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Technical note

Which factors affect the willingness of consumers to adopt renewable energies?

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ABSTRACT

This study presents insights into the determinants of consumers' willingness to adopt renewable energies in the residential sector. The empirical analysis is based on the estimation of binary probit regression models. Empirical results suggest that middle-aged and highly educated people are probably more willing to adopt renewable energy sources in their home. In general, income positively affects consumers' acceptance of renewable energy projects in the residential sector. However, the results suggest that marital status and gender are not statistically significant factors in the willingness to adopt renewable energies. A tax deduction is estimated to be the most effective financial policy measure to promote consumers' acceptance of renewable energies in the residential sector, more so than an energy subsidy. Our analysis is focused on intention because we expect that those people willing to adopt renewable energy sources in their residence are a potentially relevant market segment for the application of renewable energies.

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1. Introduction

Carbon emissions generated by fossil fuels are a major barrier to achieving sustainable development. On the other hand, the penetration of renewable energy projects in the residential sector is linked to zero greenhouse gas emissions. Thus, consumers' acceptance of the use of renewable energy sources in the residential sector is important in achieving this goal.

The deployment of renewable energy in the residential sector depends on the consumers' intention to adopt a technological innovation. Classical economic theory suggests that individuals make consumption decisions that maximize their welfare given the capital constrained derived demand function. Within this framework, demand for one good or service occurs as a result of the demand for another intermediate/final good or service. Thus, consumers usually think of themselves as the central actor in a decision process [1]. Previous studies have focused on attitudes towards green energy and on public acceptance of renewable energy projects [2–8]. Several studies have also been conducted on the willingness to pay a premium for domestic use of micro-generation renewable sources and on the impact of several consumer characteristics such as demographic, economic, information dissemination and socio-psychological determinants [9–17]. Researchers have also pointed out the barriers [10,15,17,18] and the motives [18,19] to the adoption of renewable energy systems in the residential sector.

The aim of this study is to examine the determinants that affect consumers' intention towards the adoption of renewable energy sources in the residential sector. We chose to investigate consumers' attitudes in the residential sector because we expect consumers' willingness to adopt renewable energies in the residential sector to be a potentially important market segment for the development of sustainable lifestyles and the application of renewable energies in Greece.

The paper proceeds as follows: Section 2 presents the methodological issues and the data used in the empirical analysis, while Section 3 presents the empirical results. The conclusions of the analysis are discussed in Section 4.

2. Methodological issues and data

The research provides some insights into the determinants that affect consumers' attitude towards willingness to adopt renewable energy in their residence, employing a cross-sectional data set from Greece. We carried out a survey of 200 consumers, from December 2009 to January 2010, using the random stratified sampling method.

Empirical results are based on the estimation of the following expanded probit specification for a consumer's willingness to adopt renewable energy sources in their home:

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$$\begin{aligned}\mathrm{ADOPT}_{\mathrm{RES}_i} = {} & b_0 + b_1\mathrm{Gender}_i + b_2\mathrm{Age}_i + b_3\mathrm{Age2}_i + b_4\mathrm{Married}_i \\ & + b_5\mathrm{Degree}_i + b_6\mathrm{Public}_i + b_7\mathrm{Income}_i + b_8\mathrm{Owner}_i \\ & + b_9\mathrm{Elbill}_i + b_{10}\mathrm{Imcost}_i + b_{11}\mathrm{Uneff}_i + b_{12}\mathrm{Usef}_i \\ & + b_{13}\mathrm{Taxded}_i + b_{14}\mathrm{Subsidy}_i + b_{15}\mathrm{Dprice}_i + u_i \end{aligned} \quad (1)$$

where:

$\mathrm{ADOPT}_{\mathrm{RES}_i}$: the consumer i is willing to adopt in their residence renewable energy sources or not (YES = 1, 0 = otherwise). Gender_i is a dummy variable accounting for 1 if the respondent is female and zero if male; Age is the respondent's age; $\mathrm{Age2}_i$ is the square of the respondent's age; $\mathrm{Married}_i$ is a dummy variable taking the value 1 if the respondent is married and zero otherwise; Degree_i is a dummy variable accounting for 1 if the respondent has completed undergraduate studies and zero otherwise; Public_i is a dummy variable accounting for 1 if the respondent is a public servant employee and zero otherwise; Income_i is the respondent's monthly private income in Euro; Owner_i is a dummy variable accounting for 1, if the respondent owns his/her house and zero otherwise; Elbill_i is a quantitative variable expressing the average electricity cost per household; Im cost_i is a dummy variable taking the value 1 if the respondent considers that the installation and maintenance costs of renewable energies in the residential sector are too high and zero otherwise; Uneff_i is a dummy variable accounting for 1, if the respondent is uncertain about the efficiency of domestic renewable energy projects and zero otherwise; Usef_i is a dummy variable accounting for 1, if the respondent would install a renewable energy system in his/her home if his/her family or friends would encourage him/her to do so and zero otherwise; Taxded_i is a dummy variable taking the value 1 if the respondent considers that an energy tax deduction would encourage them to adopt renewable energy sources in the residence and zero otherwise; $\mathrm{Subsidy}_i$ is a dummy variable accounting for 1 if the respondent would adopt renewable energy sources in their home in case of an energy subsidy and zero otherwise; Dprice_i is a dummy variable taking the value 1 if the respondent is willing to adopt renewable energy projects in their home as a result of energy prices of non-renewable sources doubling and zero otherwise; and u is an error term. The empirical results from the estimation of Eq. (1) are presented in the next Section.

3. Results

In this section we present the results of the statistical and econometric analyses to estimate the profile of consumers willing to adopt renewable energies in the residential sector and the effectiveness of financial policies.

3.1. Descriptive statistics

From the sample of 150 consumers in question, 66% were women and 34% were men. Most respondents were between the ages of 36 and 50 years (55.3%); 20% were between 25 and 35 years, 19.3% between 51 and 70 years, and only 3.7% above 70 years. As regards the educational level, 35.3% were university-educated and 39.3% had graduated from a secondary school. The majority were employees with 38.7% working in the public and 22.7% in the private sector, whereas 14.7% were freelancers. The consumers' average monthly private, non property-related, income was €1125. As to family income per year, the majority reported having an income below €40,000, 76.7% of consumers were married and the majority of them had two children (46.7%). The great majority of households in question own their house (85.3%). As regards average electricity expenses for the winter period, the majority (31.3%) reported between €91 and €120. To find out consumers' stated awareness towards renewable, we asked if they knew that it is possible to produce energy for domestic use from the implementation of five alternative renewable energy technologies (namely, solar, wind, biomass and geothermal). As regards the potential use of renewable energy sources in the residential sector, the great majority of consumers were informed about the potential use of solar (98.7%) and wind energy (83%), 60% were aware of hydropower applications, whereas possible applications of geothermal (38%) and biomass (36%) were less well-known (Fig. 1). Finally it is important to notice that none of the households in question had previously adopted renewable energy sources for electricity supply of their residence, but almost 65% used solar thermals for water heating.

Next, interviewees were asked about the effectiveness of three possible governmental policy measures to encourage the adoption of renewable energy systems in their residence. The three scenarios were the following: (i) the energy price doubling, (ii) a tax deduction for those households adopting RES in their residence and (iii) an energy subsidy for all consumers willing to adopt renewable energy sources in the residential sector.

As shown in Fig. 2, a tax deduction for those adopting renewable energies in their home was considered to be the most effective financial measure (67.3%), followed by the energy price doubling (44.7%). A possible explanation is that they perceive an energy price doubling as a mandatory measure, whereas an energy tax deduction is a measure with high probability to be materialized. Consumers' response to different policy measures depends upon a combination of income and substitution effects. Interviewees reported that an energy subsidy would also be an effective policy in promoting renewable energy practices in their home (42.3%). Finally, the main sources of information for the possible applications of renewable energies in the residential sector were television (78.7%) and newspapers and magazines (62.7%).

3.2. Probit regression analysis

Several interesting results were obtained from the empirical estimation of Eq. (1). Table 1 summarizes the empirical results of the logit equation's estimated coefficients with respect to consumers' intention to adopt renewable energy sources within their residence in case of a tax exemption. Statistically non-significant variables were omitted from model I and the final results are presented in Model II. In general results are in line with previous studies.

As follows from Table 1, age is a statistically significant factor in the adoption of RES in the residential sector. Indeed, it is estimated

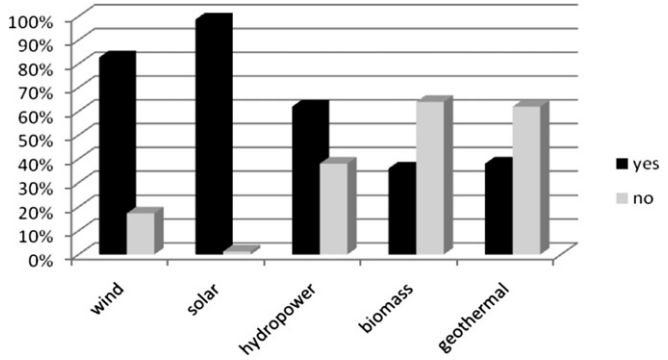

Fig. 1. Consumers' awareness of the potential use of each renewable energy technologies in the residential sector.

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