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Modeling individual preferences for energy sources: The case of IV generation nuclear energy in Italy

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Abstract

The planned re-introduction of nuclear energy in Italy was abandoned in the aftermath of the Fukushima nuclear accident. Twenty years earlier, soon after the Chernobyl accident, Italians had also voted against nuclear energy. However, a new nuclear energy technology, i.e. fourth generation, is under research and development. This paper investigates its social acceptance by means of a robust methodology, employing 1) choice experiments, 2) structural equation modeling and 3) information treatments within an online nation-wide survey. Results show a great deal of preference heterogeneity: the majority of the sampled respondents oppose new nuclear plants in Italy, with some not willing to accept any monetary compensation at all. However, another segment of respondents, more confident that fourth generation nuclear energy goals will be achieved, show a modest support towards the implementation of new nuclear projects. Additional variables were found to affect opposition.

Keywords: Fourth generation nuclear energy, choice experiments, Fukushima, Italy.

1. Introduction

In 2011, the European Commission released the 2050 roadmap which aims to reduce CO_2 emissions by a remarkable 80%, when compared to 1990 levels (European Commission 2011). Italy has recently adopted the National Energy Strategy, which aims to go beyond the 20% reduction goal by 2020 set by EU 2020 strategy. Nevertheless, there are arguably no policies planned or in place so as to reach the European Commission roadmap's goals (ENEA 2013).

Fossil fuels currently dominate both the energy mix and the amount of energy imported in Italy (ENEA 2013). This poses at least two problems. First, the heavy reliance on fossil fuels makes it impossible to achieve the Greenhouse Gas (GHG) emission reductions needed to tackle climate change. Second, there are risks associated with having a high share of imports such as reliance on politically unstable countries and the burden posed to the trade balance (IEA 2009). Hence, it is desirable to decrease fossil fuel consumption and switch to energy sources with zero (or next to zero) GHG emissions, as well as to reduce energy imports and/or make them more diversified. In 2012, Italy's total GHG emissions amounted to about 379 million tons, representing 10.03% of EU's emissions (Eurostat 2014). This share has increased slightly from 1990 levels, when it accounted for 9.2%, although Italian emissions in 2012 decreased by 11.3% compared to twelve years earlier. However, another 8.7% reduction by 2020 is needed to comply with the EU 2020 strategy and both short and long term structural reforms are necessary to aim at the challenging 2050's 80% reduction. Achievement of these targets can be accomplished by increasing the share of renewables and, arguably, by including nuclear power in the energy generation mix.

Nuclear energy is not part of the current Italian energy mix. In 1987, one year after the Chernobyl accident, the Italian population voted against nuclear energy. Similarly, public opinion elsewhere was negatively affected by the Chernobyl (Eiser et al. 1989; Renn 1990; Verplaken 1989) and also the Three Mile Island nuclear accidents (Melber 1982). But almost twenty years later, the re-introduction of nuclear appeared to be very likely in Italy (Iaccarino 2010). This was not an isolated case: in 2009, there were 52 countries considering the implementation of nuclear energy at the time (Jewell 2011). However, in 2011 there was another serious nuclear accident, this time in Fukushima, Japan. Mimicking the events of 1987, via a referendum, Italians once again declared widespread opposition towards the building of new nuclear plants[1].

Unsurprisingly, the Fukushima accident generally worsened nuclear energy's acceptability worldwide (Kim et al. 2013), especially in Japan (Poortinga et al. 2013), as well as negatively affecting subjective well-being (Welsch and Biermann 2014; Rehdanz et al. 2015). There were a few exceptions: after the accident in Japan, nuclear energy's acceptability seems to have remained unchanged in the USA and indeed it appears to have improved in the UK (Srinvasan and Gopi Rethinaraj 2013). The negative effect on public opinion is expected to decrease over time (Siegrist and Visschers 2013). But in 2012, public acceptance of nuclear energy in Italy was still below the EU-27 average (European Commission 2013): only 11% of Italians surveyed would prioritize nuclear energy as an energy option for the next 30 years, vis-à-vis an EU-27 average of 18%, with stronger support being found in the Czech Republic (44%) and Sweden (33%). All in all, preferences towards nuclear energy in Europe seem to be largely negative, especially when compared to renewable energy acceptance: 8 in 10 citizens of the EU-27 would prioritize renewable energy sources over nuclear, energy efficiency, and carbon capture and storage (European Commission 2013).

Nonetheless, a new technology to generate electricity from nuclear power is currently under research and development (R&D). In 2000, the Generation IV Energy Forum (GIF) was established , '*a cooperative international endeavor organized to carry out the R&D needed to establish the feasibility and performance capabilities of the next generation nuclear energy systems'* (GIF 2014). It consists of twelve countries and the EURATOM, through which Italy is present indirectly[2]. Its work is now focused on developing six fourth generation nuclear energy projects, selected in 2002: Gas-Cooled Fast Reactor, Lead-Cooled Fast Reactor, Molten Salt Rector, Sodium-Cooled Fast Reactor, Supercritical-Water Reactor and Very-High Temperature

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[1] In contrast, the Italian government openly declared its interest in contributing towards R&D of new generation reactors (Pistelli 2013).

[2] For example, the Italian company Ansaldo Nucleare and the Italian National Agency for New Technologies, Energy and Sustainable Economic Development (ENEA) form part of a consortium to develop a fourth generation prototype (Agostini and Alemberti 2014).

Reactor. All these reactors have the following goals in common: i) to minimize the probability of catastrophic accidents; ii) to minimize the amount of nuclear waste produced; iii) to reduce the number of years needed to dispose and store the nuclear waste; iv) to increase the cost competitiveness compared to other energy sources; v) to increase the protection against terrorist attacks; and vi) to increase passive security. These so-called fourth generation (FG) nuclear energy systems can be thought of as revolutionary if compared to current nuclear technology (Grape et al. 2014).

The first nuclear plants belonging to the fourth generation are forecasted to be available by 2030 (Locatelli et al. 2013), just in time to be able to contribute to the 2050 roadmap targets. However, the FG technology is still underdeveloped (Murty and Charit 2008). For instance, there are currently no materials which can bear the pressure and temperatures planned for the 'Very high temperature reactors' project (Abram and Ion 2008; Locatelli et al. 2013). The technology costs are the other issue of concern as they are currently undetermined (Kessides 2012; Kosenius and Ollikainen 2013). As such, besides social acceptability, FG nuclear energy implementation also needs to rise to both technological and economic challenges.

This paper focuses on social acceptability and preferences for FG nuclear energy technology; to the best of our knowledge, this is the first study on the matter. We employ choice experiments, a survey-based stated preference method (Bateman et al. 2002), to estimate the willingness to accept (WTA) compensation of Italian residents, and its determinants, for the installation of new FG nuclear power plants in Italy. In addition, we use a structural equation modeling framework in order to further characterize the determinants of acceptance, drawing on the environmental psychology literature. Finally, an information treatment is carried out to test the sensitivity of results to different levels of information on nuclear energy. The rest of the paper is structured as follows. The next section provides a review of the literature on nuclear energy's acceptance studies. Section 3 describes the data collection methods (i.e. choice experiments) as well as the data analysis methods used. Results are presented and discussed in Section 4. Section 5 contains the results of heterogeneity and sensitivity tests whereas Section 6 concludes.

2. Literature review

2.1 Stated preference methods

Survey-based stated preference methods have been widely used to estimate public preferences towards a range of energy sources. A body of empirical work has investigated preferences for green electricity without reference to the energy sources that make up the green power mix. Fimereli's (2011) review of the topic concludes that the public tends to be supportive of green power and that willingness to pay is generally positive. In terms of specific attributes of energy sources, the public seems to attach a high value to reductions in GHG emissions while proximity of energy plants to the place of residence negatively affects public support (Fimereli 2011). Moreover, there appears to be the need for direct economic benefits to the host communities (Van der Horst 2007). However, support for clean energy sources in general can mask substantial differences between specific clean energy technologies (Borchers et al. 2007; Walker 1995).

More relevant to this paper is the body of work that has investigated preferences for specific energy technologies, particularly nuclear energy. Public views on nuclear power have been found to be heterogeneous and vary worldwide (Ansolabehere 2007; European Commission 2013; Ipsos MORI 2011; Macintosh and Hamilton 2007; OECD 2010). There is also mounting evidence on public preferences for nuclear energy with a number of valuation studies, mostly contingent valuation, conducted in Taiwan (Liao et al. 2010), China (Sun and Zhu 2014), South Korea (Choi et al. 1998; Huh et al. 2015; Jun et al. 2010), Hong Kong (Woo et al. 2014), USA (Murakami et al. 2015; Riddel and Shaw 2003), Japan (Itaoka et al. 2006; Murakami et al.2015), Germany (Kaenzig et al. 2013), UK (Fimereli 2011; Fimereli and Mourato 2013), and Italy (Cicia et al. 2012). Unsurprisingly, attitudes towards and preferences for nuclear power appear to be driven more by perceived risk and safety than by perceived environmental benefits (Ansolabehere et al. 2003; Choi et al. 1998; De Boer and Catsburg 1988; Itaoka et al. 2006; Kato 2006; Riddel and Shaw 2003; Rosa and Dunlap 1994). Of particular interest to our research, Cicia et al. (2012) investigated the acceptability of different energy sources in Italy, including nuclear, in a study conducted prior to the Fukushima accident. Their results suggest that Italian preferences can be clustered in four groups, none of which are in favor of nuclear energy. Indeed, Italians seem to consistently prefer renewable energy sources (Bigerna and Polinori

2014; Bollino 2009; Strazzera et al. 2012b).

Despite the abundance of previous work on preferences for energy sources, only a handful of studies used the choice experiment approach to investigate preferences for particular attributes of nuclear energy technology: e.g. Huh et al. (2015), Itaoka et al. (2006), Kaenzig et al. (2013), Murakami et al. (2015), and Cicia et al. (2012), which is to our knowledge the only choice experiment study on this topic conducted in Italy. The current study adds to this body of evidence by estimating preferences and their determinants for fourth generation nuclear power plants in Italy.

2.2 Environmental psychology

In addition to the economic valuation literature, accumulating evidence in the environmental psychology field has highlighted the complex interplay of factors influencing social acceptance of nuclear energy, including its perceived benefits and risks, values, place identity-attachment, concern, trust, and socio-economic variables. These factors are usually measured by means of psychometric scales or Likert-like questions.

The role of values appears to be of paramount importance as far as nuclear energy is concerned (De Groot et al. 2013). These are defined as determinants of '*beliefs and intentions related to ESB* [Environmentally Significant Behavior]' (De Groot and Steg 2008, p.331) and have been detected extensively in a number of empirical studies (Schwartz 1992; Schwartz 1994; Schwartz and Bardi 2001; Schwartz and Huismans 1995; Schwartz and Sagiv 1995). More generally, values serve as guiding principles in one's life (Schwartz 1992) and they form part of the Value Belief Norm (VBN) theory (Stern et al. 1999; Stern 2000). According to De Groot et al. (2013), perceived risks and benefits mediate the relationship between egoistic, altruistic and biospheric values, and acceptance of nuclear energy. Individuals with greater egoistic value orientation tend to consider risks and benefits of nuclear mostly for themselves; those who predominately have an altruistic value orientation instead, tend to consider risks and benefits for other people. Finally, biospheric-led individuals are expected to focus on the effects for the biosphere.

Several studies have also suggested the importance of concern and emotional involvement in shaping acceptance of energy projects; such factors have been found to be important predictors of the willingness to take action against the implementation of contested projects (Atkinson et al. 2004; Han 2014). As our study focuses on a new fourth generation of nuclear energy technology still under research and development, we hypothesize that confidence that this new generation will achieved its proposed goals, together with perceived risks and benefits, will affect public acceptance[3]. Finally, we also measure place identity-attachment, which has been suggested to mediate risk perception with effects that differ depending on whether respondents have been living close to nuclear plants (Kovacs and Gordelier 2009; Venables et al. 2012).

3. Methodology

3.1 Choice Experiments

3.1.1 Overview

Choice experiments (CE) are a stated preference technique that has become a popular alternative to contingent valuation (Bateman et al. 2002; Hanley et al. 2001; Louviere et al. 2000). In a choice experiment, respondents are presented with a series of scenarios, each composed of different attributes, varying at different levels. Respondents are then asked to choose their most preferred scenario. If a money attribute is included, the implicit price of each of the other attributes (i.e. marginal WTP or WTA) can be calculated as well as the total welfare change provided by various scenario options. Although widely used in the environmental valuation field, specific applications of CE to the valuation of nuclear energy are uncommon.

There are potentially two distinct advantages of using this methodology for the valuation of preferences for nuclear energy. First, CE are particularly well suited to value changes that are multidimensional (with scenarios being presented as bundles of attributes) and where trade-offs between the various dimensions are of particular interest. Second, WTP or WTA is inferred implicitly from the stated choices, avoiding the need for

[3] Note that confidence in the FG nuclear technology reaching its intended goals, as used in this study, is related to but distinct from trust. In the context of nuclear energy, Siegrist et al. (2000) defined trust as '*the willingness to rely on those who have the responsibility for making decisions and taking actions related to the management of technology* […]' (Siegrist et al. 2000, p.354).

respondents to directly place a monetary value on scenario changes. This latter characteristic has led to suggestions that CE formats may be less prone to protest responses than contingent valuation as attention is not solely focused on the monetary attribute but on all the scenario attributes (Hanley et al. 2001). This is particularly relevant when dealing with nuclear energy-related scenarios that may be particularly prone to protest votes, given the notoriously strong views held towards nuclear energy by many people. On the negative side, complex CE can pose a significant cognitive burden to respondents leading to non-utility maximizing strategies and choice errors (Bateman et al. 2002; Hanley et al. 2001).

3.1.2 Experimental design

Table 1. Attributes and levels of the choice experiment*

Attributes	**Levels**
Distance from the nuclear plant	20, 50, 100, or 200 Km from the city of residence
Nuclear waste reduction	30%, 20%, 10% or no reduction
Atmospheric emission reduction	20%, 10% or no reduction
Electricity bill reduction	30%, 20%, 10% or no reduction
Public investments 1: Construction of hospitals	Yes or No
Public investments 2: Land recovery measures	Yes or No

**Public investments' levels were dummy coded in the Bayesian efficient design*

Our choice experiment scenario asked respondents to imagine they had a chance to choose between a series of options regarding the construction of FG nuclear power plants in Italy. The selection of attributes and levels was informed by a literature review and interviews with experts, while pilot studies (via 15 face-to-face pre-test questionnaires and three on-line questionnaire pilots with 60 respondents) were also used to fine-tune the survey instrument as well as some of the attribute definitions and levels. The attributes chosen were: atmospheric emission reductions, nuclear waste reduction, distance of city of residence from the nuclear power plant, public investments, and electricity bill reductions. Table 1 depicts the attributes and their levels.

Nuclear energy is generally identified as an energy source with close to zero atmospheric emissions and therefore instrumental in tackling climate change (Apergis et al. 2010; Hayashi and Hughes 2013; Samseth 2013; Srinivasan and Gopi Rethinaraj 2013; Van der Zwaan 2013; Wang et al. 2013). However, evaluations of actual emissions differ depending on assumptions made about fuel cycle (i.e. whether the fuel is, at least partly, re-used), emissions during the construction phase, and waste management and decommissioning. In light of these considerations, we selected the attribute *Atmospheric emission reduction* associated with implementation of nuclear energy in Italy, starting from the first year of operation, and compared to current levels of emissions.

The production of nuclear waste has also been found to be an important perceived risk of nuclear energy (Truelove 2012). This is particularly relevant for the case of Italy, where a national waste disposal site is yet to be established. Moreover, as noted above, nuclear waste reduction represents a common goal of the FG generation technology. Hence, we selected the attribute *Nuclear waste reduction* with respect to current nuclear technology. The levels were set according to current information and discussions with experts. It was not specified whether the waste reduction would be derived from recycling the fuel, from greater efficiency or from a combination of the two[4].

During normal operation, a nuclear plant poses potential threats to the environment (Beheshti 2011) and human health (Fairlie 2013). In case of nuclear accident, those living nearby would suffer the most (Munro 2013; Steinhauser et al. 2014). We therefore selected *Distance from the nuclear plant* as a further attribute. On this note, previous research has shown that proximity to nuclear plants in operation tends to reduce the extent to which risks are perceived (Pidgeon et al. 2008; Venables et al. 2012). However, in Italy there are no nuclear plants in operation. Hence, a project including a nuclear plant further away should be preferred, ceteris paribus. The smallest level of 20 Km from the town of residence of the respondent was chosen following Italian laws regulating compensation measures in case of construction of nuclear plants (Iaccarino 2010).

[4] The pre-test suggested that respondents were not responsive to these additional pieces of information.

In order to offer public benefits to respondents (Mansfield et al. 2002), it was fundamental to include an attribute representing *Public investments* (Gregory et al. 1991; Yamane et al. 2011). The importance of including such attributes in a study aimed at assessing social acceptance of energy sources was previously shown by Strazzera et al. (2012a). The choice of what type of public investments to include was informed by the online pilots, where new hospitals, as well as investments in land recovery measures appeared to be highly valued[5].

As the study aims to unveil Italians' willingness to accept compensation for FG nuclear power plants, a monetary attribute was included in the choice cards. The payment vehicle employed was an *Electricity bill reduction*. It is beyond the scope of this work to establish what effect the re-introduction of nuclear power in Italy might have on electricity prices and on the bill of households and firms. A multitude of factors can influence these outcomes: the level of competition in the Italian electricity market (Creti et al. 2010), characterized by high transaction costs between producers and communities (Garrone and Groppi 2012), the price of other energy sources in the energy mix, and the possible escalation in construction costs (Kessides 2012; Kosenius and Ollikainen 2013). The Italian government might even decide to subsidize prices, at least for those living in proximity to the nuclear power plants, as planned when the nuclear re-introduction was under way before the Fukushima accident (Iaccarino 2010). For the purposes of the current exercise, we selected plausible electricity bill reductions, likely to span respondents' value range as informed by our pre-tests, along with a '*no decrease'* level.

Respondents were presented with a series of choice tasks, each consisting of a pair of nuclear energy scenarios, containing the five attributes and levels described in Table 1, and were asked to choose their most preferred scenario in each case. In addition, there was also a 'none' option, that is, respondents could decide to choose neither of the two nuclear energy options. Given five attributes and their levels, with two options per choice task, the total number of possible choice scenarios is 576. This is clearly excessive and it was therefore necessary to reduce the number of choice tasks to present to respondents using experimental design.

[5] Alternative public investments and benefits tested were 'electricity bill reduction for public companies' and 'new schools'.

A main effects orthogonal design was used leading to a total of 64 choice pairs. This was still excessive for any single respondent and hence the 64 pairs were organized into 8 blocks of 8 choice tasks each.

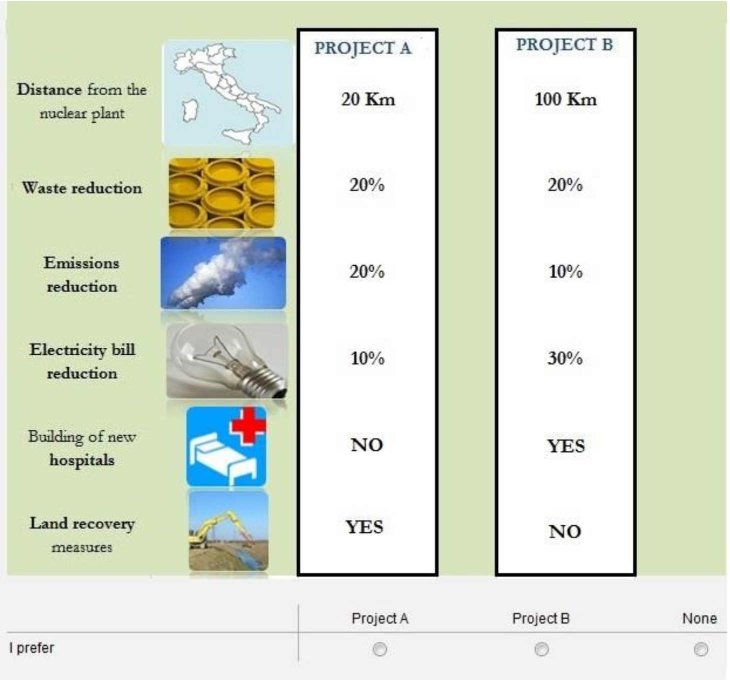

Figure 1: Example of a choice task

The first 25% of respondents were each asked to complete a block of 8 choice tasks. These results were analyzed and produced priors for a subsequent Bayesian efficient design (Ferrini and Scarpa 2007; Rose and Bliemer 2009), which was then administered to the remaining 75% of the sample. The analysis of the initial responses revealed non-linear effects with respect to the *Public investments* attribute levels. Hence these were subsequently included in the design as dummy-coded. For the final Bayesian efficient design, 5 blocks of 8 choice tasks each were retained[6]. The number of attributes and choice tasks appeared not to be an issue for the respondents at the pre-test stage. An example of a choice task is presented in Figure 1.

[6] The matrix of the experimental design is available from the authors upon request. Overlapping levels (equal between alternatives) were allowed, whereas no dominated alternatives were allowed.

3.2 Questionnaire design and information provision

Beside the choice experiment, the questionnaire also collected extensive information on socio-economic characteristics and attitudes. The latter included views on preferred public expenditure areas, level of skepticism towards climate change, views on different energy sources, several psychometric scales, questions on Chernobyl and Fukushima, and level of concern about Fukushima. Further details on the psychometric scales (used to measure egoistic, altruistic and biospheric values, as well as perceived risks and benefits, confidence and place attachment) can be found in Appendix A (Tables A1-A4)

Furthermore, prior to the choice experiments, all respondents were given information on the fourth generation nuclear technology. First, they were asked to state the importance of a set of nuclear industry goals (see Section 1), without mentioning the label 'fourth generation'. After having answered these questions, respondents were told those were actually the goals expected of the fourth generation nuclear technology. Subsequently, they were asked whether they had heard of this technology before and the extent to which they were confident the goals would be reached. The question order was chosen so as to make the respondent focus first on the level of importance of each goal, and later on the extent to which they believe the goals will be successfully attained. As noted above, in the aftermath of the Chernobyl and Fukushima accidents, Italians took part in referendums so as to state their views on nuclear power. Media coverage in these times of nuclear crisis appeared to be framed mostly in a negative way (Koerner 2014). In this respect, the role of information has been shown to be crucial in shaping nuclear acceptance (Jun et al. 2010; Peters and Slovic 1996; Slovic 1987; Slovic et al. 1991; Slovic et al. 2005; Zhu et al. 2016). Moreover, information seems to be important within the broader context of social acceptance of energy sources (Hobman and Ashworth 2013). For instance, Strazzera et al. (2012b) show the significant effect of information on consumers' willingness to pay for electricity generated by solar versus coal-fired power plants.

	Chernobyl (1986)	Fukushima (2011)
	The accident happened whilst testing the nuclear plant's safety and reliability. The reactor was not protected by a containment dome.	The nuclear accident happened after a Tsunami damaged the nuclear plant's cooling system. The nuclear plant was protected by a containment dome.
	Following the explosions and release of radioactive material, a fire started lasting at least 10 days. 2 workers died immediately. 28 died within the following weeks, whereas about 100 had wounds due to radiations' exposure.	Explosions have been reported, as well as release of radioactive material. Different sources report 3 workers died. Critiques towards information's transparency regarding the health of the workers.
	Evacuation started 3 days after the accident.	Evacuation started within the same date and continued for two days
	Long term effects: more than 6000 cases of tyroid cancer among those who were children or adolescents at the time of the accident.	Long term effects: too soon to tell

Figure 2: Information treatment part A

Drawing on this literature, in order to test the effect of detailed information provision on willingness to accept for FG nuclear power, we conducted a split-sample experiment with an information treatment. Specifically, half the sample was presented with: a. additional information on the Chernobyl and Fukushima's accidents[7] (Fig. 2); and b. information on where nuclear plants are located in Europe (Fig. 3), together with symbols indicating reactors in operation (green), not in operation (red), under construction (yellow) and planned (blue)[8]. Respondents were randomly assigned into the information treatment group.

[7] The information presented on the two accidents was based on IAEA (2006), Steinhauser et al. (2014), and UNSCEAR (2013).
[8] Source: World Nuclear Association

Figure 3: Information treatment part B

3.3 Data collection

The questionnaire was programmed in Qualtrics and implemented online, during March and June 2014, administered to a sample of 1,200 Italian respondents. The choice on an online survey mode allowed us to achieve a reasonably sized sample and nation-wide coverage of respondents within the available budget. On-line survey instruments have a number of advantages over other survey modes: they are relatively inexpensive and quick to implement; they do not suffer from interviewer/ social desirability bias and they make it easier for respondents to answer sensitive or difficult questions, allowing time to think. In addition, they allow the researchers to enhance respondents' engagement with the survey with the aid of graphical representations and tailored survey flow, especially useful when dealing with the valuation of environmental goods that respondents are unfamiliar with (Colombo et al. 2015). However, online surveys can be prone to issues of sample representativeness and self-selection, as not everyone has access to the internet. In our case, we made use of an on-line panel of respondents, provided by a professional market research company (Toluna), with quotas for gender, age, and macro area of residence to ensure representativeness in relation to the target population, i.e. Italian residents, aged 18 or more (DemoIstat 2013). The use of online panels is now commonplace in stated preference studies.

Overall, survey mode effects are not thought to be a major concern for stated preference surveys: a number of authors found insignificant differences in terms of WTP when comparing online and offline surveys in both choice experiments (Olsen 2009; Windle and Rolfe 2011) and contingent valuation studies (Lindhjem and Navrud 2011; Mozumder et al. 2011).

3.4 Statistical and econometric models

The choice experiment data was analyzed employing a multinomial logit model (MNL), a random parameters model with error components (RPL_EC) and a latent class model. An overview of these models is presented in Appendix E.

3.4.1 Analysis of psychometric variables[9]

We use a structural equation model framework to analyze the psychometric variables. The model is characterized by seven latent variables: the values Egoistic, Altruistic and Biospheric; and perceived Benefits, Risks, Confidence and Acceptance[10]. Description of these variables and how they were elicited in the survey can be found in Appendix A.

Before running the model, seven independent factor analysis were carried out in order to confirm the validity of each construct. Each analysis consists of estimating a set of k regressions of the form:

$$v_i = \lambda_i \xi + \delta_i \qquad (1)$$

where v_i represents the items, λ_i the factor loadings, ξ stands for the latent construct, and δ_i are the specific factors. For example, for the Egoistic latent factor we have a set of four regressions, as we used four

[9] This section draws on Bartholomew et al. (2008).
[10] The construct place attachment is not included in the structural equation model.

statements to measure this construct (Table A1). The items of each construct, along with the scales according to which they were measured, are presented in Tables A1, A2, A3 and A4, in Appendix A. The model implies the following variances:

$$\mathrm{Var}(v_{ik}) = (\textstyle\sum_k \lambda_{ik}{}^2) + \theta_{ii} \tag{2}$$

The loadings can be interpreted as the covariance between each v_i and the latent factor ξ. The unique variance of each item is represented by θ_{ii}. The complement of uniqueness represents the communality, whose mean is the proportion of total variance explained by the factor.

Once the constructs are validated, we can estimate relationships between the constructs by means of a structural equation model. This is characterized by the following measurement equations:

$$x_{i=}\tau_i^{(x)} + \lambda_{i1}^{(x)}\mathrm{Egoistic} + \delta_i,\ i = 1, \dots 4 \tag{3}$$

$$x_{i=}\tau_i^{(x)} + \lambda_{i2}^{(x)}\mathrm{Altruistic} + \delta_i, i = 1, \dots 4 \tag{4}$$

$$x_{i=}\tau_i^{(x)} + \lambda_{i3}^{(x)}\mathrm{Biospheric} + \delta_i, i = 1, \dots 3 \tag{5}$$

$$x_{i=}\tau_i^{(x)} + \lambda_{i4}^{(x)}\mathrm{Confidence} + \delta_i, i = 1, \dots 5 \tag{6}$$

$$y_{i=}\tau_i^{(y)} + \lambda_{i1}^{(y)}\mathrm{Benefits} + \epsilon_i, i = 1, \dots 6 \tag{7}$$

$$y_{i=}\tau_i^{(y)} + \lambda_{i2}^{(y)}\mathrm{Risks} + \epsilon_i, i = 1, \dots 7 \tag{8}$$

$$y_{i=}\tau_i^{(y)} + \lambda_{i3}^{(y)}\mathrm{Acceptance} + \epsilon_i, i = 1, \dots 4 \tag{9}$$

As regards the structural equations, these are as follows:

$$\mathrm{Acceptance} = \beta_{11}\mathrm{Benefits} + \beta_{12}\mathrm{Risks} + \beta_{13}\mathrm{Confidence} + \zeta_1 \tag{10}$$

$$\mathrm{Benefits} = \gamma_{11}\mathrm{Egoistic} + \gamma_{12}\mathrm{Altruistic} + \gamma_{13}\mathrm{Biospheric} + \zeta_2 \tag{11}$$

$$\mathrm{Risks} = \gamma_{21}\mathrm{Egoistic} + \gamma_{22}\mathrm{Altruistic} + \gamma_{23}\mathrm{Biospheric} + \zeta_3 \tag{12}$$

The values Egoistic, Altruistic, Biospheric and Confidence are assumed to be exogenous latent variables. Instead Risks, Benefits and Acceptance are assumed to be endogenous constructs. The x_{i} in equations (3)-(6) are the indicators of the exogenous constructs, whereas y_{i} in equations (7)-(9) represent the indicators of the endogenous latent variables. Moreover, $\tau_{\mathrm{i}}^{(\mathrm{x})}$ and $\tau_{\mathrm{i}}^{(\mathrm{y})}$ symbolize constants whereas $\lambda_{\mathrm{i1}}^{(\mathrm{x})}, \lambda_{\mathrm{i1}}^{(\mathrm{y})}$ represent the loadings. Considering the structural equations, γ_{ii} stands for the coefficient attached to the exogenous constructs whereas β_{ii} are the coefficients attached to endogenous constructs. Finally ζ_{i}, δ_{i} and ϵ_{i} indicate error terms.

4. Descriptive statistics

4.1 Sample characteristics

Table 2. Socio-demographic characteristics

		OVERALL			INFO Treatment			No INFO Treatment		
Variable	*Statistics*	North	Centre	South	North	Centre	South	North	Centre	South
Age	Mean	45.9	42.3	41.6	45.1*	42.5	42.8	46.7*	42.2	40.9
	S.D.	13.4	14.4	13.7	13.3	14.2	13.6	13.4	14.5	13.7
Household size	Mean	2.9	3.1	3.3	2.9	3	3.3	2.9	3.2	3.4
	S.D.	1.1	1.2	1.2	1.1	1.2	1.2	1.1	1.3	1.1
Gender	% Male	45.8	40.6	49.9	43	38.3	48.6	47.5	42.5	51
Education[a]	% Before high school	15.8	8.6	10.8	15.8	10.4	10.9	15.7	6.9	10.6
	% High school	55.3	54.6	52.8	56.1	50.4	54.8	54.4	57.5	51
	% Degree	14.2	21.7	18.2	15.4	22.6	14.7**	13	21.2	21**
Observations		529	261	408	221	115	177	308	146	231

[a]The remaining share belongs to *other.*

*Level of significance: *10%,, ** 5%. T-Test between means, Test of proportions between shares.*

Descriptive statistics for key socio-economic variables are presented in Table 2. The sample is broadly representative of the target population in terms of age, gender and macro-region as expected from the quota sample procedure, but highly educated people are somewhat over-represented (we did not set a quota for education). This type of sample bias has been documented in online surveys (Kellner 2014).

As noted above, half of the respondents starting the survey were randomly assigned to receive the additional information treatment. However, due to incompletes and dropouts, in the final sample considered for analysis 43% of the respondents received the treatment. Only minor differences were found to be present between the two subsamples, with and without information treatment. Specifically, mean age in the North region is different between treatments at the 10% level of significance, while the share of degree holders in the South is significantly different at the 5% level (Table 2).

4.2 Attitudes towards energy sources

Fig. 4 offers a first glance at preferences towards nuclear energy, when compared to other energy sources. Nuclear energy is, by far, the least preferred energy source: 45% of the respondents would not want Italy to invest anything at all in it. The percentage of those against investments in nuclear energy is even greater than the comparable statistic for fossil fuels (20%). Conversely, Italian respondents seem to strongly prefer investments in renewable energy sources, especially solar/photovoltaic and wind energy.

In addition, as shown in Figure 5, around half of respondents believe nuclear energy will never be re-introduced in Italy, whereas 17% believe it could be re-introduced in 5 to 10 years.

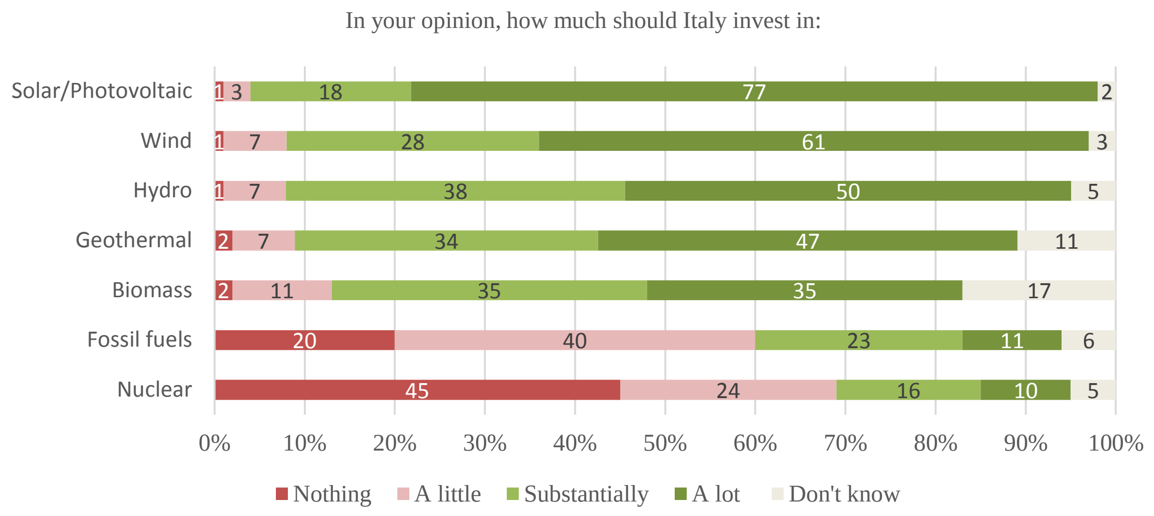

Figure 4: Energy sources-preferences

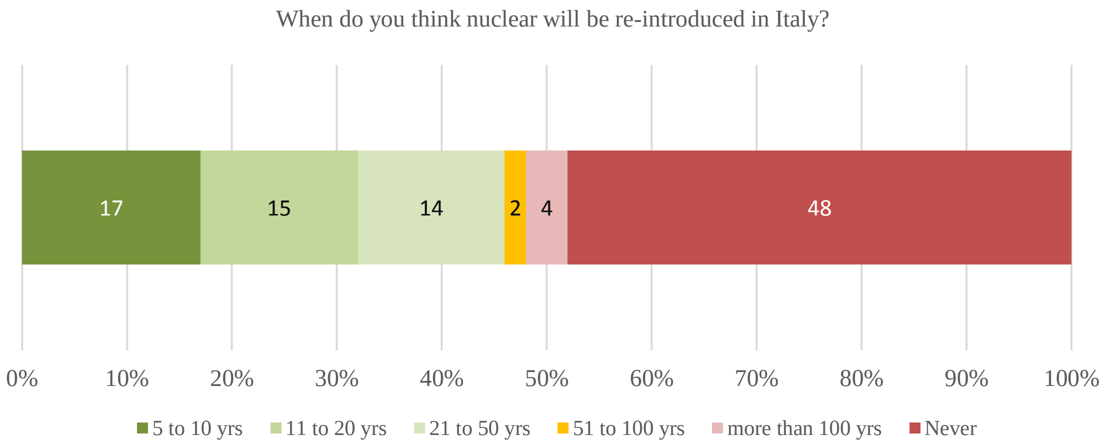

Figure 5: Nuclear energy re-introduction in Italy

As regards the perceived risks of nuclear energy, 65% of the sample considered very likely risks arising from projects undertaken from the public sector in Italy; while 62% of respondents indicated that nuclear waste-related risks and risks for the environment were very likely. On the opposite end we find the perceived risk of using nuclear energy for military purposes which was considered to be very likely for less than 20% of the sample. As regards perceived benefits, 34% of respondents thought it very likely that energy imports would decrease as a result of the introduction of nuclear energy. Surprisingly, only 20% thought atmospheric emission would be reduced. Similarly, few foresaw positive impacts, either in terms of economic growth (20%) or reduced unemployment (18%). The answers to all the benefits and risks statements are reported in Appendix B, Table B1.

4.3 Views on fourth generation nuclear energy

Next, we investigate the level of confidence in fourth generation nuclear energy technology specifically. First, respondents were asked to indicate the level of importance of a set of goals of the nuclear energy industry, without reference to any specific nuclear energy technology. In turn, respondents were told that those were the goals of the fourth generation nuclear energy technology and were asked to indicate how confident they were about their achievement. Unsurprisingly, the most important goal seems to be the reduction of the probability of catastrophic accidents (with 63% claiming it was extremely important), followed by nuclear waste reduction (which was extremely important for 58% of the sample). However, only 7%-8% of respondents declared themselves to be extremely confident that these goals would be reached.

We also asked respondents if they had heard before of FG generation nuclear energy, finding an affirmative answer from a large minority of 37%. These individuals seem to be characterized by a slightly greater level of confidence towards the realization of the FG goals, as the share of extremely confident people in this group ranges between 10-12%. This aspect will be investigated further in section 5.3.

Seven independent factor analyses were run so as to confirm the existence of the constructs which will be later employed in the structural equation model. Table A5 in Appendix shows the corresponding results. All in all, based on the proportion of variance explained, results provide support for the selection of one latent construct in each analysis. All the factor loadings are positive, in line with the correlations between the items.

A brief analysis of the magnitude of the factor loadings and uniqueness' values is discussed. Considering the factor egoistic, the item v_1 has the smallest uniqueness: most of the variance in the item *social power* is explained by the construct. Instead, the item *peace* seems to be the best represented when it comes to the factor altruistic. For the third value, biospheric, *respect the Earth* has a uniqueness of .29: around 71% of its variance is explained by this factor. All the factor loadings' magnitude for confidence are greater than .81 and uniqueness' values are smaller than .34.

As far as the factor risk is considered, the *risk for human health* and the *risk for the environment* show the greatest covariance, as well as the smallest uniqueness. The factor benefits presents all factor loadings greater than .77 and fairly small uniqueness values. Finally, the construct acceptance seems to account mostly for the variance of the item *the realization of nuclear plants in Italy is acceptable*.

The structural equation model is presented in Figure 6. In order to ease the presentation, only the coefficients of the structural equations are shown, whereas the coefficient of the measurement equation are shown in Table A6. The model has a log-likelihood of -53400.537 and a comparative fit statistic (CFI) of .912. All the coefficients of the structural equations are statistically significant. In addition, estimated residuals are fairly low[11]. In line with the hypothesis, the path analysis shows that risks and benefits influence acceptance of nuclear energy. The effect of the benefits on acceptance is positive, with a coefficient equal to .273. Instead, perceived risks affect acceptance in a negative way (-.366). In addition, confidence towards the realization of fourth generation goals has a positive effect (.355). In this study, perceived risks and benefits are linked respectively to the values altruistic and egoistic. In line with De Groot et al. (2013) there is no significant effect of the value Biospheric on acceptance of nuclear energy; nevertheless, there is a significant covariance with the value altruistic. In addition, a significant positive covariance is found between confidence and the value egoistic. The measurement equations present all the coefficients statistically significant, consistent with the factor analysis shown in Table A5.

[11] Standardized root mean squared residual equal to .06.

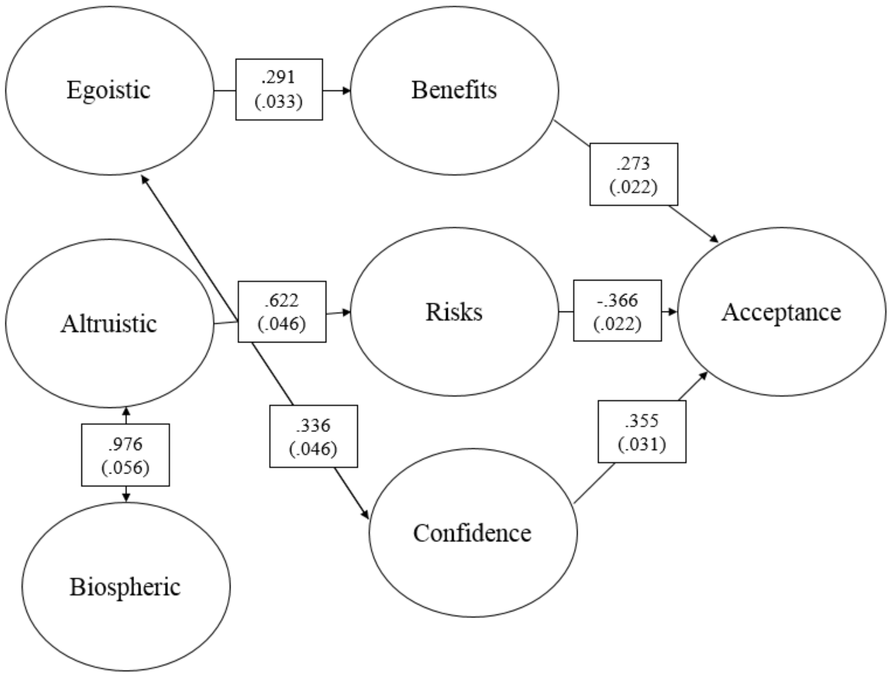

Figure 6: Structural equation model: Path diagram

5.2 Choice experiments results

5.2.1 MNL and RPL_EC models

The choice models have been estimated by means of the software LIMDEP NLOGIT. As a first step, respondents' choices were inspected so as to check for the presence of anomalies; the retained observations amount to 9107. The number of opt outs by respondent is presented in Figure 7. 23% of the respondents always chose none of the options and the same share selected always either project A or B. Notably, the share of respondents opting out decreases monotonically until 6, before slightly increasing to 7. All in all, it does not appear to be present a strong tendency towards choosing the 'none' option.

In the following analysis, the deterministic component of the utility function is specified as follows[12]:

$$V_{ij} = \beta_1 ASC + \beta_2 Distance_{200} + \beta_3 Distance_{100} + \beta_4 Distance_{50} + \beta_5 Waste_{30} + \beta_6 Waste_{20} + \beta_7 Waste_{10} + \beta_8 Emission + \beta_9 Hospitals + \beta_{10} Land + \beta_{11} Bill \quad (13)$$

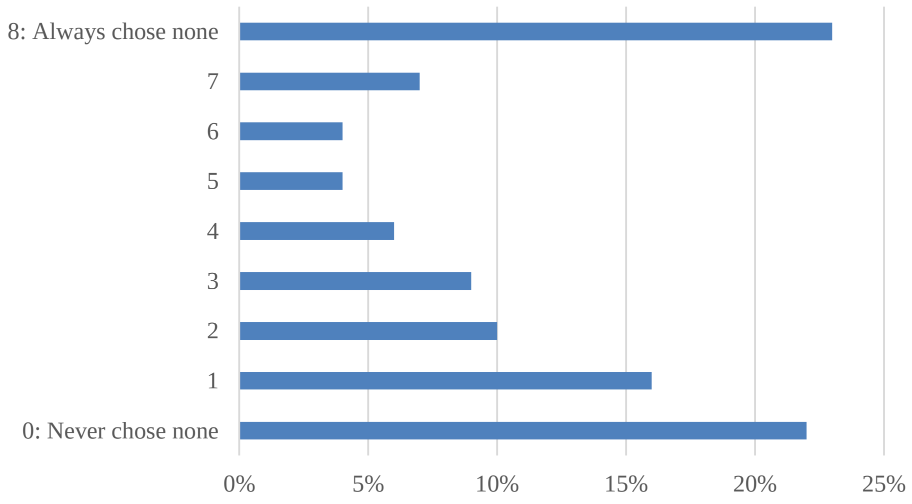

Figure 7: Frequency of choosing 'none'

The ASC refers to the alternative specific constant identifying which of the options, in each choice task, is the 'none' option. Hence, the coefficient attached to it describes whether, overall, individuals were more likely to choose either of the projects or none, thereby providing a measure of broad acceptance or opposition towards FG nuclear energy. As a preliminary step, the analysis of the choice experiment data started with the estimation of a MNL and a Nested Logit model. Although presenting a slightly greater pseudo R^2, the Nested Logit (LL -9188.534 with 13 parameters) did not represent a significant improvement over the MNL (LL -9188.826 with 11 parameters). This is in line with the observed moderate frequencies of 'none'.

[12] The code of the variables is presented in Appendix, Table C1. Non-linearities were not found in correspondence of different emissions' reduction levels.

Subsequently, a RPL model with error components was estimated, leading to a substantial improvement in terms of goodness of fit (LL -6882.151 with 21 parameters).

Table 3. MNL and RPL_EC models. Dependent variable: Choice

	MNL	RPL_EC	RPL_EC	MNL	RPL_EC
Variable	Coeff. (S.e.)	Coeff. (S.e.)	S.D.	Monetary Valuations (€)	
ASC	1.60*** (.068)	1.96*** (.141)	3.67*** (.138)	753.4	668.5
Distance: 200 Km	.72*** (.050)	.980*** (.065)	.514*** (.098)	337.8	334.1
Distance: 100 Km	.579*** (.052)	.743*** (.065)	.317** (.154)	273.7	253.1
Distance: 50 Km	.431*** (.053)	.507*** (.063)	.060 (.141)	201.25	172.7
Waste Reduction: 30%	.726*** (.051)	.865*** (.061)	.322** (.162)	340.6	294.8
Waste Reduction: 20%	.606*** (.050)	.723*** (.060)	.187 (.182)	284.9	246.5
Waste Reduction: 10%	.367*** (.052)	.413*** (.063)	.253 (.167)	170.85	140.7
Emission Reduction	.274*** (.021)	.366*** (.026)	.049 (.097)	129.04	124.8
Hospitals	.326*** (.035)	.493*** (.049)	.487*** (.092)	153.2	168.1
Land Recovery	.516*** (.034)	.652*** (.049)	.575*** (.093)	242.3	222.3
Bill Reduction (€)	.0021*** (.000)	.002***[b] (.000)	/	/	/
Log-Likelihood	-9188.826	-6882.151			
R squared	0.08	0.31			
Observations	9107	9107			

Level of significance: *10%, **5%, ***1%. Robust standard errors estimated. b: fixed coefficient.

All the random parameters were set to be randomly distributed but the monetary attribute, assumed to be fixed (following Revelt and Train 1998). Table 3 shows the estimated coefficients and monetary valuations.

Starting with the analysis of the coefficients, RPL_EC and MNL portrait an analogous picture. Unsurprisingly, respondents prefer nuclear plants away from their area of residence. Moreover, this effect is non-linear: the magnitude of the coefficients increases with distance. The attribute representing the fourth generation nuclear, i.e. waste reduction, is highly and positively valued. Similarly, sampled individuals attach a positive value to the reduction of atmospheric emissions. With regards to the public benefits, namely the realization of hospitals and land recovery measures, these are positively valued too. Finally, the private benefit bill reduction is significantly and positively valued.

The monetary valuations represent the willingness to accept a compensation for a worse level of a given attribute (for example, a closer nuclear power plant) or, alternatively, the willingness to forgo so as to assure an improvement of the same. On average, considering RPL_EC results, individuals would be willing to forgo 334 € per year for a nuclear plant 200 Km away; this reduces to 172 for a distance of 50 Km. In addition, waste reduction is valued up to 294 €, more than land recovery measures (222 €), hospitals (168 €) and emission reduction (124 €).

5.2.2 Latent class model

The latent class approach represents an alternative way to model preference heterogeneity (Boxall and Adamowicz 2002; Green and Hensher 2003). In addition, we aimed to employ a model that allows to assess the importance of the factors employed in the structural equation model. Specifically, the results of the structural equation model highlighted the role of perceived benefits, risks and confidence in shaping acceptance of nuclear energy. Hence, the score factors of each of these variables have been included in the segment membership probability. In other words, we expect class allocation to be influenced by the three constructs affecting acceptance. In addition, a latent class model was estimated including in the segment membership probability the variable identifying whether a given individual received the information treatment, besides the individual score factors of the construct mentioned above. However, this model did not converge to a global maximum. For comparative purposes, a separate latent class model was estimated with only information treatment in the class allocation function; these results, in line with the preferences depicted in this section, are commented in the next section and estimates are shown in Appendix, Table C2.

As regards the utility function, this has been specified as follows:

$$V_{ij|s} = \beta_{1|s}ASC + \beta_{2|s}Distance_{200} + \beta_{3|s}Distance_{100} + \beta_{4|s}Distance_{50} + \beta_{5|s}Waste_{30} + \beta_{6|s}Waste_{20} + \beta_{7|s}Waste_{10} + \beta_{8|s}Emission + \beta_{9|s}Hospitals + \beta_{10|s}Land + \beta_{11|s}Bill \tag{14}$$

A three latent class specification, chosen on the basis of the goodness of fit and parameters' significance, is presented in Table 3. The pseudo R squared now equals .358. Inspecting the coefficients, it is indeed confirmed the presence of a great deal of heterogeneity in the data. The goodness of fit has improved considerably compared to the analogous statistic for the MNL and the RPL_EC. According to the model selection criteria AIC, AIC3, CAIC and BIC, this model is deemed to be preferred. In addition, the Ben-Akiva and Swait (1986)'s test for strictly non-nested models confirms the selection of the latent class model over the RPL_EC. These are strong indications in favor of the selection of the Latent class model (Strazzera et al. 2013).

The three segments are characterized as follows. The first class presents the greatest value attached to the status quo, as well as for the distance from the nuclear plant. Respondents more likely to belong to this class positively value the health and environmental benefits: waste and atmospheric emissions reduction. Furthermore, land recovery measures are positively valued. Instead, the construction of hospitals and bill reduction are not significantly valued. Respondents more likely to belong to this class are significantly associated with less perceived benefits arising from nuclear than the rest of the sample.

In contrast, the second segment presents a negative value for the ASC: these respondents are more likely to have chosen one of the projects[13]. Unsurprisingly, although distance is positively valued, the magnitude of its coefficients is the lowest across the three segments. Public and private benefits are all positively and significantly valued in this class. Remarkably, this segment is characterized by a significant and positive effect of the variable confidence in affecting class allocation; at the same time, perceived risks are negatively associated to this class. Finally, the third class attaches a positive value to all attributes. However, its distinctive feature is the great value attached to the health and environmental benefits, as well as the public benefit attributes. The difference between class 3 and 2 becomes more apparent after inspecting the monetary valuations. The status quo is valued almost 750€ per family per year in class 3. This becomes negative in class 2: these individuals, confident the FG technology will be effective, seem to be willing to forsake 220 € per family per year so as to assure the construction of the nuclear plants. On the other hand, in class 1 is envisaged the presence of individuals which are not willing to accept any monetary compensation at all, although they value public and health/environmental benefits[14]. All in all, one segment of respondents, amounting to 33% of the sample, seem to be strongly against the realization of fourth generation nuclear power plants in Italy whereas another segment, representing the 42% of the sample, appears to be open towards this possibility. These respondents are more prone to believe the FG goals will be met. Finally, a third segment emerges, characterized by preferences positioned in between the other two classes: these respondents would accept monetary compensations, besides public benefits.

[13] This is in line with the large magnitude of the standard deviation of the ASC in the RPL_EC model.

[14] The computation of these monetary valuations (see eq. E.4 in Appendix E) is affected by the non-significance of the denominator, namely the coefficient attached to the electricity bill's reduction. When the numerator is significant, the monetary valuation tends to infinity; when this is non-significant too, the monetary valuation is not defined.

Table 3. Latent class model. Dependent variable: Choice

	CLASS 1	CLASS 2	CLASS 3	CLASS 1	CLASS 2	CLASS 3
Variable		Coeff. (S.e.)			Monetary Valuations (€)	
ASC	5.82*** (.629)	-.623*** (.075)	2.08*** (.110)	→+∞	-221.4	750.8
Distance: 200 Km	1.42** (.579)	.684*** (.047)	1.19*** (.081)	→+∞	243.0	429.8
Distance: 100 Km	1.47** (.563)	.618*** (.049)	.865*** (.089)	→+∞	219.8	311.7
Distance: 50 Km	1.42** (.591)	.391*** (.052)	.580*** (.090)	→+∞	138.9	209.1
Waste Reduction: 30%	.752* (.470)	.748*** (.052)	1.05*** (.085)	→+∞	265.8	380.6
Waste Reduction: 20%	.818* (.458)	.696*** (.050)	.766*** (.086)	→+∞	247.5	275.9
Waste Reduction: 10%	.594 (.467)	.271*** (.050)	.622*** (.088)	n.d.[b]	96.4	224.2
Emission Reduction	.399** (.202)	.311*** (.021)	.426*** (.035)	→+∞	110.7	153.7
Hospitals	.236 (.307)	.351*** (.036)	.667*** (.058)	n.d.[b]	124.9	240.2
Land Recovery	1.007*** (.306)	.454*** (.035)	.910*** (.056)	→+∞	161.5	327.9
Bill Reduction	.0007 (.001)	.002*** (.0002)	.002*** (.0004)			
		Class membership function				
Constant	.271*** (.098)	.560*** (.101)	0[a]	/	/	/
Confidence	.001** (.0007)	.368*** (.084)	0[a]	/	/	/
Risks	.146 (.106)	-.175* (.100)	0[a]	/	/	/
Benefits	-.362*** (.100)	-.101 (.111)	0[a]	/	/	/

Average class probability	0.330	0.426	0.244	0.330	0.426	0.244
Log-Likelihood			-6416.967			
Pseudo R^2			0.358			
Observations			9107			

Level of significance: *10%, **5%, ***1%. Robust standard errors estimated. [a]: constrained values. [b]: not defined.

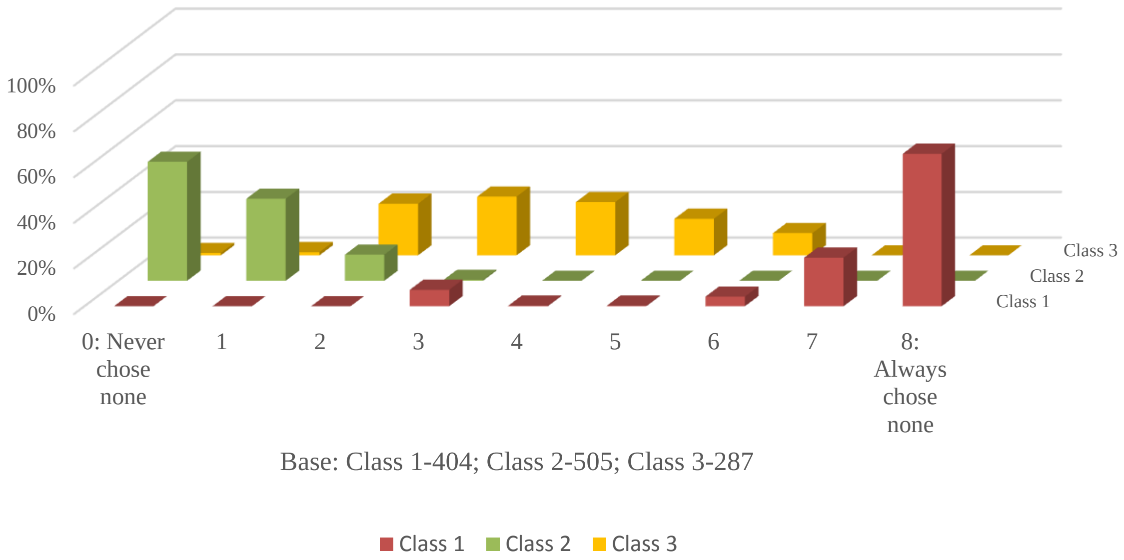

Figure 8: Frequency of 'NONE' by class

Posterior class probabilities have been computed so as to assign each respondent to a class, depending on the greatest class membership probability[15]. Individuals assigned to class 2 rarely chose none as shown in Figure

[15] See equation E.9 in Appendix E. It is worth remarking that class allocation is probabilistic, hence no statistical test can be performed in order to assess whether differences in shares between segments are statistically significant. Nevertheless, the inspection of the differences in shares can aid the description of the segments. What is more, average posterior membership probability of individuals is quite high: in class 1 equals 97%, in class 2 equals 92% and in class 3 amounts to 87%.

8. As noticed above, these respondents are more prone to believe the fourth generation goals will be met. Instead, those belonging to class 1, not accepting monetary compensations at all, are those who more frequently chose none. Remarkably, 88% of the individuals included in this class chose none of the projects in either 8/8 or 7/8 choice tasks, therefore signalizing a strong opposition towards nuclear. Finally, class three has a number of none chosen almost entirely between 2 and 6 (98%).

As far as the information treatment is considered, in both class 1 and class 2, 38% of the respondents received the additional pieces of information, whereas only 22% of those allocated in class 3 did. More pronounced differences are found when inspecting the share of individuals who stated to have heard of fourth generation before: they are 47% in class 2, 32% in class 1 and only 21% in class 3. In addition, we find that segment 2 has the highest share of right wing voters (segment 2: 18.6%, segment 1: 9.75%; segment 3: 12.9%), the highest share of individuals in favor of Italy investing in nuclear energy (segment 2: 34.2%, segment 3: 24.7%; segment 3: 16.3%), as well as the lowest share of respondents indicating the Fukushima accident as serious or very serious (segment 2: 54%, segment 1: 68%; segment 3: 62.3%).

5.3 Effect of prior knowledge and information treatment

In this section we look at the validity of results with a focus on the effect of information. Firstly, we look at the effect of having prior knowledge of FG nuclear technology. Secondly, we analyse the results of the information treatment, where a sub-sample of respondents were presented with additional information on the Chernobyl and Fukushima’s accidents, as well as information on where nuclear plants are located in Europe (Section 3.2).

For this purpose, we estimated an additional econometric model, modeling the probability of opting-out (that is choosing the status quo option, i.e. ‘none’ of the nuclear scenarios) and the probability of having heard of fourth generation technology prior to the study. This entailed estimating two equations, where in both cases the dependent variables are discrete. In order to allow for correlation between the error terms of the two equations, we estimated a bivariate ordered probit model (briefly described in Appendix F). The findings from this analysis, which are reported in detail in Tables D1 and D2, in Appendix D, are supportive of the consistency of results with prior expectations.

In terms of the determinants of opting-out (Table D1, Equation 1), we found that right-wing voters and those who attached a lower probability to a nuclear accident happening in Europe were less likely to opt out. Instead, those who stated that nuclear energy in Italy would not be introduced before at least one hundred years were more likely to opt-out. In addition, and reassuringly, the findings of the structural equation model seem to be confirmed: individuals characterized by lower perceived Risks, higher perceived Benefits and higher Confidence, were less likely to choose the option ‘none’. In terms of those having prior information of FG nuclear technology (Table D1, Equation 2), their profile is as follows: men, right-wing voters, higher income, and in favor of Italy investing in biomass and geothermal. A negative correlation between the error terms is found, although significant only at the 15% level: this suggests that individuals who opted out more frequently are less likely to have prior information on FG technology.

We also used the bivariate ordered probit model to investigate the impact of the information treatment (Table D1, Equation 1). The information treatment appears to have affected the degree of opposition towards nuclear energy. Specifically, those who received the additional information were more likely to choose the opt-out/‘none’ option.

Furthermore, in order to look at the effect of the information treatment on the choice experiments results, a latent class model was also estimated including, in the segment membership probability, a dummy variable identifying whether a given individual received the information treatment, besides the individual score factors of the variables mentioned above. However, this model did not converge to a global maximum. For comparative purposes, a separate latent class model was estimated with only the information treatment dummy in the class allocation function; these results are contained in Appendix C, Table C2[16]. The key

[16] The preferences described in the three segments of the latent class model with the information treatment (Table C2) are analogous to those of the model presented in Table 4, without considering the treatment. However, former model’s

finding is that the information treatment had a significantly positive effect in affecting class 1 allocation, that is, the provision of additional information seems to have increased the likelihood of a respondent being allocated to the class most likely to oppose nuclear energy technology.

Table 4. Mean and S.D. of latent constructs

A: Test by "Have heard of FG nuclear"

	HAVE HEARD of FG			HAVE NOT HEARD of FG			
	Mean	S.D.	Base	Mean	S.D.	Base	T-test[a]
Benefits (***)	.083	1.05	430	-.048	.919	752	-2.2521
Risks (***)	-.095	1.05	430	.059	.920	752	2.6355
Confidence (***)	.090	1.06	425	-.047	.925	743	-2.3274
Acceptance (***)	.096	1.05	429	-.057	.934	750	-2.5867

B: Test by information treatment

	Information treatment: YES			Information treatment: NO			
	Mean	S.D.	Base	Mean	S.D.	Base	T-test[a]
Benefits (***)	-.066	.997	513	.050	.947	682	2.0638
Risks (*)	.045	.987	513	-.030	.970	682	-1.3273
Confidence (**)	-.057	.957	506	.040	.992	675	1.6930
Acceptance (*)	-.045	.967	510	.029	.990	681	1.2977

C: Test by information treatment and by "Have heard of FG nuclear"

	Information treatment: YES			Information treatment: NO			
	Mean	S.D.	Base	Mean	S.D.	Base	T-test[a]
HAVE HEARD of FG							
Benefits (**)	-.020	1.05	170	.150	1.05	258	1.6486
Risks	-.087	1.10	170	-.094	1.02	258	-0.0667
Confidence	.027	1.02	168	.127	1.08	255	0.9457
Acceptance (*)	.007	1.05	170	.146	1.06	257	1.3373
HAVE NOT HEARD of FG							
Benefits	-.083	.971	334	-.019	.876	417	0.9486
Risks	.106	.922	334	.023	.919	417	-1.2370
Confidence	-.093	.918	329	-.011	.931	413	1.2035
Acceptance	-.065	.936	332	-.052	.935	417	0.1981

[a]Difference between Mean (no information treatment) and Mean (information treatment). ***: 1%, ** 5%, * 10% level of significance.

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goodness of fit is inferior.

We also looked at the effect of the information treatment in the RPL_EC model[17] (Table C3, Appendix C). Here, the effect seems to be limited to the ASC; specifically, the additional information provided positively affected the coefficient of the ASC, suggesting a lessened degree of nuclear acceptance, in line with the previous findings.

Finally, the negative effect of the information treatment on nuclear energy acceptance is confirmed by the inspection of the individual score factors for the construct Acceptance, which is significantly lower among information-treated respondents (Table 5, panel B). In line with this, respondents who received the information treatment are characterized by lower perceived Benefits, higher perceived Risks and lower Confidence. However, differences emerge considering respondents with prior stated knowledge of FG technology (Table 5, panel A). Overall, these respondents are characterized by a greater Confidence towards the realization of FG goals, along with greater perceived Benefits and lower Risks, thereby presenting a greater score of Acceptance, as discussed in the context of the structural equation model and in line with the bivariate ordered probit results. Finally, those who had not heard of FG technology before do not seem to be affected significantly by the information treatment, appearing to be less open to seek and process information (Table 5, panel C).

6. Conclusions

In the aftermath of the Fukushima accident, Italy recently abandoned all plans for the re-introduction of operating nuclear power plants in the country, mimicking the earlier decision of phasing out nuclear technology following the events of Chernobyl in the 80's. In order to reach European targets, Italy's energy policy needs to be improved by reducing reliance on fossil fuels, diversifying energy sources and increasing the share of energy sources with zero or next to zero GHG emissions. From the point of view of the proponents of fourth generation nuclear energy technology, that aims to minimize many of the problems that affected earlier technologies, the latter issue may be tackled by including nuclear energy in the Italian power

[17] This is a RPL_EC model with heterogeneity decomposition, where all mean coefficients are interacted with the dummy variable indicating whether the respondent received the information treatment.

generation mix. No study has yet been conducted on social acceptance of fourth generation nuclear energy: this paper opens this stream of research and offers a methodological combination of choice experiments, psychometric scales, modeled within a structural equation framework, and information sensitivity tests. Importantly, discrete choice modeling and structural equation modeling results were aligned, providing evidence of the robustness of the findings.

Firstly, a structural equation model was employed, following De Groot et al. (2013). Acceptance of fourth generation nuclear energy was found to be greater among those who envisage the presence of benefits, are less concerned about the risks and, above all, are confident that the goals of the FG nuclear technology will be achieved. The effects of risks and benefits on acceptance are in line with expectations from the environmental psychology literature. In addition, egoistic values were seen to affect perceived benefits, whereas altruistic values affected perceived risks. As in De Groot et al. (2013) biospheric values had no significant effect on acceptance of nuclear energy. A key new finding of our analysis is the importance of the construct Confidence, which in our case referred to individuals' beliefs in whether the objectives of the FG nuclear technology would be achieved. Hence, we recommend that future work investigating social acceptance of energy technologies still under R&D should include measures of confidence in the goals of the technology. In terms of policy, public acceptability of nuclear power is therefore likely to depend on the nuclear industry and the government‘s ability to deploy information campaigns and other initiatives aimed at increasing public confidence in the safety of the new generation of this technology.

These findings from the psychometric analysis were then taken into account when analyzing the choice experiment data. This type of joint analysis, bringing together two related but distinct disciplinary traditions, is uncommon. A latent class estimator was applied, with class membership modeled as a function of perceived benefits, risks and confidence. Although this is the first analysis of its kind, and without direct comparators, some of our estimates of the value of the attributes of nuclear energy are in line with those in the stated preference literature. Like other authors, we found, for example, that the potential for nuclear energy to reduce GHG emissions is positively valued, as is increased distance from the energy facility (e.g. Fimereli, 2011).

Our latent class model findings depict a situation characterized by three distinct segments of preferences. The first class of respondents refer to those strenuously against nuclear energy implementation in Italy, and not willing to accept any monetary compensation for the deployment of nuclear energy: this is the class of the *strong opposers (class 1),* negatively associated with the benefits. A second class shows respondents with less pronounced opposition, willing to accept monetary compensations in order to put up with new nuclear facilities and valuing some of the health, environmental and other benefits associated with an improved technology: this is the segment of the *moderate opposers (class 3).* We also found a third class of respondents, more confident that the goals of the FG nuclear technology will be accomplished, possibly willing to pay to have the new technology and appreciating its benefits, that can be defined as the segment of the *moderate supporters (class 2)*.

Our study also provides a useful characterization of individuals more likely to favor FG nuclear implementation, following the analysis of the posterior class membership probabilities and multivariate analysis. It emerges that right-wing voters are more likely to favor nuclear energy, in line with previous research (Franchino 2013; Zwick 2005). In addition, opposition seems to be greater among those who perceive the Fukushima accident as serious or very serious. Such market segmentation can be useful for those devising targeted information campaigns. We also explored the effect of information on preferences, both prior information and new information given during the survey. Those more likely to have prior information on FG nuclear energy tended to be right wing male voters, in higher income groups. Moreover, our study found evidence that those who are more opposed to nuclear energy are less likely to have had prior information on FG technology. Previous research has highlighted the role of knowledge and experience with the technology in heightening support (Sjoberg 2004, 2009).

In line with other authors (Jun et al. 2010; Peters and Slovic 1996; Slovic 1987; Slovic et al. 1991; Slovic et al. 2005; Zhu et al. 2016) the role of new information was found to be key in shaping acceptance of nuclear energy: our results were sensitive to information provided regarding the events of Fukushima and Chernobyl, together with a map showing nuclear plants’ location in Europe. Adding to Jun et al. (2010), who suggested that precise and specific information on nuclear energy might lead to higher acceptance in a country with nuclear plants in operation, this study shows that focusing the information on accident histories, in a country with no nuclear plants in operation, might lead instead to heightened opposition.

All in all, our results suggest that the future of fourth generation nuclear energy in Italy will likely depend on the information provided to the public, hence media, politicians and corporations play a crucial role. Currently, nuclear energy appears to be the least preferred energy option, with renewable sources coming top in terms of the policy agenda and public support in Italy (Bigerna and Polinori 2014; Bollino 2009; Cicia et al. 2012; Strazzera et al. 2012b). In addition, a section of our respondents were found to be strong opposers of the construction of FG nuclear power plants. Although amounting to a (sizeable) minority of the sampled respondents, the share of strong opposers could substantially increase in case of negative shocks, such as targeted negative media campaigns, or even the occurrence of further nuclear accidents (even linked to older generation nuclear reactors) especially near the time of FG generation R&D completion. Further research is needed in order to investigate social acceptability of fourth generation nuclear energy in other nations. For instance, it would be interesting to extend the study to countries where nuclear energy is in operation and/or with nuclear plants under construction. In addition, research is needed so as to further investigate the role and determinants of confidence in the realization of the FG nuclear energy goals.

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Appendix A: Psychometrics scales and structural equation modeling results

Table A1. Egoistic, Altruistic and Biospheric items

How important are these values for you as guiding principles in your life?

		Opposite to my values	Not at all Important	Very Unimportant	Neither Important nor unimportant	Very Important	Extremely Important
Egoistic	v_1	Social Power: control people					
	v_2	Wealth: money and material goods					
	v_3	Influence: Impact other people's life					
	v_4	Authority: command others					
Altruistic	v_1	Equity: equal opportunities for all					
	v_2	Peace: no war no conflicts					
	v_3	Work for the others					
	v_4	Justice: fight injustices					
Biospheric	v_1	Prevent Pollution					
	v_2	Respect the Earth					
	v_3	Protect the Environment					

Table A2. Confidence items

How confident are you that fourth generation technology goals will be achieved?

		Very unconfident	Not confident	Somewhat not confident	Undecided	Somewhat confident	confident	Very confident
Confidence	v_1	Reduce the probability of catastrophic accidents						
	v_2	Minimize nuclear waste						
	v_3	Reduce the long term stewardship burden of nuclear waste						
	v_4	Increase the cost-competitiveness compared to other energy sources						
	v_5	Increase protection against terroristic attacks						
	v_6	Increase passive security						

Table A3. Place attachment items

Think about the region you currently reside in. To what extent do you agree or disagree with the following statements?						
		Extremely disagree	Disagree	Neither agree nor disagree	Agree	Extremely agree
Acceptance	v_1	Building nuclear plants in Italy is acceptable				
	v_2	Building nuclear plants in your region of residence is acceptable				
	v_3	It is acceptable to import nuclear energy				
	v_4	Building nuclear plants in Italy is acceptable				
Place attachment	v_1	I want to live here				
	v_2	I feel I belong here				
	v_3	I feel connected to the people living here				
	v_4	Here I feel at home				

Table A4. Perceived risks and benefits items

How likely are these risks/benefits stemming from the realization of nuclear plants in Italy?

		Very Unlikely	Unlikely	Somewhat Unlikely	Undecided	Somewhat likely	Likely	Very Likely
Risks	v_1	Risk of catastrophic accident						
	v_2	Nuclear waste's risk						
	v_3	Risks arising from the public sector investing in nuclear plant projects						
	v_4	Risk for human health						
	v_5	Risk for the environment						
	v_6	Risk of terrorist attacks						
	v_7	Risk of nuclear proliferation						
Benefits	v_1	Economic growth						
	v_2	Rise in employment						
	v_3	Atmospheric emissions' reduction						
	v_4	Energy imports' reduction						
	v_5	Reduction of fossil fuels' consumption						
	v_6	Energy 's prices more affordable						

Table A5. Factor loadings and uniqueness

Item	ξ: Egoistic		ξ: Altruistic		ξ: Biospheric		ξ: Confidence	
	F.L.	UN.	F.L.	UN.	F.L.	UN.	F.L.	UN.
v_1	0.87	0.24	0.75	0.44	0.83	0.31	0.90	0.18
v_2	0.53	0.72	0.79	0.38	0.84	0.29	0.89	0.20
v_3	0.58	0.66	0.51	0.74	0.64	0.59	0.90	0.19
v_4	0.84	0.30	0.70	0.50	/	/	0.81	0.34
v_5	/	/	/	/	/	/	0.84	0.30
v_6	/	/	/	/	/	/	0.91	0.17
	ξ: Risks		ξ: Benefits		ξ: Acceptance		ξ: Place Attachment	
	F.L.	UN.	F.L.	UN.	F.L.	UN.	F.L.	UN.
v_1	0.89	0.21	0.89	0.21	0.97	0.06	0.83	0.31
v_2	0.85	0.28	0.84	0.28	0.91	0.17	0.92	0.15
v_3	0.54	0.70	0.77	0.40	0.59	0.65	0.84	0.30
v_4	0.93	0.13	0.83	0.31	0.90	0.17	0.91	0.16
v_5	0.93	0.13	0.82	0.33	/	/	/	/
v_6	0.64	0.59	0.89	0.23	/	/	/	/
v_7	0.62	0.61	/	/	/	/	/	/

F.L.: Factor loadings. UN: Uniqueness

Table A6. Measurement equations' coefficients

	Egoistic		Altruistic		Biospheric		Confidence	
	Coeff.	Std. Err	Coeff.	Std. Err	Coeff.	Std. Err	Coeff.	Std. Err
$\lambda_{ii}^{(x)}$	1	c	1	c	1	c	1	c
$\tau_{i}^{(x)}$	3.07	0.04	5.84	0.039	5.84	0.038	2.81	0.032
$\lambda_{ii}^{(x)}$	0.55	0.031	1.07	0.047	1	0.032	1.01	0.021
$\tau_{i}^{(x)}$	4.03	0.043	5.91	0.040	5.92	0.037	2.78	0.032
$\lambda_{ii}^{(x)}$	0.65	0.033	0.81	0.050	0.84	0.033	0.98	0.020
$\tau_{i}^{(x)}$	4.04	0.047	4.95	0.04	5.99	0.036	2.74	0.031
$\lambda_{ii}^{(x)}$	0.90	0.031	1.13	0.045	/	/	0.872	0.023
$\tau_{i}^{(x)}$	2.91	0.045	5.90	0.037	/	/	2.91	0.031
$\lambda_{ii}^{(x)}$	/	/	/	/	/	/	0.833	0.021
$\tau_{i}^{(x)}$	/	/	/	/	/	/	2.87	0.030
$\lambda_{ii}^{(x)}$	/	/	/	/	/	/	1.00	0.020
$\tau_{i}^{(x)}$	/	/	/	/	/	/	2.87	0.032

	Risks		Benefits		Acceptance	
	Coeff.	Std. Err	Coeff.	Std. Err	Coeff.	Std. Err
$\lambda_{ii}^{(y)}$	1	c	1	c	1	c
$\tau_{i}^{(y)}$	5.4	0.04	4.1	0.47	2.31	0.033
$\lambda_{ii}^{(y)}$	0.85	0.02	0.94	0.02	0.92	0.015
$\tau_{i}^{(y)}$	5.72	0.03	4.08	0.04	2.13	0.033
$\lambda_{ii}^{(y)}$	0.51	0.02	0.93	0.027	0.51	0.022
$\tau_{i}^{(y)}$	5.87	0.04	3.99	0.05	2.40	0.031
$\lambda_{ii}^{(y)}$	0.99	0.019	0.91	0.024	0.89	0.014
$\tau_{i}^{(y)}$	5.65	0.041	4.76	0.047	2.46	0.03
$\lambda_{ii}^{(y)}$	0.98	0.019	0.90	0.024	/	/
$\tau_{i}^{(y)}$	5.7	0.040	4.60	0.047	/	/
$\lambda_{ii}^{(y)}$	0.74	0.029	1.05	0.023	/	/
$\tau_{i}^{(y)}$	4.98	0.045	4.32	0.05	/	/
$\lambda_{ii}^{(y)}$	0.81	0.033	1.05	0.023	/	/
$\tau_{i}^{(y)}$	4.93	0.051	4.32	0.05	/	/

c: constrained

Appendix B: Descriptive statistics on perceived risks, benefits and confidence

Table B1. Answers to the risks, benefits and confidence's statements (% reported)

RISKS	*In your opinion, how likely are the following risks?*				
	Not at all/a little	Somewhat unlikely	Neutral	Somewhat Likely	Very/Extremely likely
Public Investments in Italy	1	3	10	21	65
Nuclear waste related risks	2	4	12	20	62
Risks for the environment	4	4	10	20	62
Risks for human health	4	4	12	21	60
Risk of catastrophic accidents	6	5	15	22	52
Terrorist attacks	7	7	24	22	40
Use of nuclear for military purposes	11	9	18	44	19

BENEFITS	*In your opinion, how likely are the following benefits?*				
	Not at all/a little	Somewhat unlikely	Neutral	Somewhat Likely	Very/Extremely likely
Less energy's imports	11	8	18	29	34
Less fossil fuels' consumption	12	9	20	29	30
More convenient energy prices	17	11	20	26	26
Economic growth	18	11	28	24	20
Atmospheric emissions' reduction	21	13	25	21	20
Less unemployment	18	11	28	24	18

	In your opinion, how important are the following goals of the nuclear industry?				
Importance of goals of nuclear industry	*Not at all*	*A little*	*Somewhat*	*Very*	*Extremely*
Reduce the probability of catastrophic accidents	1	1	12	24	63
Reduce nuclear waste production	1	2	12	27	58
Increase passive security	1	2	13	28	55
Reduce the number of years nuclear waste needs to decay	1	2	15	30	52
Increase protection against external attacks	1	5	20	32	42
Foster cost competitiveness	5	10	25	31	29

Table B1-Continued

Confidence	*How confident are you that these goals will be reached?*				
	Not at all	*A little*	*Somewhat*	*Confident*	*Very confident*
Reduce the probability of catastrophic accidents	11	28	34	19	7
Reduce nuclear waste production	12	29	33	17	8
Increase passive security	10	27	35	20	8
Reduce the number of years nuclear waste needs to decay	11	32	33	16	7
Increase protection against external attacks	9	26	39	18	7
Foster cost competitiveness	9	27	36	21	8

Appendix C: Choice experiments analysis

Table C1. Variables used in the CE econometric models

Choice Experiments-Utility function Variables	Type	Mean	S.D.	Min	Max
ASC	Dummy	0.33	0.47	0.00	1.00
Distance 20 Km	Dummy	0.49	0.49	0.00	1.00
Distance 50 Km	Dummy	0.17	0.37	0.00	1.00
Distance 100 Km	Dummy	0.17	0.37	0.00	1.00
Waste 30 %	Dummy	0.16	0.37	0.00	1.00
Waste 20 %	Dummy	0.17	0.37	0.00	1.00
Waste 10 %	Dummy	0.17	0.37	0.00	1.00
Emission Reduction	Discrete	0.62	0.79	0.00	2.00
Hospital	Dummy	0.27	0.44	0.00	1.00
Land Recovery	Dummy	0.27	0.44	0.00	1.00
Bill Reduction	€/household/year	68.35	78.61	0.00	203.73
Choice Experiments-Segment membership Variables					
Confidence	Score factors	2.71e-09	0.978	-1.826	2.151
Risk	Score factors	5.63e-09	0.977	-3.539	1.089
Benefits	Score factors	4.02e-10	0.969	-2.251	1.817

Notes: 1. Dummy variables were used to code some of the attributes (Distance, Waste, Public Investments in Hospitals and Land Recovery) to account for the presence of non-linearities. Non-linearities were not found in the Emission Reductions attribute which is therefore coded as a continuous variable. 2. Bill reduction was expressed in percentages in the choice tasks; these values were multiplied times the average annual electricity bill of the sampled respondents in order to obtain the €/household/year unit.

Table C2. Latent class model. Dependent variable: Choice

Variable	CLASS 1	CLASS 2	CLASS 3	CLASS 1	CLASS 2	CLASS 3
	Coeff. (S.e.)			Monetary Valuations (€)		
ASC	5.89*** (.670)	-.470*** (.069)	2.48*** (.126)	→+∞	-167.1	874.4
Distance: 20 Km	1.64** (.703)	.722*** (.045)	1.21*** (.091)	→+∞	256.4	426.1
Distance: 50 Km	1.66** (.682)	.628*** (.047)	.918*** (.101)	→+∞	223	323.1
Distance: 100 Km	1.59** (.721)	.400*** (.050)	.602*** (.103)	→+∞	141.9	212
Waste Reduction: 30%	.686 (.505)	.751*** (.049)	1.14*** (.097)	→+∞	266.7	404
Waste Reduction: 20%	.791* (.487)	.673*** (.048)	.852*** (.097)	→+∞	239	300
Waste Reduction: 10%	.581 (.493)	.301*** (.048)	.632*** (.099)	n.d.[b]	107	222.5
Emission Reduction	.379* (.219)	.304*** (.020)	.488*** (.039)	→+∞	107.8	171.7
Hospitals	.196 (.337)	.383*** (.034)	.660*** (.066)	n.d.[b]	136	232.3
Land Recovery	1.10*** (.339)	.476*** (.033)	.985*** (.062)	→+∞	169	346.7
Bill Reduction	.0007 (.002)	.002*** (.0002)	.002*** (.0004)			
Class membership function						
Constant	.269*** (.130)	.799*** (.125)	0[a]	/	/	/
Information Treatment	.324* (.195)	-.062 (.192)	0[a]	/	/	/
Average class probability	0.323	0.464	0.213	0.323	0.464	0.213
Log-Likelihood	-6448.767					
Pseudo R^2	0.355					
Observations	9107					

Level of significance: *10%, **5%, ***1%. Robust standard errors estimated. [a]: constrained values. [b]: not defined.

Table C3. RPL_EC model-Information Treatment. Dependent variable: Choice

	β	**β*Info_T**	**S.D.**
Variable		Coeff. (S.e.)	
ASC	1.49*** (.102)	.724*** (.160)	2.08*** (.046)
Distance: 200 Km	.899*** (.072)	.093 (.108)	.288*** (.083)
Distance: 100 Km	.719*** (.078)	.024 (.121)	.307** (.146)
Distance: 50 Km	.544*** (.083)	-0.38 (.127)	.155 (.150)
Waste Reduction: 30%	.828*** (.079)	.068 (.126)	.191 (.157)
Waste Reduction: 20%	.683*** (.078)	.050 (.120)	.072 (.164)
Waste Reduction: 10%	.402*** (.077)	-0.001 (.125)	.171 (.122)
Emission Reduction	.327*** (.033)	.024 (.054)	.193*** (.046)
Hospitals	.393*** (.057)	.124 (.084)	.351*** (.080)
Land Recovery	.495*** (.056)	.323 (.087)	.360*** (.082)
Bill Reduction (€)	.002*** (.000)	.0001 (.0006)	.004*** (.000)
Log-Likelihood		-7700.191	
R squared		0.228	
Observations		9107	

Level of significance: *10%, **5%, ***1%. Robust standard errors estimated.

Appendix D: Multivariate analysis

Table D1. Bivariate Ordered probit model

Equation 1-Dependent variable: Number of opt outs

Variable	Source	Coefficient	St. Error
Age	Q1	0.027	0.033
Male	Q2	-0.073	0.070
EU_Risk	Q3	-0.083***	0.032
Income	Q4	-0.005	0.024
Household size	Q5	-0.034	0.030
Right wing	Q6	-0.155*	0.096
Chernobyl Seriousness	Q7	0.019	0.070
Fukushima Seriousness	Q8	0.070	0.057
Never nuclear	Q9	0.171**	0.070
Investment_Fossil	Q10	-0.007	0.035
Investment_Wind	Q11	0.062	0.046
Investment_solar	Q12	-0.086	0.056
Investment_Nuclear	Q13	-0.007	0.039
Investment_Hydro	Q14	-0.004	0.040
Investment_Geothermal	Q15	0.005	0.031
Investment_Biomass	Q16	-0.042	0.027
Importance_School	Q17	0.039	0.050
Importance_Immigration	Q18	-0.037	0.042
Importance_Climate change	Q19	0.062	0.043
Importance_Unemployement	Q20	-0.081	0.059
Importance_Economic growth	Q21	0.061	0.050
Importance_Healthcare	Q22	0.001	0.061
Importance_Crime	Q23	0.006	0.049
Importance_Public debt	Q24	-0.027	0.043
North	Q25	-0.113	0.077
Centre	Q26	-0.110	0.090
Unemployed	Q27	0.057	0.099
Under 16 years old in the household	Q28	0.007	0.016
Degree	Q29	0.106	0.090

Table D1-Continued

Benefits	Score factors (1)	-0.075*	0.041
Risks	Score factors (2)	0.130***	0.048
Confidence	Score factors (3)	-0.169***	0.041
Place attachment	Score factors (4)	-0.004	0.034
Info_Treatment		0.127**	0.025

Table D1-Continued

Equation 2-Dependent variable: Heard of FG before

Age	Q1	-0.031	0.041
Male	Q2	0.359***	0.086
Income	Q4	0.053*	0.029
Household size	Q5	0.061*	0.035
Right wing	Q6	0.443***	0.117
Chernobyl Seriousness	Q7	0.102	0.087
Fukushima Seriousness	Q8	-0.003	0.069
Investment_Fossil	Q10	-0.041	0.044
Investment_Wind	Q11	-0.024	0.059
Investment_solar	Q12	-0.120*	0.071
Investment_Nuclear	Q13	0.063	0.043
Investment_Hydro	Q14	-0.025	0.053
Investment_Geothermal	Q15	0.136***	0.043
Investment_Biomass	Q16	0.123***	0.034
Importance_School	Q17	0.038	0.062
Importance_Immigration	Q18	0.009	0.052
Importance_Climate change	Q19	0.085	0.054
Importance_Unemployement	Q20	-0.052	0.073
Importance_Economic growth	Q21	0.014	0.063
Importance_Healthcare	Q22	0.020	0.074

Table D1-Continued			
Importance_Crime	Q23	-0.066	0.061
Importance_Public debt	Q24	-0.015	0.053
North	Q25	0.013	0.095
Centre	Q26	-0.021	0.111
Unemployed	Q27	-0.049	0.128
Degree	Q29	0.131	0.111
Log-Likelihood		-2836.0238	
ρ		-0.061	
Observations		1111	

Level of significance: *10%, **5%, ***1%.

Table D2.Bivariate ordered probit model: variables employed in Table D1

Source	Question	Scale/unit
Q1	How old are you?	years
Q2	Gender	0 Female - 1 Male
Q3	In your opinion, how likely is the occurrence of a nuclear accident in Europe?	1 Not at all likely -7 Extremely likely
Q4	What is the income level of your household?	1 less than 10,000 euro- 7 More than 60,000 euro per year
Q5	How many people live in your household?	Number of persons
Q6	For which political party would you vote right now?	1: any right wing party- 0: otherwise
Q7	In your opinion, how serious is the Chernobyl accident?	1: Not at all-5: Extremely
Q8	In your opinion, how serious is the Fukushima accident?	1: Not at all-5: Extremely
Q9	When do you think nuclear power will be re-introduced in Italy	1:Never-0:within 100 years or more
Q10	In your opinion, how much should Italy invest on…	Fossil Fuel, 1 Nothing, 4 A lot, 0 Don’t know
Q11	In your opinion, how much should Italy invest on…	Wind, 1 Nothing, 4 A lot, 0 Don’t know
Q12	In your opinion, how much should Italy invest on…	Solar, 1 Nothing, 4 A lot, 0 Don’t know
Q13	In your opinion, how much should Italy invest on…	Nuclear, 1 Nothing, 4 A lot, 0 Don’t know
Q14	In your opinion, how much should Italy invest on…	Hydro, 1 Nothing, 4 A lot, 0 Don’t know
Q15	In your opinion, how much should Italy invest on…	Geothermal, 1 Nothing, 4 A lot, 0 Don’t know
Q16	In your opinion, how much should Italy invest on…	Biomass, 1 Nothing, 4 A lot, 0 Don’t know
Q17	In your opinion, how important are the following:	School, 1 Not at all important- 5 Extremely important
Q18	In your opinion, how important are the following:	Immigration, 1 Not at all important- 5 Extremely important
Q19	In your opinion, how important are the following:	Climate Change, 1 Not at all important- 5 Extremely important
Q20	In your opinion, how important are the following:	Unemployment, 1 Not at all important- 5 Extremely important
Q21	In your opinion, how important are the following:	Economic growth, 1 Not at all important- 5 Extremely important
Q22	In your opinion, how important are the following:	Healthcare, 1 Not at all important- 5 Extremely important
Q23	In your opinion, how important are the following:	Crime, 1 Not at all important- 5 Extremely important
Q24	In your opinion, how important are the following:	Public debt, 1 Not at all important- 5 Extremely important
Q25	In which region do you currently reside?	1 any region in the North-0 otherwise
Q26	In which region do you currently reside?	1 any region in the Centre-0 otherwise
Q27	What is your occupational status	1 unemployed-0 otherwise
Q28	How many people under the age of 16 live in the household?	Number of persons
Q29	What is your highest level of education?	1 at least one university degree-0 otherwise

Appendix E: Econometric models for choice experiment data

The choice experiment method is based on Lancaster's theory of value (Lancaster 1966) and on the Random Utility theory (McFadden 1974). According to this theoretical framework, respondents choose the option which provides the greatest level of utility. Acknowledging the impossibility of fully characterizing the utility function, this is decomposed into a deterministic and a stochastic part. Formally, utility of individual *i* for alternative *j* is given by:

$$U_{ij} = V_{ij} + \varepsilon_{ij} \tag{E.1}$$

where V_{ij} and ε_{ij} are the deterministic and stochastic components respectively. Specifically, V_{ij} is given by:

$$V_{ij} = \sum_k \beta_{ikj} X'_{ikj} \tag{E.2}$$

where X is the matrix of the *k* attributes, whereas β represents the vector of coefficients to be estimated, scale parameter normalized to one. In order to define the stochastic component, the basic assumption is that the error terms are independently and identically distributed. Furthermore, assuming a Gumbel distribution, the *Multinomial Logit* model (MNL) is obtained, whose choice probabilities are given by:

$$P_{ijt} = \frac{\exp(\beta_k X'_{kjt})}{\sum_j \exp(\beta_k X'_{kjt})} \tag{E.3}$$

Once the coefficients are estimated, the monetary valuations (MV) can be computed. These are given by the ratio of the coefficients (corresponding to the marginal utility) of the non-monetary over the monetary attribute, as shown in (E.4):

$$MV = \left| \frac{\beta_{non-monetary}}{\beta monetary} \right| \tag{E.4}$$

However, the MNL assumes independence of irrelevant alternatives, whereas there might be correlation between groups of similar alternatives. As in contingent valuation studies, protest behavior can influence results in choice experiments (Adamowicz et al. 1998; Meyerhoff and Liebe 2008): in our case, respondents might choose the opt out option without seriously considering the scenario attributes just because the scenarios refer to nuclear energy options. Indeed, protest votes are just one of the possible reasons that might lead respondents to choose the status-quo or opt out options. Other studies have suggested loss aversion (Kahneman et al. 1991), task complexity (Boxall et al. 2009; Day et al. 2012; Moon 2004), lack of credibility of the survey (Kataria et al. 2012) or alternatives perceived to be too similar by the respondent (Haaijer et al. 2001). An alternative modeling strategy is represented by a Nested Logit (NL) (Ben-Akiva and Lerman 1985; Hensher et al. 2005), which allows the relaxation of the IIA assumption, although homogeneity in preferences is still in place. A strategy to introduce preference heterogeneity is represented by the *Random Parameters Logit* (RPL) model (Hensher and Greene 2003; Revelt and Train 1998). According to this model, the utility function is characterized by the presence of an idiosyncratic random deviation of respondent *i* η_{ik} from the mean value β_k for each of the K attributes:

$$U_{ijt} = \beta_k X'_{kjt} + \eta_{ik} X'_{kjt} + \varepsilon_{ijt} \tag{E.5}$$

The random distribution must be specified by the analyst, with normal and log-normal distributions often chosen. In this context, the choice probability is given by:

$$P_{ijt} = \int \frac{\exp\left(\beta_{ik} X'_{kjt}\right)}{\sum_j \exp\left(\beta_{ik} X'_{kjt}\right)} f(\beta_i|\theta) d\beta_i \quad \text{(E.6)}$$

where $f(\beta_i|\theta)$ represents the density function of the coefficients and θ the vector of parameters characterizing the deviations from the mean of the coefficients. As the integral in (E.6) does not have a close form solution, estimation requires simulated maximum likelihood (McFadden and Train 2000). Finally, in order to include correlation effects between the alternatives, additional error components are specified (Herriges and Phaneuf 2002) in order to tackle presence of status-quo/opting out effects.

Preference heterogeneity can be also modeled in a *latent class* framework (Boxall and Adamowicz 2002), according to which utility's parameters are the same within and different between classes:

$$U_{ij|s} = V_{ij|s} + \varepsilon_{ij|s} \quad \text{(E.7)}$$

Given *s* segments, the unconditional choice probability is given by:

$$Pr_{ij} = \sum_s h_s Pr_{j|s} \quad \text{(E.8)}$$

where $Pr_{j|s}$ is the choice probability conditioned on the class membership probability h_s, given as follows:

$$Pr_{j|s} = \frac{\exp(\beta_{k|s} X'_{kjt})}{\sum_j \exp(\beta_{k|s} X'_{kjt})} \quad \text{(E.9)}$$

$$h_s = \frac{\exp(\gamma_s Z_s)}{\sum_s \exp(\gamma_s Z_s)} \quad \text{(E.10)}$$

where Z_s represents the matrix of socio-economic variates and/or attitudes that condition the segment membership probability. After model estimation, posterior class probabilities can be computed including in (E.8) the estimated coefficients of the utility and segment membership probability function.

Appendix F: Econometric models for multivariate analysis-Bivariate ordered probit

The bivariate ordered model is employed in order to estimate simultaneously two equations, where the dependent variables are the number of 'none' option chosen and whether the respondent said to have heard of FG generation before the study[18]. The model is formally characterized as follows (Sajaia 2008). Assume two latent variables, y_{1i}^* and y_{2i}^*, are function of the matrices of explanatory variables X_{1i}' and X_{2i}' respectively:

$$\begin{cases} y_{1i}^* = X_{1i}'\beta_1 + \varepsilon_1 \\ y_{2i}^* = X_{2i}'\beta_2 + \varepsilon_2 \end{cases} \tag{F.1}$$

The parameters to be estimated are β_1 and β_2, whereas ε_1 and ε_2 represent the error terms. The dependent variables, discrete, are assumed to be observed depending on some threshold levels of the latent variables, as follows:

$$y_{1i} = \begin{cases} 1 \; if \; y_{1i}^* \le c_{11} \\ 2 \; if \; c_{11} < y_{1i}^* \le c_{12} \\ 3 \; if \; c_{12} < y_{1i}^* \le c_{13} \\ 4 \; if \; c_{13} < y_{1i}^* \le c_{14} \\ 5 \; if \; c_{14} < y_{1i}^* \le c_{15} \\ 6 \; if \; c_{15} < y_{1i}^* \le c_{16} \\ 7 \; if \; c_{16} < y_{1i}^* \le c_{17} \\ 8 \; if \; c_{17} < y_{1i}^* \end{cases} \tag{F.2}$$

$$y_{2i} = \begin{cases} 0 \; if \; y_{2i}^* \le c_{21} \\ 1 \; \; if \; y_{1i}^* > c_{21} \end{cases} \tag{F.3}$$

y_{1i} refers to the number of times a given respondent chose 'none' of the options, whereas y_{2i} stands for a binary variable indicating whether a given respondent declared to have heard of FG before (value 1) or not (value 0). We then model the joint probability of observing pairs of values for y_{1i} and y_{2i}, assuming the error terms are distributed following a bivariate normal distribution, with correlation ρ, as follows:

$$\Pr(y_{1i} = j, y_{2i} = k) = \Phi_2(c_{1j} - X_{1i}'\beta_1,\; c_{2k} - X_{2i}'\beta_2),\; \rho) - \Phi_2(c_{1j-1} - X_{1i}'\beta_1,\; c_{2k} - X_{2i}'\beta_2),\; \rho) - \Phi_2(c_{1j} - X_{1i}'\beta_1,\; c_{2k-1} - X_{2i}'\beta_2), \rho) + \Phi_2(c_{1j-1} - X_{1i}'\beta_1, c_{2k-1} - X_{2i}'\beta_2), \rho) \tag{F.4}$$

where Φ_2 represents the bivariate standard normal cumulative distribution function. Remarkably, the model is identified as long as at least one explanatory variable included in X_{1i}' is not in X_{2i}'. Finally, maximum likelihood estimation is implemented.

[18] See Brécard et al. (2009) for another application of the bivariate ordered probit, where it was employed in order to investigate demand for green energy products.

References

1. Abram T, Ion S (2008) Generation IV nuclear power: A review of the state of the science. Energy Policy 36:4323-4330
2. Adamowicz W, Boxall P, Williams M, Louviere J (1998) Stated preference approaches for measuring passive use values: Choice experiments and contingent valuation. American Journal of Agricultural Economics, Agricultural and Applied Economics Association 80(1):64-75
3. Agostini P, Alemberti A (2014) Progress report on the Italian national research policy on fast reactors. https://www.iaea.org/NuclearPower/Downloadable/Meetings/2014/2014-05-19-05-23-TM-NPTD/italy.1.pdf [visited on 25/07/2015]
4. Ansolabehere S (2007) Public attitudes toward America’s energy options. Report of the 2007 MIT Energy Survey- http://web.mit.edu/ceepr/www/publications/workingpapers/2007-002.pdf [visited on 25/07/2015]
5. Ansolabehere S, Deutch J, Driscoll M, Gray P, Holdren J, Joskow P, Lester R, Moniz E, Todreas N, Beckjord E (2003) The future of nuclear power: an interdisciplinary MIT study- http://web.mit.edu/nuclearpower/pdf/nuclearpower-full.pdf [visited on 25/07/2015]
6. Apergis N, Payne J E, Menyah K, Wolde-Rufael Y (2010) On the casual dynamics between emissions, nuclear energy, renewable energy, and economic growth. Ecological Economics 69(11):2255-2260
7. Atkinson G, Day B, Mourato S, Palmer C (2004) Amenity or eyesore? Negative willingness to pay for options to replace electricity transmission towers. Applied Economics Letters 11(4):203-208
8. Bartholomew D, Steele F, Moustaki I, Galbraith J (2008) Analysis of Multivariate Social Science Data. Chapman & Hall
9. Bateman I, Carson R, Day B, Hanemann M, Hanley N, Hett T, Jones-Lee M, Loomes G., Mourato S, Ozdemiroglu E, Pearce D, Sudgen R, Swanson J (2002) Economic Valuation with stated preferences Techniques: A manual. Edward Elgar, Cheltenham

10. Beheshti H (2011) The prospective environmental impacts of Iran nuclear energy expansion. Energy Policy 39(10):6351-6359

11. Ben Akiva M, Lerman S R (1985) Discrete choice analysis: Theory and applications to travel demand. MIT Press

12. Ben-Akiva M, Swait J D (1986) The Akaike likelihood ratio index. Transportation Science 20(2):133-136

13. Bigerna S, Polinori P (2014) The willingness to pay for green electricity. Renewable and Sustainable Energy Reviews 34:110-121

14. Bollino C A (2009) The willingness to pay for renewable energy sources: The case of Italy with socio-demographic determinants. The Energy Journal 30:81-96

15. Borchers A M, Duke J M, Parsons G R (2007) Does willingness to pay for green energy differ by source? Energy policy 35:3327-3334

16. Boxall P, Adamowicz W L (2002) Understanding heterogeneous preferences in random utility models: a latent class approach. Environmental and Resource Economics 23:421-446

17. Boxall P, Adamowicz W L, Moon A (2009) Complexity in choice experiments: choice of the status quo alternative and implications for welfare measurement. The Australian Journal of Agricultural and Resource Economics 53:503-519

18. Brécard D, Hlaimi B, Lucas S, Perraudeau Y, Salladarré F (2009) Determinants of demand for green products: An application to eco-label demand for fish in Europe. Ecological Economics 69:115-125

19. Choi Y, Lee S, Cho N, Lee B (1998) Development of the public attitude model toward nuclear power in Korea. Annals of Nuclear Energy 25(12):923-936

20. Cicia G, Cembalo L, Del Giudice T, Palladino A (2012) Fossil energy versus nuclear, wind, solar and agricultural biomass: Insights from an Italian National survey. Energy Policy 42:59-66

21. Colombo S, Glenk K, Rocamora-Montiel B (2015) Analysis of choice inconsistencies in on-line choice experiments: impact on welfare measures. European Review of Agricultural Economics 1-32

22. Creti A, Fumagalli E, Fumagalli E (2010) Integration of electricity markets in Europe: Relevant issues for Italy. Energy Policy 38(11):6966-6976

23. Day B, Bateman I, Carson R T, Dupont D, Louviere J, Morimoto S, Scarpa R, Wang P (2012) Ordering effects and choice set awareness in repeated responses stated preferences studies. Journal of Environmental Economics and Management 63:73-91

24. De Boer C, Catsburg I (1988) A report: the impact of nuclear accidents on attitudes toward nuclear energy. The Public Opinion Quarterly 52(2):254-261

25. De Groot JI, Steg L (2008) Value orientations to explain environmental attitudes and beliefs: How to measure egoistic, altruistic and Biospheric value orientations. Environment and Behavior 40:330-354

26. De Groot JI, Steg L, Poortinga W (2013). Values, perceived risks and benefits, and acceptability of nuclear energy. Risk Analysis 33(2):307-317

27. DemoIstat (2013) http://demo.istat.it/pop2013/index.html [visited on 25/07/2015]

28. Eiser J R, Spears R, Webley P (1989) Nuclear attitudes before and after Chernobyl: change and judgment. Journal of Applied Social Psychology 19: 689-700

29. ENEA (2013) Rapporto Energia e Ambiente. Scenari e strategie 2013. Available at: http://www.enea.it/it/produzione-scientifica/pdf-rea/REAScenariestrategie2013.pdf [visited on 25/07/2015]

30. European Commission (2011) Communication from the commission to the European Parliament, the council, the European Economic and Social Committee and the Committee of Region. A roadmap for moving to a competitive low carbon economy in 2050. COM (2011) 112

31. European Commission (2013) Attitudes of Europeans towards air quality. Flash Eurobarometer 360

32. Eurostat (2014) Energy, Transport and Environment indicators. 2014 Edition. Available at http://ec.europa.eu/eurostat/documents/3930297/6613266/KS-DK-14-001-EN-N.pdf/4ec0677e-8fec-4dac-a058-5f2ebd0085e4 [visited on 25/07/2015]

33. Fairlie I (2013) A hypothesis to explain childhood cancers near nuclear plants. Journal of Environmental Radioactivity 133:10-17

34. Ferrini S, Scarpa R (2007) Designs with a-priori information for nonmarket valuation with choice experiments: a Monte Carlo study. Journal of Environmental Economics and Management 53(3):342-363

35. Fimereli E (2011) Towards a low-carbon economy: An investigation of the public acceptability of and preferences for low-carbon energy options in the UK. PhD dissertation, Imperial College London.

36. Fimereli E, Mourato S (2013) Assessing the effect of energy technology labels on preferences. Journal of Environmental Economics and Policy 2(3): 245-265

37. Franchino F (2013) The social base of nuclear energy policies in Europe: Ideology, proximity, belief updating, and attitudes to risk. European Journal of Political Research

38. Garrone P, Groppi A (2012) Siting locally unwanted facilities: What can be learnt from the location of Italian power plants. Energy Policy 45:176-186

39. GIF (2014) GIF Annual report 2014. Available at https://www.gen-4.org/gif/jcms/c_74053/gif-annual-report-2014 [visited on 25/07/2015]

40. Grape S, Svärd S J, Hellesen C, Janson P, Lindell M A (2014) New perspective on nuclear power-Generation IV nuclear energy systems to strengthen nuclear non-proliferation and support nuclear disarmament. Energy Policy 73:815-819

41. Green W, Hensher D (2003) A latent class model for discrete choice analysis: contrasts with mixed logit. Transportation Research Part B: Methodological 37(8):681-698

42. Gregory R, Kunreuther H, Easterling D, Richards K (1991) Incentives policies to site hazardous waste facilities. Risk Analysis 11(4):667-675

43. Haaijer R, Kamakura W, Wedel M (2001) The ‘no-choice’ alternative in conjoint alternative in conjoint choice experiments. International Journal of Market Research 43:93-106

44. Han C C (2014) Demarketing fear: Bring the nuclear issue back to rational discourse. Energy Policy 64:183-192

45. Hanley, N., Mourato, S. and Wright, R. (2001) Choice Modelling Approaches: A Superior Alternative for Environmental Valuation? Journal of Economic Surveys 15:433-460

46. Hayashi M, Hughes L (2013) The policy responses to the Fukushima nuclear accident and their effect on Japanese energy security. Energy Policy 59:86-101

47. Hensher D A, Greene W H (2003) The mixed logit model: The state of practice. Transportation 30:133-176

48. Hensher D A, Rose J M, Greene W H (2005) Applied choice analysis: A primer. Cambridge University Press

49. Herriges J A, Phaneuf D J (2002) Inducing patterns of correlation and substitution in repeated logit models of recreation demand. American Journal of Agricultural Economics 84:1076-1090

50. Hobman E V, Ashworth P (2013) Public support for energy sources and related technologies: The impact of simple information provision. Energy Policy 63:862-869

51. Huh S Y, Woo J, Lim S, Lee Y G, Kim C S (2015) What do customers want from improved residential electricity services? Evidence from a choice experiment. Energy Policy 85:410-420

52. Iaccarino F (2010) Resurgence of Nuclear Energy in Italy. Nuclear Law Bulletin, Vol. 2009/2

53. IAEA (2006) Chernobyl's legacy: Health, environmental and socio-economic impacts. Available at https://www.iaea.org/sites/default/files/chernobyl.pdf [visited on 25/07/2015]

54. IEA (2009) Energy Policies of IEA countries-ITALY. Available at: http://www.iea.org/publications/freepublications/publication/italy2009.pdf [visited on 25/07/2015]

55. Ipos Mori (2011) Global citizen reaction to the Fukushima Nuclear plant disaster. Ipsos Global @dvisor Available at https://www.ipsos-mori.com/Assets/Docs/Polls/ipsos-global-advisor-nuclear-power-june-2011.pdf [visited on 25/07/2015]

56. Itaoka K, Saito A, Krupnick A, Adamowicz W, Taniguchi T (2006) The effect of risk characteristics on the willingness to pay for mortality risk reductions from electric power generation. Environmental and Resource Economics 33: 371-398

57. Jewell J (2011) Ready for nuclear Energy? An assessment of capacities and motivations for launching new nuclear power programs. Energy Policy 39:1470-1055

58. Jun E, Kim W J, Jeong Y H, Chang S H (2010) Measuring the social value of nuclear energy using contingent valuation methodology. Energy Policy 38:1470-1476

59. Kaenzig J, Heinzle S L, Wüstenhagen R (2013) Whatever the customer wants, the customer gets? Exploring the gap between consumer preferences and default electricity products in Germany. Energy Policy 53:311-322

60. Kahneman D, Knetsch J L, Thaler R H (1991) The endowment effect, loss aversion, and status quo bias. Journal of Economic Perspectives 5:193-206

61. Kataria M, Bateman I, Christensen T, Dubgaard A, Hasler B, Hime S, Ladenburg J, Levin G, Martinsen L, Nissen C (2012) Scenario realism and welfare estimates in choice experiments-A non-market valuation study on the European water framework directive. Journal of Environmental Management 94:25-33

62. Kato T (2006) Effectiveness of compensation for the risk of living near a nuclear power plant station: A natural experiment. III World Congress of Environmental and Resource Economics, Kyoto Japan

63. Kellner P (2004) Can online polls produce accurate findings? International Journal of Market Research 44(1):3-22

64. Kessides I N (2012) The future of the nuclear industry reconsidered: Risks, uncertainties, and continued promise. Energy Policy 48:185-208.

65. Kim Y, Kim M, Kim W (2013) Effect of the Fukushima nuclear disaster on global public acceptance of nuclear energy. Energy Policy 61:822-828

66. Koerner C L (2014) Media, fear, and nuclear energy. The Social Science Journal 51(2):240-249

67. Kosenius A K, Ollikainen M (2013) Valuation of environmental and society trade-offs of renewable energy sources. Energy Policy 62:1148-1156

68. Kovacs P, Gordelier S (2009) Nuclear power and the public. NEA news- Facts and opinions. Nuclear Energy Agency

69. Lancaster K J (1966) A new approach to Consumer Theory. Journal of Political Economy 74(2):132-157

70. Liao S Y, Tseng W C, Chen C C (2010) Eliciting public preference of nuclear energy against the backdrop of global warming. Energy Policy: 7054-7069

71. Lindhjem H, Navrud S (2011) Are Internet surveys an alternative to face-to-face interviews in contingent valuation? Ecological Economics 70(9):1628-1637

72. Locatelli G, Mancini M, Todeschini N (2013) Generation IV nuclear reactors: Current status and future prospects. Energy Policy 61:1053-1520

73. Louviere J, Hensher D A, Swait J D (2000) Stated choice methods: analysis and application. Cambridge University Press

74. Macintosh A, Hamilton C (2007) Attitudes to nuclear power: Are they shifting? Research Paper 43, The Australian Institute

75. Mansfield C, Houtven G V, Huber J (2002) Compensating for public harms: why public goods are preferred to money. Land Economics 78(3):368-389

76. McFadden D, 1974. Conditional logit analysis of quantitative choice behaviour. In: Zarembka, P., Frontiers in Econometrics. Academic Press, New York

77. McFadden D, Train K (2000) Mixed MNL models for discrete responses. Journal of Applied Econometrics 15: 447-470

78. Melber B D (1982) The impact of the TMI upon the public acceptance of nuclear power. Progress in Nuclear Energy 10:387-398

79. Meyerhoff J, Liebe U (2008) Do protest responses to a contingent valuation question and choice experiment differ? Environmental and Resource Economics 39:433-446

80. Moon A (2004) Assessing the impacts of complexity in Stated preference methods. Edmonton

81. Mozumder P, Vasquez W F, Marathe A (2011) Consumers' preferences for renewable energy in the southwest USA. Energy Economics 33:1119-1126

82. Munro A (2013) The economics of nuclear decontamination: assessing policy options for the management of land around Fukushima daichi. Environmental Science and Policy 33:63-75

83. Murakami K, Ida T, Tanaka M, Friedman L (2015) Consumers' willingness to pay for renewable and nuclear energy: A comparative analysis between the US and Japan. Energy Economics 50:178-189

84. Murty K L, Charit I (2008) Structural materials for Gen IV nuclear reactors: Challenges and opportunities. Journal of Nuclear Materials 383(1-2):189-195

85. OECD (2010) Public attitudes to nuclear power Available at: https://www.oecd-nea.org/ndd/reports/2010/nea6859-public-attitudes.pdf [visited on 25/07/2015]

86. Olsen S B (2009) Choosing between internet and mail survey modes for choice experiment surveys considering non-market goods. Environmental and Resource Economics 44(4):591-610

87. Peters E, Slovic P (1996) The role of affect and worldviews as orienting dispositions in the perception and acceptance of nuclear power. Journal of Applied Social Psychology 26:1427-1453

88. Pidgeon N F, Lorenzoni I, Poortinga W (2008) Climate change or nuclear power-No thanks! A quantitative study of public perceptions and risk framing in Britain. Global Environmental Change 18(1):69-85

89. Pistelli L (2013) Statement by the Vice Minister for Foreign Affairs of Italy, Hon. Lapo Pistelli. IAEA

57th General Conference. Available at: http://www.iaea.org/About/Policy/GC/GC57/Statements/italy.pdf [visited on 25/07/2015]

90. Poortinga W, Aoyagi M, Pidgeon N F (2013) Public perceptions of climate change and energy futures before and after the Fukushima accident: A comparison between Britain and Japan. Energy Policy 62:1204-1211

91. Rehdanz K, Welsch H, Narita D, Okubo T (2015) Well-being effects of a major natural disaster: The case of Fukushima. Journal of Economic Behavior and Organization 116:500-517

92. Renn O (1990) Public response to the Chernobyl accident. Journal of Environmental Psychology 10:151-167

93. Revelt D, Train K (1998) Mixed logit with repeated choices: Households' choice of appliance efficiency level. Review of Economics and Statistics 80:647-657

94. Riddel M, Shaw D (2003) Option wealth and bequest values: The value of protecting future generations from the health risk of nuclear waste storage. Land Economics 33(1):537-548

95. Rosa E, Dunlap R (1994) Poll trends: nuclear power: three decades of public opinion. The Public Opinion Quarterly 58(2):295-324

96. Rose J M, Bliemer M C J (2009) Constructing efficient stated choice experimental designs. Transport Reviews 29(5):587-617

97. Sajaia Z (2008) Maximum likelihood estimation of a bivariate ordered probit model: Implementation and Monte Carlo simulations. The Stata Journal 4(2):1-18

98. Samseth J (2013) Will the introduction of renewable energy in Europe lead to CO2 reduction without nuclear energy? Environmental Development 6:130-132

99. Schwartz, S. H. (1992) Universals in the content and structure of values: Theory and empirical tests in 20 countries. In M. Zanna (Ed.), Advances in experimental social psychology, Vol. 25 (pp. 1–65). New York: Academic Press

100. Schwartz, S. H. (1994) Are there universal aspects in the content and structure of values? Journal of Social Issues 50:19–45

101. Schwartz S H, Bardi A. (2001) Value hierarchies across cultures: Taking a similarities perspective. Journal of Cross-Cultural Psychology 32:268–290

102. Schwartz S H, Huismans S (1995) Value priorities and religiosity in four Western religions. Social Psychology Quarterly, 58, 88–107

103. Schwartz S H, Sagiv L (1995). Identifying culture specifics in the content and structure of values. Journal of Cross-Cultural Psychology, 26, 92–116

104. Siegrist M, Cvetkovich G, Roth C (2000) Salient value similarity, social trust, and risk/benefit perception. Risk Analysis 20:353-362

105. Siegrist M, Visschers V H M (2013) Acceptance of nuclear power: The Fukushima Effect. Energy Policy 59:112-119

106. Sjoberg L (2004) Local acceptance of a high-level nuclear waste repository. Risk Analysis 24(3):737-749

107. Sjoberg (2009) Precautionary attitudes and the acceptance of a local nuclear waste repository. Safety Science 47:542-546

108. Slovic P (1987) Perception of risk. Science 236:280-285

109. Slovic P, Layman M, Flynn JH (1991) Risk perception, trust, and nuclear waste-Lessons from Yucca Mountain. Environment 33(3):6-11

110. Slovic P, Peters E, Finucane ML, MacGregor DG (2005) Affect, risk, and decision making. Health Psychology 24(4):S35-S40

111.Srinvasan T N, Gopi Rethinaraj T S (2013) Fukushima and thereafter: Reassessment of risks of nuclear power. Energy Policy 52:726-736

112.Steinhauser G, Brandl A, Johnson T E (2014) Comparison of the Chernobyl and Fukushima nuclear accidents: A review of the environmental impacts. Science of The Total Environment 470-471:800-817

113.Stern P C (2000) Toward a coherent theory of environmentally significant behaviour. Journal of Social Issues 56(3):407-424

114. Stern P C, Dietz T, Abel T, Guagnano G A, Kalof L (1999) A value-belief-norm theory of support for social movements: The case of environmental concern. Human Ecology Review 6:81–97.

115. Strazzera E, Contu D, Ferrini S (2013) Check it out! A Monte Carlo analysis of the performance of selection criteria and tests for models fitted to choice experiments data. International Choice Modelling Conference- Sydney. Available at http://www.icmconference.org.uk/index.php/icmc/ICMC2013/paper/viewFile/611/212 [visited on 25/07/2015]

116.Strazzera E, Mura M, Contu D (2012a) Combining choice experiments with psychometric scales to assess the social acceptability of wind Energy projects: A latent class approach. Energy Policy 48:334-347

117. Strazzera E, Statzu V, Mura M (2012b) Powering the change: a contingent valuation study on the determinants of demand for green vs. brown energy. Journal of Environmental Economics and Policy 1-28

118.Sun C, Zhu X (2014) Evaluating the public perceptions of nuclear power in China: Evidence from a contingent valuation survey. Energy Policy 69:397-405

119.Truelove H B (2012) Energy source perceptions and policy support: Image associations, emotional evaluations, and cognitive beliefs. Energy Policy 45:478-489115. UNSCEAR (2013) Sources, effects, and risks of ionizing radiation. Volume I-Report to the General Assembly SCIENTIFIC ANNEX A:

Levels and effects of radiation exposure due to the nuclear accident after the 2011 great east-Japan earthquake and tsunami. Available at http://www.unscear.org/docs/reports/2013/14-06336_Report_2013_Annex_A_Ebook_website.pdf [visited on 25/07/2015]

120. Van der Horst D (2007) NIMBY or not? Exploring the relevance of location and the politics of voiced opinions in renewable energy siting controversies. Energy Policy 35:2705–2714

121. Van der Zwaan B (2013) The role of nuclear power in mitigating emissions from electricity generation. Energy Strategy Reviews 1(4):296-301

122. Venables D, Pidgeon N F, Parkhill K A, Henwood K L, Simmons P (2012) Living with nuclear power: sense of place, proximity, and risk perceptions in local host communities. Journal of Environmental Psychology 32(4):371-383

123. Verplaken B (1989) Beliefs, attitudes and intentions toward nuclear energy before and after Chernobyl in a longitudinal within-subjects design. Environmental Behavior 21:371-392

124. Walker, G (1995) Renewable energy and the public. Land Use Policy 12 (1):49-59

125. Wang Q, Chen Xi, Yi-Chong Xu (2013) Accident like the Fukushima unlikely in a country with effective nuclear regulation: Literature review and proposed guidelines. Renewable and Sustainable Energy Reviews 71:126-146

126. Welsch H, Biermann P (2014) Fukushima and the preference for nuclear power in Europe: Evidence from subjective well-being data. Ecological Economics 108:171-179

127. Windle J, Rolfe J (2011) Comparing responses from internet and paper-based collection methods in more complex stated preference environmental valuation surveys. Economic Analysis & Policy 41(1):83-97

128. Woo C K, Shiu A, Cheng Y S, Li R, Ho T, Horowitz I, Wang J (2014) Residential willingness to pay for reducing coal-fired generation’s emissions in Hong Kong. The Electricity Journal 27(3):50-66

129. World Nuclear Association. Nuclear Database. Available at http://world-nuclear.org/NuclearDatabase/Default.aspx?id=27232 [visited on 25/07/2015]

130. Yamane F, Matsushita K, Ohgaki H, Asano K (2011) Social factors affecting economic welfare of the residents around nuclear plants in Japan. Energy Procedia 9:619-629

131. Zhu W, Wei J, Zhao D (2016) Anti-nuclear behavioral intentions: The role of perceived knowledge, information processing, and risk perception. Energy Policy 88:168-177

132. Zwick M M (2005) Risks as perceived by the German public: pervasive risks and switching risks. Journal of Risk Research 8(6): 481-498