are often large and burdensome for heating improvements, updating current lighting equipment and appliances are a relatively cheap and fast way to reduce households` energy usage. Furthermore, motivating habitual changes, such as turning of stand-by mode on consumer electronics, turning off the light upon leaving the room, or considering an environmentally friendly transport option when possible, could lead the further energy demand reduction for the residential sector.

The paper investigates how individuals` norms, values and a general proenvironmental attitude can influence household level energy-efficiency. I argue, that solely by promoting proenvironmental attitudes, policymakers can effectively influence the energy-efficiency of the EU`s residential sector, hence reducing it`s energy demand. To investigate this relationship, I create an Attitude Index (ATI) using a recently published, cross-country survey-based dataset

consisting responses of citizens of eight European countries. The ATI is a standardized combination of four questions of the survey. The indicator is meant to measure the proenvironmental attitude of respondents by evaluating their level of moral obligation and concerns towards environmental issues. The index is regressed on three separate dependent variables that measure households' energy-efficient lightbulb share, respondents' energy-efficient appliance purchase intentions and their willingness to use environmentally friendly transport. The model estimates are verified by additional robustness checks, such as alternative model specifications and regional fixed effect models. Furthermore, a matching method is applied on the data to observe potential bias and estimation variance caused by the different group characteristics of respondents with relatively low versus relatively high Attitude Indices.

The results indicate that households with a one standard deviation higher ATI have a 3.9 percentage-points higher share of energy-efficient lightbulbs on average, the likelihood that their purchasing decision is primarily influenced by the durable's efficiency is on average 10.9 percentage-points higher and on average they have an 8.2 percentage-points higher likelihood of choosing an alternative transport method. Assuming that the limitations of this study do not significantly hinder the accuracy of the estimates, these results indicate that promoting environmental awareness can help to reduce the residential sectors' energy demand. Hence, the study can have practical policy implications for both EU-wide and national energy conservation programs.

The remainder of the paper is organized as follows: the second chapter summarizes the results of similar studies; the third chapter introduces the ENABLE EU database and the main variables used in the paper; the fourth chapter presents the research design; the fifth chapter proposes the results and the limitations of the paper; the sixth chapter discusses the possible policy implications and finally, the seventh chapter summarizes the findings.

2. Literature review

The existing literature about household level energy-efficiency behaviour and technology adoption practices is largely limited to country level observational studies, with a few notable exceptions; Mills – Schleich (2012) use a survey based database of 10 European countries to identify which household characteristics influence households` energy usage behaviour. They find that the presence of young children and respondents` education level positively affect the household`s energy-efficient technology adoption, while more elderly households rather focus on financial savings and have lower levels of efficient technology adoption. In a similar study, Urban – Scasny (2012) apply structural equation modelling on a dataset of 9 OECD countries to investigate whether environmental concerns affect energy curtailment and efficiency investments. They find a positive and significant effect for most of their predictors and their results also robust across countries. Borg – Kelly (2011) predict that energy-efficient appliances can reduce annual average electrical consumption by up to 23% in Europe and while peak load demand cannot be effectively reduced by such measures, the overall demand of individual households can be reduced over the entire duration of a single day. Almeida et al. (2011) give a significantly higher electricity savings estimate of 48% for 12 European countries if households switch to the best available technology and the best practice behaviour. They argue that with appropriate energy saving practices (e.g. turning off standby mode) the energy demand of efficient appliances such as cold appliances, lighting and desktop PCs can be reduced by 26.8%, 23.6% and 10.8%, respectively.

Whether these energy-efficient technology choices are economically beneficial is an issue of a long-lasting heated debate. Discussion about the presence of an energy efficiency gap¹ goes back to the late 1970s; Hausman (1979) was one of the first to calculate the discount rate for

¹ It refers to the difference between cost-minimizing energy-efficiency and the current level of energy efficiency, that is also applicable to residential energy consumption practices.

energy-using durables (his study focuses on air conditioners) for US households. He found that the discount rate was around 30% that households used to decide between higher initial cost and higher operation cost appliances. Since then, several studies (Hirst – Brown (1990), Reddy (2003), Kallbekken – Sælen (2012) and others) have argued for the existence of a residential energy efficiency gap, claiming that the lack of sufficient information, insufficient policy measures and inadequate discount rates lead to inefficient consumer choices regarding energy-efficient appliances. Others argue that several factors must be considered to correctly evaluate the cost-effectiveness of these choices. Heidari et al. (2018) finds that a recent drop in the price of light emitting diodes (LEDs) in Switzerland has led to a high cost-saving potential for energy-efficient lighting. However, according to Heidari – Patel (2020), due the current high prices and relatively small difference in energy consumption of energy-efficient electronics it is currently not economically beneficial to purchase them. Kim et al. (2006) finds, that the ecologically optimal lifetime of refrigerators in the US is between 2 to 11 years, while an 18-year of lifetime minimizes the economic cost incurred by the purchase. Furthermore, Young (2008) argues that other factors, such as the monetary cost of retiring the old appliance and installing the new model should also be considered. Most of the literature highlights, that cost efficiency can change rapidly over time due to fast technological development and electricity price changes, hence policymakers should closely follow these developments to correctly set new incentives.

Similarly to this paper, a considerable amount of the literature suggests that other than economic rational, often the socioeconomic characteristics, norms, morals, and personal attitudes better explain households` decision making process when purchasing energy-efficient appliances. Mills – Schleich (2010) finds that knowledge of the energy class of white appliances² increases with household size and with household income level. Younger households are also better

² Freezer, refrigerator, washing machine, dishwasher

aware of the EU labelling scheme³, while households with heads in senior management positions are less likely to invest resources to learn the energy class of their appliances. Another study by Mills and Schleich (Mills – Schleich (2012)) highlights that other than electricity price, households` social characteristics also have a significant effect on their energy-efficiency behaviour. This is reinforced by Di Maria et al. (2010), who find that education and income are significant predictors of – more energy-efficient – compact fluorescent light bulb (CFL) adoption. They also find that environmental attitudes (e.g. familiarity with environmental issues) are also influencing households` behaviour.

Several studies focus on attitudes and norms to explain individual and household level energy-efficient behaviour and technology adoption. The Value-Belief-Norm Theory (VBN), originally proposed by Stern (2000), is one of the widely cited theories providing linkage between one`s beliefs and proenvironmental behaviour. According to the VBN, religious and moral values, knowledge through education or through other forms of information gathering can help to develop proenvironmental personal norms that lead to behavioural changes. The role of the VBN in influencing behaviour is also shown by Fornara et al. (2016). They use the theory to predict which households are more prompt to adopt green energy devices and find that general beliefs and values lead to awareness of consequences which in turn affects one`s moral norms finally altering her/his behavioural intentions.

Ajzen`s (see Ajzen (1991)) Theory of Planned Behaviour (TPB) is another approach to predict how norms and attitudes steer behaviour and action towards energy efficiency. Ajzen argues that behaviour is strongly influenced by one`s intentions; „intentions are assumed to capture the motivational factors that influence a behaviour; they are indications of how hard people are willing to try, of how much of an effort they are planning to exert, in order to perform the

³ Energy labels show how the appliances rank on a scale from A to G according to their energy consumption.

behaviour” Ajzen (1991, p.181). These intentions are formed by one’s *attitude toward the behaviour*, that describes the person’s evaluation towards the specific behaviour. This is influenced by *subjective norms*, indicating the perceived social pressure regarding how to evaluate the behaviour. Finally, *perceived behavioural control*, refers to the perceived ease to perform the behaviour (e.g. what would be the obstacles to overcome to engage in the behaviour?).

The TPB has been used to empirically address the relationship between households’ energy-efficient behaviour and norms and beliefs. In their paper, Wang et al. (2017) build on the TPB to find that among China’s urban citizens environmental awareness, social relationships, age, and the level of education are significant predictors of energy-efficient appliance adoption. Zhang et al. (2020) survey Chinese households to observe how proenvironmental beliefs affect the willingness of paying a price premium for energy-saving durables. They argue that other than perceived quality and price, emotional and environmental values significantly impact consumers’ purchasing attitudes. However, they highlight that in contrary to the TPB, social values and environmental awareness did not have a significant effect. Tan et al. (2017) adds a morel extension to the TPB. They find that personal behavioural control, attitude, and moral norms significantly affect purchasing intentions, while subjective norms and environmental concerns and knowledge do not. Albayrak et al. (2012) uses Turkish survey results to confirm that consumers with high level of environmental concerns have a high positive subjective norm and perceived behavioural control, thus they are more likely to subscribe to an environmentally sensitive corporate initiative.

Finally, a few studies – similarly to this paper – attempt to find evidence on how more general concerns and environmental attitudes affect energy usage. Barr et al. (2005) set up behavioural profiles to observe how habitual- and purchase-related conservation actions interconnect. They argue that energy savings should be viewed within the context of broader environmental

actions, thus policymakers can achieve habitual and purchasing behavioural changes by focusing only on specific issues. The previously mentioned paper by Urban – Scasny (2012) also finds that concerns about waste generation, air pollution, climate change, water pollution, natural resource depletion and about the reduction of biodiversity leads to energy conserving habits and investments.

All the above literature highlights that one`s norms, beliefs and general attitude towards the environment can influence her/his behaviour toward energy-efficiency. One of the limitations of international surveys is that due to their more general approach it is hard to use them to explicitly test relevant theories. Nevertheless, this paper takes inspiration from both the VBN and TPB to answer to the research question whether the general attitude towards the environment affects households` behavioural intentions towards energy-efficiency. The added value of this study is that it uses recent data from several European countries to empirically address its research question. Secondly, to my knowledge, other than Urban – Scasny (2012), this is one of the first studies that uses more outcome variables to construct a more general and robust connection between environmental awareness and concrete action. Instead of focusing on one indicator to grasp the idea of households „energy-efficiency”, this paper adopts three separate measures (households` share of energy efficient lightbulbs, energy efficient appliance purchase intention and alternative transport choices) to give an in-depth answer.

3. Data description

The current study attempts to answer the question how households' proenvironmental attitudes affect their energy-efficient behaviour. I use a new dataset provided by the ENABLE EU project, which was established to support the European Union's Energy Union Framework Strategy (enable-eu, 2019). The dataset was created in 2017-2018 based on a randomized, nationally representative survey with an objective to collect information about the housing, heating and cooling practices; the electricity usage; the prosuming activities; the mobility choices and social characteristics of EU residents. The data is stratified on a regional level, and in some cases further stratified by a predefined typology of urbanization areas. Sample weights are given to adjust the survey results to the general population characteristic. (enable-eu, 2018)

3.1. Data- and variable description

The original dataset includes responses from 11 European countries including France, Germany, Hungary, Norway, Poland, Serbia, Ukraine, the United Kingdom, Italy, Bulgaria and Spain. Due to data limitations, observations from Italy, Bulgaria and Spain were omitted. Missing values were replaced by their population median, observations without dependent or main independent variables were dropped, this however only affected less than 3% of the sample. Furthermore, the data was restricted to respondents older than 29 to only consider households' potential decisionmakers. The final database includes 5377 observations.

Table I. shows the respondents' social characteristics and type and place of their residence. The observations are mostly evenly distributed across gender and age cohorts, even though older deciles are less represented. Large majority (58%) of the individuals in the sample have a secondary-, or post-secondary education, followed by tertiary education (30%). The income distribution is right skewed slightly overrepresenting the poorer population, however sample weights are later used in the analysis to control for this issue. More than half of the sample

population had full-time employment at the time when the survey was taken, followed by a 31% of pensioners – should be noted, that the 0% of students in the sample is due to the age limit, highlighting that the results are not robust to household heads younger than 30. The country level distribution of respondents varies between 10% (Germany, Ukraine) to 17% (France); the number of observations by country is shown in Figure 1. Most of the respondents` households are in towns or small cities (37%), followed by a 23% of villagers and 19% population who live in large cities. Finally, almost half of the households in the sample are detached from any other buildings, while an additional 29% of the respondents live in large residential buildings.

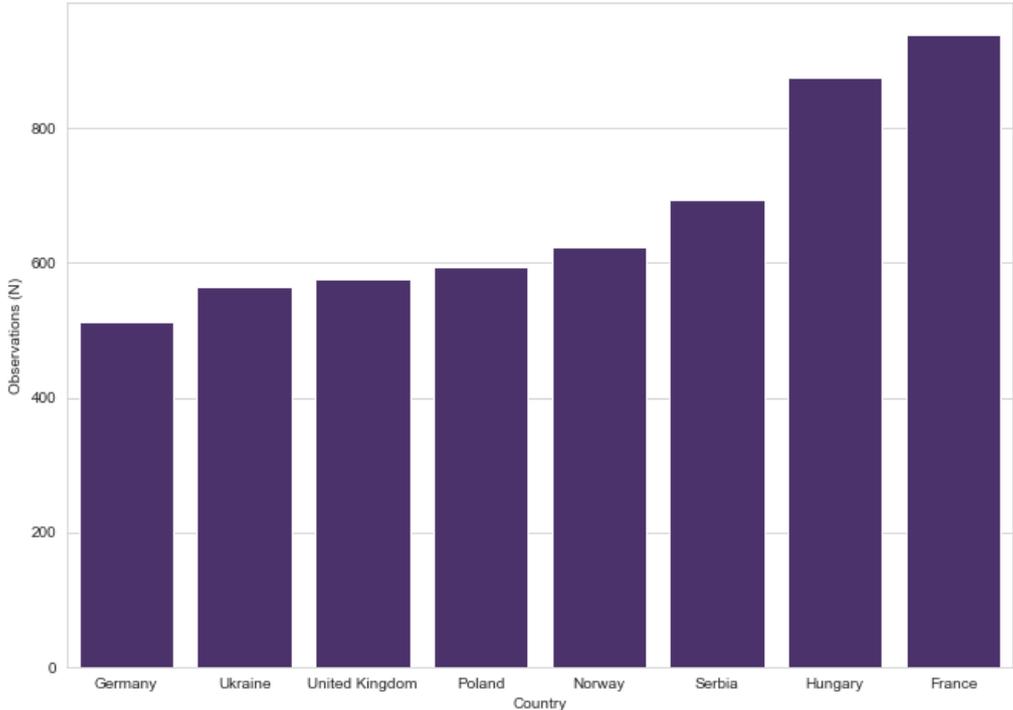


Figure 1: Number of respondents by country

Data Source: enable-eu (2019)

Table I Survey sample characteristics

Indicator	Item	Number	Percentage (%)
<i>Gender</i>	Male	2545	47
	Female	2832	53
<i>Age</i>	30-39	1241	23
	40-49	1136	21
	50-59	1087	20
	60-69	1048	19
	70-79	732	14
	80-93	133	2
<i>Education level</i>	Do not know / Refusal	47	1
	No formal education or below primary	51	1
	Primary education	336	6
	Secondary and post-secondary non-tertiary education	3126	58
	Tertiary education first stage, i.e. bachelor or master	1589	30
	Tertiary education second stage (PhD)	228	4
<i>Income quantile</i>	Refused to answer	834	16
	Poor	1171	22
	Low income	1190	22
	Lower middle income	937	17
	Upper middle income	703	13
	High income	542	10
<i>Employment status</i>	Employed full-time	2754	51
	Employed part-time	367	7
	Long time not employed (more than 3 months)	261	5
	Retired / pensioner	1652	31
	Student	22	0
	Other economically inactive person	321	6
<i>Country</i>	France	939	17
	Germany	513	10
	Hungary	874	16
	Norway	623	12
	Poland	595	11
	Serbia	693	13
	Ukraine	564	10
	United Kingdom	576	11
<i>Region</i>	A big city (more than 0,5 mln people)	996	19
	The suburbs or outskirts of a big city	742	14
	A town or a small city	1990	37
	A country village	1220	23
	A farm or home in the countryside	372	7
<i>Home type</i>	Apartment in a building with 2 to 5 flats	387	7
	Apartment in a building with 6 or more flats	1562	29
	No answer	21	0
	Single-family house attached to one or more other houses	834	16
	Single-family house detached from any other house	2573	48

Data Source: enable-eu (2019)

3.1.1. Dependent variables

Energy-efficient behaviour cannot be directly observed. As Barr et al. (2005) note, many different forms of energy-efficient actions and behaviours can arise from the same set of norms and values. Researchers attempt to generalize household level energy-efficiency by using an observable indicator that – at least partially – able to capture this latent variable. Mills – Schleich (2010), Heidari – Patel (2020) and Yilmaz et al. (2019) use energy-efficient electronic appliances, while Di Maria et al. (2010) and Heidari et al. (2018) use LED lightbulb adoption to capture energy-efficiency. Fowlie et al. (2018) uses insulation as the main predictor for households` energy-savings.

Table II/A Dependent variable description

Dependent Variable Name	Measurement Item	Measurement Type
Energy-Efficient Lightbulb share	<i>Portion of the energy efficient light bulbs inside your home</i>	Ratio (0%, 25%, 50%, 75%, 100%)
Energy-Efficient Appliance purchase intention	<i>When buying a new household appliance e.g. washing machine or fridge, you choose it mainly because it was more energy efficient than other models</i>	Binary (Yes-No)
Alternative Transport choices	<i>You regularly use environmentally-friendly alternatives to using your private car such as walking, biking, taking public transport or car-sharing</i>	Binary (Yes-No)

Table II/B Independent variable description

Latent Variable –	Measurement Item	Measurement Type
Proenvironmental attitude		
Moral obligation (active)	<i>Q1: I am not willing to do anything about the environment if others don't do the same</i>	Likert Scale (1- Strongly Agree, 2 - Agree, 3 - Disagree, 4 - Strongly Disagree)
	<i>Q2: Environmental issues should be dealt with primarily by future generations</i>	
	<i>Q3: Environmental impacts are frequently overstated</i>	
Environmental Concerns (passive)	<i>Q4: Environmental issues will be resolved in any case through technological progress</i>	

Data Source: enable-eu (2019)

One of the contributions of this paper is that instead of focusing on one indicator, it uses three separate measures to capture the effect of proenvironmental attitudes on household level energy-efficient behaviour. Table II/A shows the names of the dependent variables, the related

questions in the survey and their measurement types. The three separate indicators are meant to represent different forms of endowment.

Energy-efficient lightbulb share incorporates households' low-investment-cost decisions of energy-efficiency. This measure is less dependent on income as shown by Di Maria et al. (2010), hence the proenvironmental attitudes of lower deciles can also be adequately measured. However, it also suggests that this type of investment can be implemented with relatively low environmental commitments, hence it could underestimate the true effect of strong proenvironmental values. *Energy Efficient Appliances purchase intention* induces larger investment costs; therefore, a greater engagement is required by the households. The downside of this measure is that the poorer population often cannot afford such an investment even if they are deeply committed towards energy-efficiency. Furthermore, as mentioned earlier, it is not certain that these investments are economically beneficial, thus households' decisionmakers can find more efficient ways to save energy. Finally, *Alternative Transport choices* mostly require habitual changes instead of monetary commitment, hence in principle it should illustrate the strongest commitment towards the environment. However, this indicator has weaknesses too; for example, the lack of adequate infrastructure (e.g. inefficient public transport) can undermine respondents' intentions to switch to a more environmentally friendly way of transport. Furthermore, the phrasing of the question in the survey is unfortunate since it could lead to a positive answer even if the respondent's choice depends on non-environmental factors.

In conclusion, all the indicators have their strength and weaknesses, thus they are not immune to measurement errors, but this thought to be an inherent problem of every survey-based dataset. In this paper I argue, that by considering different measures, I can approximate the true effect of proenvironmental attitude on energy-efficient behaviour.

Figure 2 shows the distribution of each dependent variable for every country in the sample. Energy-efficient appliance purchase intentions in Figure 2/A are mostly evenly distributed,

however a mild Eastern- Western-European divide can be observed, with western respondents being more open to efficiency measures. This division is deeper for alternative transport choices; the acceptance rate of eco-friendly transport remains under 20% in all Eastern-European countries, while in most of Western-Europe it is closer 40%, except in Germany, where more than half of the respondents choose to travel in an environmentally friendly manner. Finally, the distribution of energy-efficient lightbulbs is heterogeneous across nations. Hungary and Ukraine have a mostly uniform distribution; among French, Polish, and English households the efficient lightbulb share is left-skewed, while in Serbia it is right-skewed. In a median German and Norwegian household 50% to 75% of the lightbulbs are energy efficient. This heterogeneity can be due to the different policy measures among these countries. Lightbulb usage is fairly easy and cheap to regulate, hence more progressive nations have already implemented incentives and subsidies, while others are lagging behind.

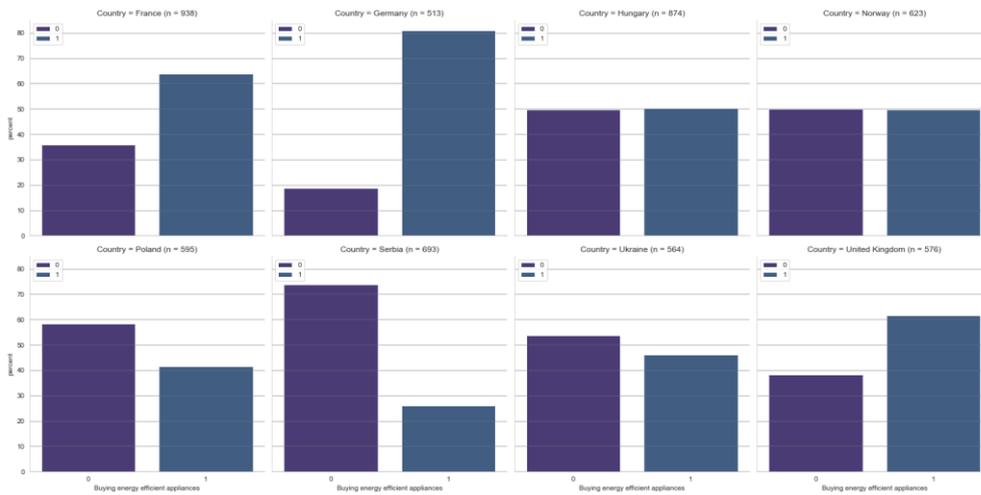


Figure 2/A: Distribution of Efficient Appliance purchase intention by country

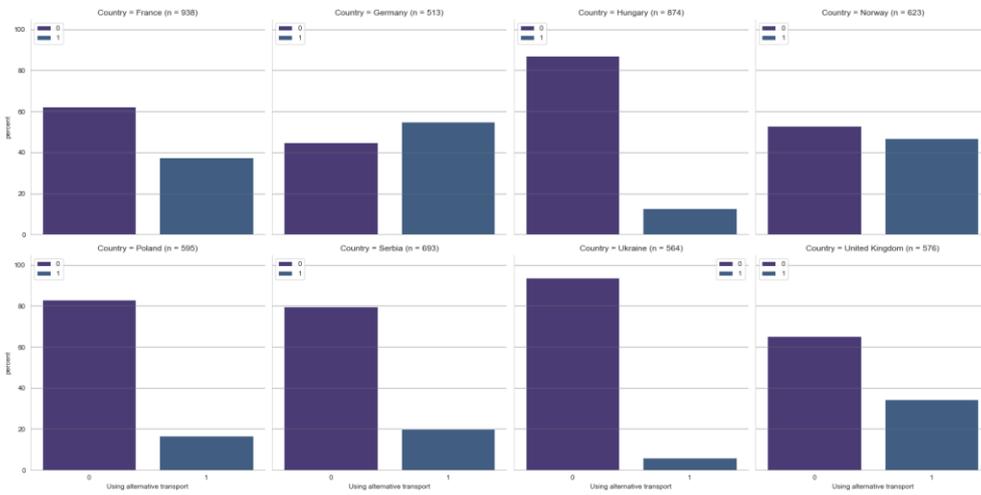


Figure 2/B: Distribution of Alternative Transport choices by country

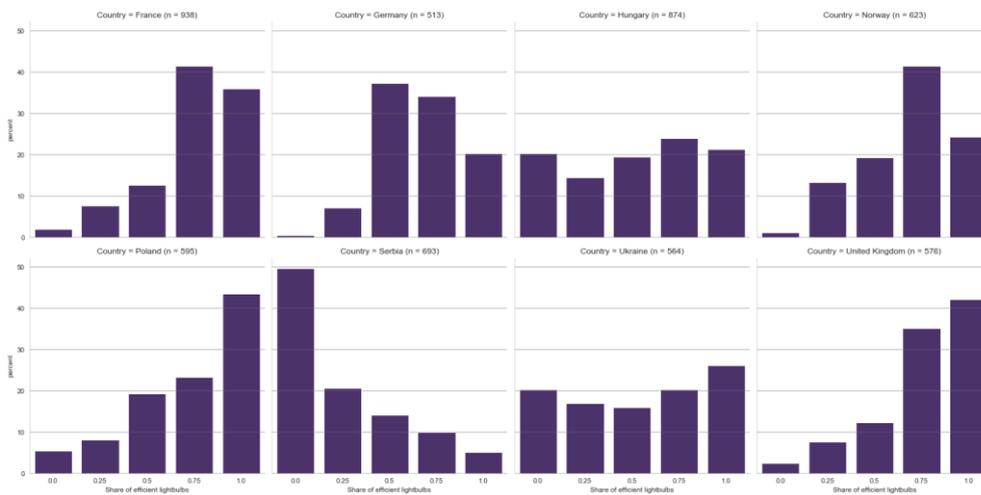


Figure 2/C: Distribution of Efficient Lightbulb share country

Data Source: enable-eu (2019)

Table III. highlights the different properties of energy-efficient households and their less energy-efficient counterparts. The differences show the simple difference of means for each covariate between the two subpopulations. According to the results, more energy-efficient respondents are more likely to have a college degree and on average they are coming from wealthier households. These findings support Mills – Schleich (2012) and Di Maria et al. (2010) who argue that income and education are significant predictors of household level energy efficiency. Household level covariates such as the number of children, the size and age of the building also significantly affect average energy-efficient behaviour. The remaining confounders only influence one or two of the dependent variables.

Table III. Descriptive statistics for covariates

	Using alternative transport				Energy-efficient appliances				Share of ef. bulbs (50% cut-off)			
	No	Yes	difference	<i>P</i> value	No	Yes	difference	<i>P</i> value	No	Yes	difference	<i>P</i> value
College deg.	0.30	0.45	-0.15	0.000	0.29	0.38	-0.09	0.000	0.25	0.41	-0.16	0.000
Income dec.	4.46	5.32	-0.86	0.000	4.32	5.05	-0.73	0.000	4.45	4.89	-0.44	0.000
Gender	0.53	0.51	0.02	0.111	0.51	0.53	-0.02	0.147	0.54	0.51	0.02	0.080
Resp`s age	53.94	52.64	1.30	0.003	53.79	53.38	0.42	0.283	54.93	52.53	2.40	0.000
N household	2.66	2.69	-0.03	0.575	2.65	2.69	-0.04	0.341	2.64	2.69	-0.05	0.227
N child. (18>)	0.65	0.72	-0.07	0.018	0.64	0.71	-0.07	0.008	0.54	0.78	-0.24	0.000
N elder. (65<)	0.61	0.62	-0.01	0.570	0.62	0.61	0.01	0.701	0.57	0.64	-0.07	0.001
House < 90sqm	0.41	0.45	-0.05	0.002	0.38	0.45	-0.07	0.000	0.38	0.45	-0.08	0.000
House bef. 1990	0.77	0.73	0.04	0.001	0.78	0.74	0.04	0.000	0.80	0.72	0.08	0.000
Detached	0.72	0.57	0.15	0.000	0.67	0.68	-0.01	0.341	0.69	0.67	0.02	0.091
Rural	0.52	0.40	0.12	0.000	0.49	0.48	0.01	0.293	0.52	0.45	0.07	0.000

Note: *p* value for *t*-test results, *N* = 5377

Data Source: enable-eu (2019)

3.1.2. Independent variable

To create adequate independent variables from Likert-type scale survey responses most of the literature uses Principle Component and Factor Analysis. These methods are efficient ways for consistent dimensionality reduction, that can also be tested for internal coherence. The disadvantage of these measures is that researchers have less control over which questions to

include and the outcome indicators require subjective interpretation. Although these methods can be useful tools for explanatory analyses, they have major issues if applied in a causal context.

Therefore, this paper uses a standardization method proposed by Bloom et al. (2014), which – according to the authors – yields similar results to taking the first component from a factor analysis. As a first step, a subsample of items (questions) were selected from the survey using Cronbach`s alpha, which measures the internal consistency of the indicators. It evaluates to what extent the items in the outcome indicator measure the same concept by evaluating average covariance between item-pairs (Peters, 2014). Table II/B shows the selected questions from the survey. The Cronbach`s alpha for the four measurement items is 0.696, which is lower than the generally recommended 0.7 value, but it`s between the 0.6-0.7 range which deemed to be the lower limit of acceptability (see Hair et al., 2009, p. 91).

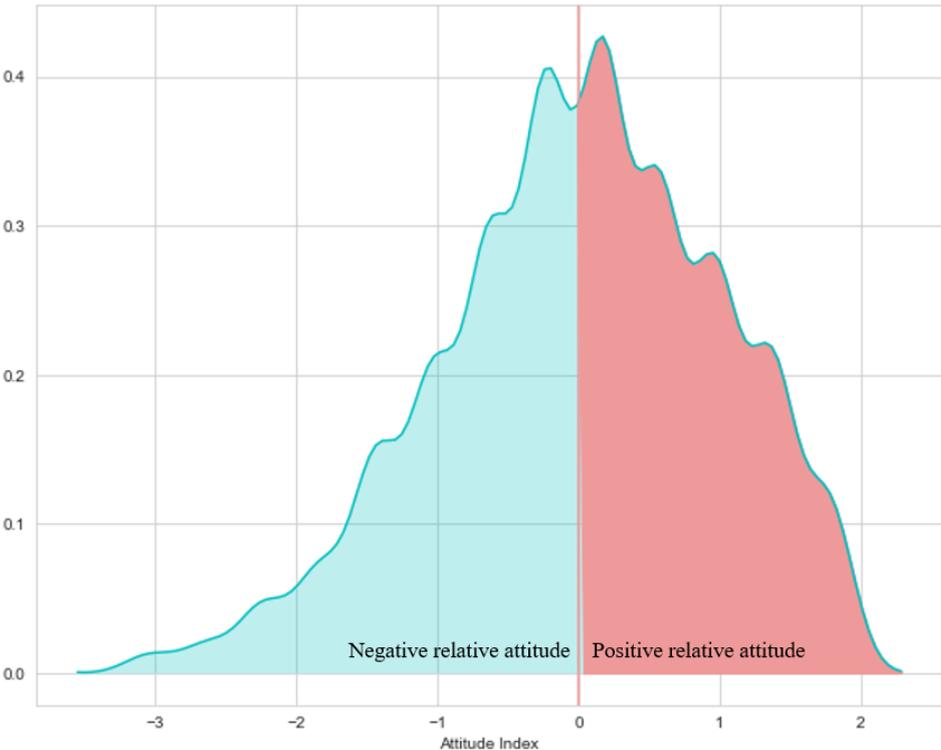


Figure 3: Distribution of the Attitude Index

Data Source: enable-eu (2019)

The four questions meant to measure the proenvironmental attitude of respondents by evaluating their level of moral obligation and concerns towards environmental issues. The four Likert-type scale items are standardized, aggregated, then standardized again to obtain the *Attitude Index* (ATI), the distribution of which is shown in Figure 3. The ATI shows the respondents proenvironmental attitude relative to the sample population. An ATI lower than zero indicates that the individual has less proenvironmental values than the average, while a value greater than zero suggests the opposite. The lowest ATI scores are 3.5 standard deviations below zero, while the highest scores are 2.5 std above.

Figure 4 depicts the distribution of the ATI by country. Although it has close to normal distribution in all nations, there are some important differences that should be noted. In Germany, Hungary, and Norway the average ATI score is above 0, indicating a higher than average proenvironmental attitude. However, while the German ATI distribution is narrow, in Hungary, and Norway many respondents are two or even three standard deviation below the mean. The remaining Eastern-European nations have an average index score below zero indicating an eastern-western divide, where Hungary acts as an outlier. Finally, France and the UK has a very similar ATI distribution with a mean of 0.

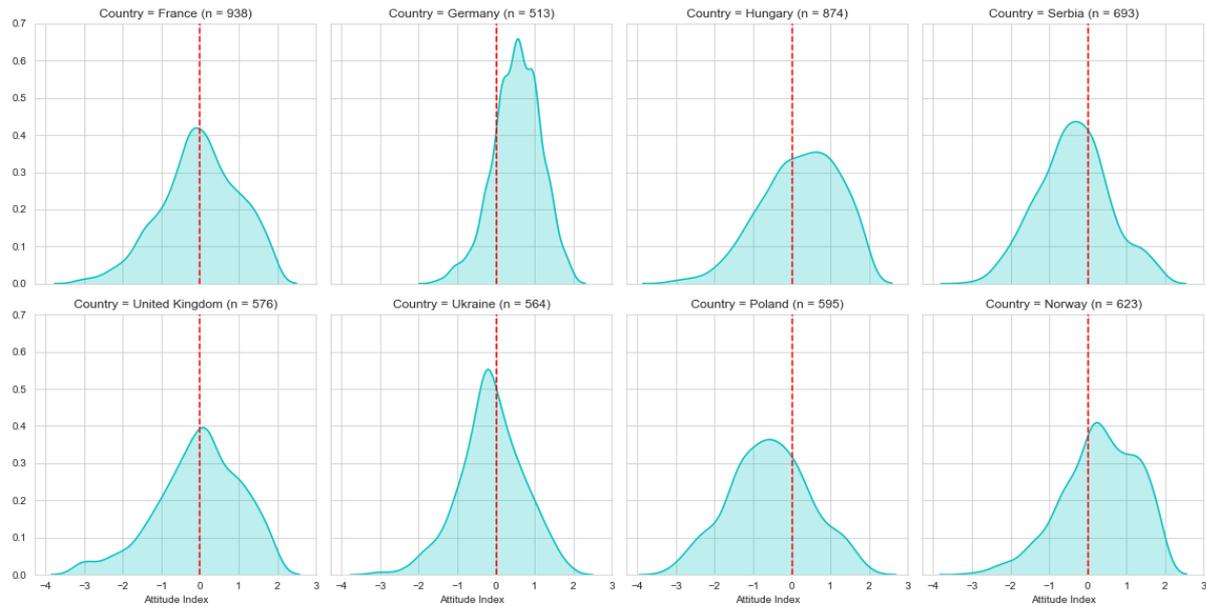


Figure 4: Distribution of the Attitude Index by country

Data Source: enable-eu (2019)

Figure 5 shows the cumulative distribution differences of the Attitude Index along respondents' individual characteristics. The Kolmogorov–Smirnov test (KS-test) indicates whether the empirical distribution pairs are significantly different from each other. The results illustrate that the wealthier and more educated population tend to have a higher average ATI. This indicates that both factors act as confounders when estimating the effect of proenvironmental attitudes on household level energy-efficiency. Furthermore, respondents' age also has a significant effect on their attitude, the younger population on average has a higher proenvironmental attitude relative to the population older than 48. Although the age difference does not seem to be significant regarding efficient appliance purchase intentions, the younger population in the sample is more likely to choose alternative transport options, and on average a higher share of their home lighting is using energy-efficient lightbulbs (see Table III.). Hence the effect of age must be also considered when estimating the effect of proenvironmental values. Lastly, gender differences can be also observed regarding the ATI, however, while females in general have more concerns about environmental change, it is not mirrored by their energy-efficient choices.

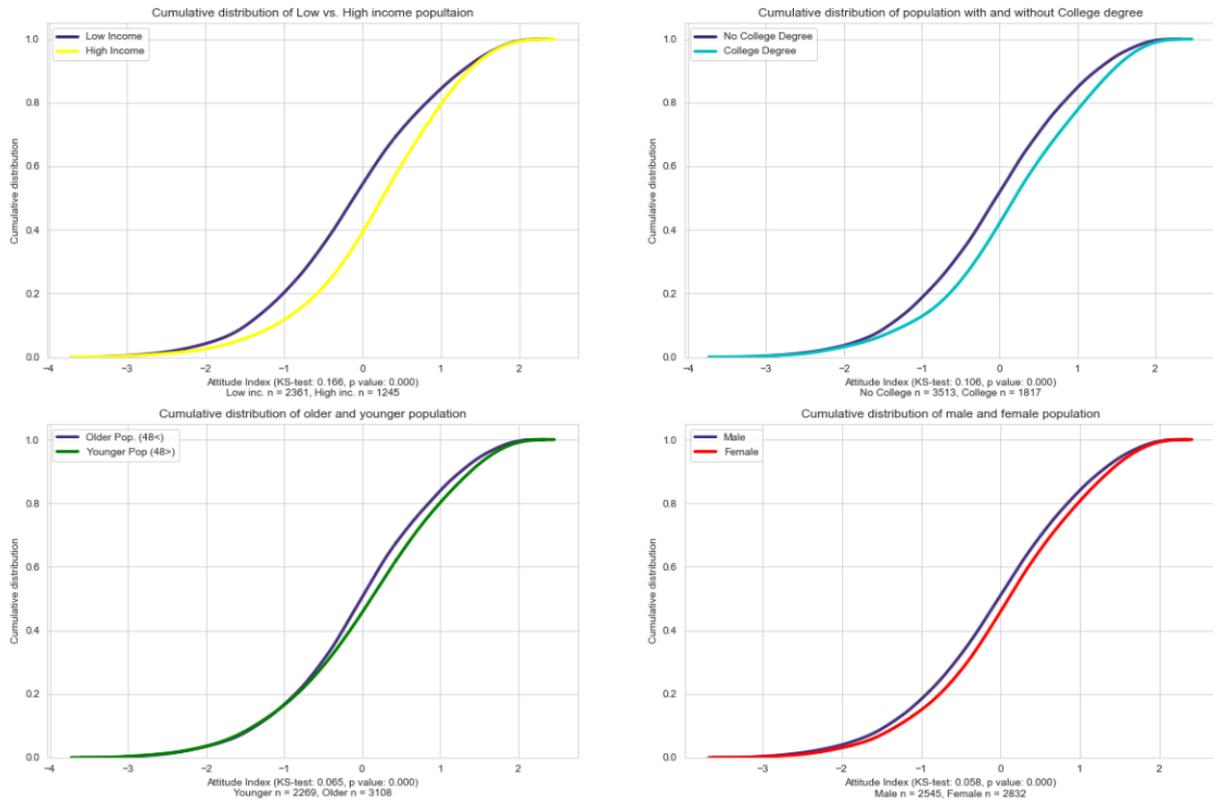


Figure 5: Cumulative distribution of the Attitude Index by personal characteristics

Data Source: enable-eu (2019)

The last figure of this section of the paper shows the relationship between the Attitude Index and the three energy-efficiency measures. Figure 6 fits a local regression on the relationship of the ATI and the three dependent variables separately. Proenvironmental attitude positively correlates with all energy-efficiency indicators, but the relationship is slightly different for each. The ATI has a positive and close to linear relationship with energy efficient appliance purchase intentions. On average 20% of the respondents at the bottom quintile of the ATI distribution consider energy-efficiency criteria when buying new durables, while almost 80% of the top quintile favours efficient appliances. The proportion of energy-efficient lightbulbs is also increasing with the Attitude Index; households with the lowest ATI on average have a 50% share of environmentally friendly lightbulbs, while it is closer to 80% for households with strong environmental concerns. Switching to alternative transport seems to be the biggest sacrifice at the altar of energy conservation. Among respondents one or more standard deviation

bellow the ATI's mean less than 20% consider using environmentally friendly ways of transport. Even among the most proenvironmental population only around 40% choose this option.

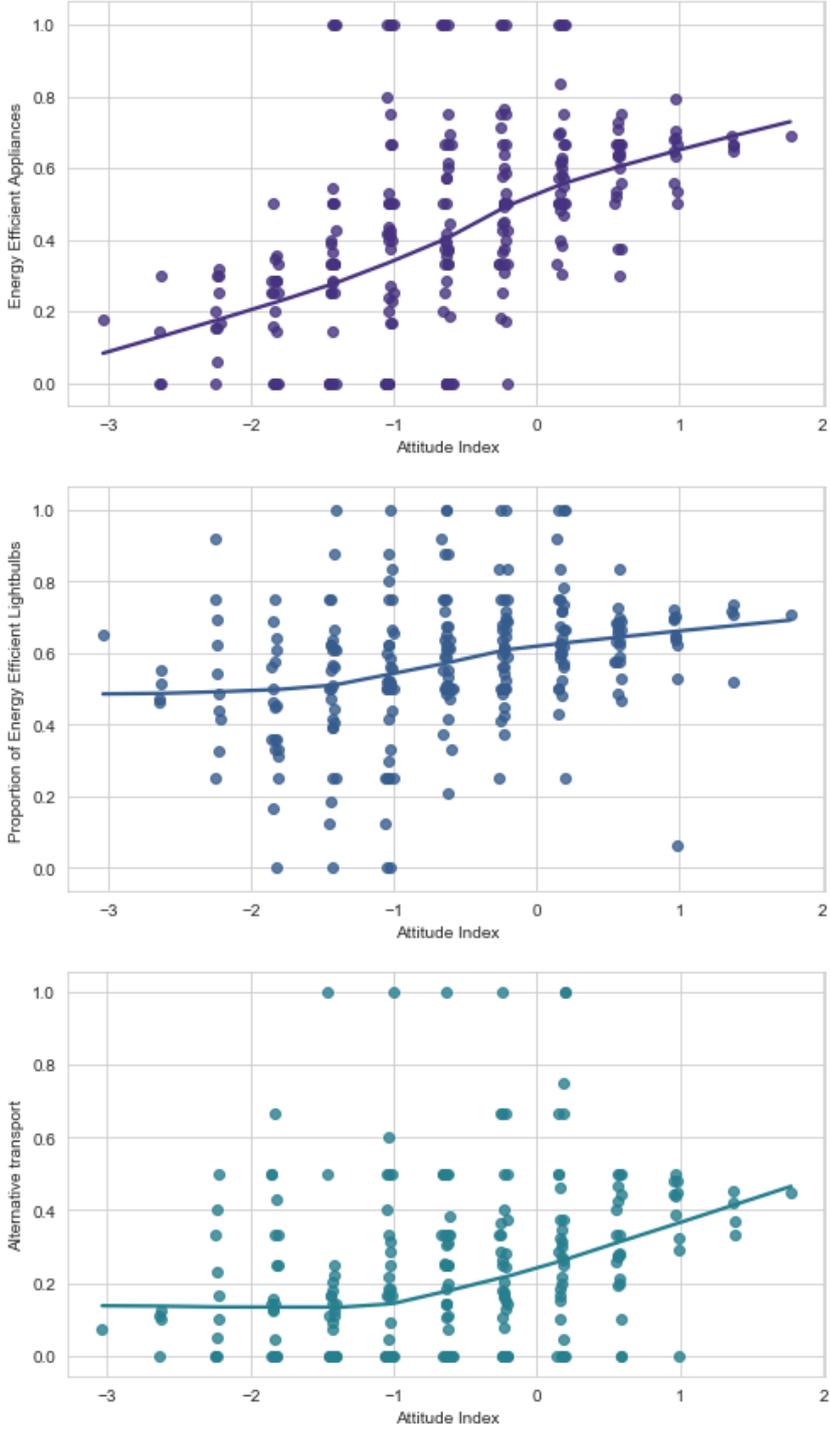


Figure 6: Lowess curve of the ATI on energy-efficiency measures

Data Source: enable-eu (2019)

Finally, Figure A1 in the Appendix shows that the relationship between the ATI and the efficiency measures can vary greatly across countries. German respondents for example generally more energy-efficient, however there seems to be no significant relationship between their attitude and their energy saving actions. Furthermore, Eastern-European citizens are seldomly choose alternative transport methods even if they hold proenvironmental values. This could be due to cultural differences and the lack of appropriate infrastructure.

The results so far indicate a positive relationship between proenvironmental attitudes and energy-efficient behaviour. However, as highlighted above, there are several other confounding factors that both affect the ATI and household level energy-efficiency such as respondents' income and education level or building characteristics and regional differences. To investigate, whether this connection is statistically plausible a more in-depth analysis is required, which is described in the next chapter.

4. Research design

4.1. Casual framework

The hypothesis of this paper argues that proenvironmental attitudes, including concerns about current environmental issues and a general moral stance towards the preservation of the environment positively affect households' energy-efficient behaviour. In other words, individuals who believe that environmental change will cause severe problems in the near future, are willing to alter their behaviour and spend their resources to take their share in the prevention process. If proved correct, this proposition can help policymakers to efficiently communicate otherwise unpopular measures such as the carbon tax or congestion charges. Furthermore, it suggests that even more general, non-monetary initiatives, such as successful awareness campaigns and early age educational policies can incentivise citizens to modify their behaviour.

This is not the first study investigating the connection between one's beliefs and their actions. As highlighted in the literature review, many papers use the Value-Belief-Norm Theory and the Theory of Planned Behaviour to investigate how individual beliefs leads to action. The present paper tries to complete the literature in three ways. Firstly, it uses a new, cross-country dataset to compare how households in different societies implement proenvironmental behaviours. If similar effects are observed, it can increase the external validity of the findings. Secondly, the Attitude Index used in this paper grasps how less specific personal norms and values affect behaviour. Finally, I use a set of outcome variables to capture the latent qualities of household level energy-efficiency, hence creating more robust results. These qualities make the result of this study more generalizable therefore, possibly a better tool for policymakers who cannot necessarily rely on a concrete policy that is empirically found to be effective.

The linkage between the dependent variable(s) and the main independent variable is depicted by the causal map on Figure 7. It shows how individuals' norms, and beliefs lead to observable action to improve households' energy-efficiency. Similarly to the VBN, the linkage suggests that awareness of the consequences of environmental change can influence one's attitude towards the environment ultimately altering her/his behavioural intentions. This can lead to habitual changes, such as choosing an environmentally friendly mean of transport, or it can cause household level energy-efficiency improvements illustrated by purchase intentions.

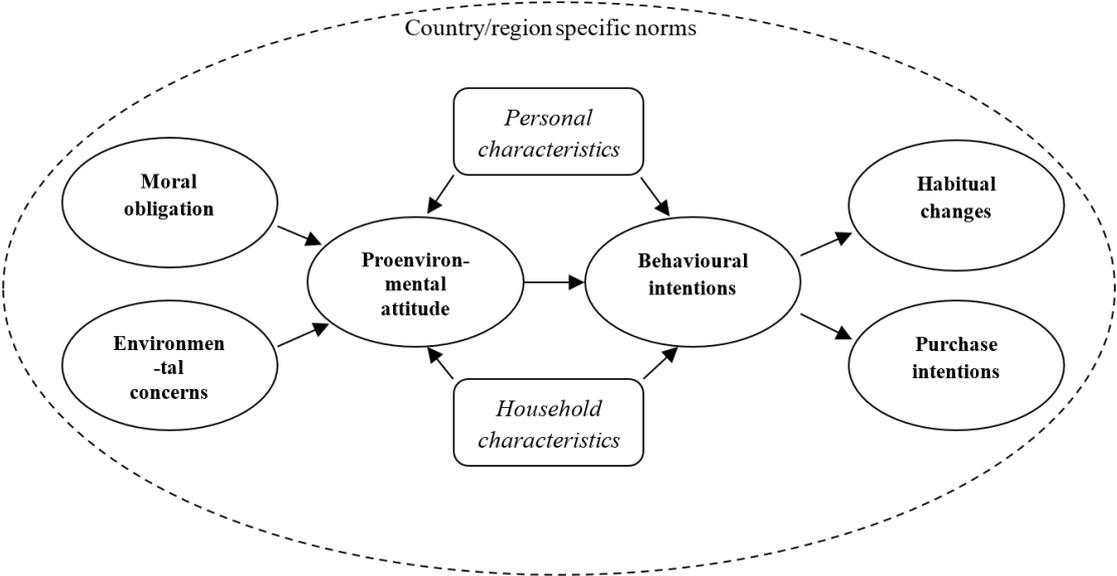


Figure 7: Causal map of the research design
 Source: Author's creation

4.2. Methodology

As could be seen in the data description chapter, other factors such as gender, age, education level and household characteristics such as settlement- and household type and size can also affect personal attitudes and behaviours. As suggested by Mills – Schleich (2010) and Di Maria et al. (2010) education and income positively affects energy-efficient behaviour. Wang et al. (2017) argues that age also have a positive effect. Figure 5 highlights that the ATI in this sample also varies with these characteristics. Furthermore, country- and region-specific factors and cultural norms can too have an effect, hence must be accounted for. To deal with endogeneity,

the paper applies regression models on the dataset, supported by several robustness checks. The base model is described by the following equation:

$$(1) Y_{hi} = \alpha_{hi} + \delta \times ATI_i + \beta_1 \times pchar_i + \beta_2 \times hchar_h + \gamma \times Country_{hi} + \omega_{hi}$$

where Y_{hi} represents the dependent variables, ATI_i is the Attitude index, hence δ shows the effect of proenvironmental attitudes on energy-efficiency. $pchar$ is a vector of personal characteristics such as gender, age, education level, $hchar$ includes household level characteristics, $Country_{hi}$ is the country level fixed effect and ω_{hi} is the error term. The equation represents a linear probability model (LPM) for the two binary dependent variables.

In addition to the base model, other model specifications are used as robustness checks. First, average marginal effects of logistic regressions are reported for the binary outcome variables to address potential non-linearities in the relationship of the ATI and energy-efficient behaviour. Secondly, NUTS 1⁴ regional fixed effects are used to investigate whether regional policies and cultural characteristics lead to estimation bias. Since different regions can have distinct policy measures and infrastructure, these could alter the level of households' energy-efficient technology adoption. Furthermore, regions' cultural heritage, religious values and even the local media could affect their citizens proenvironmental attitudes. These additional models are used to grasp whether the effects of these factors significantly alter the estimated effect of proenvironmental attitudes on energy-efficient behaviour.

4.3. Checking bias due to imbalances with Coarsened Exact Matching

Finally, a matching method is applied on the data to observe potential bias and estimation variance caused by the different group characteristics of respondents with relatively low versus relatively high Attitude Indices.

⁴ Nomenclature of Territorial Units for Statistics is a geocode standard for referencing the subdivisions of countries for statistical purposes. NUTS 1 is the widest level of classification, followed by NUTS 2 and NUTS 3.

Iacus et al. (2012) describes matching as a quasi-experimental, nonparametric method to control for confounding variables affecting both the outcome variable and the dependent variable. The goal of matching is to filter the data to only include observations that have *balance* across potential confounders, achieving a similar distribution of covariates across treated and control groups. A perfectly balanced data in theory allows researchers to observe the causal treatment effect by simply subtracting the means of treated and control units, on the other hand, a regression on an approximately balanced data should include some controls. The matching method can lead to less model dependence and reduced statistical bias compared to models applied on the full dataset. Nonetheless, it is important to highlight, that all matching techniques are based on the same exogeneity assumptions as OLS regressions, hence it cannot help reducing the bias caused by unobservable factors.

Coarsened Exact Matching (CEM), developed by Blackwell et al. (2009) is an exact matching method where balance is achieved on a predefined set of confounders. However, instead of considering an exact copy of each treated unit in the control group – based on the predefined covariates –, CEM uses a binning strategy by relaxing the condition that the control-treatment pairs must be exactly the same based on every covariate. This way the covariates are partitioned into bins and the relaxed condition states that each indicator for the treatment-control pairs should belong to the same bin but does not have to take the same value (e.g. it is sufficient for a treatment-control pair to belong to the same age cohort instead of having to have the same age).

To apply CEM in the current context, the ATI has to be transformed into a binary variable using the zero score as the cut-off point, thus observations with an ATI score higher than zero take the value 1, and observations below zero receive 0 (see Figure 3). In equation (2) the ATI is replaced with this binary variable D_i that is 1 if the respondent has positive relative attitude towards the environment and 0 otherwise. Although the transformation prevents result

comparison with the base models, it can reveal whether potential imbalances lead to significant bias.

$$(2) Y_{hi} = \alpha_{hi} + \delta \times D_i + \beta_1 \times pchar_i + \beta_2 \times hchar_h + \gamma \times Country_{hi} + \omega_{hi}$$

Table IV/A Unmatched (full) dataset

	L1 distance	Mean dif.	Min.	25%	50%	75%	Max
Respondent's age cohort	0.073	-1.760	0	-1	-2	-3	0
Respondent's gender	0.053	0.053	0	0	1	0	0
Respondent's edu. level	0.096	0.111	0	0	0	0	0
Respondent's income decile	0.111	0.016	0	0	-1	0	0
Respondent's job stat.	0.074	-0.127	0	0	-1	0	0
Country	0.240	-0.658	0	-1	-2	0	0
Household attached to others	0.016	-0.016	0	0	0	0	0
Children in household	0.010	-0.010	0	0	0	0	0
<i>Multivariate L1 distance</i>	<i>0.830</i>						

Table IV/B Matched dataset

	L1 distance	Mean dif.	Min.	25%	50%	75%	Max
Respondent's age	0.045	0.074	0	0	1	0	0
Respondent's gender	0.000	0.000	0	0	0	0	0
Respondent's edu. level	0.000	0.000	0	0	0	0	0
Respondent's income decile	0.000	0.000	0	0	0	0	0
Respondent's job stat.	0.000	0.000	0	0	0	0	0
Country	0.000	0.000	0	0	0	0	0
Household attached to others	0.000	0.000	0	0	0	0	0
Children in household	0.000	0.000	0	0	0	0	0
<i>Multivariate L1 distance</i>	<i>0.537</i>						
<i>N total</i>	<i>5377</i>						
<i>N matched</i>	<i>2371</i>						

Data Source: enable-eu (2019)

Approximate balance is achieved across age cohorts (deciles), gender, levels of education, income deciles, country of residence, number of children and across households located in rural and urban areas and whether they are detached from other buildings. Table IV/A and B show the covariate balance before and after the application of CEM. By utilizing the method proposed by Iacus et al. (2011), the paper uses the L1 distance metric to calculate the difference between the empirical distribution of covariates in the treatment and control groups. The multivariate L1 distance summarizes the difference of the joint distribution of all covariates used in the matching procedure. The indicator can vary between zero and one, and while it cannot be interpreted by itself, comparing the two tables it suggests a large relative increase in balance

across all potential confounders. The tables also report the difference in the empirical quantiles of the distributions of the two groups for every variable.

The next chapter shows the result of the base model and investigates whether the robustness checks significantly affect the estimates. Comparing the coefficients on the full dataset with the results on the matched data shows if the effect of relatively high proenvironmental values is biased due to imbalances in the confounders.

5. Results

This chapter reports the results of the empirical models to investigate the relationship between households' proenvironmental attitude and their energy-efficiency measures. The first part summarizes the results on the complete dataset using multiple model specifications. The second part presents the estimates from several robustness checks. The third part highlights the limitations of the present study and the final part of this chapter draws policy conclusions.

5.1. Main results

Table V, VI and VII report the regression results separately for each dependent variable. The first columns present the effect of proenvironmental attitude on energy-efficiency without any additional controls. Columns 2-3 add individual and household level confounders and the 4th columns extend the models with country level fixed effects. The last columns report the results of interactions between each country and the ATI to compare cross-country effects. Clustered standard errors are in parenthesis and the stars indicate significance levels. The dataset only includes respondents older than 29 to consider potential decisionmakers in each household. Finally, all models use sample weights to adjust for potential differences between personal and household level characteristics reported by countries' national statistics offices and the sample.

Results of Table V indicate a significantly positive relationship between respondents' Attitude Index and the average share of energy efficient lightbulbs in their households. Model 4 indicates that households with a one standard deviation larger ATI on average have a 3.9 percentage-points higher share of efficient lightbulbs. Other individual and household level characteristics do not affect efficient lightbulb adoption significantly, however there are measurable cross-nation differences. Model 5 reports that on average among western households the ATI's effect is significantly lower. In French (base category) and German households the effect size is around 2 to 3 percentage-points, while among Norwegian households proenvironmental values

do not lead to significantly higher energy-efficient lightbulb share. Meanwhile the Polish, Ukrainian and Hungarian effect size is considerably larger varying between 3.7 to 8.8 percentage-points. The two outliers are the UK, where the effect size is closer to the eastern estimates and Serbia, where the generally low adoption rate leads to a small impact of the ATI. As mentioned earlier, the east-west divide can be explained by national policy differences; among western households the adoption rate is already reasonably high, hence it does not reflect environmental concerns efficiently. This highlights the importance of using several outcome variables, especially in a cross-country context.

Table VI presents the results of the linear probability models of energy Efficient Appliance Purchase Intentions. This efficiency measure indicates whether respondents choose a household durable primary because it is more energy-efficient than the others. As described earlier, compared to lightbulb adoption it entails a larger initial investment cost, and its economic benefits are less obvious. Nevertheless, according to the results among respondents with a one standard deviation larger Attitude Index the likelihood that the household's purchasing decision is primary influenced by the durable's efficiency is on average 10.9 percentage-points higher. Other than the ATI, individuals' education level, and to some degree their income also affects purchase intentions. This is not at all surprising considering the higher initial investment costs and the extra knowledge required to understand more complicated labelling schemes as described by Mills – Schleich (2010). There are too cross-country differences, but the east-west division is not present. Polish, Norwegian, and Hungarian households' intentions increase the most if they are more concerned about the environment, while Germans tend to purchase energy-efficient products independently from their stance on environmental issues (also see Figure A1).

The last efficiency measure meant to investigate whether proenvironmental values can lead to significant habitual changes. The Alternative Transport Choices indicator shows whether

respondents are willing to switch from their car to more environmentally friendly means of transport. As suggested earlier, this change requires the most effort, since respondents often need to alter their everyday schedule to consider an often more time-consuming way of transport. Column 4 in Table VII reports that respondents with a one standard deviation higher ATI on average have an 8.2 percentage-points higher likelihood that they choose an alternative transport method. Education- and income-level positively affect the probability, while respondents living in a detached home or in a rural location are less likely to choose this option. This is probably because detached family houses are more likely to be outside of the city (for example in a suburbia) and rural areas are often lack alternative transport options. Finally, the lack of infrastructure could potentially explain the differences between Eastern- and Western-European countries. As highlighted by the last column of Table VII, the ATI has a larger effect in all western nations than in any eastern ones. Intuitively it is plausible that the better transport infrastructure and less dependence from the capital city allows the citizens of these countries to switch to more environmentally friendly transport without sacrificing too much of their time.

Overall, the results support the hypothesis that proenvironmental beliefs significantly positively affect household level energy-efficiency. Furthermore, as indicated by Barr et al. (2005), the ATI suggest that even more general concerns about environmental issues can lead to concrete action. However, different forms of energy-efficiency actions are affected differently depending on country level policies and investment/adoption costs. This highlights the need of measuring energy-efficiency in multiple ways so the latent qualities of the indicator can be efficiently captured. To provide more robust evidence, the next chapter considers more model specifications describing the above relationship.

Table V OLS of Households` Energy Efficient Lightbulb share on Attitude Index and controls

	(1)	(2)	(3)	(4)	(5)
Attitude Index	0.054** (0.020)	0.045** (0.018)	0.049** (0.016)	0.039*** (0.010)	0.022*** (0.002)
Respondent`s age (log)		-0.018 (0.036)	-0.015 (0.034)	-0.029 (0.024)	-0.031 (0.025)
Gender		-0.028* (0.013)	-0.021 (0.012)	-0.014 (0.012)	-0.012 (0.011)
College degree		0.253* (0.125)	0.193 (0.109)	0.111 (0.087)	0.106 (0.087)
Income decile		-0.008 (0.006)	-0.005 (0.005)	-0.003 (0.005)	-0.003 (0.005)
Number of Children (18>)			0.026* (0.012)	0.007 (0.004)	0.007 (0.004)
Number of Elderly (65<)			0.038** (0.014)	0.001 (0.007)	0.001 (0.007)
Subsidy related to energy ef. and CO2 emis.			0.100* (0.048)	0.035 (0.028)	0.035 (0.027)
Detached			-0.076*** (0.017)	-0.028 (0.017)	-0.027 (0.017)
Rural			0.004 (0.019)	0.007 (0.019)	0.003 (0.021)
Germany*Attitude Index					0.004 (0.003)
Hungary*Attitude Index					0.066*** (0.002)
Norway*Attitude Index					-0.026*** (0.003)
Poland*Attitude Index					0.015*** (0.003)
Serbia*Attitude Index					0.007 (0.004)
Ukraine*Attitude Index					0.036*** (0.004)
UK*Attitude Index					0.026*** (0.003)
Constant	0.624*** (0.066)	0.586*** (0.165)	0.522** (0.164)	0.547*** (0.113)	0.755*** (0.108)
Observations	5,377	5,377	5,377	5,377	5,377
R-squared	0.023	0.075	0.109	0.281	0.286
Sample weights	Yes	Yes	Yes	Yes	Yes
Individual Char.	No	Yes	Yes	Yes	Yes
Household Char.	No	No	Yes	Yes	Yes
Country FE.	No	No	No	Yes	Yes

Clustered standard errors in parentheses, *** p<0.01 ** p<0.05 * p<0.1

Notes: Sample weights are used in each model; the sample only includes individuals older than 29 years to observe potential decision makers; building characteristics (age, size, type) the respondents` employment status and education level are controlled for but not included in the table; the base category for the interaction is France.

Data Source: enable-eu (2019)

Table VI LPM of Energy Efficient Appliances purchase choices on Attitude Index and controls

	(1)	(2)	(3)	(4)	(5)
Attitude Index	0.137*** (0.014)	0.133*** (0.015)	0.133*** (0.014)	0.109*** (0.012)	0.091*** (0.003)
Respondent`s age (log)		0.046 (0.041)	0.055* (0.024)	0.039 (0.025)	0.035 (0.026)
Gender		0.008 (0.023)	0.014 (0.022)	0.015 (0.023)	0.015 (0.023)
College degree		0.071 (0.040)	0.056 (0.038)	0.063*** (0.013)	0.064*** (0.013)
Income decile		0.005 (0.003)	0.007* (0.003)	0.005* (0.003)	0.005* (0.003)
Number of Children (18>)			0.021 (0.014)	0.018 (0.010)	0.017 (0.010)
Number of Elderly (65<)			0.004 (0.016)	0.001 (0.010)	0.000 (0.010)
Subsidy related to energy ef. and C02 emis.			0.078* (0.036)	0.035 (0.039)	0.035 (0.040)
Detached			-0.053* (0.027)	-0.026 (0.022)	-0.027 (0.023)
Rural			0.031 (0.047)	0.057 (0.042)	0.056 (0.042)
Germany*Attitude Index					-0.055*** (0.005)
Hungary*Attitude Index					0.044*** (0.005)
Norway*Attitude Index					0.047*** (0.004)
Poland*Attitude Index					0.059*** (0.004)
Serbia*Attitude Index					-0.015*** (0.004)
Ukraine*Attitude Index					-0.016*** (0.003)
UK*Attitude Index					0.020** (0.006)
Constant	0.525*** (0.046)	0.303* (0.143)	0.141 (0.119)	0.207 (0.122)	0.315** (0.114)
Observations	5,377	5,377	5,377	5,377	5,377
R-squared	0.074	0.081	0.092	0.145	0.149
Sample weights	Yes	Yes	Yes	Yes	Yes
Individual Char.	No	Yes	Yes	Yes	Yes
Household Char.	No	No	Yes	Yes	Yes
Country FE.	No	No	No	Yes	Yes

Clustered standard errors in parentheses, *** p<0.01 ** p<0.05 * p<0.1

Notes: Sample weights are used in each model; the sample only includes individuals older than 29 years to observe potential decision makers; building characteristics (age, size, type) the respondents` employment status and education level are controlled for but not included in the table; the base category for the interaction is France.

Data Source: enable-eu (2019)

Table VII LPM of Alternative Transport choices on Attitude Index and controls

	(1)	(2)	(3)	(4)	(5)
Attitude Index	0.101*** (0.022)	0.097*** (0.022)	0.095*** (0.017)	0.082*** (0.013)	0.089*** (0.002)
Respondent`s age (log)		0.003 (0.039)	-0.011 (0.050)	-0.029 (0.049)	-0.033 (0.049)
Gender		-0.033* (0.015)	-0.029* (0.014)	-0.021 (0.015)	-0.024 (0.014)
College degree		0.103** (0.040)	0.070* (0.035)	0.058** (0.020)	0.056** (0.020)
Income decile		0.010 (0.006)	0.012* (0.005)	0.010* (0.005)	0.011* (0.005)
Number of Children (18>)			0.005 (0.016)	0.012 (0.011)	0.012 (0.012)
Number of Elderly (65<)			0.018 (0.015)	0.012 (0.008)	0.012 (0.008)
Subsidy related to energy ef. and C02 emis.			0.064** (0.024)	0.039 (0.023)	0.038 (0.021)
Detached			-0.101*** (0.012)	-0.035** (0.014)	-0.037** (0.014)
Rural			-0.097** (0.032)	-0.060* (0.027)	-0.058* (0.028)
Germany*Attitude Index					0.006* (0.003)
Hungary*Attitude Index					-0.030*** (0.003)
Norway*Attitude Index					0.086*** (0.003)
Poland*Attitude Index					-0.035*** (0.003)
Serbia*Attitude Index					-0.031*** (0.003)
Ukraine*Attitude Index					-0.045*** (0.003)
UK*Attitude Index					0.003* (0.001)
Constant	0.284*** (0.051)	0.201 (0.171)	0.270 (0.209)	0.232 (0.159)	0.456** (0.168)
Observations	5,377	5,377	5,377	5,377	5,377
R-squared	0.050	0.067	0.096	0.154	0.160
Sample weights	Yes	Yes	Yes	Yes	Yes
Individual Char.	No	Yes	Yes	Yes	Yes
Household Char.	No	No	Yes	Yes	Yes
Country FE.	No	No	No	Yes	Yes

Clustered standard errors in parentheses, *** p<0.01 ** p<0.05 * p<0.1

Notes: Sample weights are used in each model; the sample only includes individuals older than 29 years to observe potential decision makers; building characteristics (age, size, type) the respondents` employment status and education level are controlled for but not included in the table; the base category for the interaction is France.

Data Source: enable-eu (2019)

5.2. Robustness checks

This chapter provides alternative model specifications to support the findings of the main models. Most of the following estimates cannot be directly compared to the main results due to different sample size, or due to the modifications needed to apply the CEM method, therefore these models solely act as robustness checks.

5.2.1. Potential nonlinearities in binary outcome variables

The main problem with Linear Probability Models is that their estimate is not constrained into a unit interval (Friedman, 2012). This means that the outcome variable can be predicted to be higher than 1 if covariates are strong predictors. Hence, as the number of predictions exceeding 1 (or falling below 0) grows, the coefficients of the main independent variable will be more biased.

To address this problem Table VIII. compares the estimates of the LPM-s with Probit and Logit models' average marginal effects. The results suggest that while the standard error moderately decreases, the coefficients of the Attitude Index only slightly varies across models. The ATI's effect is 0.3 percentage-points lower for Efficient Appliance Purchase Intentions and only 0.1 higher for Alternative Transport Choices. This suggests that the estimates are robust to models with nonlinear conditional probability functions.

5.2.2. Regional fixed effects

Regional and other sub-country level actions can influence personal proenvironmental attitudes and households' energy-efficiency behaviours. Local governments can subsidise energy efficient durables or lighting and could also promote environmentally friendly transport by building adequate infrastructure. These policies possibly lead to sub-state variation in the estimates. To capture this heterogeneity Table IX includes NUTS 1 regional fixed effects. The results cannot be compared to previous estimates, since due to data limitation the UK and France had to be excluded from the analysis. However, comparing the results to the country

level fixed effect models (odd columns in the table) gives an idea how regional policy differences alter the effect of the ATI on the outcome variables.

According to the coefficient estimates, controlling for regional differences increases the effect size of the Attitude Index by 0.5 to 1.1 percentage-points. The largest added growth can be observed regarding Alternative Travel Choices; this could indicate that sub-national infrastructural differences can indeed prevent respondents living in poorer regions to consider this option. Differences in energy-efficient durable adoption (including lightbulbs) can be also explained by regional policies; governments of richer and more progressive regions close to the capital or located in more industrialized areas can incentivise efficient appliance purchase with subsidies, reducing the initial investment costs of poorer, but otherwise proenvironmental citizens.

5.2.3. Results on the matched data

Table X compares the coefficients estimates on the full dataset and on the matched data. As previously indicated, the Attitude Index is transformed into a binary variable which takes the value of 1 if the ATI is greater than zero and 0 otherwise. Therefore, an observation with an attitude dummy of 1 has a positive relative attitude compared to its peers.

Results on the balanced data indicate that households with proenvironmental attitudes have a 6 percentage-points higher share of energy-efficient lighting compared to their peers, their likelihood of purchasing efficient appliances is 16.5 percentage-points higher, and the respondents` likelihood of choosing environmentally friendly transport methods is 10.9 percentage-points larger. There are no significant differences for the Energy-efficient Lightbulb Share and Energy-efficient Appliance Purchase estimates, however the coefficient on Alternative Transport Choices is 1.8 percentage-points higher on the full dataset. This indicates that the imbalances in the data could cause upward bias in the estimated effect of the ATI on

using environmentally friendly travel. While this must be taken into account, the size of the bias does not suggest that different policy conclusions should be considered.

Overall, the effect of the ATI on household level energy-efficiency mostly robust to model specification differences. Although a few estimates slightly differ across these specifications, the variation is low relative to the effect size. Consequently, the above results reinforce the hypothesis of this paper, that strong moral obligation towards solving environmental issues paired with environmental concerns can act as a steppingstone for households to adopt more energy-efficiency measures. However, before drawing policy conclusions, I present the limitations of this study.

5.3. Limitations

Although the study attempts to rule out any potential estimation bias caused by endogeneity or model design, there are other factors that could possibly cause distorted results. Firstly, the Attitude Index is not a perfect measure of proenvironmental attitudes; as indicated by the literature review there are many, potentially better indicators that can explain individuals' stance on environmental issues. International surveys are meant to be less specific, hence they are not designed to focus on a narrow issue such as proenvironmental attitude. Therefore, to evaluate the policy potential of the results it is important to understand the underlying questions used to formulate the ATI. Secondly, while I use three separate indicators to capture household level energy-efficiency, there are many other aspects to this latent variable that are not being accounted for. Although there could be better indicators to measure energy-efficiency, many similar studies choose these variables as demonstrated earlier. Furthermore, probably it would be counterproductive to try to map out all potential energy-efficiency factors considering all – often unobservable – obstacles households must face to apply some energy-saving measures.

In the third place, survey data has its own limitations; respondents' answers can be inaccurate and subjective leading to biased estimates. Adverse selection is another issue, because individuals who decide to participate in the survey can be inherently different than those who reject the participation. Even if respondents correctly and mostly objectively fill the survey and the non-participation is nearly random – or at least independent from their attitude towards environmental issues –, there are other factors that can lead to potential bias. Although NUTS 1 regional fixed effects can control for some sub-country level differences, there are even smaller administrative units that can have separate policies. For example, the capital city and other rich cities can have many more subsidies towards energy-efficiency, than other, less wealthy areas. Finally, OLS assumptions can be also violated if there are unobservable confounders missing from the models. For example, religious beliefs, political views, and other similar factors could both affect individuals' energy-efficiency decisions and their stance towards the environment.

Some of these issues could certainly cause some level of estimation bias. However, I argue that even if these limitations are altering the effect size, there is a clear and significant connection between proenvironmental attitude and household level energy-efficiency, therefore, policy conclusions can be drawn.

Table VIII Probit and Logit marginal effects - Comparison with LPM

	(1)	(2)	(3)	(4)	(5)	(6)
	Efficient Appliances			Alternative Transport		
	LPM	Probit	Logit	LPM	Probit	Logit
Attitude Index	0.109*** (0.012)	0.106*** (0.010)	0.105*** (0.010)	0.082*** (0.013)	0.083*** (0.010)	0.083*** (0.010)
Respondent's age (log)	0.039 (0.025)	0.037 (0.025)	0.036 (0.025)	-0.029 (0.049)	-0.026 (0.046)	-0.028 (0.047)
Gender	0.015 (0.023)	0.016 (0.023)	0.015 (0.023)	-0.021 (0.015)	-0.022 (0.015)	-0.023 (0.014)
College degree	0.063*** (0.013)	0.061*** (0.012)	0.061*** (0.012)	0.058** (0.020)	0.054*** (0.016)	0.056*** (0.015)
Income decile	0.005* (0.003)	0.005** (0.003)	0.005* (0.003)	0.010* (0.005)	0.009** (0.005)	0.010** (0.004)
Number of Children (18>)	0.018 (0.010)	0.018* (0.010)	0.018* (0.010)	0.012 (0.011)	0.013 (0.011)	0.012 (0.011)
Number of Elderly (65<)	0.001 (0.010)	-0.000 (0.011)	0.000 (0.010)	0.012 (0.008)	0.012 (0.008)	0.012 (0.008)
Subsidy related to energy ef. and CO2 emis.	0.035 (0.039)	0.034 (0.037)	0.035 (0.037)	0.039 (0.023)	0.042* (0.025)	0.039 (0.024)
Detached	-0.026 (0.022)	-0.026 (0.022)	-0.026 (0.022)	-0.035** (0.014)	-0.038*** (0.013)	-0.038*** (0.013)
Rural	0.057 (0.042)	0.057 (0.042)	0.057 (0.042)	-0.060* (0.027)	-0.053** (0.024)	-0.054** (0.022)
Constant	0.207 (0.122)			0.232 (0.159)		
Observations	5377	5377	5377	5377	5377	5377
R-squared	0.145			0.154		
Sample weights	Yes	Yes	Yes	Yes	Yes	Yes
Individual Char.	Yes	Yes	Yes	Yes	Yes	Yes
Household Char.	Yes	Yes	Yes	Yes	Yes	Yes
Country FE.	Yes	Yes	Yes	Yes	Yes	Yes

Clustered standard errors in parentheses, *** p<0.01 ** p<0.05 * p<0.1

Notes: Sample weights are used in each model; the sample only includes individuals older than 29 years to observe potential decision makers; building characteristics (age, size, type) the respondents' employment status and education level are controlled for but not included in the table.

Data Source: enable-eu (2019)

Table IX Regression results with regional fixed effects

	(1)	(2)	(3)	(4)	(5)	(6)
	eff. bulbs	eff. bulbs	eff. appliances	eff. appliances	alt. travel	alt. travel
Attitude Index	0.040** (0.015)	0.050** (0.015)	0.112*** (0.017)	0.116*** (0.015)	0.079*** (0.020)	0.088*** (0.020)
Respondent's age (log)	-0.062** (0.018)	-0.058** (0.018)	0.010 (0.016)	0.020 (0.017)	-0.051 (0.051)	-0.029 (0.052)
Gender	-0.027** (0.010)	-0.031** (0.010)	-0.015 (0.019)	-0.015 (0.015)	-0.005 (0.014)	-0.003 (0.012)
College degree	0.106 (0.120)	0.101 (0.111)	0.081*** (0.016)	0.075*** (0.012)	0.027 (0.023)	-0.003 (0.030)
Income decile	-0.002 (0.007)	0.002 (0.008)	0.006 (0.004)	0.009 (0.005)	0.011 (0.006)	0.014** (0.005)
Number of Children (18>)	0.014** (0.005)	0.011** (0.004)	0.033** (0.009)	0.025* (0.010)	0.007 (0.008)	-0.004 (0.008)
Number of Elderly (65<)	0.009 (0.011)	0.011 (0.009)	-0.004 (0.012)	-0.005 (0.013)	0.006 (0.011)	0.007 (0.011)
Subsidy related to energy ef. and CO2 emis.	0.076 (0.044)	0.054 (0.039)	0.119*** (0.021)	0.084*** (0.018)	0.064 (0.034)	0.032 (0.037)
Detached	-0.041* (0.020)	-0.049* (0.020)	-0.022 (0.030)	-0.049 (0.050)	-0.025 (0.016)	-0.057 (0.029)
Rural	-0.009 (0.024)	-0.015 (0.018)	0.078 (0.058)	-0.010 (0.046)	-0.031 (0.030)	-0.065* (0.028)
Constant	0.788*** (0.095)	0.647*** (0.081)	0.377*** (0.067)	0.607*** (0.113)	0.266 (0.192)	0.385* (0.185)
Observations	3,817	3,817	3,817	3,817	3,817	3,817
R-squared	0.274	0.305	0.168	0.213	0.182	0.175
Sample weights	Yes	Yes	Yes	Yes	Yes	Yes
Individual Char.	Yes	Yes	Yes	Yes	Yes	Yes
Household Char.	Yes	Yes	Yes	Yes	Yes	Yes
Country FE.	Yes	No	Yes	No	Yes	No
Region FE.	No	Yes	No	Yes	No	Yes

Clustered standard errors in parentheses, *** p<0.01 ** p<0.05 * p<0.1

Notes: Sample weights are used in each model; the sample only includes individuals older than 29 years to observe potential decision makers; building characteristics (age, size, type) the respondents' employment status and education level are controlled for but not included in the table. Region FE. based on NUTS 1 regions. Models do not include UK and France.

Data Source: enable-eu (2019)

Table X Regression results on the matched data

	(1)	(2)	(3)	(4)	(5)	(6)
	eff. bulbs		eff. appliances		alt. travel	
	Full Data	Matched Data	Full Data	Matched Data	Full Data	Matched Data
Positive Attitude	0.060** (0.019)	0.060** (0.020)	0.168*** (0.029)	0.165*** (0.025)	0.127*** (0.017)	0.109*** (0.026)
Respondent`s age (log)	-0.030 (0.025)	-0.023 (0.034)	0.046 (0.025)	0.038 (0.057)	-0.037 (0.049)	-0.052 (0.043)
Gender	-0.011 (0.010)	0.011 (0.018)	0.019 (0.024)	0.013 (0.032)	-0.014 (0.017)	-0.036* (0.016)
College degree	0.132 (0.081)	0.242*** (0.042)	0.194*** (0.055)	0.319*** (0.078)	0.046 (0.038)	0.097 (0.104)
Number of Children (18>)	0.008 (0.004)	0.003 (0.006)	0.016 (0.011)	0.003 (0.011)	0.012 (0.010)	-0.002 (0.020)
Number of Elderly (65<)	0.002 (0.006)	0.004 (0.011)	-0.004 (0.009)	0.017 (0.012)	0.013 (0.008)	0.022** (0.008)
Subsidy related to energy ef. and CO2 emis.	0.034 (0.028)	0.004 (0.044)	0.014 (0.029)	-0.023 (0.035)	0.023 (0.022)	0.014 (0.044)
Detached	-0.033 (0.017)	-0.023 (0.029)	-0.023 (0.022)	0.018 (0.032)	-0.044** (0.013)	-0.043 (0.028)
Rural	0.009 (0.016)	0.016 (0.017)	0.077 (0.048)	0.101 (0.059)	-0.059* (0.029)	-0.050 (0.043)
Constant	0.748*** (0.113)	0.544** (0.182)	0.119 (0.086)	-0.150 (0.268)	0.467** (0.174)	0.440** (0.184)
Observations	5,377	2,371	5,377	2,371	5,377	2,371
Adjusted R-squared	0.268	0.307	0.129	0.120	0.149	0.139
Individual Char.	Yes	Yes	Yes	Yes	Yes	Yes
Household Char.	Yes	Yes	Yes	Yes	Yes	Yes
Country FE.	Yes	Yes	Yes	Yes	Yes	Yes

Clustered standard errors in parentheses, *** p<0.01 ** p<0.05 * p<0.1

Notes: Sample weights are used in each model; the sample only includes individuals older than 29 years to observe potential decision makers; building characteristics (size, type), the respondents` income decile, employment status and education level are controlled for but not included in the table.

Data Source: enable-eu (2019)

6. Discussion and policy implications

Respondents' proenvironmental attitudes found to have a positive relationship with their energy-efficient behaviour. Assuming that the limitations of this study do not significantly hinder the accuracy of the results, this relationship can be interpreted causally. This would indicate that a one standard deviation increase in the ATI leads to an average of 3.9 percentage-points growth in households' energy-efficient lightbulb share, an average of 10.9 percentage-points increase in the likelihood that the household's purchasing decision will be primarily influenced by the durable's efficiency, and an average of 8.2 percentage-points increase in the likelihood that individuals will choose an alternative transport method. These findings support earlier results by Di Maria et al. (2010), Albayrak et al. (2012), Urban – Scasny (2012), Fornara et al. (2016) and Wang et al. (2017) suggesting that environmental awareness and concerns regarding environmental issues lead to household level energy conservation actions.

These results have practical policy implications regarding energy-efficiency programs. Provided that proenvironmental attitudes can be influenced by relatively inexpensive awareness campaigns, household level energy-efficiency can be cheaply increased through well-designed programs. Furthermore, these policies can effectively reduce the negative sentiment against otherwise unpopular measures such as the carbon tax or congestion charges. Although, the size of the estimates does not necessarily indicate a huge and rapid drop in residential energy demand, if we consider the best-case scenario of 23% to 48% electrical consumption reduction predicted by Borg – Kelly (2011) and Almeida et al. (2011) respectively, the medium and long run effects of these policies can be very generous. Furthermore, thanks to the cross-country design of the survey, the results can be generalized to several EU countries. However, the effect size varies greatly across countries, thus additional cost-benefit analysis should be considered before policy implementation.

Besides the effect of proenvironmental attitudes, the effects of respondents' socio-economic characteristics are also considered, however these results are seemed to be less significant and mostly mixed. Although college education and income weakly affect Alternative Transport Choices and Energy-Efficient Appliance Purchase Intentions, – contrary to the results of Di Maria et al. (2010) – they do not significantly affect households' Energy-efficient Lightbulb Share. Furthermore, contrary to the results on Chinese household data of Wang et al. (2017), age does not seem to significantly affect energy-efficient behaviours in Europe.

Overall, the results indicate that promoting environmental awareness can help to reduce the residential sectors' energy demand. Thus, these policies can be important tools in the road to achieve the European Commission's 2030 Energy Efficiency Directive, which is a crucial milestone for Net-Zero 2050.

7. Conclusion

The residential sector of the European Union is accountable for close to one-third of the EU's final energy consumption, one-third of which is related to electricity usage and oil consumption. The energy demand generated by these products can be arguably reduced by low-cost energy-efficiency measures such as small household investments and by achieving personal habitual changes. The present study uses a new, cross-country survey-based dataset consisting responses of citizens of eight European countries to answer its research question whether proenvironmental attitudes promote energy-efficient behaviour.

To control for confounding factors, the paper applies regression models on the connection of the Attitude Index (ATI) and three separate energy-efficiency measures. The ATI is a standardized combination of four questions of the survey. The indicator is meant to measure the proenvironmental attitude of respondents by evaluating their level of moral obligation and concerns towards environmental issues. The dependent variables measure households' energy-efficient lightbulb share, respondents' energy-efficient appliance purchase intentions and their willingness to use environmentally friendly transport. The model estimates are further verified by additional robustness checks, such as alternative model specifications and regional fixed effect models. Furthermore, a matching method is applied on the data to observe potential bias and estimation variance caused by the different group characteristics of respondents with relatively low versus relatively high Attitude Indices.

The results indicate that households with a one standard deviation higher ATI have an average of 3.9 percentage-points higher share of energy-efficient lightbulbs, the likelihood that their purchasing decision is primarily influenced by the durable's efficiency is on average 10.9 percentage-points higher and on average they have an 8.2 percentage-points higher likelihood of choosing an alternative transport method. Assuming that the limitations of this study do not

significantly hinder the accuracy of the estimates, these results indicate that promoting environmental awareness can help to reduce the residential sectors` energy demand. Hence, the study can have practical policy implications for both EU-wide and national energy conservation programs.

Nonetheless, while the paper supports earlier research estimates further research is needed to address the limitations of the study. Furthermore, more specific cost-benefit analysis should be considered before implementing policies drawing on the ideas of this and previous studies.

Appendix



Figure A1: Lowess curve of the ATI on energy-efficiency measures by country

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Data cleaning, visualisation and regression codes are available at:
https://github.com/horn1994/CEU_Thesis_Codes