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The Effects of Informational Feedback on the Energy Consumption of Online Services: Some Evidence for the European Union

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Abstract: Information and Communication Technologies (ICT) have scarcely been considered in studies on green consumption. Likewise, little attention has been paid to the effects of informational feedback on household energy ICT-related consumption. This paper aims to fill these gaps in the literature. Using microdata from a representative sample of the European Union population, this paper analyzes, in a novel way, whether the provision of information about the energy consumed by online services would make internet users change to a greener ICT consumption behavior. To assess this issue, Heckman type selection models are estimated. The results show that people's concerns about environmental problems, their environmental activism and self-perceived efficacy as consumers are directly related to the influence that information provision exerts. We also find that frequent internet users and those with better digital skills are more willing to change their online behavior if given information on energy consumption.

Keywords: energy consumption; informational feedback; information and communication technologies (ICT); internet; consumer efficacy; environment

Citation: García-Muñiz, A.S.; Vicente, M.R. The Effects of Informational Feedback on the Energy Consumption of Online Services: Some Evidence for the European Union. *Energies* **2021**, *14*, 2940. https://doi.org/10.3390/en14102940

Academic Editor: Yuriy Bilan

Received: 27 April 2021
Accepted: 17 May 2021
Published: 19 May 2021

1. Introduction

Accomplishing economic growth and sustainable development entails the shrinking of our ecological footprint. This requires changing to more responsible and sustainable lifestyles, wherein the impacts of technology, production and consumption on the environment are reduced. The promotion of green consumption implies that both firms and citizens make informed choices that have less harmful environmental effects [1].

The European Commission has undertaken several initiatives to empower consumers and businesses and boost more sustainable choices. On 25 January 2021, the Green Consumption Pledge was launched; this is an initiative to accelerate the involvement of enterprises in sustainable recovery and to develop consumer trust in green companies and products [2]. The green transition is also one of the priorities of the New Consumer Agenda of the European Union (EU). The goal is to ensure the green and digital transformation of the EU, wherein consumers have better information to make informed choices about sustainable products [3]. In addition, this agenda supplements other initiatives to make the EU climate-neutral by 2050, such as the European Green Deal or Circular Economy Action Plan. The European Green Deal focuses on the efficient use of resources to boost the circular economy [4]. The new Circular Economy Action Plan (2020) follows the first one, launched in 2015, and encourages the development of circular economy processes, sustainable products and consumer empowerment [5]. Sustainable consumption is also supported by the United Nations (UN) 2030 Agenda for Sustainable Development. Specifically, the UN Sustainable Development Goal (SDG) 12 refers to "Responsible consumption and production" and proposes encouraging "companies to adopt sustainable practices and to integrate sustainability information into their reporting cycle" (p. 22) and "ensuring that people everywhere have the relevant information and awareness for sustainable development and lifestyles" by 2030 [6] (p. 23).

In line with the raising interest in green consumption of international organizations, governments and society, research in this area has significantly increased in the last few years [7–9]. Testa et al. [10] provides an extensive review of the literature. Findings highlight the importance (in terms of green consumption) of individual internal factors, such as values, knowledge, personal norms, beliefs, attitudes, intentions, motivations, perceived consumer effectiveness, and trust, among others. Other structural elements also play a role, such as infrastructural constraints, price, product availability, social norms, product attributes and quality, store-related attributes, brand image, and eco-labelling.

The Information and Communication Technologies (ICT) industry has received relatively little attention in the field of green consumption. Despite all the efforts to foster the adoption of new technologies, "green ICT is a young and pioneering field" [11] (p. 37). In this era of unprecedented digital disruption, there is an ongoing debate about how ICT development can be turned to a more sustainable direction [12]. "The hopes set on digitalization reducing energy consumption have not yet been justified. Instead of saving energy, digitalization has brought additional energy consumption (. . .). This increasing energy consumption is likely to persist as the energy-reducing effects tend to trigger mechanisms leading to the energy-increasing effects" [13] (p. 8). ICT's current share of global greenhouse gas emissions is more than 2%, and the ICT footprint could rise to 14% of global emissions by 2040 [14]. Furthermore, it is expected that "the energy consumption of data centers and telecommunication networks will grow at alarming rates of 35% and 150% respectively over 9 years" (from 2018) [15] (p. 1).

At present, the lockdowns imposed due to the COVID-19 pandemic have boosted the digitization of all areas of the economy and society, accelerating the pace of adoption by several years. Consumers and businesses have struggled to adapt to the new circumstances. During this period, internet traffic has raised by approximately 30% and it seems that it will not go back from these new levels [16]. e-Commerce has sped its growth and the trend is expected to be unremitting during recovery [17]. All this has occurred along with subsequent increases in energy consumption [18–20].

In this context, finding a balance between the growing role of ICT and energy consumption has become a must. Several international institutions have stressed the challenges of the transition to a green and new digital world. ICT can support the achievement of the SDGs but, at the same time, these technologies represent a major threat if their current energy consumption patterns do not change [21]. Therefore, the EU has set the goal for the ICT sector to reach climate neutrality by 2030; this requires firms to improve the sustainability of their data centers and their environmental footprint transparency [22,23]. Data centers need to become more energy-efficient, reuse waste energy, and switch to renewables [24]. The European Parliament has recently (February 2021) drawn attention to the problem posed by the early obsolescence of ICT devices and the need to harmonize and improve the associated recycling infrastructure [25]. Accordingly, last March, 2021, several electronic companies and international organizations signed a declaration to support the green and digital transformation of the EU [26].

The literature about green ICT has addressed the relationship between these technologies and the environment under different scopes. On the one hand, the direct effects of the energy consumption of ICT haven been analyzed, paying attention to their global emissions (production and the operational energy of ICT devices included) [27,28] and the subsequent e-waste. Belkhir and Elmeligi [29] estimate that the impact of mobile phones in greenhouse gas emissions grew by 730% from 2010 to 2020. Such an increase is mainly due to the short average useful life of smart phones. On the other hand, the so-called enabling or secondary effects have been studied. These effects refer to the benefits that the use of ICT technologies might bring in terms of supporting the decarbonization of other sectors and reducing the environmental footprint [30]. Bieser and Hilty [31] details an extensive literature review about the indirect environmental effects of ICT with a focus on virtual mobility, virtual goods, and smart transport, among others. ICT-based applications can contribute to more efficient, and green lifestyles in several ways. For instance, smart grids generate information which allow both consumers and firms to make more informed choices about energy use. Smart meters and appliances help consumers to be aware of their energy consumption so that they can change their behavior in real time. Intelligent building management systems monitor energy consumption and heat/cool buildings automatically. Technologies in smart cities are designed to control energy consumption in transportation, agriculture, logistics or healthcare, among others.

One recognized way to address the pernicious effects of ICT on the environment is the promotion of their sustainable consumption [32]. For this, the provision of information to consumers about their energy consumption and carbon footprint is an essential element [33,34]. Vandenbergh et al. [35] argues that labelling consumer products and services with this type of information "could fill the climate-policy gap by influencing the behavior of consumers and corporate supply chains" (p. 4). "The expectation is that this feedback will motivate" people "to change their energy behaviors in positive ways" [36] (p. 1).

However, little attention has been paid to these issues in the field of green ICT and sustainable energy consumption [11,37]. Previous research has focused on identifying determinants on green consumption in general, with mixed results regarding sociodemographic characteristics but agreeing on the role of beliefs, attitudes, and pro-environmental behavior (see an extensive review of the literature in [1,10]). Recent studies have highlighted the role of the circular economy paradigm [38] and underlined the importance of individuals' consumption model. Another strand of research has paid attention to understanding consumers' decisions on general home energy consumption [39–42], without any specific focus on ICT. In fact, green ICT has mainly been studied from business and education perspectives [43], whereas few studies have adopted a consumer perspective [44].

The goal of this paper is to investigate the role energy-related information plays in the use of ICT. The provision of information about the benefits and risks associated with the production and consumption of these technologies is relevant to both consumers and public organizations in order to promote green consumption [32,45]. The information about the energy consumed by the use and provision of online services would allow consumers to make better and most energy-efficient choices about which software to use, the internet browser, and the amount of time they spend of the internet, among others. If people knew how much energy is consumed when they watched some series on the internet, they could make better choices about the number of episodes to watch per day and the time to watch them. Similarly, if people knew how much energy is consumed when they surf the web through their smart phones or tablets while commuting in public transporting, they might choose other things to do during the trip. Furthermore, the internet allows consumers to access to information about sustainability which can help them to re-orient their consumption decisions towards greener options [46]. Being informed about one's own level of energy consumption and of the alternatives to save energy are recognized as key determinants of users' attitudes towards smart technologies [47,48]. In fact, the EU recognized the importance of being informed: "European consumers rightly expect (. . .) to be empowered to make informed choices and play an active role in the green and digital transition whenever and wherever they are in the EU" [3] (p. 1). Limited knowledge can substantially hamper the implementation of greener actions [32].

Then, this paper aims to bridge the identified gap in the literature. Previous research has mainly focused on the relationship between social factors and a households' willingness to pay for green ICT products [49–51]. The present analysis will provide useful and new evidence on the effects that the provision of information about energy consumption might have on the use of greener ICT. It can be concluded that there is a need to implement awareness-raising campaigns to encourage greener practices.

Regarding the methodological approach, Heckman type models are used. These are a very popular analytical tool in Labor Economics. The use of them offers two main advantages for the present analysis. First, this kind of model appropriately fits the survey design, in which the data about the impact of energy-related information are collected only for those individuals that currently use the internet; this econometric modelling will allows us to control for any sample selection bias that could be introduced if the sample was directly restricted to internet users without taking into account that the reference population in the survey includes users and not-users of the internet. Second, Heckman type models mirror individuals' decision-making process very well. Individuals make two decisions: whether to use the internet or not, and then whether to change their online behavior if given information about the energy consumed by online services.

The data source, the Eurobarometer, is also of interest for two main reasons. First, it covers the full population of the European Union; accordingly, it allows us to explore any cross-country differences. Second, to the extent of our knowledge, it is the only data source that provides detailed information about the potential impact of the feedback on energy consumed by online services. The effects of informational feedback on energy consumption have been largely explored in the literature regarding new in-home displays and appliances (such as smart grids), through the evaluation of specific programs, interventions or the implementation of experiments [52,53]. However, little is known about the effects that providing information about the energy consumed by online services might have on individuals' behavior.

2. Materials and Methods

The data for this study come from the recent Eurobarometer 94.2 [54]. Hence, we use a secondary data source. The EU's Eurobarometers are key sources of cross-national empirical microdata, which allow for the assessment of European attitudes in general, and those related to the environment in particular. The reference population is residents in any of the 28 member states of the EU (the United Kingdom included) aged 15 and older. A multi-stage, random sampling design was applied to draw representative samples of the population in each country. A total of 27,427 face-to-face interviews were successfully collected from December 6 through 19, 2019 at people's homes. (Technical details of the standard procedure of data collection for the Eurobarometer series can be checked at: https://www.gesis.org/en/eurobarometer-data-service/survey-series/standard-special-eb/sampling-and-fieldwork. Accessed on 17 May 2021). Sample sizes are about 1000 individuals per country, except for Germany with 1500 and Cyprus, Luxembourg and Malta with 500. The questionnaire was organized into four blocks of questions: (i) attitudes towards the environment; (ii) attitudes towards corruption; (iii) use of information and communication technologies (ICT); (iv) sociodemographic information. For the case of analysis, the second block (corruption issues) is not considered. Concerning the use of ICT, interviewed individuals were asked about their internet use. If they reported being users, then they were asked whether having information about the energy consumed in the provision and use of online services would influence their use of them. This last question is the object of interest in this study.

To analyze the influence of informational feedback on the energy consumption of online services, there are two essential methodological issues. First, the binary and discrete nature of the variable (whether information would influence or not); this suggests the appropriateness of discrete choice models (either probit or logit models). Second, the relevant population is internet users, and not the full survey population; therefore, potential sample selection bias should be considered. This latter point is especially important since the use of the internet is clearly shaped by individuals' sociodemographic features [55–57]. To take account of these two issues, the most appropriate framework is that of Heckman sample selection models [58]; specifically, a probit model with sample selection.

Accordingly, our empirical model is composed of the two following equations

$$\text{Outcome equation: } y^* = X\beta + u_1 \; y = 1[y^* > 0] \quad (1)$$

$$\text{Selection equation: } s^* = Z\gamma + u_2 \; s = 1[s^* > 0] \quad (2)$$

$$\text{where } u_1 \approx N(0, 1) \text{ and } u_2 \approx N(0, 1);\ \text{corr}(u_1, u_2) = \rho$$

where y* is a latent variable, associated with the binary and observed variable y, which takes value 1 if an individual reports that having information about the energy consumed by the provision and use of online services would influence his/her use of them. However, the variable y is not always observed, except when the binary and observed variable s equals 1, that is, when the respondent is an internet user. X and Z are the corresponding vectors of explanatory variables, and u_1 and u_2 are the error terms. If $\rho \neq 0$, the estimation of the outcome Equation (1) as a standard Probit model would yield biased results; in such a case, the joint estimation of the selection and outcome equations provides consistent and efficient estimates. The Heckman-type model should fulfil the following exclusion restriction: at least one of the variables included in the selection equation should not be included in the outcome equation. Table 1 describes the variables used in the analysis. Descriptive statistics of these variables are presented in the Table A1 in Appendix A.

Table 1. Description of variables.

Dependent Variable	Description
INFO_ENERGY	=1, if respondent reports that having information about the energy consumed by the provision and use of online services would influence his/her use of these services (0, otherwise)
INTERNET_USE	=1, if respondent reports using the internet (0, otherwise)
Independent Variables	
Attitudes towards environment	
CLIMATE_CHANGE	Respondent' self-assessed degree of seriousness of climate change in his/her country. Scale 1–10, (1: "not at all a serious problem"; 10; "an extremely serious problem")
ENVIR_IMPORTANCE	=1, if respondent reports that protecting the environment is very/fairly important to him/her personally (0, otherwise)
Environmental activism	Respondent's number of environmental actions in the last six months (reference: none)
ENVIR_ACTIVISM1–3	=1, if respondent reports having done between 1 and 3 environmental actions (0, otherwise)
ENVIR_ACTIVISM4–6	=1, if respondent reports having done between 4 and 6 environmental actions (0, otherwise)
ENVIR_ACTIVISM7–14	=1, if respondent reports having done between 7 and 14 environmental actions (0, otherwise)
CONS_EFFICACY	=1, if respondent reports that changing the way we consume is the one of most effective ways of tackling environmental problems (0, otherwise)
Internet use	
INTERNET_DAILY	=1, if respondent reports that he/she uses the internet every day or almost every day (0, otherwise)
DIGITAL_SKILLS4JOB	=1, if respondent totally agree or tend to agree that he/she is sufficiently skilled in the use of digital technologies to do his/her job (0, otherwise)
Sociodemographic features	
FEMALE	=1, if female respondent (0, otherwise)
AGE	Respondent's age
Difficulties paying bills	Respondent's frequency of having difficulties in paying bills (reference: never)
BILLS_TIME2TIME	=1, respondent reports having difficulties in paying bills from time to time (0, otherwise)
BILLS_MOSTIME	=1, respondent reports having difficulties in paying bills most of the time (0, otherwise)
Social Class	Respondent' self-assessed social class (reference: working class)
C_LOWER_MIDDLE	=1, if respondent considers him/herself to belong to lower middle class (0, otherwise)
C_MIDDLE	=1, if respondent considers him/herself to belong to middle class (0, otherwise)
C_UPPER_MIDDLE	=1, if respondent considers him/herself to belong to upper middle class (0, otherwise)
C_HIGHER	=1, if respondent considers him/herself to belong to higher class (0, otherwise)
C_DK/DA	=1, if respondent do not answer the question about social class (0, otherwise)
Education	Respondent's age when stopped full-time education (reference: up to 15 years old)
HIGHSCHOOL	=1, if respondent stopped full-time education when aged 16–19 years old (0, otherwise)
COLLEGE/UNIVER	=1, if respondent stopped full-time education when aged 20 years old and older (0, otherwise)
STUDYING	=1, if respondent is still studying (0, otherwise)
Employment	Respondent's employment situation (reference: employed)
UNEMPLOYED	=1, if respondent is unemployed (0, otherwise)
INACTIVE	=1, if respondent is not in the labor market (0, otherwise)
Location	Type of location where respondent lives (reference: rural area/village)
SMTOWN	=1, if respondent lives in a small/medium-sized town (0, otherwise)
LTOWN	=1, if respondent lives in a large town (0, otherwise)
COUNTRY	Categorical variable, with each category indicating respondent's country of residence
EXPENDITURE	National expenditure on environmental protection (% of national Gross Domestic Product)
ECO_VITAL	Ecosystem vitality index
BIODIVERSITY	Biodiversity and habitat index

The regressors in the outcome equation are related to people's attitudes towards the environment and their use of internet. Specifically, attitudes towards the environment are measured by the following variables: two dummy variables related to the importance attached to environment protection (ENVIR_IMPORTANCE), and to changes in consumption as the one of most effective ways of tackling environmental problems (CONS_EFFICACY); a series of dummy variables which consider respondents' level of environmental activism in the last six months (ENVIR_ACTIVISM); one continuous variable in a scale 1–10 related to respondents' self-assessed degree of seriousness of climate change in his/her country (CLIMATE_CHANGE).

Regarding internet use, a dummy variable considers respondents' frequency of internet use (INTERNET_DAILY) and another dummy variable, his/her level of digital skills (DIGITAL_SKILLS4JOB).

We also include three variables at national level to explore whether the environmental situation of the country, wherein an individual lives, might be related to the likelihood of changing his/her online usage if given information about energy consumption. On the one hand, we consider national efforts to protect the environment in terms of the expenditure devoted to this issue (EXPENDITURE). These data are sourced from Eurostat [59].

On the other hand, we take two measures of country's environmental state into account: the ecosystem vitality (ECO_VITAL), and the biodiversity and habitat indexes (BIODIVERSITY). Both of them are components of the Environmental Performance Index (EPI) developed by the Yale Center for Environmental Law and Policy [60]. The EPI is a composite index which summarizes the state of sustainability around the world. The higher the score of the index, the better the national situation in terms of sustainability. For the development of the EPI, two main policy goals are considered: environmental health and ecosystem vitality, which include four and seven dimensions, respectively. The biodiversity and habitat index (BIODIVERSITY) is one of the seven dimensions included in the ecosystem vitality policy goal (ECO_VITAL).

Then, the scope of the former is less than the latter. (See [60] for more technical details on the EPI.) A large set of environmental-related indicators (from different sources) were considered to explore the aforementioned relationship between national environmental situation and potential changes in online consumption behavior. Only the two previous EPI indicators were found to be statistically significant for the present analysis.

In the selection equation, the regressors include a set of sociodemographic variables: age, gender, educational attainment, employment situation, and location. Two variables measure respondents' economic situation: self-assessed social class and self-reported frequency of having difficulties in paying bills. In addition, respondents' country of location is included. To code this variable, we use the "deviation from the means" method [61], which sets the reference category to −1 and the rest as 0, 1 (as it corresponds). This technique will allow us to identify whether each country is above (or below) the European average. The academic literature on digital divide has paid attention to the identification of the socio-economic factors that describe the diverse levels of digital development [62]. Inequalities have been studied at different levels: the access to ICT (first divide), the skills required for ICT use (second divide) and the disparities in the benefits derived from ICT use (third divide).

Pairwise correlations have been run between all regressors to check any potential collinearity issues. The results show that the associations between explanatory variables are low enough not to raise any collinearity concerns. Sociodemographic variables are not included in the outcome equation for the following two reasons: first, to fulfill the exclusion restriction of the Heckman models; second, to avoid endogeneity problems, given that the use of the internet is included in the outcome equation as an explanatory variable, and we know, from the selection equation, that this is shaped by people' sociodemographic features. Finally, survey weights are used to estimate the empirical model. (Technical details of the weighting procedure of data in the Eurobarometer series can be checked at: https://www.gesis.org/en/eurobarometer-data-service/survey-series/standard-special-eb/weighting-overview accessed on 17 May 2021).

3. Results

Tables 2 and 3 present the weighted estimates of the selection equation and Table 4 introduces the estimates of the outcome equation, respectively. The selection equation has been estimated using the full sample, that is, 27,427 respondents, and refers to whether an individual uses the internet or not: 22,427 individuals reported using the internet in the sample, while 4710 did not.

Table 2. Weighted coefficient estimates for selection equation (dependent variable: INTERNET_USE).

Independent Variables	Coefficients (1)
AGE	−0.0151
AGE^2	−0.0004 ***
FEMALE	−0.0014
UNEMPLOYED	−0.5839 ***
INACTIVE	−0.5247 ***
HIGHSCHOOL	0.5777 ***
COLLEGE/UNIVER	1.1377 ***
STUDYING	0.8757 ***
SMTOWN	0.0965 **
LTOWN	0.2430 ***
BILLS_TIME2TIME	−0.0931 *
BILL_MOSTIME	−0.3539 ***
C_LOWER_MIDDLE	0.4586 ***
C_MIDDLE	0.5908 ***
C_UPPER_MIDDLE	0.8059 ***
C_HIGHER	0.2066
C_DK/DA	−0.0346

Note: ***, **, * indicate statistical significance at 1, 5, and 10 percent levels, respectively.

Table 3. Weighted coefficient estimates for selection equation (continued).

Independent Variables	Coefficients (1)	Independent Variables	Coefficients (1)
Austria	0.0760 ***	Latvia	−0.3299 ***
Belgium	0.4933 ***	Lithuania	−0.5852 ***
Bulgaria	−0.5066 ***	Luxembourg	0.2132 ***
Croatia	−0.1398 ***	Malta	−0.3298 ***
Cyprus	−0.5941 ***	Netherlands	1.5300 ***
Czech Republic	−0.2856 ***	Poland	−0.7877 ***
Denmark	0.8586 ***	Portugal	−0.0377
Estonia	−0.1063 ***	Romania	−0.9506 ***
Finland	0.4110 ***	Slovakia	1.2522 ***
Germany	0.2351 ***	Slovenia	−0.2233 ***
Greece	−0.4476 ***	Spain	0.4696 ***
Hungary	−0.4675 ***	Sweden	−0.5760 ***
Ireland	0.2489 ***	United Kingdom	0.6117 ***
Italy	0.0345		

Note: ***, indicate statistical significance at 1 percent levels, respectively.

Almost all the sociodemographic variables included in the selection equation are statistically significant. The only exceptions are FEMALE and two categories of the variable related to self-assessed social class (C_HIGHER and C_DK/DA). The variable AGE is non-significant, but its square term is statistically significant at the one percent level with a negative sign. This suggests an inverse relationship between age and the use of the internet (as age increases, the likelihood of using the internet decreases), in which the older the individual, the lower the likelihood of using the internet. A high numbers of studies have emphasized the digital divide around older and younger adults [63].

Table 4. Weighted coefficient estimates for outcome equation (dependent variable: INFO_ENERGY).

Independent Variables	(1)	(2)	(3)	(4)
CLIMATE_CHANGE	0.0496 ***	0.0456 ***	0.0488 ***	0.0487 ***
ENVIR_IMPORTANCE	0.1887 ***	0.1783 ***	0.1906 ***	0.1724 ***
ENVIR_ACTIVISM1–3	0.3292 ***	0.3535 ***	0.3347 ***	0.3435 ***
ENVIR_ACTIVISM4–6	0.4767 ***	0.5116 ***	0.4865 ***	0.4919 ***
ENVIR_ACTIVISM7–14	0.6605 ***	0.7063 ***	0.6820 ***	0.6819 ***
CONS_EFFICACY	0.0600 **	0.0612 **	0.0645 **	0.0632 **
DIGITAL_SKILLS4JOB	0.0746 **	0.0691 **	0.0717 **	0.0715 **
INTERNET_DAILY	0.2773 ***	0.2721 ***	0.2709 ***	0.2753 ***
EXPENDITURE		−0.1479 *		
ECO_VITAL			−0.0117 *	
BIODIVERSITY				−0.0130 **
Wald test of independence between equations (ρ = 0) [(chi2(1)]	77.35 ***	97.30 ***	83.99 ***	76.98 ***
N	27,427 (Selected: 22,717; Non-selected: 4710)			

Note: ***, **, *, indicate statistical significance at 1, 5, and 10 percent levels, respectively.

Meanwhile, educational attainment is positively associated with the use of the internet. People with high school education and those with a college or university degree are correspondingly more likely to use the internet than those who stopped their full education at 15 years old. The academic literature on ICT adoption highlights the key role played by the level of education [64].

Compared to employed people, those who are unemployed or out of the labor market are less likely to use the internet. The size of the town is also significantly related to the use of the internet; specifically, the larger the town, the higher the likelihood of using the internet. The two variables related to respondents' economic situation are also statistically significant and point in the same direction: people in a better economic situation are more likely to use the internet than those who are not. Compared to people who do not have any difficulty in paying their bill, those who have problems are less likely to use the internet. In the same sense, people who consider themselves in a social class above the working class are more likely to use the internet. Previous studies have confirmed the link of ICT use with employment polarization and income inequality [63].

In addition, estimates in Table 3 show the existence of significant cross-country differences in the use of the internet between EU member states. Austria, Belgium, Denmark, Finland, Germany, Ireland, Luxembourg, Netherlands, Slovakia, Spain, and United Kingdom are more likely to use the internet than the average. In countries as Bulgaria, Croatia, Cyprus, Czech Republic, Estonia, Greece, Hungary, Latvia, Lithuania, Malta, Poland, Portugal, Romania, Slovenia, and Sweden, the likelihood of using internet is lower than the average. In EU, the digital divide shows some spatial patterns, with a clear gap between North and South and Eastern Europe [65].

Table 4 shows the results of the estimation of the outcome equation, which uses the information from the 22,427 individuals who reported using the internet in the sample. Out of the total, 7156 (31.5%) individuals stated that if they had information about the energy consumed by online services, this would influence their use of them; the rest, 15,561 (68.5%) respondents, report that it would not. It seems that empowering the consumer through reliable and useful information about energy consumed by online services does not facilitate the green transition of many consumers. This is in line with previous empirical findings around the gap between pro-environmental attitudes and green behavior [10]. In this sense, providing individuals with energy information does not unavoidably boost them to change to a greener behavior. Usual energy-consuming behaviors based on automatic processes can be resilient to transformation [66]. The lack of time and/or adequate information on how to change their behavior might also constrain consumers' willingness to change. Accordingly, conditions which provide useful information should be created. People would be more likely to change their behavior if they have short-term, easy-to-achieve green goals and have been provided with tailored tips on the most effective ways to move towards greener consumption.

Column (1) presents the estimates when we only consider variables with information at the individual level in the outcome equation; columns (2–4) show the estimates when we also include variables at country level. The estimates of the selection equations associated with the outcome equations (columns (2)–(4), Table 4) are not reported due to space constraints. They are fairly similar to those presented in Table 3 and can be provided by authors upon request.

In this case, all the explanatory variables included are statistically significant. The results suggest that people's concerns regarding environmental problems are directly related to the influence that the provision of information about the energy consumed by online services might exert on them. Thus, respondents who report that environment protection is important for them personally are more likely to report that information would influence their use of online services. In the same sense, the positive sign of the variable CLIMATE_CHANGE indicates that the higher people rate the seriousness of climate change, the more likely that information would influence them. In addition, people's environmental engagement is linked to information influence. Respondents who are environmentally active are more likely to report that their use of online services would be influenced by information. Specifically, the probability of changing their online behavior increases with the number of environmental actions carried out in the last six months. Consumer effectiveness is also directly related to the influence of information. Respondents who report that changing the way we consume is the one of most effective ways of tackling environmental problems are more likely to be influenced by information than those who consider other ways of action. Thus, the attitudes related to both active environmental behavior and environmental sensitivity have positive influences on individuals' readiness to be empowered by information on energy.

The results also show that the frequency of internet use and the level of digital skills are directly related to the influence of information. People who use the internet daily and who considered themselves to have enough digital skills for their job both report that the information about the energy consumed by online services would influence their use.

Regarding the variables that take account of a country' environmental situation and of the efforts towards its protection, all of them are statistically significant and show negative signs.

Finally, the results of the Wald test of independence between the two equations lead to a clear rejection of the null hypothesis of independence ($\rho = 0$). Accordingly, the estimation of Heckman type selection models appears as the most appropriate modelling approach to our data.

4. Discussion

The gender divide that characterized the take-up of ICT in the early 2000s [56] appears to have disappeared now, as shown by the non-significant coefficient of FEMALE in our regression. The well-known age divide (with youngsters more likely to use the internet than the elderly) not only remains, but seems to have worsened, as suggested by the negative and statistically significant coefficient of the square term of the variable AGE. The urban versus rural divide persists, i.e., people living in towns (and especially those in large cities) are much more likely to the use the internet than those in rural areas. While the prices of ICT devices and of internet access have been constantly decreasing over the years [67], our estimates show that people's economic situation is clearly related to internet use. Specifically, the well-off appear to be more likely to use the internet compared to people in disadvantaged economic situations, either because they have difficulties in paying bills or they belong to the lowest class of society (e.g., the working class). This result raises some serious concerns [57]. On the one hand, the well-off are in a better position to take advantage of all the benefits associated with the use of online services. On the other hand, they are the ones that can afford the latest ICT gadgets, which are usually the most efficient in terms of energy consumption. Cross-country differences in terms of internet use are also significant. A clear divide remains between the Old and New member states of the European Union, as previously shown by Vicente and López [68]. Northern European countries are above the European average, while all of Eastern Europe is below it. Overall, these results suggest that the successive action plans implemented by the EU (eEurope 2002 and 2005, i2010, the Digital Agenda) and at the national level have had a limited success in bridging digital divides. This situation has become obvious during the COVID-19 pandemic [69].

The pandemic and the subsequent lockdowns and restrictions have caused the worldwide population to stay at home more. First, neither the society nor the economy were prepared to move from a face-to-face environment to an online one as quickly as the lockdowns required. Second, the pandemic made the precarious access to the internet in many households evident: while they did have a connection to the internet, in many cases the quality was not good enough and did not support the use of advanced online services (e.g., e-learning, e-health). This situation has produced more energy consumption in general, and especially of that related to the use of online services. In this context, it becomes crucial to identify the sources, on both sides of the market, that can make this consumption more energy-efficient. On the supply side, this requires further investment in green ICT development [45,70,71]. On the demand side, our results suggest that providing consumers with information about the energy consumed by online services might be an easy and possibly effective way of fostering more energy efficient behaviours. Information can make consumers aware that their decisions about internet usage are not neutral in energy terms.

It is also interesting to note that daily users of the internet would be more likely to change their online usage if they had information about energy consumption compared to those who use it with less frequency. This finding points out the potential that providing this type of information might have for promoting more energy-efficient internet usage.

The results also suggest the existence of some negative relationship between the country's general environmental situation and individuals' willingness to change their behavior. This is a first exploration of this issue, so these results must be interpreted with caution. A possible explanation for this would be that people might not be as pressed to change their routines if they live in country in which the environmental situation is fine, possibly because they might not perceive environmental degradation as an urgent issue in their immediate habitat.

Focusing on the promotion of the empowerment of vulnerable consumers [70], policymakers should provide special attention to providing incentives and support to boost awareness of the benefits of green ICT consumption among the elderly, the unemployed and people at risk of poverty. The results reinforce the importance of the so-called nudging or soft policy measures for promoting green energy solutions among individuals. Nudging interventions could be implemented to foster the green consumption of ICT. This type of policy can boost the effectiveness of other stimulus based on fiscal policies and regulations. Overall, achievement of the green consumption of ICT implies enhancing people's environmental education in order to foster knowledge and awareness of energy sustainability.

5. Conclusions

This paper has explored the influence that the availability of information about the energy consumed by online services might exert on people's use of these services. To do this, we first explored internet use among Europeans. The results have confirmed that, despite the widespread diffusion of the internet, its use is still shaped by people' sociodemographic features.

Regarding the effect of the informational feedback on the energy consumed by online services, estimates allow us to clearly identify the profile of those whose usage would change if they had such information. Specifically, these are people concerned about the environment. They believe that the climate change is a serious problem in their countries and, for them, protecting the environment is an important issue. They are also environmentally active, i.e., they carry out regular actions to protect the environment. Hence, environment-friendly practices seem to be part of their daily life. In addition, they belief that, as consumers, through their consumption decisions, they can effectively help to protect the environment. These findings are in line with some recent evidence which points out that the adoption of smart grids largely depends on people's motivation and attitudes towards the environment [48].

In addition, people who consider themselves to be digitally skilled appear to more likely to change their online behaviour if they had information on energy consumption. This positive association might be related to some (lower) opportunity costs. Specifically, the costs of changing online routines might be lower for highly digitally skilled individuals than for the low-skilled. It might be easier for them and take them less time to find ways to optimize the relation between their online usage and energy consumption.

The main limitation of this analysis is that our database does not include any information about the type of online services that people use. The amount of energy consumed differs in terms of the type of online service, since they involve different amounts of data traffic [72,73]. Unfortunately, we cannot assess to what extent the differences in the patterns of online service usage might be related to people's willingness to change his/her online behavior (if they were given information about energy consumption). It is also important to note that, with our data, we can only analyze people's willingness to change. There is a well-known inconsistency in the literature between what people declare they will do (or are willing to do) and what they actually do. This is the so-called green intention (motivation, attitude)–behavior gap. Future research should try to explore these issues.

Author Contributions: Conceptualization, A.S.G.-M. and M.R.V.; methodology, A.S.G.-M. and M.R.V.; software, A.S.G.-M. and M.R.V.; validation, A.S.G.-M. and M.R.V.; formal analysis, A.S.G.-M. and M.R.V.; investigation, A.S.G.-M. and M.R.V.; resources, A.S.G.-M. and M.R.V.; data curation, A.S.G.-M. and M.R.V.; writing—original draft preparation, A.S.G.-M. and M.R.V.; writing—review and editing, A.S.G.-M. and M.R.V.; visualization, A.S.G.-M. and M.R.V.; supervision, A.S.G.-M. and M.R.V.; project administration, A.S.G.-M. and M.R.V.; funding acquisition, A.S.G.-M. and M.R.V. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Data are available from: European Commission, "Eurobarometer 92.4 (ZA7602 Data file Version 1.0.0)." GESIS Data Archive, Cologne, 2020, doi: 10.4232/1.13652.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. Descriptive statistics.

Variable	Observations	Mean	Std. Dev.	Minimum	Maximum
INTERNET_USE	27,427	0.8282714	0.3771513	0	1
AGE	27,427	51.85616	18.19588	15	98
FEMALE	27,427	0.5413643	0.4982951	0	1
UNEMPLOYED	27,427	0.0518467	0.2217215	0	1
INACTIVE	27,427	0.4436504	0.4968236	0	1
HIGHSCHOOL	27,427	0.4336967	0.4955934	0	1
COLLEGE/UNIVER	27,427	0.350494	0.4771334	0	1
STUDYING	27,427	0.0607066	0.2387957	0	1
SMTOWN	27,427	0.3847304	0.4865404	0	1
LTOWN	27,427	0.2865425	0.4521541	0	1
BILLS_TIME2TIME	27,427	0.2420607	0.4283387	0	1
BILLS_MOSTIME	27,427	0.0766033	0.2659659	0	1
C_LOWER_MIDDLE	27,427	0.1511285	0.3581806	0	1
C_MIDDLE	27,427	0.4726	0.4992578	0	1
C_UPPER_MIDDLE	27,427	0.0688008	0.2531197	0	1
C_HIGHER	27,427	0.005542	0.0742393	0	1
C_DK/DA	27,427	0.0386845	0.1928455	0	1
INFO_ENERGY	22,717	0.3150064	0.4645286	0	1
DIGITAL_SKILLS4JOB	22,717	0.4795968	0.4995945	0	1
INTERNET_DAILY	22,717	0.8897742	0.3131779	0	1
CONS_EFFICACY	22,717	0.3333187	0.4714097	0	1
ENVIR_ACTIVISM1–3	22,717	0.4151516	0.492759	0	1
ENVIR_ACTIVISM4–6	22,717	0.3452921	0.4754739	0	1
ENVIR_ACTIVISM7–14	22,717	0.2105031	0.407675	0	1
ENVIR_IMPORTANCE	22,717	0.535326	0.4987615	0	1
CLIMATE_CHANGE	22,717	7.557424	2.196745	1	10
EXPENDITURE	22,717	1.878069	0.6009279	0.6	3.2
ECO_VITAL	22,717	66.75881	5.84899	53.7	76.4
BIODIVERSITY	22,717	81.97476	7.0601	56.5	89

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