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THE ROLE OF ENVIRONMENTAL AND FINANCIAL MOTIVATIONS IN THE ADOPTION OF ENERGYSAVING TECHNOLOGIES: EVIDENCE FROM EUROPEAN UNION DATA

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The Role of Environmental and Financial Motivations in the Adoption of Energy-Saving Technologies: Evidence from European Union Data

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Abstract

This paper investigates whether households' environmental and financial motivations affect their investments in energy-saving technologies. Exploiting a comprehensive dataset covering 30 European countries, we investigate whether financially motivated and environmentally minded households present different adoption paths. The results show that environmental and financial motivations play an essential role in the decision to adopt energy-saving technologies, thus paving the way for policy actions targeted at enhancing consumer awareness. Our analysis also reveals that environmentally and financially motivated households exhibit different socio-economic profiles. We find that environmentally minded, highly educated households living in urban areas with a large family size are more likely to adopt energy-saving technologies than their counterparts with low levels of education living in rural locations. In addition, their financial situation is an important factor in explaining the adoption patterns of financially motivated households. From a methodological point of view, our analysis exploits both parametric and nonparametric methods. We use stochastic dominance analysis to rank the distribution functions of household behaviours and the logit model to investigate the socio-economic profiles of different groups.

Keywords: energy efficient technologies, adoption, environmental and financial motivation, stochastic dominance

***JEL* classification:** Q40, Q55, D1

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1. Introduction

Energy and climate policy focus on why there are still untapped opportunities for reducing energy costs through increased energy efficiency in the private residential sector. The economic literature has thoroughly investigated the causes of such under-investment, providing a large and variegated body of theory and evidence on the barriers to adopting energy-efficient technologies (Jaffe and Stavins, 1994; Jaffe et al., 2002). A growing quantity of scientific research demonstrates that consumer choices and actions often deviate from rational choice models, which suggest that economic actors objectively weigh up the costs and benefits of all alternatives before choosing the optimal course of action (Frederiks et al., 2015).

Against this background, in this paper, we contribute to the debate by examining the role of environmental and financial motivations in the adoption of energy-saving technologies. Exploiting data from the *Second Consumer Market Study on the Functioning of the Retail Electricity Markets for Consumers in the EU* (2017), which covers 30 European countries, we investigate whether households' environmental and financial motivations have an impact on the adoption of energy-saving technologies. The questions we are trying to answer in this work are the following: do financially and environmentally motivated households show different patterns of adoption in relation to energy-saving technologies? In addition, does a statement about being environmentally minded or financially motivated actually induce individuals and households to engage in the adoption of energy-saving technologies? In other words, does awareness translate to action? Moreover, there is substantial evidence that households' decisions to invest in energy-saving technology heavily depend on socio-economic factors (see Schleich, 2019; Trotta, 2018; Urban and Ščasný, 2012 among others). Accordingly, a second objective of this paper is to investigate whether the socio-economic determinants of adoption are different for financially and environmentally minded households. To account for financial motivations in the household decision-making process, we consider three energy-saving technologies of increasing cost: low-cost, low-energy bulbs, middle-cost energy efficiency-rated appliances, and investment in the thermal insulation of private buildings, which constitutes the most expensive form of energy-saving technology.

Our empirical investigation proceeds in two steps. In the first stage, we analyse whether household environmental and financial motivations induce different patterns in the adoption of energy-saving technologies in the European countries under consideration. Unlike previous literature, we use stochastic dominance methodology to determine whether environmental and financial motivations affect household behaviour. The stochastic dominance method is a useful tool for comparing distribution functions without relying on parametric assumptions. In this study, the stochastic dominance inference procedure is used to test several hypotheses concerning theoretical models regarding the so-called attitude-action gap (see, for example, Frederiks et al., 2015; Kollmuss and Agyeman, 2002).

In the second stage of our investigation, we delve further and analyse the socio-economic determinants of adoption. In this stage we are particularly interested in investigating whether households that reported different degrees of financial and environmental motivations also feature diverse socio-economic profiles. To examine this issue, we turn to a parametric model specification and estimate the probability of adopting energy-saving technologies in environmentally and financially minded households as a function of a number of socio-economic factors. In line with the extant literature, the covariates include socio-economic factors such as age, gender, education, family size, and household financial situation (Kastner and Stern, 2015; Mills and Schleich, 2010; Urban and Ščasný, 2012).

This paper is structured as follows: Section 2 describes the theoretical background in relation to the existing literature. Section 3 illustrates the data used in the analysis. Section 4 introduces the stochastic dominance procedure. Section 5 presents discusses the empirical results of the stochastic dominance analysis in addition to an investigation on the socio-economic determinants of adoption. Finally, Section 6 concludes the paper and presents some policy implications.

2. Motivation and Theoretical Background

How to encourage consumers to adopt environmentally friendly technologies represents a significant challenge for academics and policymakers. This is because the motivation that leads consumers to adopt energy-saving activities is complex and not easily identified. In the literature, a growing number of works support the view that the adoption of energy-saving technologies is not driven exclusively by financial reasons (i.e. saving on energy bills), but is also determined by pro-social behaviour (i.e. activities that are costly to those who undertake them and primarily benefit others) (see, for example, Whitmarsh, 2009). In the context of energy-saving technologies, pro-social behaviour translates into environmental motivation: an intrinsic motivation to protect the environment as a public good, for which individuals internalise the benefits associated with their decision (see, for example, Achtnicht, 2011; Benabou and Tirole, 2011; Brekke and Johansson-Stenman, 2008; Chersoni et al., 2022; Whitmarsh and O'Neill, 2010).

A significant number of studies provide evidence on the importance of cost reduction factors (e.g. reducing energy bills, paying less for energy-efficient appliances) as drivers for the adoption of energy-efficient technologies (Aravena et al., 2016; Jacksohn et al., 2019; Sütterlin et al., 2011; Zundel and Stieb, 2011). However, the available empirical investigations offer less clear-cut evidence on the role of environmental motivation[1] in adopting such technologies, providing sometimes controversial results (Martinsson et al., 2011; Schleich, 2019; Whitmarsh and O'Neill, 2010). In that respect, the literature presents evidence of the so-called attitude-action gap, a situation where there is a misalignment between consumer attitude and consumer's practical steps to reduce household energy consumption (Frederiks et al., 2015; Kollmuss and Agyeman, 2002). Although the attitude-action gap seems to grow wider for technologies whose implementation requires considerable monetary costs (Kastner and Stern, 2015; Pothitou et al., 2016; Whitmarsh and O'Neill, 2010), several studies offer contrasting evidence showing that environmental motivations also have positive effects on the adoption of costly technical measures such as energy-efficient appliances and home insulation (Poortinga et al., 2002; Schleich, 2019; Urban and Ščasný, 2012).[2] Despite an increasing interest in the financial and behavioural determinants of technologies, previous works have so far considered these issues separately (Kastner and Stern, 2015). This paper tries to reconcile these two strands of research while focusing on the attitude-action gap. In particular, this study contributes to the literature by investigating the following issues:

[1] Environmental motivation seems to influence behaviour by affecting attitudes to pro-environmental behaviour (Bamberg 2003).

[2] The same result also holds for photovoltaic systems, with environmental motivations and knowledge of renewable energies positively increasing the probability of adoption (Bashiri and Alizadeh, 2018; Bergek and Mignon, 2017).

i) We ask whether households that are highly financially or environment motivated adopt more than little (or no) motivated households (see also Frederiks et al., 2015).

ii) We explore the attitude-action gap hypothesis, asking whether attitudes towards environmental and financial matters lead to adoption (Claudy et al., 2013).[3]

iii) We investigate the relative impact of environmental and financial motivations on adoption decisions.

iv) We identify the socio-economic background of the adopting households who express financial or environmental motivations.

To investigate points *i–iii* we apply a nonparametric stochastic dominance approach, whereas point *iv* is examined by estimating a logistic regression model.

3. Data

This study exploits data from the *Second Consumer Market Study on the Functioning of the Retail Electricity Markets for Consumers in the EU* (2017), which investigates consumers' awareness, attitude, and experience in relation to electricity services. The survey, in the form of a questionnaire, was administered between July 2014 and October 2015 to individuals (aged 18 to 95) in charge of paying the electricity bill in their household. The original dataset includes 29,119 interviews conducted with a mixed-mode approach (online, telephone, and face-to-face) across 30 European countries (28 countries in the European Union, in addition to Iceland and Norway). Quotas regarding age, gender and region ensure the sample representativity in each country. The number of completed interviews per country was, on average, 1,000, whereas for smaller countries (i.e. Cyprus, Iceland, Luxemburg and Malta), the average number of interviews was approximately 500.

In addition to households' socio-demographic background (see Table 1, Panel A), the survey includes information about the consumers' attitudes towards energy efficiency. Our analysis of households' financial and environmental attitudes pivots on the following statements: "It is important for me to save energy for financial reasons" and "It is important for me to save energy for environmental reasons". Respondents indicate the importance of energy savings for environmental or financial reasons using an 11-point Likert-type variable ranging from totally disagree (0) to totally agree (11). We re-arranged the information contained in the original dataset into three groups to define low (0–3), medium (4–7), and high (8–11) levels of financial and environmental motivations (see Table 1, Panel B). The questions are particularly suitable for investigating the attitude-action gap hypothesis, as we can observe different levels of motivation regarding both adopting and non-adopting households. Moreover, the questions provide a cardinal order for the level of pro-energy-saving attitude. Often, attitudes are much broader in scope than the measured actions, leading to significant discrepancies in measurement and correlation between attitude and behaviour (Kollmuss and Agyeman, 2002).

[3] Claudy et al. (2013) have approached the matter in a similar way, suggesting that households' attitudes towards solar panels' environmental and economic benefits influence consumers' adoption intentions. However, the authors do not investigate whether those attitudes translate into behaviour.

We also observe the adoption rate of three technologies: light emitting diodes (LED bulbs), efficient appliances, and thermal insulation (see Table 1 Panel C). These technologies reflect the increasing cost and complexity level of the adoption, from the lowest level (i.e. LED bulbs) to the highest (i.e. thermal insulation). It is worth noting that the adoption of energy-efficient appliances and LED bulbs are explored for tenants and homeowners, whereas insulation measures are considered for homeowners only.[4] After data cleaning[5], our sample includes 23,808 households. Table 1 describes the sample in more detail.

These data allow us to investigate: *i*) for what type of households, and *ii*) at what level of motivation the attitude-action gap begins. In particular, we will explore how socio-demographic features (PANEL A) relate to households' individual environmental and financial motivations (PANEL B) and the importance of attitude (PANEL B) in determining the adoption of energy-saving technologies (PANEL C).

[4] This avoids the split incentives problem (Castellazzi et al., 2017; Melvin, 2018), ensuring that the household has the contractual power to enact the investment decision (Bertoldi et al., 2021).
[5] To ensure the accuracy analysis, we preprocessed the dataset by removing the observations with missing values.

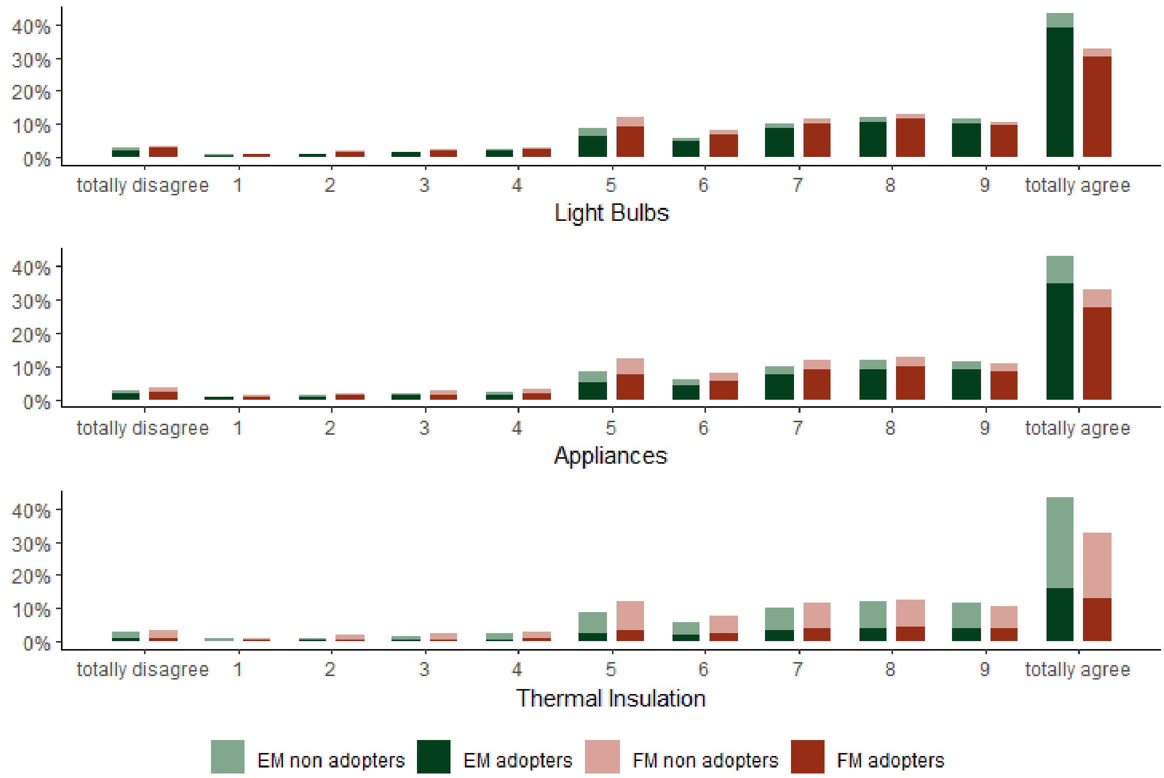
Table 1. Descriptive Statistics.

	Number of Observations	*Frequency*
Panel A: Socio-Economic Variables		
Age		
18-30	5502	23.11
	24.89 (mean)	3.34 (sd)
31-65	17322	72.76
	45.81(mean)	9.49 (sd)
>65	984	4.13
	71.83 (mean)	5.22 (sd)
Gender		
Male	11,672	49.03
Female	12,136	50.97
Education		
Primary education	2,984	12.53
Secondary education	10,900	45.78
Tertiary education	9,924	41.68
Population density		
Urban areas[6]	13,806	57.99
Rural areas	10,002	42.01
Financial situation		
High/Medium High	11,584	48.66
Low/Medium Low	12,224	51.34
Family size		
1	9,178	38.55
2	6,471	27.18
3	5,495	23.08
4	1,901	7.98
More than 4>	679	3.2
Family size	3.12 (mean)	1.17 (sd)
Panel B: Attitude		
Financially motivated households		
No/Low financial motivations	1,542	6.48
Medium	6,420	26.97
High financial motivations	15,820	66.57
Environmentally motivated households		
No/Low environmental motivations	2,176	9.14
Medium	8,265	34.72
High financial motivations	13,361	56.14
Panel C: Technologies		
Energy-saving light bulbs (LED)		
Non-adopters	3,088	12.97
Adopters	20,720	87.03
Energy-efficient appliances		
Non-adopters	5,981	25.12
Adopters	17,827	74.88
Insulation		
Non-adopters	15,572	65.41
Adopters	8,236	34.59

It is worth noting that most households declare a high level of motivation and that the adoption rate decreases as the cost and the complexity of technology increases. Figure 1 shows the distribution of financial and environmental motivations among adopters and non-adopters of the observed technologies.

[6] Urban areas encompass at least 5,000 residents per squared kilometer. Territories that do not meet this criterion classify as Rural.

Figure 1. Distribution of financial and environmental motivations.



It appears that for insulation, the technology that involves the highest cost, the level of both environmental and financial motivations are more remarkable for non-adopters hinting at the presence of the attitude action gap. The opposite occurs for LED bulbs and energy efficient appliances, where high motivations are more likely to result in adoption.

4. Stochastic Dominance Inference Procedure for Energy-Saving Behaviour

Stochastic dominance is a nonparametric procedure that allows for comparing different empirical cumulate distribution functions. The procedure was first introduced by Smirnov (1939) and it was followed by numerous extensions to different concepts of stochastic dominance under alternative data-generating process assumptions; see, for example, McFadden (1989), Anderson (1996), Barrett and Donald (2003) and Scaillet and Topaloglou (2010), among others. This methodology has been used in financial applications to rank different investment strategies (see, for example, Wong et al., 2008, and the references therein). In economic applications it has often been employed to measure income and poverty inequality, or to assess the effects of different treatments, social programmes, or policies (see, for example, Davidson and Duclos, 2000).

To the best of our knowledge this is the first application in the field of energy economics. Most related works investigate the association between pro-environmental attitudes and energy-saving behaviours mainly by utilising simple correlation analysis or different types of parametric models. In this respect, limited dependent variable models are popular choices, because the variables representing various attitudes (e.g. willingness to pay more for energy-efficient appliances) are typically binary (see, for example, Aguilar and Vlosky, 2007; Ku and Yoo, 2010; Liang et al., 2019). However, motivational factors relating to households' energy-saving and pro-environmental behaviour are latent variables, which are not directly observable by the investigator and are challenging to measure. As a result, these types of parametric models are likely to suffer from simultaneity bias and omitted variable problems. In this respect, the stochastic dominance procedure, being a model-free nonparametric approach, is robust to these types of specification issues. In addition, linear correlation type models make inferences on the conditional or unconditional distribution of variables of interest using the first and second statistical moments, while, in contrast, the stochastic dominance criterion considers the entire distribution of the data. This is an important feature, since the actual data-generating process of the variable under investigation is unknown.

4.1. Concepts of Stochastic Dominance

This section presents the conceptual framework for the stochastic dominance procedure. Following standard consumer theory, we assume that households maximise their utility function either: *i*) by minimising energy costs for financial reasons, or *ii*) by minimising adverse environmental effects related to their energy consumption; or *iii*) they can have both objectives *i*) and *ii*) in their utility function. In particular, households can increase their welfare by making three energy efficiency investments with an increasing monetary cost from low to high. The first type of energy-saving investment is classified as low-cost and corresponds to the adoption of low-energy bulbs, which we refer to as "*Lights*". The second type of energy-saving investment is the medium-cost adoption of energy-efficiency-rated appliances, which we label "*Appliances*". Finally, the most expensive energy-saving technology is the investment in thermal insulation for their property, which we refer to as "*Insulation*" hereafter.

Let W_1 denote the class of all von Neumann-Morgenstern type of utility functions, *w*, such that households' utility decreases in energy-related cost that is $w' \leq 0$. Also, let W_2 denote the class of all utility functions in W_1 for which $w'' \leq 0$ (i.e. strict concavity), and W_3 denote a subset of W_j for which $\text{u}''' \leq 0$. Let X_1 and X_2 be two random variables related to adopting a given energy-saving technology. We assume that $\{x_1\}_{k=1}^{n}$ is a vector of α-mixing, possibly dependent observations, and $\{x_2\}_{k=1}^{n}$ is an analogous vector of realisations of X_2. Let $F_1(x)$ and $F_2(x)$ be the cumulative distribution functions of X_1 and X_2, respectively. Using this notation below, we briefly define the concepts of first and second-order stochastic dominance.

Definition 1. X_1 first-order stochastically dominates X_2, if and only if either:

$i)$ $E[u(X_1)] \geq E[u(X_2)]$ for all $u \in U_1$
$ii)$ $F_1(x) \leq F_2(x)$ for every x with strict inequality for some x.

According to Definition 1, households are averse to increasing energy costs, which is implied by the assumption of strict concavity of the utility function. First-order stochastic dominance implies that all utility maximising households prefer X_1 to X_2. Second-order stochastic dominance implies the usual assumption of diminishing marginal utility, a negative second derivative of the household's utility function. More formally, we define second-order stochastic dominance.[7] As follows:

Definition 2. The prospect X_1 second order stochastic dominates X_2 if and only if either:

i) $E[u(X_1)] \geq E[u(X_2)]$
ii) $\int_{-\infty}^{x} F_1(t)dt \leq \int_{-\infty}^{y} F_2(t)dt$ for every x with strict inequality for some x.

According to Definition 2, if X_1 second order stochastically dominates X_2 , then the expected household utility from X_1 is at least as great as that from X_2 for all (decreasing and strictly concave) utility functions in the class W_2, with strict equality holding for some utility functions in the class. Note that first-order stochastic dominance implies second order, and if X_1 second order stochastically dominates X_2 is consistent, then the mean of X_1 is either greater than, less than, or equal to the mean of X_2.

Testing for stochastic dominance involves comparing the cumulate distribution functions of the random variables relating to households' attitudes toward financial and environmental issues. However, the true cumulated distribution functions are unknown in practice. Therefore, stochastic dominance tests rely on the empirical distribution functions. The literature proposes several procedures to test for stochastic dominance. An early work by McFadden (1989) proposed a generalisation of the Kolmogorov-Smirnov test of first and second-order stochastic dominance among several prospects (distributions) based on *i.i.d.* observations and independent prospects. Later works by Klecan *et al*. (1991) and Barrett and Donald (2003) extended these tests allowing for dependence in observations and replacing independence with a general exchangeability amongst the competing prospects. This paper uses the inference procedure suggested in Linton *et al.* (2005), where consistent critical values for testing stochastic dominance are obtained for serially dependent observations. The procedure also accommodates for general dependence amongst the prospects to be ranked. Below, we state the hypotheses under investigation and describe the testing procedure for stochastic dominance adopted in the paper.

4.2. The Hypotheses of Interest

Let Ω be the households that adopted at least one energy-saving technology. Let $\{X_{i,j}: x_{i,j} \subseteq \Omega\}\}$ and $\{\bar{\bar{X}}_{i,j}: \bar{\bar{x}}_{i,j} \subseteq \Omega\}$ be the subsets of households that expressed high and low (or no) motivation, respectively, in the *i* motivation, for $i = 1,2,$ (i.e. financially motivated, environmentally motivated) and let *j* be the energy-saving technology, for $j = 1, \ldots, 3,$ (i.e., lights, appliances, insulation). Let Ψ represents the set of households that did not adopt energy-saving technologies so that $\{Y_{i,j}: y_{i,j} \subseteq \Psi\}$ and $\{\bar{\bar{Y}}_{i,j}: \bar{\bar{y}}_{i,j} \subseteq \Psi\}$ denote the subsets of households that expressed high and low motivation in *i* the matter, respectively.

We test several related hypotheses to investigate the issues introduced in Section 2. We summarise them below:

[7] See Levy (1992) for more details on defining first and second order stochastic dominance.

Proposition 1: *Highly motivated households adopt more environmentally sustainable technologies than little (or no) motivated households*.

This proposition introduces the hypothesis that, for both environmental and financial motives, a higher level of motivation is more likely to result in adopting technology. To assess the validity of Proposition 1, for each technology *j*, we test the hypothesis that adoption from highly motivated households stochastically dominates the adoption level of households that expressed low (or no) motivation. To establish the direction of stochastic dominance between $X_{i,j}$ and $\bar{\bar{X}}_{i,j}$, we test the following null hypotheses:

$$H_0^1: X_{i,j} \succ_s \bar{\bar{X}}_{i,j},$$

where the operator "$\succ_s$" indicates the dominance relation and the null hypothesis

$$H_0^2: \bar{\bar{X}}_{i,j} \succ_s X_{i,j},$$

with the alternative hypotheses being the negation of the null hypothesis for both H_0^1 and H_0^2. We infer that households with a high level of motivation in the *i* matter stochastically dominate households with low level of motivations in the same matter if we accept H_0^1 and reject H_0^2. Conversely, we infer that households with low motivation stochastically dominate households with high motivation in the *i* matter if we fail to H_0^2 and reject H_0^1. In cases where neither of the null hypotheses can be rejected, we conclude that the stochastic dominance test statistic is not conclusive.

Proposition 2: *Strong financial motivations translate to greater adoption of energy-saving technologies*.

Proposition 3: *Strong environmental motivations translate to greater adoption of energy-saving technologies*

Propositions 2 and 3 state that households with high motivation in the *i* matter stochastically dominate non-adopting households with low (or no) motivations in the same matter. These propositions test for the attitude-action gap. To assess the validity of these propositions, we consider adopting and non-adopting households and test the following null hypotheses:

$$H_0^1: X_{i,j} \succ_s \bar{\bar{Y}}_{i,j},$$

and

$$H_0^2: \bar{\bar{Y}}_{i,j} \succ_s X_{i,j},$$

with the alternative hypotheses being the negation of the null hypothesis for both H_0^1 and H_0^2. For each technology, *j*, we conclude that the adoption for households that are highly motivated in the matter *i* stochastically dominate not adopting households with low motivation if we accept H_0^1 and reject H_0^2. On the other hand, we infer that non-adopting households with low motivation in *i* matter stochastically dominate adopting households with low motivation in the same matter if we accept H_0^2 and reject H_0^1. In cases where neither of the null hypotheses can be rejected, we conclude that the stochastic dominance test statistic is not conclusive.

Proposition 4: *Strong financial and environmental motivations jointly lead to higher adoption of energy-saving technologies*.

Proposition 4 states that adopting households with jointly high financial and environmental motivations stochastically dominate adopting households with low (or no) motivations in both matters. To assess the empirical validity of Proposition 4, we consider the intersection, $\Theta_j = (X_{E,j} \cap X_{F,j})$ (that is, the subsets of adopting households that are jointly highly financially and environmentally motivated), and the intersection $\bar{\bar{\Gamma}}_j = (\bar{\bar{X}}_{E,j} \cap \bar{\bar{X}}_{F,j})$ (that is, the subset of households neither (or little) environmentally nor financially motivated) and test the hypotheses

$$H_0^1: \Theta_j \succ_s \bar{\bar{\Gamma}}_j,$$

and

$$H_0^2: \bar{\bar{\Gamma}}_j \succ_s \Theta_j,$$

with the alternative hypotheses being the negation of the null hypothesis for both H_0^1 and H_0^2.

Proposition 5: *Financial motivations lead to greater adoption than environmental motivations.*

In Proposition 5, we assess the hypotheses that financial motivations overtake environmental motivations in adopting energy-saving technologies. In the literature, it is not clear if the motivation that leads households to adopt energy-saving technologies financial matters impact more than environmental attitude. For example, Whitmarsh (2009) finds that economic factors overtake environmental motivations as driving factors for curtailments and energy investments. However, the literature is inconclusive on the motivations that lead households to engage in energy-saving activities (Steg et al., 2015). For this reason, under the null hypotheses, we state that

$$H_0^1: \bar{\bar{X}}_{F,j} \succ_s X_{E,j},$$

and

$$H_0^2: X_{E,j} \succ_s \bar{\bar{X}}_{F,j},$$

with the alternative being the negation of the null hypothesis for both H_0^1 and H_0^2.

4.3. Testing Procedure for Stochastic Dominance

To test the hypotheses above, we consider the functional distribution functions of the random variables in Ω and Ψ. Below we specify the testing procedure for Proposition 1 only, as all the other hypotheses can be tested similarly.

Let $D_{i,j}^s(x)$ and $D_{i,j}^s(\bar{\bar{x}})$ be the empirical distributions of $X_{i,j}$ and $\bar{\bar{X}}_{i,j}$, respectively. To test the null hypothesis in Proposition 1, we test that

$$H_0: D_{i,j}^s(x; F_{i,j}) \leq D_{i,j}^s(\bar{\bar{x}}; F_{i,j}),$$

$\forall\, x \in \mathbb{R}, s = 1,2$. The alternative hypothesis is the negation of the null, that is

$$H_1: D_{i,j}^s(x; F_{i,j}) > D_{i,j}^s(\bar{\bar{x}}; F_{i,j}),$$

$\forall\, x \in \mathbb{R}, s = 1,2$. To construct the inference procedure, we consider the Kolmogorov-Smirnov distance between functionals of the empirical distribution functions of $X_{i,j}$ and $\bar{\bar{X}}_{i,j}$ and define the test statistic as

$$\widehat{\Lambda}\text{=}min\ sup_{x\in\mathbb{R}}\sqrt{N}\left[\widehat{D}_{i,j}^{s}\left(x;\hat{F}_{i,j}\right)-\widehat{D}_{i,j}^{s}\left(\bar{\bar{x}};\hat{F}_{i,j}\right)\right], \tag{1}$$

where

$$\widehat{D}_{i}^{s}\left(x;\hat{F}_{i,j}\right)=\frac{1}{N(s-1)!}\sum_{t=1}^{T}1\left(X_{i,j}\le x\right)\left(x-X_{i,j}\right)^{s-1}, \tag{2}$$

and $\widehat{D}_{i,j}^{s}(\bar{\bar{x}};\hat{F}_{i,j})$ is similarly defined. Linton *et al.* (2005) show that under suitable regularity conditions $\widehat{\Lambda}$ converges to a functional Gaussian process. However, the asymptotic null distribution of $\widehat{\Lambda}$ depends on the unknown population distributions. Therefore, to estimate the asymptotic *p*-values of the test, we use the overlapping moving block bootstrap method. The bootstrap procedure involves calculating the test statistics $\widehat{\Lambda}$ using the original sample and then generating the subsamples by sampling the overlapping data blocks. Once the bootstrap subsample is obtained, one can calculate the bootstrap analogue of $\widehat{\Lambda}$. In particular, let B be the number of bootstrap replications and b the block size. The bootstrap procedure involves calculating the test statistics $\widehat{\Lambda}$ in Eq. (1) using the original sample and then generating the subsamples by sampling the $N-b+1$ overlapping data blocks. Once the bootstrap subsample is obtained, one can calculate the bootstrap analogue of $\widehat{\Lambda}$. Defining the bootstrap analogue of Eq. (1) as

$$\widehat{\Lambda}^{*}\text{=min sup}_{x\in\mathbb{R}}\sqrt{N}\left[\widehat{D}_{i,j}^{s*}\left(x;\hat{F}_{i,j}\right)-\widehat{D}_{i,j}^{s*}\left(\bar{\bar{x}};\hat{F}_{i,j}\right)\right] \tag{3}$$

where

$$\widehat{\mathrm{D}}^{*}\left(\hat{F}\right)=\frac{1}{N(s-1)!}\sum_{h=1}^{N}\{1\left(X_{i,j}^{*}\le x\right)\left(x-X_{i,j}^{*}\right)^{s-1}-\omega(h,b,N)1(\bar{\bar{X}}_{i,j}^{*}\le\bar{\bar{x}})\left(\bar{\bar{x}}-\bar{\bar{X}}_{i,j}^{*}\right)^{s-1}\},$$

and

$$\omega(h,b,N)=\begin{cases}\kappa/b & if\ \ \in[1,b-1]\\ 1 & if\ i\in[1,N-b+1]\\ (N-i+1)/b & if\ [N-b+2,N]\end{cases}$$

The estimated bootstrap *p*-value function is defined as the quantity

$$p^{*}\left(\hat{\Lambda}\right)=\frac{1}{N-b+1}\sum_{h=1}^{N-b+1}1\left(\Lambda^{*}\ge\hat{\Lambda}\right).$$

Under the assumption that the random variables $X_{i,j}$ and $\bar{\bar{X}}_{i,j}$ are α-mixing with $\alpha(j)=O(j^{-\delta})$, for some $\delta>1$, when $B\to\infty$ the expression in Eq. (3) converges to Eq. (1). Also, the asymptotic theory requires that $b\to\infty$ and $b/N\to 0$ as $N\to\infty$.

5. Empirical Results

Table 2 reports the results of the stochastic dominance test concerning the propositions stated above. In columns 1 and 2, the propositions under assessment and the corresponding null hypotheses are reported, respectively. Columns 3-8 report the *p*-values of the stochastic dominance test concerning the three different energy-saving technologies considered in this work. The *p*-values are reported for the first and second-order stochastic dominance, referred to as "FSD" and "SSD", respectively. The *p*-values were obtained using a number of $B=1000$ bootstrap replications. Results are supported by the robustness check presented in the Appendix, where we use the stochastic dominance procedure to test several corollaries to the main propositions.

Table 2. Test for stochastic dominance results for assessing Propositions 1-5.

	Null Hypotheses	*Energy saving technologies*					
		Bulbs		*Appliances*		*Insulation*	
		FSD	SSD	FSD	SSD	FSD	SSD
Proposition 1	$H_0^1: X_{F,j} \succ_s \bar{\bar{X}}_{F,j}$	0.962	0.554	0.999	0.935	0.999	0.941
	$H_0^2: \bar{\bar{X}}_{F,j} \succ_s X_{F,j}$	0.000	0.001	0.000	0.000	0.000	0.000
	$H_0^1: X_{E,j} \succ_s \bar{\bar{X}}_{E,j}$	0.999	0.985	0.999	0.982	0.666	0.961
	$H_0^2: \bar{\bar{X}}_{E,j} \succ_s X_{E,j}$	0.000	0.000	0.000	0.000	0.000	0.000
Proposition 2	$H_0^1: X_{F,j} \succ_s \bar{\bar{Y}}_{F,j}$	0.950	0.637	0.999	0.949	0.999	0.987
	$H_0^2: \bar{\bar{Y}}_{F,j} \succ_s X_{F,j}$	0.000	0.002	0.000	0.000	0.000	0.000
Proposition 3	$H_0^1: X_{E,j} \succ_s \bar{\bar{Y}}_{E,j}$	0.999	0.652	0.711	0.952	0.000	0.000
	$H_0^2: \bar{\bar{Y}}_{E,j} \succ_s X_{E,j}$	0.000	0.000	0.000	0.000	0.697	0.896
Proposition 4	$H_0^1: \Theta_j \succ_s \bar{\bar{\Gamma}}_j$	0.999	0.969	0.999	0.956	0.999	0.983
	$H_0^2: \bar{\bar{\Gamma}}_j \succ_s \Theta_j$	0.000	0.000	0.000	0.000	0.000	0.000
Proposition 5	$H_0^1: \bar{\bar{X}}_{F,j} \succ_s X_{E,j}$	0.745	0.796	0.922	0.629	0.934	0.549
	$H_0^2: X_{E,j} \succ_s \bar{\bar{X}}_{F,j}$	0.937	0.528	0.882	0.554	0.000	0.002

Note: The table reports the p-values of the test for first and second-order stochastic dominance. The p-values are obtained using the nonparametric block-bootstrap method with $B = 1000$ replications. The five propositions are stated as follow: Proposition 1: "highly motivated households adopt more environmentally sustainable technologies than little (or no) motivated households"; Propositions 2: "Strong financial motivations translate to greater adoption of energy saving technologies"; Proposition 3: "Strong environmental motivations translate to greater adoption of energy saving technologies; Proposition 4: "Strong financial and environmental motivations jointly lead to higher adoption of energy-saving technologies"; Proposition 5: "Financial motivations lead to greater adoption than environmental motivations".

Proposition 1 which states that "*highly motivated households adopt more environmentally sustainable technologies than little (or no) motivated households*" is confirmed in our analysis as the null hypotheses $H_0^1: X_{i,j} \succ_s \bar{\bar{X}}_{i,j}$ are not rejected. Conversely, the null hypotheses $H_0^2: \bar{\bar{X}}_{i,j} \succ_s X_{i,j}$ are rejected in favour of the alternative hypotheses. Therefore, we conclude that highly motivated adopting households stochastically dominate adopting households with low (or no) motivation in financial or environmental matters. Remarkably, this result holds no matter the cost of the technology under consideration and the order of stochastic dominance. Traditional economic theory assumes that agents make rational decisions, i.e. gather and process *all* decision-relevant information and select profit or utility maximizing decision alternatives. Our results, instead, confirm that the decision-making process also depends on the agent's involvement with a decision problem, that is, their motivation. Motivation is related the properties of the decision: its individual or social relevance, costliness, or riskiness (Kastner and Stern, 2015). As the observed investments in energy-efficient technology decisions feature – in various degrees – these properties, we can confirm that motivation plays a crucial role in determining households' behavior.

We then refine the level of investigation by observing the two motivations separately, stating **Proposition 2** (*Strong financial motivations translate to greater adoption of energy saving technologies)* and **Proposition 3**

(*Strong environmental motivations translate to greater adoption of energy saving technologies)*. In more detail, we aim to investigate whether households with high financial or environmental motivations adopt and whether financial and environmental motivations have a similar impact on the adoption. The results in Table 2 highlight that the cost of energy-saving technologies affects the decision to adopt. Differently from Proposition 2, the null hypotheses $H_0^1: X_{F,j} \succ_s \bar{\bar{Y}}_{F,j}$ are not rejected at first order stochastic dominance for all three technologies, whereas $H_0^2: \bar{\bar{Y}}_{F,j} \succ_s X_{F,j}$ are rejected in all cases. Therefore, we can conclude that highly financially motivated adopting households first-order stochastically dominate non-adopting households with low (or no) financial motivations. These results confirm the positive associations between energy-relevant investment decisions and expected financial benefits, but, differently from the majority of the extant literature (Kastner and Stern, 2015), also find a positive association for all the observed levels of technology cost. The finding has relevant implications; however, it is rather difficult to interpret. Unlike other studies that cover only one country (see, for instance, Achtnicht and Madlener, 2014), we observe households in a vast area that cover a broad spectrum of internal dispositions, cultural, climatic and institutional settings. Thus, the quality of data might have uncovered a previously unobserved pattern. Moreover, the EU has funded numerous programs[8] to provide financial support for adopting costly energy-efficient technologies. Such support removed, at least partially, the financial burden, possibly giving more space to financial motivations to adopt.

Looking at Proposition 3, the results relating to low-to-medium costs energy-saving technologies are not different. This result contradicts existing evidence that shows a positive (Pothitou et al., 2016) or a non-significant (Whitmarsh and O'Neill, 2010) association between environmental attitudes toward energy savings and the installation of energy-saving light bulbs. Instead, when investing in costly property thermal insulation the null hypothesis $H_0^2: \bar{\bar{Y}}_{E,j} \succ_s X_{E,j}$ cannot be rejected, whereas the null hypothesis $H_0^1: X_{E,j} \succ_s \bar{\bar{Y}}_{E,j}$ is rejected in favour of the alternative hypothesis. These results show that high environmental attitudes do not always correspond to the actual adoption, finding evidence of the attitude-action gap as the cost of the technology increases.[9] This finding is consolidated from the beginning or the studies on this topic (Black et al., 1985; Guagnano et al., 1995; Qiu et al., 2022). As the cost of technology increases, the motivation to protect the environment, which is intrinsically pro-social and altruistic, becomes less critical than the egoistic motivation. The literature finds that this result correlates to the household characteristics (for a survey, see Kastner and Stern, 2015), such as income, education, and area of residence. Considering the importance of this result for policy interventions (Stern, 2020), we will delve further into this topic in Section 5.1.

Regarding **Proposition 4** (*Strong financial and environmental motivations jointly lead to higher adoption of energy-saving technologies*), we can infer that adopting households that are highly motivated in both environmental and financial matters first-order stochastically dominate their counterpart with low (or no) motivations, for all the technologies under consideration. In this respect, these results are consistent with the

[8] We have identified 62 interventions regarding building insulation, mainly in energy grants, loans, and tax incentives. Some policies target specific socio-economic groups, in particular low-income and vulnerable consumers. The distribution of policies by country is the following: Belgium, France, UK, Ireland >= 6; Austria, Cyprus, Estonia, Germany, Hungary, Malta, Poland, Sweden = 0; the remaining countries have between 2 and 3 policies. Regarding appliances, we have identified 30 interventions consisting mainly of energy audits for low-income households.
(Source: https://energy-poverty.ec.europa.eu/discover/policies_en).

[9] Note that one of the most frequently mentioned barriers to the uptake of energy-efficient technologies relates to their high up-front cost (Whitmarsh et al., 2011).

conjecture in Proposition 1, where environmentally and financially minded households were considered separately. The assessment of Proposition 4 makes our conclusion that a positive attitude toward environmental and financial matters increases households' energy-saving investments stronger.[10] However Proposition 4 is not informative on their relative effects; we therefore proceed with testing this hypothesis in **Proposition 5** (*Financial motivations lead to greater adoption than environmental motivations*). From Table 2 we can infer that financial benefits are essential when adopting costly insulation technology. However, there is no clear winner in the adoption of less expensive technologies since the stochastic dominance test is not conclusive in the latter case. In other words, a statement of “high motivation” in environmental matters translates to action only for low-to-middle cost technologies, but not for costly thermal insulation technology[11]. This result is reinforced when we looked at the test results for Corollary 5 (see Appendix).

To summarise, one of the main results of our investigation is that economic factors have greater impact on the adoption of costly energy-saving technologies than environmental factors. Even though the literature focuses on the attitude-action gap between environmental attitudes and pro-environmental behaviours (Whitmarsh and O'Neill, 2010), here we bring evidence on the relative importance of financial and environmental motivations, showing that the former prevails in the case of high-cost technologies. There are many reasons behind these findings. For example, behavioural economics provide an argument that insists on the “timing effects” of the investment. Energy-saving technologies generate their environmental effects in the future and their financial effects in the present. Agents tend to discount the future in favour of today (Discount of the future bias) (Ahmed, 2020). As the technology cost increases and the household has to renounce a higher consumption today, the bias reduces the motivation to undertake the investment.

5.1. What Determines Financial and Environmental Motivations?

In Section 4, the stochastic dominance analysis has revealed several insights into the impact of financial and environmental motivations on the adoption patterns of energy-saving technologies. However, the nonparametric analysis is relatively silent on the socio-economic background of adopting households. This section explores how socio-demographic features relate to households’ individual environmental and financial motivations. We are interested in identifying the differences across adopting households (Mills and Schleich, 2012; Shen and Saijo., 2008; Torgler et al., 2008; Urban and Ščasný, 2012)[12] to contribute to the debate on increasing the adoption of energy-saving technologies. For this purpose, we use parametric modelling and estimate a logit model to investigate the relationship between motivations and the profiles of adopting households.

For the motivation I (financial or environmental), the probability of adopting the technology j (bulbs, appliances, or insulation) is given by

[10] The same results hold true for Corollaries 3 and 4 (see Appendix), where the findings match those of Proposition 2 and 3, thus strengthening the validity of our conjectures.

[11] This result is reinforced when we looked at the test results for Corollary 5: even when households express low (or no) motivations financial matters overtake environmental matters (see Appendix).

[12] Our focus is different from the one prevailing in the empirical literature where the target is usually determining how energy-saving behaviour is associated with personal, family, and housing characteristics, as well as the availability and quality of information, in addition to attitudes towards energy savings or the environment, and climatic factors (Mills and Schleich, 2012; Qiu et al., 2022). Concerning the adoption of energy-saving technology and household features, see Achtnicht and Madlener (2014) Trotta (2018) and Sütterlin et al. (2011). For the literature on the latter and the impact of environmental motivation on energy-saving behaviours, see Gadenne et al. (2011), Martinsson et al. (2011) and Schleich (2019).

$$\pi_k = \Pr(Adopt_k \,|X_k = x_k) = \frac{e^{x_k'\beta}}{1+ e^{x_k'\beta}} \quad (4)$$

where the dependent variable, π_k, is the probability of adopting conditional to vector X of covariates.[13]

In particular, $X_k = \{Age_k, Fem_k, SecEdu_k, Univ_k, City_k, Inc_k, FamSize_k\}$ where Age and $FamSize$ are continuous variables for the respondent's age and the number of household members, respectively. The covariate *Fem* is a dummy variable for gender that takes a value of zero for males and one for females. The covariate *SecEdu* is a discrete variable that takes a value of one if the respondent has a secondary level of education and zero otherwise. Similarly, the dummy *Univ* takes a value of one if the respondent has a tertiary level of education and zero otherwise. The dummy variable *City* takes a value of one if the respondent is resident in large urban areas and zero elsewhere. Finally, *FinSit* captures the perceived financial situation of the household.[14] It is a dummy variable that takes a zero value for households that declare they have difficulties in making ends meet every month and one for households that respond otherwise.

Table 3 reports the estimation results for six different models.[15] The determinants of adoption for environmentally motivated (EM) and financially minded (FM) households are regressed over the vector X_k for each technology under consideration. We refer to as these models as M1–M6, respectively. In particular, for each technology, models M1, M3 and M5 relate to the specification in Eq. (4) with the environmentally minded households (EM_k) as the dependent variable. Similarly, models M2, M4 and M6 refer to the model in Eq. (4) with financially motivated households (FM_k) as the dependent variable. The technology under consideration is reported in the first row of Table 3. The estimation results in Table 3 allow us to compare the probability of adoption by the *k* respondent with the profile in the baseline model relating to a male respondent in a difficult financial situation, with low educational attainment, living in rural areas, with little or no motivation regarding the *i* matter.

It appears that gender is an essential determinant of adoption since the estimated coefficients for Fem_k are significant in all the estimated models. This finding implies that women are more likely to adopt energy-efficient technologies for all technologies and both environmental and financial motivations. The effect, however, is more substantial for households that expressed environmental motivations. This result corroborates the view in the related literature that men are generally less motivated about the environment than women: Urban and Ščasný (2012) find compelling evidence for Australia, Canada, Czech Republic, France, Italy, South Korea, the Netherlands, Norway, and Sweden. Torgler et al. (2008) also observe the same result for 33 eastern and western countries. An important exception to these findings is the study by Shen and Saijo (2008), which shows that men in Chinese households are more motivated about environmental problems and have stronger preferences for environmentally friendly behaviour.

In terms of age, from Table 3 we can infer that being older also increases the probability of adoption for environmentally minded households across all the technologies under consideration (Shen and Saijo, 2008; Urban

[13] We select socio-demographic information, housing characteristics, and location based on data availability. These covariates are commonly used in studies on the topic (see Kastner and Stern, 2015, for a review), enabling comparison with the extant literature.

[14] The survey question was: "Thinking about your household's financial situation, would you say that making ends meet every month is: not easy at all, not easy, fairly easy, very easy".

[15] Estimation results for the subsample of households that reported environmental *and* financial motivations are not reported but are available on request.

and Ščasný, 2012).[16] In contrast, Age_k is not significant for LED bulbs and insulation in relation to financially motivated households, whereas the estimated coefficient is significant (with a negative sign) for energy-efficient appliances. However, the magnitude of the estimated coefficient for the latter technology is rather small, thus casting some doubts on the actual impact of this covariate on the probability of adoption.

Considering the effect of education, the estimation results highlight that higher education attainment increases the probability of adopting all energy-saving technologies for environmentally minded households (see models M1, M3 and M5). These results are consistent with the empirical literature (Mills and Schleich, 2012; Shen and Saijo, 2008; Torgler et al., 2008; Urban and Ščasný, 2012), supporting the idea that well-educated citizens have stronger environmental motivations. The same does not hold for financially motivated households where the covariates for education are not significant predictors for adopting any observed technologies.[17]

When examining the results for $FamSize_k$, it appears that the estimated coefficients for environmentally minded households are also positive and significant in all estimated models except M5. These findings contradict the results in Urban and Ščasný (2012) and Shen and Saijo (2008), where the household size seems to have no direct effect on households' environmental motivations. It is reasonable to expect the same sign of the estimated coefficients of $FamSize_k$ for both environmentally and financially motivated households but with a greater magnitude for the latter group, since as the family grows, the need to save on energy bills becomes more compelling.

In terms of financial situations, estimation results show that for financially minded households, a difficult financial situation increases the probability of adoption. This result suggests that less financially constrained households are less interested in the cost-saving potential of energy-efficient technologies. The estimated coefficients for environmentally motivated households are not significant, indicating that the household's financial situation does not affect the likelihood of adopting any of the technologies under study.[18]

Finally, living in a large urban area increases the probability of adoption for environmentally motivated respondents. The same does not hold for financially minded households, as the estimated parameters for *City* are significant for all the technologies under study (models M1, M3 and M5). As pointed out by Kastner and Stern (2015), a residential location may stand in for a wide range of explanatory variables. It remains unclear as to which ones contribute to what degree to energy-relevant investment decisions. We therefore limit ourselves to highlighting the differences between the types of households without attempting further interpretations.

[16] Somewhat puzzlingly, in the studies by Mills and Schleich (2012) and Torgler et al. (2008), the age of the respondents negatively affects the households' environmental motivation and willingness to prevent environmental damages.

[17] Similarly, Mills and Schleich (2012) find that university education significantly decreases the probability of adoption by households that claim it is necessary to save electricity for financial reasons.

[18] The evidence in this respect is mixed. Urban and Ščasný (2012) find that high-income households are generally less motivated about the environment, while Shen and Saijo (2008) find that high-income levels are positively associated with environmental motivations.

Table 3. Determinants of adoption for environmentally motivated (EM) and financially minded (FM) households.

	Lights		***Appliances***		***Insulation***	
Dependent variable:	EM	FM	EM	FM	EM	FM
	M1	M2	M3	M4	M5	M6
Age_k	0.019***	-0.003	0.017***	-0.006**	0.020***	0.002
	(0.002)	(0.002)	(0.002)	(0.003)	(0.004)	(0 .004)
Fem_k	0.520***	0.316***	0.579***	0.373***	0.596***	0.284***
	(0.053)	(0.061)	(0.061)	(0.068)	(0.098)	(0.108)
$SecEdu_k$	0.372***	-0.147	0.473***	-0.095	0.320**	-0.267
	(0.080)	(0.107)	(0.091)	(0.118)	(0.156)	(0.208)
$Univ_k$	0.610***	-0.153	0.664***	-0.075	0.435***	-0.186
	(0.084)	(0.109)	(0.095)	(0.120)	(0.160)	(0.211)
$City_k$	0.118**	-0.005	0.166***	0.001	0.182*	-0.020
	(0.054)	(0.062)	(0.062)	(0.068)	(0.102)	(0.111)
$FinSit_k$	0.044	-1.512***	0.016	-1.612***	0.099	-1.580***
	(0.053)	(0.073)	(0.061)	(0.083)	(0.096)	(0.137)
$FamSize_k$	0.063***	0.143***	0.047*	0.138***	0.065	0.173***
	(0.024)	(0.029)	(0.027)	(0.032)	(0.043)	(0.051)
Const	0.249	3.068***	0.457**	3.310***	0.293	3.000***
	(0.156)	(0.200)	(0.178)	(0.222)	(0.305)	(0.383)
Observations	13,906	15,509	12,261	13,55	4,768	5,146
Log Likelihood	-5,008.86	-4,005.43	-3,979.15	-3,319.69	-1,586.705	-1,317.93
Akaike Inf. Crit.	10,033.74	8,026.87	7,974.31	6,655.38	3,189.41	2,651.87

Note: the table reports the estimation results of the logit specification for six estimated models labelled as M1-M6. Note that: *), **) and ***) denote a significance level at 10%, 5% and 1%, respectively.

6. Conclusions and Policy Implications

The empirical investigation presented in this work complements the literature on energy-saving behaviour by providing new evidence on the role of households' attitudes when adopting energy-efficient technologies. Using a large sample of 30 European countries, this study provides new insights into the behaviour of financially and environmentally minded households when adopting energy-efficient technologies.

The contribution of this paper to the extant literature can be summarised as follows. First, the empirical investigation reveals that the adoption of energy-efficient technologies is not exclusively grounded on financial motivations, but is also affected by non-economic factors such as environmental attitude. However, the latter becomes less important as the cost of the energy-efficient technology increases. In this respect, using the stochastic dominance procedure, this study shows that households that are highly motivated about environmental and/or financial matters adopt more energy-efficient technologies than their counterparts with low (or no) motivations, no matter the cost of the technology under consideration (Propositions 1 and 4). However, the stochastic dominance analysis suggests that economic factors mitigate the impact of environmental and financial attitudes on the adoption attitude, thus supporting the attitude-action gap hypothesis largely investigated by the related literature (see also Corraliza and Berenguer, 2000; Trotta 2018). A statement of “high motivation” in environmental matters translates to action only for low- to middle-cost technologies (low-energy bulbs and energy-efficient appliances, respectively), but not for costly thermal insulation technology (Proposition 3). Similarly, the comparison between environmentally and financially motivated households shows that the former is a stronger determinant than the latter for low- to medium-cost technologies, whereas financially motivated households adopt more high-cost ones compared to environmentally motivated households (Proposition 5). A robustness analysis, presented in the Appendix (see Corollaries 1 and 2), shows that low motivation towards environmental or financial matters leads households to act accordingly and not invest in expensive insulation technologies.

Second, this study takes a novel approach with respect to the extant literature by attempting a joint analysis of the role of environmental and financial motivations in terms of the adoption of energy-efficient technologies. Most empirical studies consider these issues separately. However, no matter how strong the households’ environmental motivation may be, adopting energy-saving technologies, in most cases, is not cheap. The two issues should therefore not be considered separately for policy-related purposes. The stochastic dominance results presented in this paper corroborate this conjecture: when adopting new energy-saving technologies, environmental matters are stronger determinants than financial motivations for low-cost technologies only, since financially motivated households adopt more high-cost technologies than environmentally motivated households (Proposition 5).

Third, looking at the households’ socio-economic background, the estimation results of the logistic regression model suggest that environmentally minded and financially motivated households who have adopted energy-saving technologies feature different socio-economic profiles. Age and education are statistically significant predictors for strong environmental attitudes. On the other hand, large households declaring financial motivations are more likely to adopt energy-efficient technologies. Overall, the estimation results suggest that environmentally minded, highly educated households, living in urban areas, with large family sizes, are more likely to adopt energy-efficient technologies than their counterparts with low levels of education in rural areas.

The proposed methodological approach is the fourth contribution of this paper. The stochastic dominance procedure adopted in this paper is extremely flexible, as it is robust to departures of cross-dependency between random variables, serial correlation, and unconditional heteroscedasticity (see Linton et al., 2005). This constitutes a significant departure from the traditional stochastic dominance inference procedures which strongly rely on the on the independent and identically distributed assumption (see, for example, Barrett and Donald, 2003; Davidson and Duclos, 2000).

The joint interpretation of empirical results presented in this paper provides several insights that may be useful for designing more effective interventions to promote energy conservation policies across the EU countries. The differences in the profiles of the adopters highlight that policy interventions may have a different impact on adoption according to the households’ socio-economic characteristics. In this respect, policy interventions targeted at low-income households such as subsidies, tax credits, deductions, rebates, or loan subsidies may be more effective than watering can interventions. In the literature, it has been argued that fiscal policy instruments such as tax reduction are effective in encouraging efficient investment decisions. For example, Sardianou and Genoudi (2013) suggest tax deduction is the most effective financial policy instrument for promoting consumers’ acceptance of renewable energy sources (see for example, Economidou et al., 2019, 2021; Kanes and Wohlgemuth, 2008).

Moreover, the stochastic dominance analysis reveals that environmental and financial motivations affect attitudes towards energy efficiency. Although the issue of the consistency between attitude and behaviour is still an open question in the literature, it is largely accepted that attitude is a necessary precursor of energy-saving and pro-environmental behaviour (see Poortinga et al., 2002, and the references therein). In this respect, our results in Table 2 see also Table 1A) suggest that information measures designed to promote a reduction in energy consumption across the EU member states may be used to support more expensive policy tools such as subsidies, loans, and tax incentives (see also Kastner and Stern, 2015; Maki et al., 2019). Information campaigns are low-cost policy instruments that do not require the deployment of financial tools and impose a low bureaucratic burden on citizens and institutions. Various actors, including governments, educational institutions, and business organisations, as well as those in civil society, may promote energy-saving campaigns and contribute to the sustainable energy transition. The literature suggests that these actors can play a key role in promoting the adoption of sustainable energy behaviours (see, for example, Nielsen et al., 2021, and the references therein).

Third, the stochastic dominance analysis allows us to investigate under what conditions the attitude-action gap prevents households from adopting certain technologies. From a policy perspective, knowing when motivations fail to translate into adoption emphasises the limitations of the policies that aim at increasing households' environmental awareness.

The results in Table 2 (see also the Appendix) suggest that high-cost technologies require financial interventions since motivations constitute a necessary but not sufficient condition for adoption. In this respect, policymakers in the EU have set binding targets to achieve a 32.5% improvement in energy efficiency by 2030, relative to a "business as usual" scenario (see Directive (EU) 2018/2002). Targets pivot on several actions, including reducing energy consumption for households and businesses and improving energy performance in buildings. Despite implementing energy efficiency legislation and ambitious programmes in Europe, empirical evidence shows that energy consumption is still above the targets. Investments in sustainable energy production (e.g. solar panels) and building renovation and insulation, as well as low-carbon innovations (e.g. heat pumps) and energy storage facilities (e.g. batteries) are particularly important, as many such investment behaviours are associated with a relatively high greenhouse gas emissions reduction potential and may thus be critical for meeting such ambitious climate targets (see Stern, 2020).

A possible limitation of this study is that, even though the number of countries included in the sample is large, the timespan under consideration is limited to one year. This provides a screenshot view of households' environmental and financial motivations when adopting new energy-saving technologies. However, pro-environmental and financial attitudes change over time and may be affected by geopolitical events. The recent energy crisis, with huge surges in fuel and other energy prices, along with major natural disasters related to climate change, may have induced attitude changes, and stimulate more societal support for the actions needed to reduce greenhouse gas emissions. For policy purposes, it is of paramount importance to monitor pro-environmental attitudes in order promote energy conservation. In this respect, further work will be needed to implement the findings of this study should more data be available in the future.

References

Achtnicht, M. (2011). “Do environmental benefits matter? Evidence from a choice experiment among house owners in Germany”. *Ecological Economics*, *70*(11), 2191-2200.

Achtnicht, M., and Madlener, R. (2014). “Factors influencing German house owners' preferences on energy retrofits.” *Energy policy*, *68*, 254-263

Aguilar, F.X., Vlosky, R.P. (2007). “Consumer Willingness to Pay Price Premiums for Environmentally Certified Wood Products in the US.” *Forest Policy and Economics*, 9, 1100-1112.

Ahmed, A. (2020). “Rationality and Future Discounting”. *Topoi* 39, 245–256

Anderson, G.J. (1996). “Nonparametric Tests of Stochastic Dominance in Income Distributions.” *Econometrica*. 64, 1183-1193.

Aravena, C., Riquelme, A., and Denny, E. (2016). “Money, comfort or environment? Priorities and determinants of energy efficiency investments in Irish households”. *Journal of consumer policy*, *39*(2), 159-186.

Bamberg, S. (2003). “How does environmental concern influence specific environmentally related behaviors? A new answer to an old question”. *Journal of environmental psychology*, *23*(1), 21-32.

Barrett, G., and Donald, S. (2003). “Consistent Tests for Stochastic Dominance.” *Econometrica*. 71, 71-104.

Bashiri, A., and Alizadeh, S.H. (2018). “The Analysis of Demographics, Environmental and Knowledge Factors Affecting Prospective Residential PV System Adoption: A Study in Tehran.” *Renewable and Sustainable Energy Reviews,* 81, 3131-3139.

Benabou, R., and Tirole, J. (2011). *Laws and norms* (No. w17579). National Bureau of Economic Research.

Bergek, A., and Mignon, I. (2017). “Motives to adopt renewable electricity technologies: Evidence from Sweden. *Energy Policy*, *106*, 547-559”.

Bertoldi, P., Boza-Kiss, B., Della Valle, N., and Economidou, M. (2021). “The Role of One-Stop Shops in Energy Renovation- A Comparative Analysis of OSSs Cases in Europe.” *Energy and Buildings, 250, 111273*.

Black, S.J., . Stern, P.C, Elworth, J.T. (1985), Personal and contextual influences on household energy adaptations, *Journal of Applied Psychology*, 70(1) , pp. 3-21.

Brekke, K. A., and Johansson-Stenman, O. (2008). “The behavioural economics of climate change”. *Oxford review of economic policy*, *24*(2), 280-297.

Castellazzi, L., Bertoldi, P., and Economidou, M. (2017). Overcoming the Split Incentive Barrier in the Building Sector. *Publications Office of the European Union, Luxembourg*.

Claudy, M. C., Peterson, M., and O’Driscoll, A. (2013).” Understanding the attitude-behavior gap for renewable energy systems using behavioral reasoning theory””. *Journal of Macromarketing*, *33*(4), 273-287.

Chersoni, G., DellaValle, N., and Fontana, M. (2022). “Modelling thermal insulation investment choice in the EU via a behaviourally informed agent-based model”. *Energy Policy*, *163*, 112823.

Corraliza, J.A., and Berenguer, J. (2000). “Environmental Values, Beliefs, and Actions: A situational Approach.” *Environment and Behavior*, 32, 832-848.

Davidson, R. and Duclos, J.-Y. (2000). “Statistical Inference for Stochastic Dominance and for the Measurement of Poverty and Inequality.” *Econometrica*, 68, 1435-1464.

Economidou, M., Della Valle, N., Melica, G., Valentini, O. and Bertoldi, P. (2021). "Financing Energy Renovations at Local and Regional Levels." *EUR 30815 EN*, Publications Office of the European Union, Luxembourg, 2021, ISBN 978-92-76-41141-3, doi:10.2760/52526, JRC123755.

Economidou, M., Todeschi, V., Bertoldi, P., (2019). "Accelerating Energy Renovation Investments in Buildings. EUR–Scientific and Technical Research Reports." Ispra: Joint Research Centre *(JRC)*.

European Commission. (2018). Directive (EU) 2018/2002 of the European Parliament and of the Council of 12 December 2018 amending Directive 2012/27/EU on energy efficiency. Official Journal of the European Union, L 328/210. https://eur-lex.europa.eu/eli/dir/2018/2002/oj

Frederiks, E. R., Stenner, K., Hobman, E. V. (2015)." Household energy use: Applying behavioural economics to understand consumer decision-making and behaviour". *Renewable and Sustainable Energy Reviews*, *41*, 1385-1394.

Gadenne, D., Sharma, B., Kerr, D., and Smith, T. (2011). "The influence of consumers' environmental beliefs and attitudes on energy saving behaviours." *Energy policy*, *39*(12), 7684-7694.

Guagnano, G. A., Stern, P. C., and Dietz, T. (1995). Influences on Attitude-Behavior Relationships: A Natural Experiment with Curbside Recycling. *Environment and Behavior*, *27*(5), 699–718

Jacksohn, A., Grösche, P., Rehdanz, K., and Schröder, C. (2019). "Drivers of renewable technology adoption in the household sector". *Energy Economics*, *81*, 216-226.

Jaffe, A. B., and Stavins, R.N. (1994). "The Energy–Efficiency Gap: What Does It Mean?." *Energy Policy*, 22, 804-10.

Jaffe, A. B., Newell, R.G. and Stavins, R.N. (2002). "Environmental Policy and Technological Change." *Environmental and Resource Economics*, 22, 41–70.

Kanes, D.A., Wohlgemuth N. (2008). "Evaluation of Renewable Energy Policies in an Integrated Economic Energy Environment Model." *Forest Policy Economics*, 10:128–39.

Kastner, I., and Stern, P. C. (2015). "Examining the Decision-Making Processes Behind Household Energy Investments: A Review." *Energy Research and Social Science*, 10, 72-89.

Klecan, L., McFadden, R., and McFadden, D. (1991). "A Robust Test for Stochastic Dominance". Working Paper, Department of Economics, MIT.

Kollmuss, A., Agyeman, J. (2002). "Mind the Gap: why Do People Act Environmentally and What Are the Barrier to Pro-Environmental Behavior?" *Environmental Education Research*, 8, 239-260.

Ku, S. J., and Yoo, S. H. (2010). Willingness to pay for renewable energy investment in Korea: A choice experiment study. *Renewable and Sustainable Energy Reviews*, 14(8), 2196-2201.

Levy, H. (1992). "Stochastic Dominance and Expected Utility: Survey and Analysis." *Management Science,* 38, 555-593.

Liang, J., Qiu, Y., Hu, M. (2019). "Mind the Energy Performance Gap: Evidence from Green Commercial Buildings." *Resources Conservation Recycling*, 141, 364-377.

Linton, O., Maasoumi, E., and Whang, Y.W. (2005). "Consistent Testing for Stochastic Dominance under General Sampling Schemes." *Review of Economics Studies*, 72, 735-765.

Maki, A., Carrico, A.R., Raimi, K.T., Truelove, H.B., Araujo, B., Yeung, K.L. (2019). "Meta-Analysis of Pro-Environmental Behaviour Spillover." *Nature Sustainability*, 2, 307–315.

Martinsson, J., Lundqvist, L. J., and Sundström, A. (2011). "Energy saving in Swedish households. The (relative) importance of environmental attitudes". *Energy policy*, *39*(9), 5182-5191.

McFadden, D. (1989). "Testing for Stochastic Dominance", in T. Tomby and T.K. Seo (eds.). *Studies in the Economics of Uncertainty*, Part II. Springer.

Melvin, J. (2018). "The Split Incentives Energy Efficiency Problem: Evidence of Underinvestment by Landlords." *Energy Policy,* 115, 342-352.

Mills B., Schleich, J. (2010). "What's Driving Energy Efficient Appliances Label Awareness and Purchase Propensity?." *Energy Policy*, 38, 814-825.

Mills, B. and Schleich, J. (2012). "Residential Energy-Efficient Technology Adoption, Energy Conservation, Knowledge, and Attitudes: An Analysis of European Countries." *Energy Policy*, 49, 616-628.

Nielsen, K. S., Clayton, S., Stern, P. C., Dietz, T., Capstick, S., and Whitmarsh L. (2021). "How Psychology Can Help Limit Climate Change." *The American Psychologist*, 76, 130–144.

Pothitou, M., Hanna, R.F., and Chalvatzis, K.J. (2016). "Environmental Knowledge, Pro-Environmental Behaviour and Energy Savings in Households: An Empirical Study." *Applied Energy*, 84, 1217-1229.

Poortinga, W., Steg, L., Vlek, C. (2002). "Environmental Risk Concern and Preferences for Energy-Saving Measures." *Environment and Behavior*, 34, 455-478.

Qiu, X., Ji, J., He, R., Mao, J. (2022). "The Deviation Between the Willingness and Behavior of Farmers to Adopt Electricity-Saving Tricycles and its Influencing Factors in Dazu District of China". *Energy Policy*, 167:113069. doi: 10.1016/j.enpol.2022.113069.

Sardianou E, Genoudi P. (2013). "Which Factors Affect the Willingness of Consumers to Adopt Renewable Energies?." *Renew Energy*, 57:1-4.

Scaillet, O., and N. Topaloglou (2010). "Testing for Stochastic Dominance Efficiency." *Journal of Business and Economic Statistics.* 28, 169-180.

Schleich, J. (2019)."Energy Efficient Technology Adoption in Low-Income Households in the European Union-What is the Evidence?." *Energy Policy*, 125, 196-206.

Shen, J., and Saijo, T. (2008). "Reexamining the Relations Between Socio-Demographic Characteristics and Individual Environmental Concern: Evidence from Shanghai Data." *Journal of Environmental Psychology,* 28, 42-50.

Smirnov, N.V. (1939), "An Estimate of Divergence Between Empirical Curves of a Distribution in two Independent Samples." *Bulletin Mathématique del Úniversité de Moscou*," 2, 3-14.

Steg, L., Perlaviciute, G., and van der Werff, E. (2015). "Understanding the Human Dimensions of a Sustainable Energy Transition." *Frontiers in Psychology*, 6, 805.

Stern, P. C. (2020). "A Re-Examination on how Behavioral Interventions Can Promote Household Action to Limit Climate Change." *Nature Communications*, 11:1-3.Sütterlin, B., Brunner, T.A. and Siegrist, M. (2011). "Who Puts the Most Energy Into Energy Conservation? A Segmentation of Energy Consumers Based on Energy-Related Behavioural Characteristics." *Energy Policy*, 39, 8137-8152.

Sütterlin, B., Brunner, T. A.,and Siegrist, M. (2011). Who puts the most energy into energy conservation? A segmentation of energy consumers based on energy-related behavioral characteristics. *Energy Policy*, 39(12), 8137-8152.

Torgler, B., Garcia-Valiñas, M. A., and Macintyre, A. (2008). "Differences in Preferences Towards the Environment: The Impact of Gender, Age and Parental Effect." *No 2008.18, Working Papers from Fondazione Eni Enrico* Mattei.

Trotta, G., (2018). “Factors Affecting Energy-Saving Behaviors and Energy Efficiency Investments in British Households”. *Energy Policy*, 114, 529–539.

Urban, J., and Ščasný, M. (2012). “Exploring Domestic Energy-Saving: The Role of Environmental Concern and Background Variables.” *Energy policy*, 47, 69-80.

Whitmarsh, L., (2009). “Behavioural Responses to Climate Change: Asymmetry of Intentions and Impacts.” *Journal of Environmental Psychology*, 29, 13–23.

Whitmarsh, L., O’Neill, S., (2010). “Green Identity, Green Living? The Role of Pro-Environmental Self-Identity in Determining Consistency Across Diverse Pro-Environmental Behaviors.” *Journal of Environmental Psychology*, 30, 305–314.

Whitmarsh, L. E., Upham, P., Poortinga, W., McLachlan, C., D., A., Sherry-Brennan, F., Devine-Wright, P., and Demski, C. C. (2011). “Public Attitudes, Understanding, and Engagement in Relation to Low-Carbon Energy. A Selective Review of Academic and Non-Academic Literatures.” *Report for RCUK Energy Programme*. Research Councils UK.

Wong, W.K., Phoon, K.F., and Lean, H.H. (2008). “Stochastic Dominance Analysis of Asian Hedge Funds.” *Pacific-Basin Finance Journal*, 16, 204-223.

Zundel, S., and Stieß, I. (2011). “Beyond profitability of energy-saving measures—attitudes towards energy saving”. *Journal of Consumer Policy*, *34*(1), 91-105.

Appendix

Robustness Check: Some Ancillary Stochastic Dominance Analysis

In this Appendix some robustness analysis is reported to support the results of Proposition 1-5 in Section 4. The corollaries reported below relate to Proposition 1-5 and the hypotheses are, once again, tested using the stochastic dominance procedure.

Corollary 1: *Low financial motivations lead households not to adopt energy saving technologies.*

Corollary 2: *Low environmental motivation leads households not to adopt energy saving technologies.*

Corollaries 1 and 2 are nuances of Proposition 2 and 3 since they state that non-adopting households that expressed low (or no) motivation in the *i* matter stochastically dominate adopting households with a similar level of motivation in the same matter. The proposition is meant to answer the following question: Do non-adopting and not (or little) motivated households adopt more than not motivated (or little) adopting households? The validity of these propositions can be assessed by testing that following null hypotheses

$$H_0^1: \overline{\overline{Y}}_{i,j} \succ_s \overline{\overline{X}}_{i,j},$$

and

$$H_0^2: \overline{\overline{X}}_{i,j} \succ_s \overline{\overline{Y}}_{i,j},$$

with the alternative hypotheses being the negation of the null hypothesis for both H_0^1 and H_0^2.

Corollary 3: *Households that are jointly strongly motivated about the environmental and financial matters adopt more than households that expressed little (or no) motivations.*

Corollary 3 is closely related to Propositions 2 and 3 in the sense that we test the same hypotheses, but this time we consider the subset of households that expressed both environmental and financial motivations. Let $\bar{\bar{\Upsilon}}_j = (\bar{\bar{Y}}_{E,j} \cap \bar{\bar{Y}}_{F,j})$ be the intersection of $\{\bar{\bar{Y}}_{E,j}: \bar{\bar{y}}_{E,j} \subseteq \Psi\}$ and $\{\bar{\bar{Y}}_{F,j}: \bar{\bar{y}}_{F,j} \subseteq \Psi\}$ where $\bar{\bar{Y}}_{E,j}$ and $\bar{\bar{Y}}_{F,j}$ are the subsets households that did not adopt energy saving technologies and expressed low (or no) motivations on environmental and financial matters, respectively. To investigate the validity of Corollary 3, we test the hypothesis that adopting households with low (or no) motivation in the both matters stochastically dominate non-adopting households with similar level of motivation in the both matters. Therefore, the null hypotheses are

$$H_0^1: \Theta_j \succ_s \bar{\bar{\Upsilon}}_j,$$

and

$$H_0^2: \bar{\bar{\Upsilon}}_j \succ_s \Theta_j,$$

with the alternative hypotheses being the negation of the null hypothesis for both H_0^1 and H_0^2.

For completeness, Corollary 4 states that non-adopting households that expressed low (or no) motivations in both matters stochastically dominate adopting households that also expressed low (or no) motivations in both matters jointly. To assess this proposition, we test the following null hypotheses

$$H_0^1: \bar{\bar{\Upsilon}}_j \succ_s \bar{\bar{\Theta}}_j,$$

and

$$H_0^2: \bar{\bar{\Theta}}_j \succ_s \bar{\bar{\Upsilon}}_j,$$

where $\bar{\bar{\Theta}}_j$ is the intersection

$$\bar{\bar{\Theta}}_j = (\bar{\bar{X}}_{E,j} \cap \bar{\bar{X}}_{F,j}),$$

and $\bar{\bar{X}}_{E,j}$ and $\bar{\bar{X}}_{F,j}$ are the subsets households that did adopt energy saving technologies and expressed low (or no) motivations on environmental and financial matters, respectively. As before the alternative hypotheses are the negation of the null hypothesis for both H_0^1 and H_0^2.

Corollary 4: *Negative attitude toward environment and low financial motivations lead households to avoid adopting energy saving technologies.*

For completeness, Corollary 4 states that non-adopting households that expressed low (or no) motivations in both matters stochastically dominate adopting households that also expressed low (or no) motivations in both matters jointly. To assess this proposition, we test the following null hypotheses

$$H_0^1: \bar{\bar{\Upsilon}}_j \succ_s \bar{\bar{\Theta}}_j,$$

and

$$H_0^2: \bar{\bar{\Theta}}_j \succ_s \bar{\bar{\Upsilon}}_j,$$

where $\bar{\bar{\Theta}}_j$ is the intersection

$$\bar{\bar{\Theta}}_j = (\bar{\bar{X}}_{E,j} \cap \bar{\bar{X}}_{F,j}),$$

and $\bar{\bar{X}}_{E,j}$ and $\bar{\bar{X}}_{F,j}$ are the subsets households that did adopt energy saving technologies and expressed low (or no) motivations on environmental and financial matters, respectively. As before the alternative hypotheses are the negation of the null hypothesis for both H_0^1 and H_0^2.

Corollary 5: *Households with low (or no) financial motivations adopt more than households with little (or no) environmental motivations.*

Corollary 5 tests the hypothesis that even when households express low (or no) motivations, financial matters overtake environmental matters when it comes to investment decisions in energy saving technologies. Accordingly, we state the following null hypotheses:

$$H_0^1: \bar{\bar{X}}_{F,j} \succ_s \bar{\bar{X}}_{E,j},$$

and

$$H_0^2: \bar{\bar{X}}_{E,j} \succ_s \bar{\bar{X}}_{F,j},$$

with the alternative being the negation of the null hypothesis for both H_0^1 and H_0^2.

Table 1A. Test for Stochastic dominance results for assessing corollaries 1-5.

	Null Hypotheses	*Energy saving technologies*					
		Bulbs		*Appliances*		*Insulation*	
		FSD	SSD	FSD	SSD	FSD	SSD
Corollary 1	$H_0^1: \bar{\bar{Y}}_{F,j} \succ_s \bar{\bar{X}}_{F,j}$	0.000	0.000	0.653	0.684	0.795	0.595
	$H_0^2: \bar{\bar{X}}_{F,j} \succ_s \bar{\bar{Y}}_{F,j}$	0.999	0.889	0.865	0.577	0.071	0.019
Corollary 2	$H_0^1: \bar{\bar{Y}}_{E,j} \succ_s \bar{\bar{X}}_{E,j}$	0.000	0.000	0.538	0.205	0.999	0.967
	$H_0^2: \bar{\bar{X}}_{E,j} \succ_s \bar{\bar{Y}}_{E,j}$	0.999	0.972	0.981	0.927	0.000	0.000
	$H_0^2: \bar{\bar{\Gamma}}_j \succ_s \Theta_j$	0.000	0.000	0.000	0.000	0.000	0.000
Corollary 3	$H_0^1: \Theta_j \succ_s \bar{\bar{\Upsilon}}_j$	0.999	0.979	0.999	0.968	0.000	0.000
	$H_0^2: \bar{\bar{\Upsilon}}_j \succ_s \Theta_j$	0.000	0.000	0.000	0.000	0.999	0.963
Corollary 4	$H_0^1: \bar{\bar{\Upsilon}}_j \succ_s \bar{\bar{\Theta}}_j$	0.999	0.987	0.237	0.563	0.000	0.000
	$H_0^2: \bar{\bar{\Theta}}_j \succ_s \bar{\bar{\Upsilon}}_j$	0.000	0.000	0.945	0.688	0.994	0.973
Corollary 5	$H_0^1: \bar{\bar{X}}_{F,j} \succ_s \bar{\bar{X}}_{E,j}$	0.000	0.003	0.888	0.716	0.268	0.660
	$H_0^2: \bar{\bar{X}}_{E,j} \succ_s \bar{\bar{X}}_{F,j}$	0.986	0.686	0.624	0.455	0.945	0.452

Note: The table reports the *p*-values of the test for first and second-order stochastic dominance Corollaries 1-5. The *p*-values are obtained using the nonparametric block-bootstrap method with $B = 1000$ replications. **Corollary 1:** Low financial motivations lead households not to adopt energy-saving technologies. **Corollary 2**: A negative attitude toward environmental problems leads households not to adopt energy-saving technologies. **Corollary 3:** Households jointly strongly motivated about environmental and financial matters adopt more than households with little (or no) motivations. **Corollary 4:** Negative attitude toward the environment and low financial motivations lead households to avoid adopting energy-saving technologies. **Corollary 5:** Households with low (or no) financial motivations adopt more than households with little (or no) environmental motivations. Note that each corollary is related to the correspondent Proposition.

The assessment of the validity of Corollary 1 and 2 gives mixed results for the data at hand (See Table 1A). For what concerns *Appliances,* we do not reject the null hypotheses $H_0^1: \bar{\bar{X}}_{i,j} \succ_s \bar{\bar{Y}}_{i,j}$, but the null hypotheses $H_0^1: \bar{\bar{Y}}_{i,j} \succ_s \bar{\bar{X}}_{i,j}$ are rejected. Therefore, we can infer that in the case of adoption of low-cost technology, low level of financial or environmental motivations still leads households to adopt energy saving technologies. However, the picture changes when we consider more expensive technologies such as thermal insulation, where we do no reject the null hypothesis that $H_0^1: \bar{\bar{Y}}_{i,j} \succ_s \bar{\bar{X}}_{i,j}$, whereas the hypothesis $H_0^1: \bar{\bar{X}}_{i,j} \succ_s \bar{\bar{Y}}_{i,j}$ can be rejected. Therefore, in this case we can conclude that low motivation toward environmental or financial matters leads households to act accordingly and not to invest in expensive insulation technologies. Interestingly enough, the test results for the moderate cost energy efficiency-rated-appliances are not conclusive as in the case of *Insulation* where both null hypotheses can't be rejected.

As in proposition 4 positive attitude toward environmental or financial matters increase households' energy-saving investments. The same results hold true for Corollary 3 and 4 where the findings exactly match with those for Proposition 2 and 3, thus strengthening the validity of our conjectures. This result is reinforced (proposition 5) when we looked at the test results for Corollary 5. In this case we do not reject the null at first order only for the hypothesis $H_0^2: \bar{\bar{X}}_{E,j} \succ_s \bar{\bar{X}}_{F,j}$ for the adoption low energy bulbs only, whereas for the other more expensive technologies the test statistic is not conclusive. Therefore, we conclude that households with low (or no) environmental motivations stochastically dominate households with low (or no) financial motivations for the adoption of the low-cost bulbs only.