The London School of Economics and Political Science

Modeling individual preferences towards nuclear energy

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For my wife Pritika, and my Italian-Indian family.

Declaration

I certify that the thesis I have presented for examination for the PhD degree of the London School of Economics and Political Science is solely my own work with the following exceptions: chapter 3 is 90% my own work.

I declare that this thesis consists of approximately 70,000 words.

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Abstract

This thesis investigates preferences for nuclear energy and the determinants of its social acceptance, through a combination of methods from Environmental Economics and Environmental Psychology.

In particular, we use stated preference surveys to investigate the social costs of nuclear energy in three different contexts: 1) Italy, a country that currently has no nuclear power plants in operation, and twice expressed its disapproval through referenda; 2) United Kingdom (UK), a country with nuclear energy; and 3) the United Arab Emirates (UAE), a country that plans to introduce nuclear energy by 2020. The determinants of social acceptance of nuclear energy are assessed in each of these different contexts. We investigate preferences for current nuclear technology as well as preferences for a new advanced 4th generation nuclear energy technology. In addition, we analyse the effects of having a transient population on support for nuclear energy.

Moreover, this thesis investigates a number of methodological issues pertaining to stated preference methods: 1) heuristics in choice modeling; 2) combination of choice modeling and structural equation modeling; and 3) links between propensity to contribute in contingent valuation questions and choices within the choice experiment tasks.

Overall, the thesis aims to contribute to the debate on public acceptability of nuclear energy after the Fukushima accident. In addition, it provides a framework to model individual preferences towards energy sources and assess departures from fully compensatory decision processes

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List of abbreviations

AED: United Arab Emirates Dirham

ANA: Attribute non-attendance

ASC: Alternative Specific Constant

CE: Choice experiment

CFI: Comparative fit statistic

CV: Contingent valuation

ESB: Environmentally significant behavior

EU: European Union

FG: Fourth Generation

GBP: British Pound

GCC: Gulf Cooperation Council

GHG: Greenhouse Gas

GIF: Generation IV International Forum

GW: Gigawatt

LC: Latent Class

LL: Log-Likelihood

MNL: Multinomial Logit

MV: Monetary valuations

OLS: Ordinary least squares

QR: Quantile regression

R&D: Research and development

RP: Revealed Preferences

RPL: Random Parameters Logit

SP: Stated preferences

UAE: United Arab Emirates

VBN: Value Belief Norm

WTA: Willingness to accept

WTP: Willingness to pay

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Chapter 1

Introduction

1.1 Background: The controversial nature of nuclear energy

Nuclear technology exploits the enormous energy released by splitting the atoms of particular elements and it is argued it does not emit CO_2 whilst generating electricity (Apergis et al. 2010; Knapp et al. 2010; Srinivasan and Gopi Rethinaraj 2013; Hayashi and Hughesm 2013; Wang et al. 2013; Samseth 2013; Van der Zwaan 2013; Huhtala and Remes 2017). This can contribute to curb climate change in parallel with fossil fuel consumption reduction (COM 2011; 2007; EC 2009; UNFCCC 1992). In addition, nuclear energy can support the enhancement of energy diversification and the mitigation of energy security risks (Watson and Scott 2009). Further, while renewable energy tends to present intermittency issues in electricity generation (Cany et al. 2016; Waterson 2017), nuclear plants routinely provide base-load energy, namely a reliable minimum amount of power (Huhtala and Remes 2017). Yet, major risks are associated with nuclear energy, including the possibility of accidents, the production of radioactive waste disposal, the risk of nuclear proliferation and the uncertainties about construction time and highly expensive capital costs. This makes its implementation undoubtedly contentious (Kassides 2010; Kassides 2012; Vander Beken et al. 2010), and generally surrounded by unfavourable public opinion (Eurobarometer 2007; Globescan 2005; OECD 2010; Schneider et al. 2016; van de Graaff 2016).

Public acceptance has a critical role in the siting and building of new nuclear power plants (Hammond 1996; Ansolabehere et al. 2003; Weisser et al. 2008; Schneider et al. 2016).[1] Since the 1970s, public attitudes towards nuclear power seem to be more negative than

[1] Acceptability of energy technologies refers to how acceptable a proposed new technology is to the individual, namely whether the energy source is evaluated in a positive manner (O'Garra 2005).

positive when compared to other energy sources (Rosa and Freudenburg 1993; Eiser et al 1995). The level of opposition, however, is different between and within countries (Slovic 1987, Slovic et al. 1991; Rosa et al. 2000; Slovic et al. 2000). Also, support for nuclear energy seems to have increased over time with fluctuations around various worldwide disasters (Knight 2005; Grove-White et al. 2006; OECD 2010; He et al. 2014). Years after the Chernobyl disaster of 1986 and prior to the 2011 Fukushima accident, acceptance was on the rise around the world (OECD 2010) and in 2009 there were 52 countries considering nuclear power implementation (Jewell 2011). However, after the Fukushima accident, polls conducted in 23 countries by the same company used in the OECD (2010) study show that people were significantly more opposed to building new nuclear reactors than they were in 2005. Only 22% agreed that '*nuclear power is relatively safe and an important source of electricity, and we should build more nuclear power plants*' (Globescan 2011). Even in the United States of America, a country with generally favourable public opinion towards nuclear power, this worsening trend was observed. A 2015 Gallup poll in the USA found support for nuclear power at 51%, with 43% opposing its usage for electricity. This was the lowest level of support for nuclear power in the past 20 years and significantly lower than the 2010 peak of 62% in favour, versus 33% against (Riffkin 2015). In general, public acceptance appears to be hard to improve and easy to worsen.

Unsurprisingly, soon after the accident in Fukushima in 2011, energy policies worldwide were deeply affected. Italy stopped all plans of investments in nuclear energy after negative public opinion was voiced in a referendum which took place a few months after the accident. This mirrored what happened in 1987 following the Chernobyl accident, when Italy decided to phase out the existing nuclear plants (Esposto 2008). Similarly, Germany and Switzerland announced that they would gradually phase out nuclear energy (Wang et al. 2013). Conversely, the situation is rather different in the UK. Prior to the Fukushima accident, in 2008 the UK government declared nuclear power to be a lucrative opportunity for investors, yielding economic benefits to the country (BERR 2008). Such position did not change following Fukushima. In a context where most the country's existing nuclear plants are expected to be closed by the end of 2020s, 14 GW of new nuclear energy are projected by 2035 (NAO 2016). In addition, public opinion in the UK did not seem to have deteriorated following Fukushima (Poortinga et al. 2014). Recently, more countries have been investing in nuclear energy notwithstanding the Fukushima accident. As of January 2017, there were 55 reactors under construction in 13 countries (Bulletin of the Atomic Scientist 2017). An interesting case is that of the UAE, aiming to become '*a role model for nuclear energy development worldwide'* (ENEC 2014): four nuclear reactors are under construction in the country and scheduled to be completed by 2020. But on the whole, the worldwide share of nuclear electricity generated is declining: it was 10.7% in 2015 vis-à-vis 17.6% in 1995. Furthermore, over 70% of the global nuclear electricity was generated in just five countries: US, France, China, Russia, South Korea (Schneider et al. 2016).

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. Its work is 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 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 (Brook 2012; Grape et al. 2014). The first nuclear plants belonging to the fourth generation are forecasted to be available after 2030 (Locatelli et al. 2013). This technology remains majorly 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, FG nuclear energy implementation needs to rise to technological and economic challenges, as well as social acceptability[2].

In a nutshell, this thesis contributes to the literature on preferences towards and social acceptability of nuclear energy. The next sections introduce the aims and objectives of the thesis, the empirical case studies described in each of the thesis main chapters, and the contribution to knowledge. Finally, the outline of the following chapters is presented.

1.2 Research aims and objectives

This thesis aims to contribute to the literature on preferences towards potentially controversial energy projects using stated preference methodologies, whilst presenting policy-relevant empirical valuation models in the context of nuclear energy[3]. The thesis addresses these aims through empirical research chapters. The overarching aim is assessing

[2] There are also great expectations from research in the area of nuclear fusion (Ongena and Ogawa 2016).

[3] It is worth remarking that the thesis focuses on individual preferences, not on macroeconomic or geopolitical aspects related to nuclear energy. It does not aim to assess whether nuclear energy should be implemented in the countries considered in the various studies.

and evaluating preferences and attitudes towards nuclear energy post the Fukushima events. The key **objectives** are as follows:

1) assess the determinants of social acceptance of nuclear energy in different policy and geographical contexts;
2) investigate the social costs of nuclear energy in three different contexts: Italy, a country that currently has no nuclear power plants in operation, and twice expressed its disapproval through referenda; UK, a country with nuclear energy; and the UAE, a country that plans to introduce nuclear energy by 2020;
3) assess differences in preferences and attitudes towards nuclear energy, other energy sources and related attitudes, in countries with different nuclear energy policies in place;
4) assess the impact of specific information on preferences towards FG nuclear energy;
5) analyse the effects of having a transient population on support for nuclear energy;
6) investigate a number of methodological issues pertaining to stated preference methods that are relevant in the context of controversial energy projects: 1) heuristics in choice modeling; 2) combination of choice modeling and structural equation modeling; and 3) links between propensity to contribute in contingent valuation questions and choices within the choice experiment tasks.

The contribution to knowledge of each of the thesis' four studies are detailed in Section 1.5.

1.3 The countries selected

To enable the investigation of preferences towards nuclear energy in a number of different contexts, three countries were selected for the empirical applications: Italy, the UK and the UAE. First, the countries present remarkable differences in terms of their energy mixes. The UK currently generates electricity by means of nuclear energy, whereas Italy and the UAE do not. At the same time, the UK plans to shut down most of its existing reactors whilst building new ones, whereas there is no plan of reintroducing nuclear energy in Italy. With regards to the UAE, the building of new nuclear plants is well under way (ENEC 2014). Hence, this thesis covers one country without nuclear plants in operation (Italy), one country with nuclear plant in operation (the UK), and one country which is building nuclear plants (the UAE). Second, with respect to the energy consumption mix, all of the three countries heavily rely on fossil fuels, especially oil and gas. But while Italy has to import almost all of the fossil fuels it consumes (IEA 2009; ENEA 2013), the UK has an extremely low level of energy import dependency (European Commission 2011); instead, the UAE is one of the world's largest exporters of fossil fuels (IEA 2014). Furthermore, these three nations differ in terms of the political process: Italy and the UK are respectively a parliamentary republic and a parliamentary monarchy, whereas the UAE is a federal presidential absolute monarchy. Finally, the UAE is characterized by an extraordinarily vast share of expatriate residents, amounting to around 85% of the population in 2010 (National Bureau of Statistics UAE 2013). These residents normally do not have access to citizenship and usually are in the country for only part of their lives (Koch 2016).

1.3.1 Case study 1: Italy

The planned re-introduction of nuclear energy in Italy was halted in 2011 following the Fukushima nuclear accident. Earlier in 1987, another nuclear accident, which took place in Chernobyl, led Italy to phase out nuclear energy. Although in the short term it is hard to expect any step towards nuclear energy in Italy, a new revival cannot be excluded in the next decades either. As noted above, a new nuclear energy technology, fourth generation nuclear energy, is under research and development. Arguably, it could reduce some of the controversies of the current generation in the decades ahead.

Social acceptance of IV generation nuclear energy in Italy is investigated in this study. A nation-wide online survey was conducted for this purpose. The rich dataset obtained includes choice experiment and psychometric data. Further, information treatments were administered to a random sub-set of respondents. This allows us to test the extent to which results concerning social acceptance of nuclear energy are sensitive to the information provided. From a methodological point of view, this study offers a robust framework given by the combination of discrete choice models applied to choice experiment data and structural equation modeling applied to psychometric data.

1.3.2 Case study 2: The UK

The UK is a pioneer of nuclear energy. The country has had nuclear plants in operation since the 1960s. Currently, 15 nuclear reactors are in operation, and 21% of the electricity is generated by means of nuclear power (WNA 2017; National Statistics 2017). However, most of the existing nuclear reactors are scheduled to be closed down by 2030. In 2013, the government laid out a plan to prepare their replacement, envisaging 16 GW of nuclear power by 2030, and up to 75 GW in the following twenty years (HP 2014). The strategy foreseen in order to expand the domestic generation of electricity from nuclear, during the post 2030 phase, includes a mix of generation III+, IV and Small Modular Reactors-SMRs (HM 2013).

In this work we assess social acceptance of IV generation nuclear energy in the UK. We conducted an online survey, with respondents residing in England, Scotland, Wales and Northern Ireland. The policy implications discussed are of particular relevance for countries with nuclear power plants in operation. The dataset built includes choice experiment, contingent valuation and psychometric data. Further, considering the methodological contribution, this study complements choice experiments with contingent valuation data, with the aim of testing the internal validity of results and gaining a richer insight on individual preferences.

1.3.3 Case study 3: The United Arab Emirates (UAE)

The UAE is on track to be the first Arab country to generate electricity from nuclear energy. The continued growth in energy demand, the forecasted reduction of fossil fuels availability and the attention to climate change, led the country to resolutely invest in nuclear. Four nuclear reactors are expected to be in operation by 2020, located in the emirate of Abu Dhabi. These are expected to deliver 5.6 GW of nuclear energy, contributing to around 20% of domestic power demand (Masdar/IRENA 2015).

Given the ongoing development in the country, this study investigates social acceptance of current generation nuclear energy in the UAE. The survey was administered online, sampling respondents across the various Emirates of the UAE. Data collected includes choice experiment and life satisfaction data. In line with the structure of the population, the vast majority of the sampled respondents are expatriates. This study hypothesizes that their concern towards long-term risks arising from nuclear are significantly lower than permanent residents, thereby presenting a heightened degree of acceptance towards nuclear energy implementation in the UAE. This work is policy-relevant for the energy policy of other Gulf Cooperation Council (GCC) states as well, most of them characterized by a high share of expatriates. Further, this study adds to the literature on preferences towards nuclear energy by investigating the impact of transiency and life satisfaction.

1.4 Saliency in choice experiments

A common element across the three empirical studies discussed above is the administration of choice experiments, a stated preference technique (Hanley et al. 2001). That is, individuals were asked to choose between hypothetical projects describing the construction of nuclear plants. In the context of nuclear energy, some attributes that characterize these scenarios might evoke particularly strong reactions including fear (Hartmann et al. 2013). In turn, this might lead the respondents to disproportionally focus on this information when making their choices. Namely, the decision processing strategy might be affected by the particular good under evaluation. The thesis also aims to contribute to the literature on decision processing strategies in choice modeling. In a separate chapter, we test the following behavioral assumption: in some choice situations, respondents fail to compare all of the attributes between alternatives and base their choices on the presence (or absence) of the attribute's level that they consider to be the most relevant, or that captures their attention. From an econometric modelling point of view, this chapter implements a constrained latent class model in which it is possible to isolate probabilistically whose choice sequence is best approximated by a fully compensatory model, or otherwise.

1.5 Summary of contributions

In terms of policy contributions, the thesis includes works that:

1) to the best of our knowledge, open the stream of research on investigating the social acceptance of IV generation nuclear energy and its determinants (Chapters 3, 4);
2) estimate the willingness to accept nuclear power plants in countries with different nuclear energy policies in place, following the Fukushima accident, being one of very few studies to employ choice experiments-based survey that focus on nuclear energy (Chapters 3, 4, 5);

3) add to the literature on the impact of providing additional information when assessing preferences and attitudes towards nuclear energy, in the context of FG nuclear energy technology (Chapters 3, 4, 7);
4) provide comparative evidence on preferences and attitudes towards nuclear energy, other energy sources and related attitudes (Chapters 3, 4, 5, 7), whilst presenting the first study to asses individual stated preferences for energy sources in the UAE (Chapter 5);
5) to the best of our knowledge, investigate for the first time the impact of transiency of residence and life satisfaction on acceptance of nuclear energy (Chapter 5);

With regards to methodological contributions, the thesis offers:

1) an original combination of discrete choice modeling and structural equation modelling (Chapters 3), presenting both applications with the same set of respondents;
2) an original connection of choice experiments and contingent valuation data, showing links between WTP towards R&D of FG nuclear energy and WTA the building of new nuclear plants (Chapter 4);
3) a novel approach to model choices in a context where the good under valuation might affect the decision strategy of the respondents (Chapter 6).

1.4 Outline

This thesis consists of three case studies which share the aim of investigating preferences for and acceptance of nuclear energy. Additionally, it offers a framework for modeling choice experiment data in the context of controversial energy sources. The next chapter presents a literature review of stated preferences studies, with emphasis on nuclear energy applications, and describes the data captured along with the core econometric methods used. In chapters 3, 4 and 5, the three case studies are presented. Drawing on the choice experiment data collected in these three case studies, in chapter 6 we test the empirical validity of the attributes' saliency hypothesis. Finally, chapter 7 concludes.

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Chapter 2

Review of core studies and methodology

This chapter introduces the Stated Preferences (SP) framework and the techniques implemented in this thesis: choice experiments (CE) and contingent valuation (CV). Next, we discuss the core literature on stated preferences studies on nuclear energy. Subsequently, we present key findings concerning attitudes towards nuclear energy arising from the environmental psychology literature. It is then introduced the main econometric framework employed in the empirical chapters. Finally, we discuss the choice of online data collection, common across the case studies.

2.1 Stated preferences and attitudes

2.1.1 The Stated preferences method

The aim of the thesis is to investigate the economic value of IV generation nuclear energy, in Italy and UK, and of current generation nuclear energy in the UAE. We assess the willingness to accept (WTA) new nuclear power plants in each of these three countries. Also, we measured the willingness to pay (WTP) for further research and development of IV generation nuclear energy technology as part of the UK case study. Economic values are determined with the aid of preference-based techniques, which can be broadly divided into Stated Preferences (SP) and Revealed Preferences (RP) techniques.

SP techniques are employed within surveys to assess preferences of goods, or services, in hypothetical settings (Bateman et al. 2002). This is particularly relevant when there is no market for the good under consideration, a common scenario in the context of environmental goods and services. SP techniques are also applied in circumstances where markets are available. Such contexts include goods, or characteristics of goods, which are yet to be introduced to the market. An alternative procedure to assess preferences towards environmental goods and services is the RP method. This is based on the assumption that preferences can be inferred from related existing markets. Examples of RP methods include the hedonic price and the travel cost method[4] (Pearce 2002). However, RP studies are limited to the markets available and to a given technology structure. Instead, SP techniques thrive in scenarios where technological changes are part of the evaluation (Louviere et al. 2000).

SP methods include contingent valuation (CV) and choice experiments (CE). CV consists of questions that invite respondents to directly state their WTP or WTA for a given good or service. Respondents are presented with hypothetical scenarios in which one key characteristic of the good varies: its monetary value. Such scenarios should be carefully designed to be perceived by the respondents as comprehensible, plausible and meaningful (Mitchell and Carson 1989). Moreover, research suggests to include follow up questions so as to distinguish between genuine answers and protests (Strazzera et al. 2003; Meyerhoff and Liebe 2006; Meyerhoff and Liebe 2008), warm glow-driven choices (Chilton and Hutchinson 2000; Nunes and Schokkaert 2003), as well as preference uncertainty (Akter et al. 2008).

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 requested to choose their most preferred scenario. If a monetary attribute is included, the implicit

[4] In the case of hedonic price method, the focus is on observed price changes. For instance, a change in environmental quality that affects housing prices. The travel cost method instead focuses on the quantity. For instance, the number of observed visits to a recreational site. These visits are linked to the respective time and cost.

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. Grippingly, 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 CE 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 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 attributes (Hanley et al. 2001). This is particularly relevant when dealing with nuclear energy-related scenarios that may be particularly inclined to protests, 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; DeShazo and Fermo 2002; Caussade et al. 2005, Bech et al. 2011). Hence, it is recommended that the CE should be carefully piloted so as to make the presentation of the choice tasks engaging, realistic and understandable.

2.1.2 Stated preferences towards nuclear energy

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 is negatively viewed (Fimereli 2011). Furthermore, 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 thesis is the body of work that has investigated preferences for specific energy technologies, particularly nuclear energy. There is 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; Byun and Lee 2017; 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). The majority of them refer to countries with nuclear plants in operation, especially in South-East Asia. With regards to South Korea, a country with nuclear plants in operation, Huh et al. (2015) show respondents would be willing to pay for more renewables in the energy mix. This contrasts with an earlier study (pre-Fukushima accident) which found a positive WTP for nuclear energy expansion, further magnified in case of precise and concise information on nuclear energy (Jun et al. 2010). A more recent study conducted with South Koreans further confirms the preference for renewable over nuclear and fossil fuels (Byun and Lee 2017). With a sample of respondents from Taiwan, Liao et al. (2010) found a substantial preference for the status quo, which at the time consisted of 20% of electricity generation by means of nuclear energy; whereas no significant WTP was found towards new nuclear plants. Similarly, in a contingent valuation survey conducted in Hong Kong, it was found support towards the reduction of Coal-fired generation emissions by increasing the share of natural gas rather than nuclear (Woo et al. 2014). The case of China has also been investigated: Sun and Zhu (2014) find evidence of WTP to avoid the construction of new nuclear plants. Aligned with these results are the preferences of a sample of US and Japanese respondents, who would prefer less nuclear in the energy mix (Murakami et al. 2015). Japanese respondents were also surveyed by Itaoka et al. (2006), who investigated the willingness to pay for mortality risk reduction in the fossil fuel sector and in the nuclear sector by means of a CE, suggesting individuals associate nuclear with significantly higher chances of disastrous events. US respondents' preferences were also studied in Riddel and Shaw (2003), who found a significant WTP to protect future generations from nuclear waste storage. Moving to Europe, research suggests that Germans and Italians prefer a nuclear-free energy mix (Kaenzig et al. 2013; Cicia et al. 2012). On the whole, stated preferences studies indicate respondents would prefer to avoid nuclear energy and tend to support renewable energy.

Of particular interest to this thesis is the work by Cicia et al. (2012), who 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 three groups, none of which are in support of nuclear energy. Indeed, different studies have suggested Italians tend to 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). The latter seems to be the only published choice experiment study on this topic conducted in Italy.

Stated preferences towards nuclear energy have not been receiving much attention in the UK, an exception being the work of Fimereli (2011). The study investigated English and Scottish respondents' preferences for wind, biomass and nuclear power. Although respondents prefer an increase in low-carbon energy sources compared to the status quo, both English and Scottish respondents favour wind energy over nuclear power. In addition, it was found that both groups of respondents would prefer power plants away from their area of residence; and they would particularly value emissions' reductions. When it comes to the case of the United Arab Emirates, there appears to be no evidence of stated preference study conducted in the field of acceptance of nuclear energy. More broadly, it appears scant the literature on stated preferences towards energy sources in the GCC states.

2.1.3 Psychological determinants of acceptance of nuclear energy

A major contribution to the understanding of public beliefs, attitudes and acceptance of nuclear energy has been provided within the environmental psychology realm. Perceived risks and benefits of nuclear energy appear to be crucial determinants of acceptance (Ansolabehere et al. 2003; Ansolabehere and Konisky 2009; Bronfman et al. 2012; Choi et al. 1998; De Boer and Catsburg 1988; Groot and Steg 2008; Greenberg 2009; Groot et al. 2013; Kato 2006; Rosa and Dunlap 1994; Zhu et al. 2016; Wu 2017). Hence, across the three case studies presented in this thesis, we have measured the extent to which respondent agree or disagree with a set of statements related to potential benefits and risks of nuclear energy.

The way individuals perceive risks and benefits can be affected by a multitude of factors. One of these is represented by trust towards regulatory agencies, as investigated by Ansolabehere and Konisky (2009), Greenberg (2009), Siegrist and Cvetkovich (2000), Siegrist et al. (2000), Greenberg and Truelove (2011), Bronfman et al. (2012). Additionally, 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; biospheric-led individuals are expected to focus on the effects for the biosphere. Besides, individual perception might be affected by protected values (Visschers and Siegrist 2014); that this, values that cannot be negotiated. In the context of nuclear energy, some respondents might not want to negotiate any compensation.

Studies have also suggested the importance of concern and emotional involvement in shaping acceptance of energy projects; such factors have been found to affect acceptance (Peters and Slovic 1996; Truelove 2012), and to be important predictors of the willingness to take action against the implementation of contested projects (Atkinson et al. 2004; Han 2014). Acceptance of nuclear energy might also be linked to proximity and sense of place/place attachment (Kovacs and Gordelier 2009; Venables et al. 2012), concern towards climate change (Visschers et al. 2011; Ertör -Akyazi et al. 2012).

Media coverage in times of nuclear crisis appears 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. (2012) show the significant effect of information on consumers' willingness to pay for electricity generated by solar versus coal-fired power plants. 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.

2.2 Data

This section presents the data collected as part of the different case studies, along with its links with the thesis' objectives. Furthermore, it discusses survey implementation and limitations across the three case studies.

2.2.1 Survey flow

The survey flow followed across the three case studies is displayed in Figure 2.1. Table 2.1 displays the link between the objectives stated in the earlier chapter (section 1.2) and the areas of data captured. Each survey started with the gathering of basic socio-demographic data, needed to control quotas. Furthermore, this helped providing an easy start to the survey. More questions on socio-demographic (such as income, information on household characteristics) were left for the very last part of the survey, as considered more sensitive.

The stated preference part of the survey, key for objectives 1, 2, 5, and 6 (Table 2.1), was introduced only after respondents had the time to answer questions related to nuclear energy and energy more broadly. Respondents were exposed to questions and information to introduce topics such as electricity bill expenditure, risks and benefits of nuclear energy, climate change, attitudes towards different energy sources.

Closer to the choice experiment, in the Italy and UK case studies, all respondents were shown a section describing goals and principles of IV generation nuclear energy. Questions were also asked to measure confidence towards the achievement of such goals. Furthermore, in these two case study, a random set of respondents were treated with additional information, displaying a map of Europe with nuclear plants in operation, planned, shut down, as well as information on the Fukushima's and Chernobyl's accidents. This information treatment has been placed before the stated preference exercises to assess whether choices would differ significantly between treated versus non-treated respondents, thereby providing insights into whether and to what extent choices could be sensitive to the information provided. Following the choice experiment exercise, individuals were presented with an attribute ranking exercise. This data is needed to model saliency in choice experiments as explored in Chapter 6.

Latent constructs that might affect acceptance of nuclear energy as well as influencing choices within the choice experiments have been investigated in the case studies presented in this thesis. A great deal of this data was collected by means of psychometric scales, drawing from literature and following pilots. In the empirical study focusing on the UK, country with a long history of nuclear plants in operation, data has been collected on trust towards regulatory agencies and the nuclear industry.

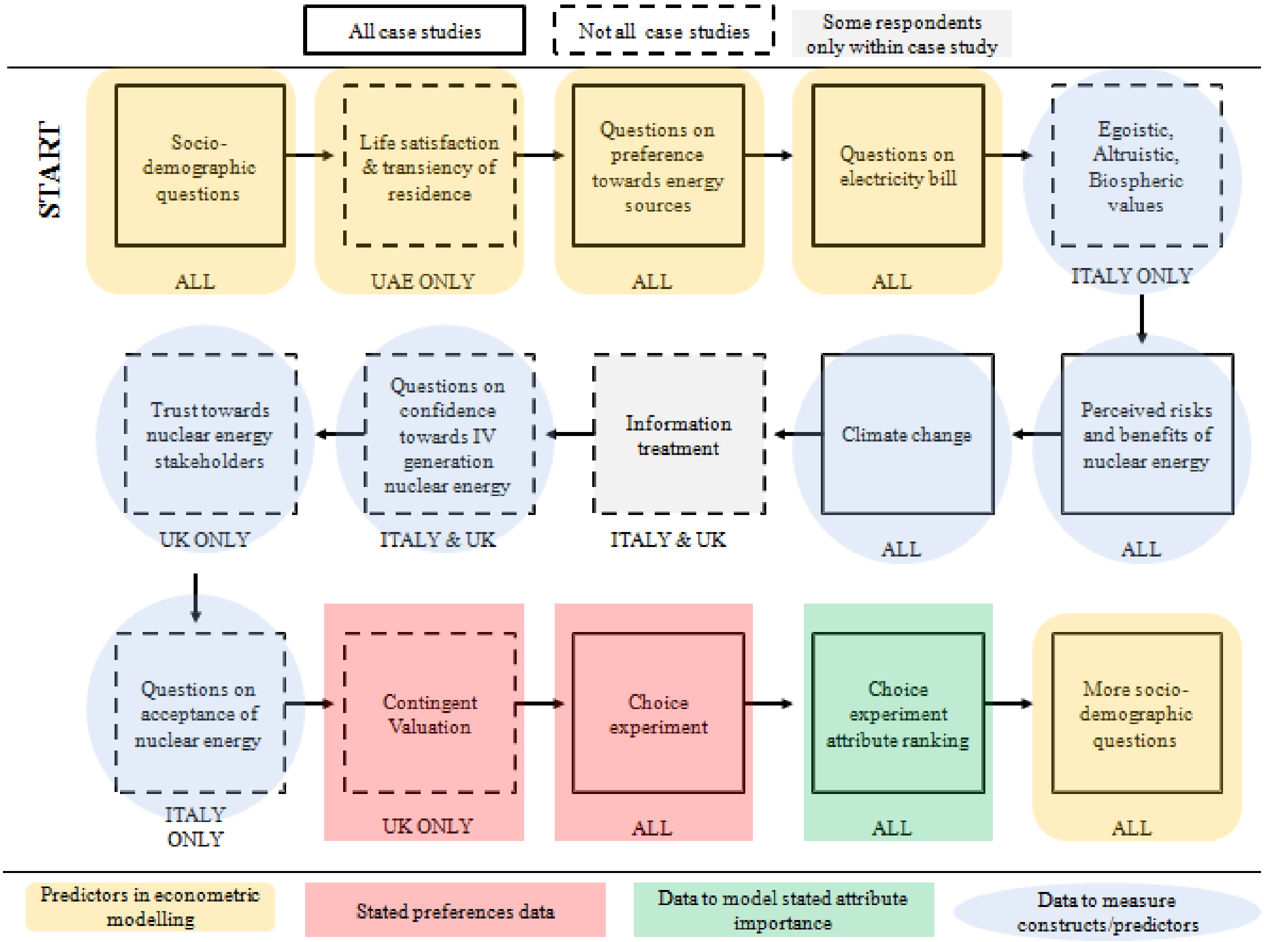


Figure 2.1: Survey flow across case studies

Values have been explored extensively within the Italy case study, where data has been collected to measure egoistic, altruistic and biospheric values[5]. In the empirical studies which focus on fourth generation nuclear energy technology (Italy and UK), we hypothesized that confidence that this new generation will achieved its proposed goals, together with perceived risks and benefits, would affect public acceptance[6]. Hence, scales to measure confidence towards the IV generation goals were presented to the respondents. Finally, the role of transiency and life satisfaction has been explored as part of the UAE

[5] As part of this section in the Italy case studies, place attachment values were also measured, but not found to be worthy of inclusion in the final econometric models.

[6] 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).

case study, in the particular setting of a country with transient residents. Given the type of data collected, the following main modelling needs arise: discrete choice modelling, factor analysis and structural equation modelling; these will be discussed in section 2.3.

Table 2.1: Thesis' objectives and related data

OBJECTIVES	DATA
1) assess the determinants of social acceptance of nuclear energy in different policy and geographical contexts;	Choice experiments, social acceptance of nuclear energy; socio-demographic; perceived risks and benefits of nuclear energy; life satisfaction and transiency; confidence towards IV gen goals; trust towards nuclear energy stakeholders; egoistic, altruistic, biospheric values
2) investigate the social costs of nuclear energy in three different contexts: Italy, a country that currently has no nuclear power plants in operation, and twice expressed its disapproval through referenda; UK, a country with nuclear energy; and the UAE, a country that plans to introduce nuclear energy by 2020;	Choice experiments
3) assess differences in preferences and attitudes towards nuclear energy, other energy sources and related attitudes, in countries with different nuclear energy policies in place;	Questions on preferences towards different energy sources
4) assess the impact of specific information on preferences towards FG nuclear energy;	Information treatment
5) analyse the effects of having a transient population on support for nuclear energy;	Choice experiments; life satisfaction and transiency of residence
6) investigate a number of methodological issues pertaining to stated preference methods that are relevant in the context of controversial energy projects: 1) heuristics in choice modeling; 2) combination of choice modeling and structural equation modeling; and 3) links between propensity to contribute in contingent valuation questions and choices within the choice experiment tasks.	Attribute rankings; perceived risks and benefits of nuclear energy; confidence towards IV gen goals; trust towards nuclear energy stakeholders; egoistic, altruistic, biospheric values; acceptance of nuclear energy; contingent valuation & choice experiments

2.2.2 Survey pilots

Survey flow, length, type of questions, wording and images, were carefully piloted prior to proceeding with the full survey roll out. The Italy case study was the first that got implemented and it underwent the greatest deal of piloting. First, the survey was tested face to face with 15 students at the University of Cagliari, Italy. These initial tests helped especially with crafting the wording, adding more explanations when needed to avoid ambiguities. To help assess this, respondents were asked to verbalize whilst answering.

Also, they were probed after answering or reading the questions to confirm their understanding. In a subsequent phase, the survey was prepared for online administration in Qualtrics, and tested with 60 students from the University of Cagliari. These students were invited in a room with laptops and observed whilst taking part in the survey. These tests were needed to check that the randomizations in the flow (information treatment and choice tasks presented) were working seamlessly, whilst also providing room for a group discussion to further gather feedback on the survey.

The survey for the UK case was also prepared in Qualtrics, following a face to face pilot with 20 students from the London School of Economics. Both surveys (for Italy and UK case studies) were administered to panels provided by Toluna. Finally, the UAE survey was prepared in Gryphon, survey programming tool used by YouGov, and made available in both English and Arabic. 10 face to face pilots were conducted to test the flow and content. The finalized survey was initially soft-launched with 50 respondents to check for lack of bugs in the survey flow and subsequently fully launched. All the surveys' views were optimized for both laptop and mobile view.

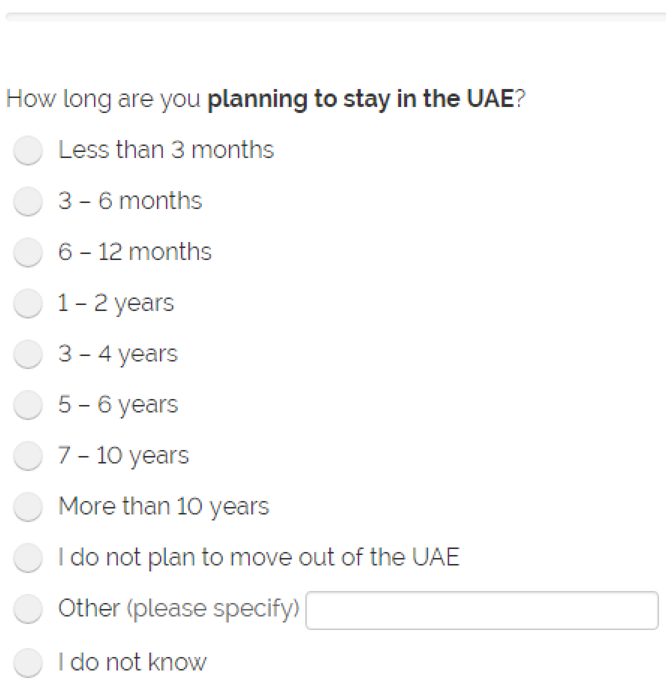
2.2.3 Key questions, scales, information presented[7]

This section presents key questions used in the three case studies. Answers to these questions were used to measure latent constructs, both in a confirmatory and exploratory approach, or to support in multivariate analysis as well as serve as predictors.

2.2.3.1 Life satisfaction and transiency of residence

[7] When survey snapshots are shown for Italy, these contain text that was translated from Italian to English just to show it in the thesis.

Considering the UAE case study, the questions on life satisfaction and transiency of residence are of paramount importance. Two questions on life satisfaction were asked. Respondents were presented with a scale ranging from 1 to 10, where 1 meant 'Not at all satisfied' and 10 'Extremely satisfied'. They were asked to rate thinking about how satisfied they were with their life in general and, separately, with their life in the UAE. This can be defined as the evaluative account of wellbeing (Dolan and Metcalcfe 2012); whilst it can be affected by recall bias, it seems an apt indicator of whether the individual is satisfied in relation to her life in the country, as a whole. In order to measure transiency, we opted for a single question asking the following: 'How long are you planning to stay in the UAE?'. Possible options were presented as intervals, from 'less than 3 months' to 'more than 10 years'. The minimum was set to take into account the possibility of respondents about to leave the Country due to, for instance, job loss (notice period in the UAE is a minimum of a month according to UAE Labor Law, article 117). We kept the upper option to 'more than 10 years' to maintain the list short and reasonable in terms of time period considered.


How long are you **planning to stay in the UAE**?

- Less than 3 months
- 3 – 6 months
- 6 – 12 months
- 1 – 2 years
- 3 – 4 years
- 5 – 6 years
- 7 – 10 years
- More than 10 years
- I do not plan to move out of the UAE
- Other (please specify)
- I do not know

Figure 2.2: Question to measure transiency, UAE study

2.2.3.2 Questions on preferences towards energy sources

Across the three case studies, respondents were asked to state how much the country they reside in should invest in different energy sources (Figure 2.3 shows the screen for Italy). This question is adapted from Pidgeon et al. (2008)[8], where instead of an agreement and disagreement scale respondents were asked to pick between invest 'nothing' and invest 'a lot'. Following the pilots, this format seemed to be easier for the respondents to grasp.

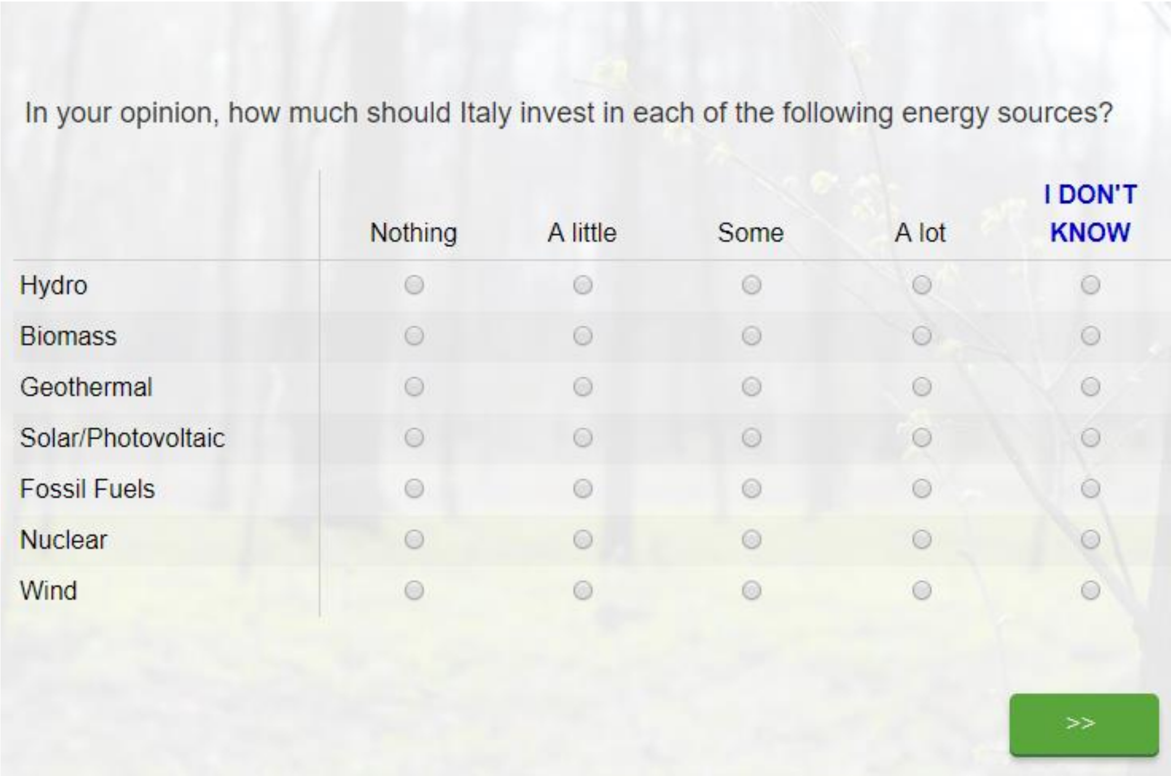
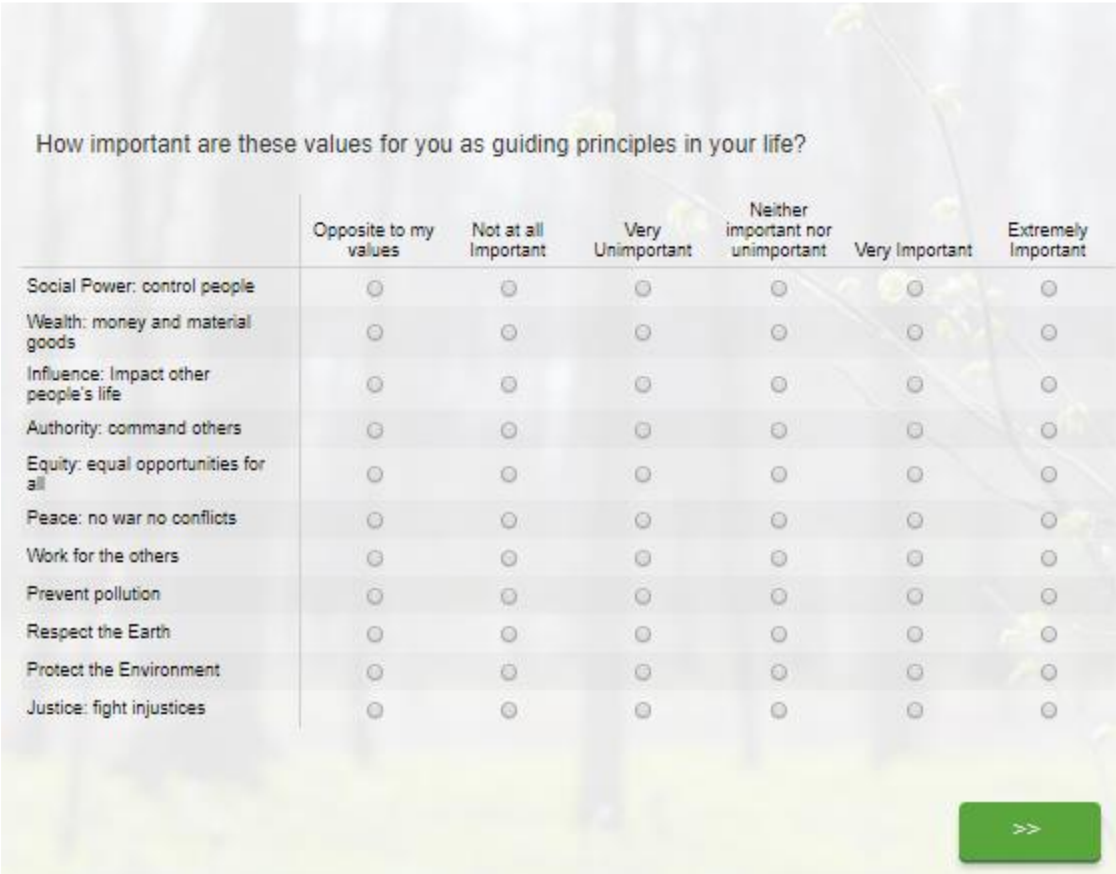


Figure 2.3: Questions on preference towards energy sources

2.2.3.3 Egoistic, Altruistic, Biospheric values

[8] To what extent do you agree or disagree that the following energy sources will make a substantial contribution to reliable and secure supplies of electricity in Britain in the future?

The questions to measure egoistic, altruistic and biospheric values are presented in figure 2.3. These items and scales were developed following Stern et al. (1999) and De Groot and Steg (2007). We retained 4 items each to measure the constructs Egoistic and Altruistic, whereas 3 were kept to measure the construct Biospheric. The item ‘unity with nature’, used in De Groot and Steg (2007), was removed from the list of items to measure the construct Biospheric as the pilots conducted shown individuals were questioning the clarity of such item. Also, following pilots, a 5 points scale was chosen, rather than a 7 points scale, to reduce the cognitive effort required by the respondents.



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
Social Power: control people						
Wealth: money and material goods						
Influence: Impact other people's life						
Authority: command others						
Equity: equal opportunities for all						
Peace: no war no conflicts						
Work for the others						
Prevent pollution						
Respect the Earth						
Protect the Environment						
Justice: fight injustices						

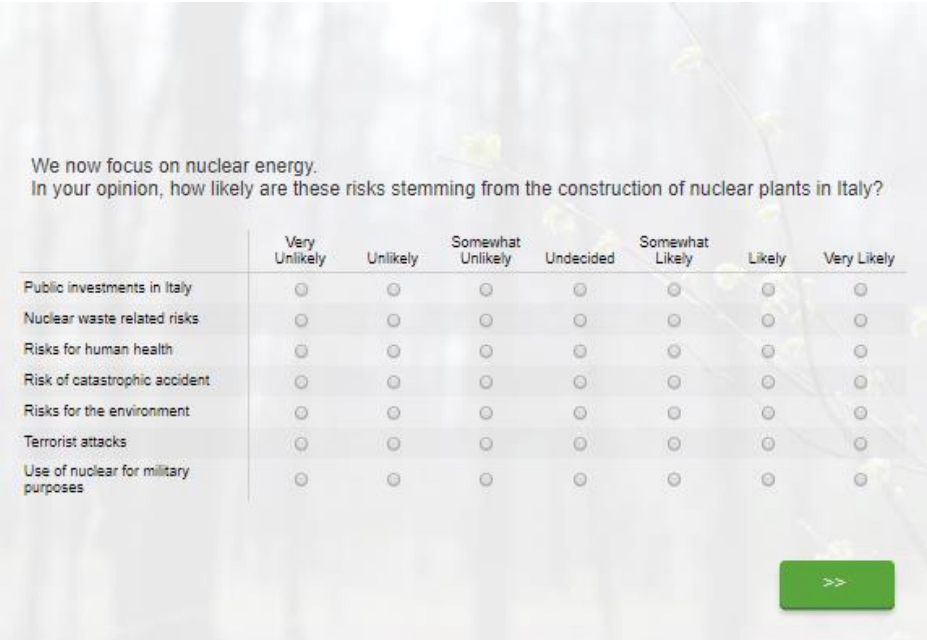
>>

Figure 2.4: Questions on Egoistic, Altruistic, Biospheric values, Italy case study

The first 4 items shown in Figure 2.4 were included to measure the construct Egoistic, whereas the next 4 items to measure the construct Altruistic, and the remaining 3 to measure the construct Biospheric. The order of the items in the list was randomized.

2.2.3.4 Perceived risks and benefits of nuclear energy

Perceived risks and benefits of nuclear energy were assessed across all the three case studies. Figures 2.5 and 2.6 show the corresponding screen shown as part of the Italy case study. These were finalized following literature review on the matter (as discussed in Section 2.1.3) as well as considering the feedback from cognitive interviews. A few differences between the three case studies need to be outlined: the UK survey did not include the item ‘Public investments’ as specific to Italy[9]. In the UAE case study, respondents answered the set of questions on risks and benefits twice: once whilst thinking about nuclear energy in general, and then considering nuclear energy in the UAE. 7 points scales were provided for both Italy and UK, whereas 5 points scales for the UAE. This reduction was chosen, again, to limit the amount of information to process, given the that respondents were asked to answer twice each set.



We now focus on nuclear energy.
In your opinion, how likely are these risks stemming from the construction of nuclear plants in Italy?

	Very Unlikely	Unlikely	Somewhat Unlikely	Undecided	Somewhat Likely	Likely	Very Likely
Public investments in Italy	○	○	○	○	○	○	○
Nuclear waste related risks	○	○	○	○	○	○	○
Risks for human health	○	○	○	○	○	○	○
Risk of catastrophic accident	○	○	○	○	○	○	○
Risks for the environment	○	○	○	○	○	○	○
Terrorist attacks	○	○	○	○	○	○	○
Use of nuclear for military purposes	○	○	○	○	○	○	○

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Figure 2.5: Questions on perceived risks of nuclear energy, Italy case study

[9] Historically, organized crime in Italy has been impacting public investments (see Pinotti 2015).

In your opinion, how likely are these benefits stemming from the construction of nuclear plants in Italy?

	Very Unlikely	Unlikely	Somewhat Unlikely	Undecided	Somewhat Likely	Likely	Very Likely
Energy's prices more affordable	○	○	○	○	○	○	○
Reduction of Fossil fuels' consumption	○	○	○	○	○	○	○
Economic Growth	○	○	○	○	○	○	○
Atmospheric emissions' reduction	○	○	○	○	○	○	○
Rise in employment	○	○	○	○	○	○	○
Energy imports' reduction	○	○	○	○	○	○	○

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Figure 2.6: Questions on perceived benefits of nuclear energy, Italy case study

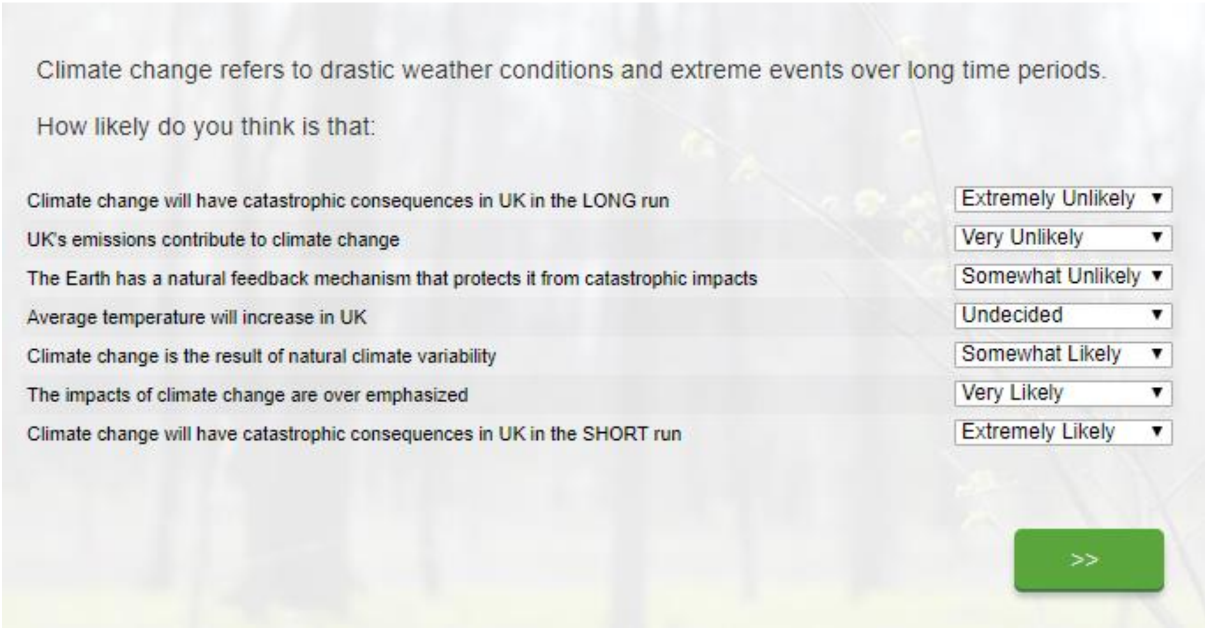
2.2.3.5 Questions on climate change

The questions on climate change are presented in Figure 2.7 (UAE case study) and 2.8 (UK case study). Whereas for the UAE and UK case study 7 items were included, the Italy case study only included the items: ‘Average temperatures will increase in Italy’, ‘Italy’s emissions contribute to climate change’ and ‘climate change will have catastrophic consequences in Italy’. The items were designed to give the respondent the opportunity to express their concern towards climate change in relation to the country considered; also, following Islam et al. (2013), items were added in the UK and UAE study to assess whether respondents believe climate change is caused by emission or rather it is the result of natural climate variability. 7 points scales were used for the Italy and UK study, whereas 5 points scale for the UAE. Across all of the three studies, the order of the items presented was randomized. In the UK and UAE case studies, it was also added an open-ended question asking respondents to describe their top of mind thought when hearing ‘climate change’.


Climate change refers to the gradual warming of the planet and higher chances of drastic wheather conditions and extreme events over long time periods. **How likely do you think is that..?**

	Very unlikely	Unlikely	Neutral	Likely	Very likely
Climate change will have catastrophic consequences in the UAE in the short term	○	○	○	○	○
Climate change will have catastrophic consequences in the UAE in the long run	○	○	○	○	○
UAE's emission contribute to climate change	○	○	○	○	○
Average temperature will increase in the UAE	○	○	○	○	○
The Earth has a natural feedback mechanism that protects it from catastrophic impacts	○	○	○	○	○
Climate change is the result of natural climate variability	○	○	○	○	○
The impacts of climate change are over emphasized	○	○	○	○	○

Figure 2.7: Questions climate change, UAE case study


Climate change refers to drastic weather conditions and extreme events over long time periods.

How likely do you think is that:

Climate change will have catastrophic consequences in UK in the LONG run	Extremely Unlikely ▼
UK's emissions contribute to climate change	Very Unlikely ▼
The Earth has a natural feedback mechanism that protects it from catastrophic impacts	Somewhat Unlikely ▼
Average temperature will increase in UK	Undecided ▼
Climate change is the result of natural climate variability	Somewhat Likely ▼
The impacts of climate change are over emphasized	Very Likely ▼
Climate change will have catastrophic consequences in UK in the SHORT run	Extremely Likely ▼

>>

Figure 2.8: Questions climate change, UK case study

2.2.3.6 Information treatment

In both the Italy and UK case studies, a random half of the respondents starting the survey were presented with: a) additional information on the Chernobyl and Fukushima's accidents[10] (Fig. 2.9); and b) information on where nuclear plants are in Europe (Fig. 2.10), together with symbols indicating reactors in operation (green), not in operation (red), under construction (yellow) and planned (blue)[11].

Figure 2.9: Information treatment part A

[10] The information presented on the two accidents was based on IAEA (2006), Steinhauser et al. (2014), and UNSCEAR (2013).

[11] Source: World Nuclear Association.

[redacted]

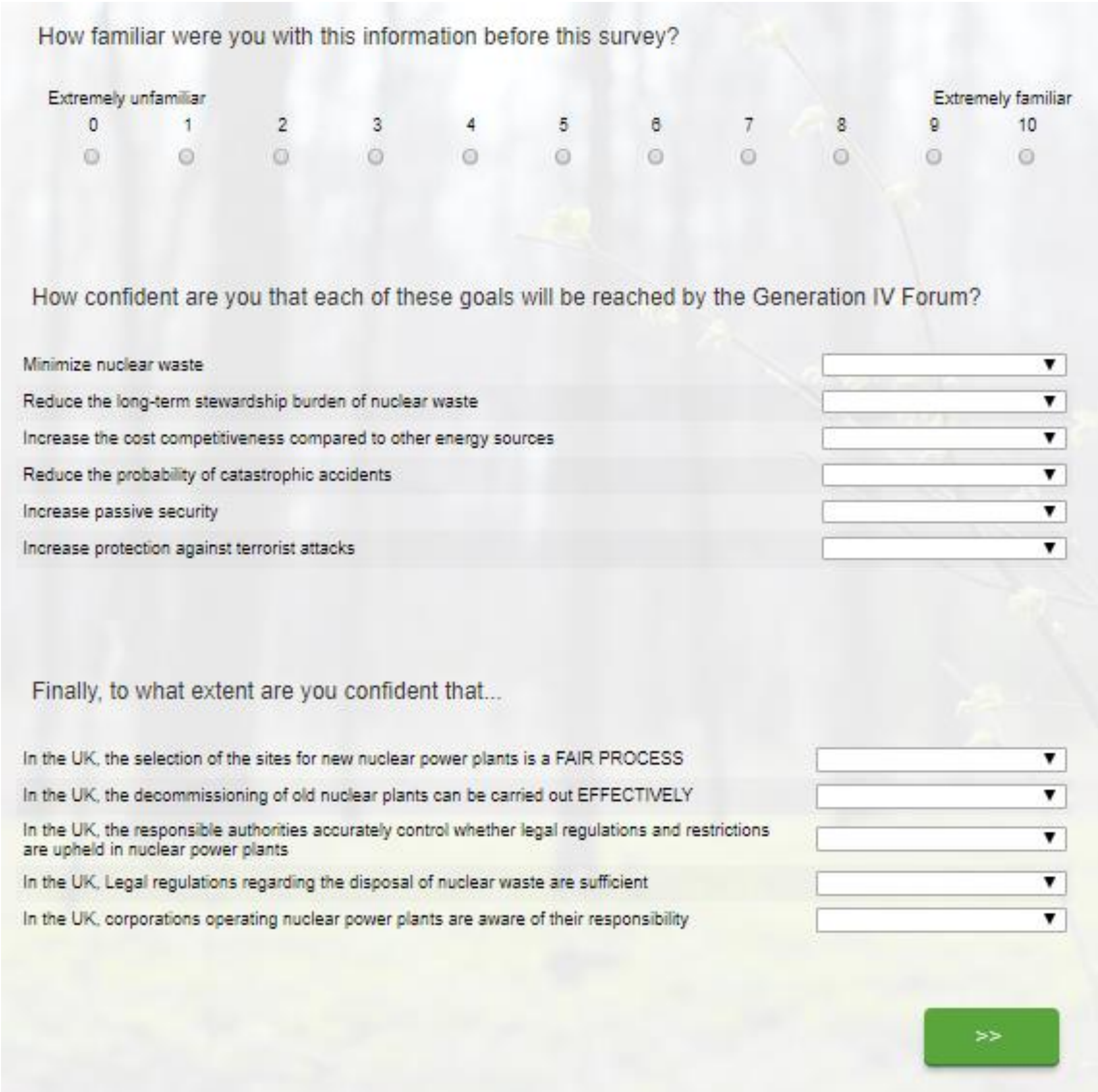
Figure 2.10: Information treatment part B

2.2.3.7 Information on IV generation nuclear energy

A major area of information in the UK and Italy case studies is represented by the introduction to the IV generation nuclear energy technology (Figure 2.11 and 2.12). The information presented was developed to provide a quick overview of the goals of this technology and to highlight that this is still under research and development; finally, it was mentioned there is a coordinated effort led by the IV generation international forum. Next, respondents were asked to state their confidence towards the achievement of such goals. This had a twofold purpose: first, to reinforce the goals of this technology; second, to gather data to measure the latent construct of confidence towards the realization of these goals. In the UK case study, it was also added a question on familiarity with the information presented. Also, since in the UK there are nuclear plants in operation, a set of questions to measure trust towards nuclear energy stakeholders was included, adapting from the questions used in Visschers et al. (2011).

[redacted]

Figure 2.11: Introduction to IV generation nuclear energy, UK & Italy case study


How familiar were you with this information before this survey?

Extremely unfamiliar ... Extremely familiar

0 1 2 3 4 5 6 7 8 9 10

How confident are you that each of these goals will be reached by the Generation IV Forum?

- Minimize nuclear waste
- Reduce the long-term stewardship burden of nuclear waste
- Increase the cost competitiveness compared to other energy sources
- Reduce the probability of catastrophic accidents
- Increase passive security
- Increase protection against terrorist attacks

Finally, to what extent are you confident that...

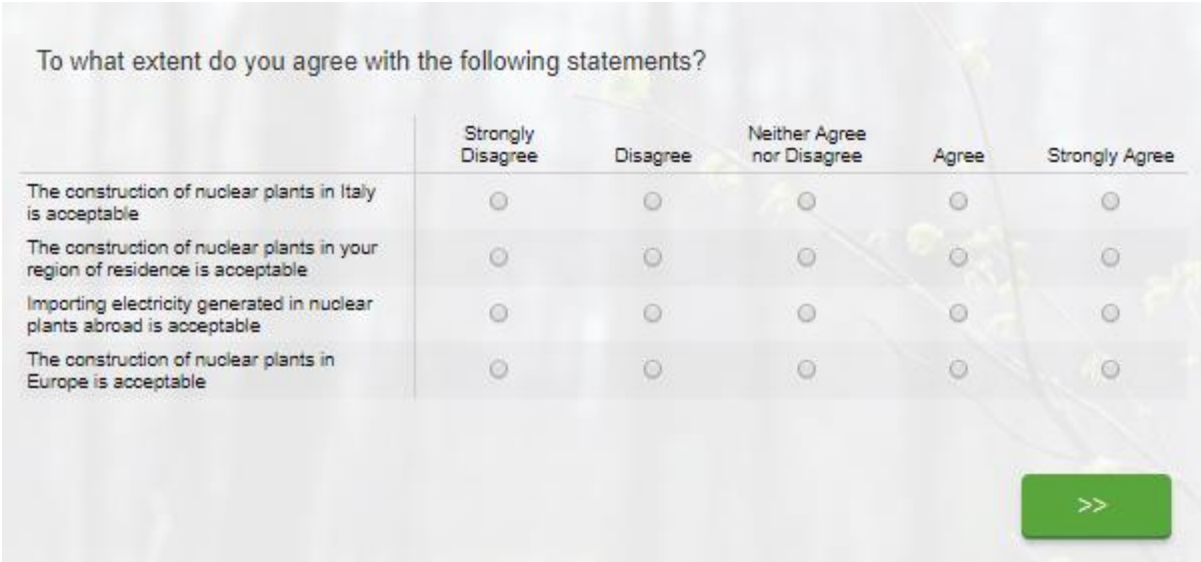
- In the UK, the selection of the sites for new nuclear power plants is a FAIR PROCESS
- In the UK, the decommissioning of old nuclear plants can be carried out EFFECTIVELY
- In the UK, the responsible authorities accurately control whether legal regulations and restrictions are upheld in nuclear power plants
- In the UK, Legal regulations regarding the disposal of nuclear waste are sufficient
- In the UK, corporations operating nuclear power plants are aware of their responsibility

>>

Figure 2.12: Confidence towards IV gen goals & trust towards nuclear energy stakeholders, UK case study

2.2.3.8 Acceptance of nuclear energy

As part of the Italy case study a set of questions on acceptance of nuclear energy were presented (Figure 2.13). Respondents were asked to express their agreement or disagreement (5 points scale) towards the construction of nuclear plants in their area of residence, Italy and Europe, as well as whether it was acceptable to import electricity generated abroad from nuclear plants. Data obtained from this question will be used to measure the construct ‘acceptance’ of nuclear energy.



To what extent do you agree with the following statements?

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
The construction of nuclear plants in Italy is acceptable					
The construction of nuclear plants in your region of residence is acceptable					
Importing electricity generated in nuclear plants abroad is acceptable					
The construction of nuclear plants in Europe is acceptable					

>>

Figure 2.13: Acceptance of nuclear energy, Italy case study

2.2.3.9 Introduction to choice experiments

In each case study, the choice experiment exercise was preceded by an explanation of what the respondent was expected to do, along with a remark that there is no right nor wrong choice, but that is rather a matter of individual preferences. Figure 2.14 presents the guidelines given for the UK study; analogous information was shared as part of the Italy and UAE studies, with the difference in the attributes presented. Choice tasks presented will be shown in Chapter 3 for the Italy case study, Chapter 4 for the UK case study, and Chapter 5 for the UAE case study,

[redacted]

Figure 2.14: Introduction to Choice Experiment, UK case study

2.2.4 Sampling and survey mode

Data collection has been conducted online for all of the case studies presented in this thesis. A number of reasons lead to the choice of the online survey administration mode. First, this is less expensive than face to face or telephone interviews and quicker to implement. In addition, online surveys do not suffer from interviewer bias and are less prone to social desirability bias (Tourangeau and Yan 2007). At the same time, they allow to answer sensitive or difficult questions privately. Researchers can also take advantage of this survey instrument to foster respondents' engagement with the survey. For instance, graphical representations can be used, as well as a tailored survey flow. This appears particularly important when dealing with the valuation of environmental goods, some of which respondents might have scarce understanding (Colombo et al. 2015).

Arguably, using different survey modes might impact results. However, this does not appear to be a major issue for stated preference surveys, as insignificant differences in monetary valuations were found when comparing online and offline surveys (Olsen 2009; Windle and Rolfe 2011; Lindhjem and Navrud 2011; Mozumder et al. 2011). Nevertheless, online surveys commonly face issues of sample representativeness and self-selection, as segments of the population are less likely to be active online; this, coupled with the absence of post-weight stratification weights, leads to requiring caution when inferring results to the broader popolation. Across the three case studies discussed in this thesis, respondents were surveyed from commercial panels, consisting of individuals who opt in to answer online surveys. Quotas were set across the three studies, with more challenges arising during the UK case study. In the Italy case study quotas were set for gender, age, area of residence. In this instance, the quotas achieved for the 1198 sampled respondents are fairly close to the population values. Samples shares by macro region are 44%, 22% and 34% for North, Centre, South respectively, against population shares of 46%, 20% and 34%; samples share for gender are 46% males against 49% for the population; finally, sample age average of 44 against population average of 48 years old (DemoIstat 2013). With regards to the UK case study, a quota on the share of residents in England versus rest of the UK was placed. Of the 887 sampled respondents, 68.5% of reside in England, 16% in Scotland, 11% in Wales and 4.5% in Northern Ireland, against population shares of 84% for England, 8.3% for Scotland, 4.8% for Wales and 2.9% for Northern Ireland (ONS 2014). Finally, for the UAE study, a quota on the share of nationalities was set to obtain 11.5% of UAE nationals[12]. Of the sampled 1961 respondents, we achieved 10% Emiratis.

2.3 Core econometric models

2.3.1 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, for each individual (*i)* and alternatives (*j)*, the utility function is expressed as:

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

where V_{ij} and ε_{ij} are the deterministic and stochastic components, respectively. In choice experiments, respondents take part in a sequence of T choices. In such context, the deterministic component is a function of the matrix of attributes **x** and the vector of coefficients **β**:

[12] https://www.government.ae/en/information-and-services/social-affairs/preserving-the-emirati-national-identity/population-and-demographic-mix

$$V_{it,j} = \mathrm{f}(\mathbf{x}'_{it,j}\boldsymbol{\beta}) \quad (2)$$

A linear specification would entail $V_{it,j} = \mathbf{x}'_{it,j}\boldsymbol{\beta}$. 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:

$$P_{ijt} = \frac{\exp(\mathbf{x}'_{it,j}\boldsymbol{\beta})}{\sum_j \exp(\mathbf{x}'_{it,j}\boldsymbol{\beta})} \quad (3)$$

This model was estimated using the command CLOGIT in STATA. The MNL presents a number of limitations. It assumes independence of irrelevant alternatives (IIA), whereas there might be correlation between groups of similar alternatives. In the context of this work, respondents might choose the 'none' option without seriously considering the scenario attributes, but rather just because the scenarios refer to nuclear energy options. This is an example of how protest behavior might influence results in choice experiments (Adamowicz et al. 1998; Meyerhoff and Liebe 2008). Respondents might also choose none of the projects for reasons including 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 (Haaijer et al. 2001). An alternative modeling strategy is represented by a Nested Logit (NL) (Ben-Akiva and Lerman 1985, Hensher et a. 2005), which allows the relaxation of the IIA assumption, although homogeneity in preferences is still in place.

Preference heterogeneity can modeled according to the Random Parameters Logit (RPL), or Mixed Logit model (Hensher and Greene 2003; Revelt and Train 1998). The key assumption of this model is that its parameters follow a continuous distribution across individuals. Specifically, we pass from one coefficient $\boldsymbol{\beta}$ per attribute, or level of this, to estimating individual specific effects $\boldsymbol{\beta}_i$, with the choice probabilities as follows:

$$P_{ijt} = \frac{\exp(\mathbf{x}'_{it,j}\boldsymbol{\beta}_i)}{\sum_j \exp(\mathbf{x}'_{it,j}\boldsymbol{\beta}_i)} \quad (4)$$

Formally, for each of the K parameters assumed to be continuously distributed, the vector of individual coefficients equals:

$$\boldsymbol{\beta}_\mathbf{i} = \boldsymbol{\beta} + \Delta\mathbf{z}_\mathbf{i} + \boldsymbol{\Gamma}\mathbf{m}_\mathbf{i} \quad (5)$$

where $\mathbf{z}_\mathbf{i}$ is a vector of individual characteristics affecting the mean of $\boldsymbol{\beta}_\mathbf{i}$, and Δ indicates the matrix of parameters to be estimated. The random effect $\mathbf{m}_\mathbf{i}$ has the following expected value and variance:

$$\boldsymbol{E}[\mathbf{m}_\mathbf{i}]=0,\ \mathbf{Var}[\mathbf{m}_\mathbf{i}]=\underline{\Sigma}=\mathbf{diag}[\boldsymbol{\sigma}_\mathbf{1}, \dots, \boldsymbol{\sigma}_\boldsymbol{k}] \quad (6)$$

The analyst has to specify the distribution of the random parameters. Furthermore, $\boldsymbol{\Gamma}$ represents the lower triangular matrix containing the variances and covariances of the joint distribution of $\boldsymbol{\beta}_\mathbf{i}$, to be estimated. Giving that respondents are engaged in a sequence of choices, the conditional distribution is given by:

$$P_i|\mathbf{m}_i = \prod_{t=1}^{T} P_{it}|\mathbf{m}_i \quad (7)$$

In turn, the unconditional probability, obtained by integrating $\mathrm{m_i}$ out of the joint probability is as follows:

$$P_i = \int_{\mathbf{m}i} P_i|\mathbf{m}_{\boldsymbol{i}}\, h(\mathbf{m}_i)\mathrm{d}\mathbf{m}_i \quad (8)$$

where $h(\mathbf{m}_i)$ stands for the density of $\mathbf{m}_i$. As normally this integral does not have a close form solution, estimation requires maximizing a simulated log likelihood approach (McFadden and Train 2000):

$$\mathrm{ln}L_s = \sum_{\mathrm{i}=1}^{N} \ln\left[\frac{1}{R}\mathrm{lnP_i}|\mathbf{m}_{\mathrm{ir}}\right] \quad (9)$$

with $\mathbf{m}_{\mathrm{ir}}$ being a simulated draw from the distribution hypothesized, out of the total R draws. The simulation process allows to produce an average over a high number of draws, de facto replacing the continuous integral by summation. Finally, in order to include correlation effects between the alternatives, additional error components can be specified (Herriges and Phaneuf 2002) to tackle the presence of status-quo/opting out effects. This model was estimated in Limdep Nlogit; estimates cross-checks were also conducted in STATA with the command mixlogit.

Preference heterogeneity can be also modeled in a latent class framework (Boxall and Adamowicz 2002, Greene and Hensher 2003). In this context, heterogeneity is modeled in a discrete, rather than a continuous fashion. The utility's parameters are the same within and different between the 's' classes or segments:

$$U_{ij|s} = V_{ij|s} + \varepsilon_{ij|s} \qquad (10)$$

The key behavioral model is once again a logit model for discrete choice, but with coefficients $\boldsymbol{\beta}_\mathbf{s}$ being segment specific:

$$P_{it,j|s} = \frac{\exp(\mathbf{x}'_{it,j}\boldsymbol{\beta}_s)}{\sum_j \exp(\mathbf{x}'_{it,j}\boldsymbol{\beta}_s)} \qquad (11)$$

We specify the probability of a specific choice being made by the respondent i as $P_{it|s}(j)$. Assuming the T choices are independent given the class allocation, the joint probability of the set of choices is given by:

$$P_{i|s} = \prod_t^T P_{it|s} \qquad (12)$$

With regards to the class assignment, whose outcome needs to be between 0 and 1, a common formulation employed is the multinomial logit:

$$\mathrm{H}_{\mathrm{is}} = \frac{\exp(\mathbf{z}'_i\boldsymbol{\theta}_s)}{\sum_s \exp(\mathbf{z}'_i\boldsymbol{\theta}_s)} \qquad (13)$$

where $\mathbf{z}_\mathbf{i}$ represents a set of individual characteristics that might affect class allocation. In order for the model to be identified, the parameters of one of the segments have to be normalized to zero. Furthermore, the unconditional choice probability for each individual is given by:

$$P_i = \sum_s^S H_{is} P_{i|s} \tag{14}$$

Finally, the log likelihood for the whole sample, to be maximised with respect to $\boldsymbol{\beta_s}$ and $\boldsymbol{\theta_s}$, is as follows:

$$\ln L = \sum_i^N \ln P_i = \sum_i^N \ln \left[\sum_s^S H_{is} \left(\prod_t^T P_{it|s}\right)\right] \tag{15}$$

The analyst has to specify the number of classes to be estimated. Next, given the goodness of fit, significance of parameters and overall analyst's judgement, the choice of the final model can be made. The latent class models were estimated in Limdep Nlogit. Once the parameters have been estimated, it is also possible to compute individual segment probabilities and the individual coefficients by employing the following formula:

$$\widehat{\mathrm{H}}_{s|\mathrm{i}} = \frac{\widehat{P}_{i|\mathrm{s}} \widehat{H}_{is}}{\sum_s \widehat{P}_{i|\mathrm{s}} \widehat{H}_{is}} \tag{16}$$

$$\widehat{\boldsymbol{\beta}}_i = \sum_s \widehat{\mathrm{H}}_{s|\mathrm{i}} \widehat{\boldsymbol{\beta}}_{\mathrm{s}} \tag{17}$$

This is an example of posterior analysis that allows to unveil further insights other than the variation of a given coefficient across respondents (Hess 2014).

The latent class model, as described above, is a model of pure preference heterogeneity. Namely, utility functions present the same specification across different segments. In addition, different utility functions can be set for each segment, allowing to introduce different explanatory variables or even different decision rules. This topic will be explored further in Chapter 6.

Irrespective of the model estimated, with a linear in parameters utility function, the coefficients estimated directly represent marginal utilities, and their ratio indicates a marginal rate of substitution. When the denominator is the coefficient attached to the monetary attribute, the resulting ratio represents a monetary valuation (MV). Given K attributes and a monetary attribute m, in the context of the MNL model the monetary valuation will be unique for each attribute or level of the same:

$$MV_k = |\frac{\beta_k}{\beta_m}| \quad (18)$$

Instead, in the context of a latent class model, this will be conditional on a given segment:

$$MV_{k|s} = |\frac{\beta_{k|s}}{\beta_{m|s}}| \quad (19)$$

Finally, if a RPL/mixed logit model is estimated, the resulting monetary valuations will follow a distribution, if defined, resulting from the ratio of the parameters' distributions. For instance, if the numerator is given by random parameter assumed to be normally distributed, whilst the monetary attributed is kept fixed, the resulting ratio is normally distributed. However, if the denominator is assumed to follow a continuous distribution, this might lead to the moments of the resulting ratio which might not exist. A strategy to deal with this issue is to directly estimate the monetary valuations, i.e.: the ratio of coefficients. This approach has been labelled as estimation in willingness to pay space, as opposed to the standard preference space (Train and Weeks 2005). Mixed logit models in WTP space were estimated in R[13].

2.3.2 Experimental design for choice experiments[14]

When preparing a choice experiments great care is needed to define the set of combinations that will be presented to the respondents. The full factorial design, namely the full set of

[13] Details on code available upon contacting the author. These were adaptations of the codes presented during the Choice Modelling and Survey Design and Advanced choice modelling, run by the Choice Modeling Center, Univesity of Leeds, with S. Hess and T. Dekker (2015-2016).
[14] Based on Ngene User Manual (2018), Ferrini and Scarpa (2007).

combinations for given the number of attributes, attributes levels and alternatives, is usually too large to be administered to the sampled respondents. Hence, a subset of such design needs to be extracted. Different criteria have been suggested in the literature to select the choice situations. The orthogonal design has been a popular fractional design used in the literature. The underpinning criteria is the minimization of the correlation between the attribute levels in the choice tasks for estimation purposes. This approach has been derived with linear models in mind; yet, in choice experiments, models are non-linear.

Another approach is represented by the so called efficient design, which aims at generating parameter estimates with the smallest standard errors. The standard errors are predicted from the AVC matrix[15], which is a function of the unknown parameter estimates, the attributes' levels in the alternatives, and the econometric model chosen as a different log-likelihood would be derived. For this reason, values to be set as priors are needed to prepare an efficient design. These priors can be either fixed values or assumed to be random following a probability distribution to take into account uncertainty around the prior. The latter is the Bayesian approach. To select the most efficient design, given the set of priors and assumption around them, different values of the AVC matrix are computed based on set of combinations considered in a given iteration. In order to select the best out of the set, a criterion that can be followed is the minimization of the determinant if the AVC matrix, measure defined as D-error.

Given the absence of prior, we chose to start the first study (Italy) with an orthogonal design for the first 25% of the sample. With the observed choices, and priors obtained from a mixed logit model, a Bayesian efficient design was generated and administered to the remaining 75% of the respondents. In turn, the parameters obtain from a Mixed logit model

[15] The AVC matrix is given by the negative inverse of the Fisher information matrix. This, in turn, is equal to the second derivatives of the log-likelihood function.

applied to the whole sample were then used to derive priors for the UK case study, again following a Bayesian efficient design approach. Finally, from the combined choices obtained from the Italy and UK studies, priors were generated for the UAE case study. Given this approach, uncertainty around the parameter estimates were greater for the UAE case study, for which greater standard deviations were imposed (an increment of 5% across the parameters was set for this purpose[16]). The Italy and UK case studies contain the same number and set of attributes (6 attributes), as well as attributes' levels. For the Italy case studies, a design with 8 choice tasks per respondents was set for both the studies, out of total 64 choice tasks generated for each. In the UK case study, 8 choice tasks per respondents were presented as well, but out of a total set of 40 choice tasks. Instead, the UAE case study contains a total of 4 attributes; 4 choice tasks that were set for each respondent, out of a set of 32 choice tasks generated[17]. For each case study, blocks of choices were randomly generated, and then allocation of blocks was randomized within the survey flow. Across the designs for the three case studies, parameters were assumed to be normally distributed, but the cost kept positive log-normal, and 2000 Halton draws were specified to evaluate the designs over the parameters' distribution[18]. The software NGENE was used for the creation of designs, with iterations kept on running for a minimum of 24 hours to allow for even marginal improvements in the lowest D-Error search.

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[16] The reader should not consider a 5% as a rule to apply; rather, this is left to the judgement of the researcher for the given study at hand and further research on this aspect. Also, it should be noticed that a preferable approach, in the absence of budget constraint, would be to run an extensive pilot for each case study and derive priors from each of them.

[17] 3 out of 4 attributes are present in the UAE study are also in the UK and Italy studies. However, one attribute is specific to the UAE study (Construction of parks and related recreation spaces). The prior for this attribute was derived from the average of the parameters linked to the two 'public investments' attributes that were included in the Italy and UK studies, namely 'land recovery measures' and 'construction of hospitals'.

[18] Non-Bayesian designs were first tested, without setting any distribution, to assess presence of extreme choice probabilities and other issues before adding complexity to the design.

2.3.3 Econometric models for psychometric data[19]

In environmental psychology a common goal is that of evaluating variables of interest which are not directly measurable. Throughout the thesis, we will refer to such variables with the terms 'constructs' or 'latent factors'. An example of such constructs are the egoistic, altruistic and biospheric values in Chapter 3. These latent factors are measured by means of questionnaire items, which then form the inputs of factor analyses. Formally, given a set of k items relatable to a set of constructs, factor analysis involves estimating the following equation for each item i:

$$v_i = \sum_j \lambda_{ij} \xi_j + \delta_i \quad (20)$$

where v_i represents the item, λ_{ij} the factor loadings, ξ_j the latent construct, and δ_i are the specific factors. The model implies the following variances:

$$\mathrm{Var}(v_i) = (\sum_j {\lambda_{ij}}^2) + \theta_{ii} \quad (21)$$

The loadings λ_i can be interpreted as the covariance between each v_i and the latent factor ξ_j. 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. Given the factor loading obtained, it is possible to compute individual scores:

$$\hat{v}_i = \sum_i (\lambda_{ij} / \theta_{ii}) v_i \quad (22)$$

[19] Based on Bartholomew et al. (2008).

Once the constructs are validated, we can estimate relationships between the constructs by means of a structural equation model. This is characterized by a set of measurement and structural equations. The measurement equations are defined as follows:

$$x_{i}=\tau_i^{(x)} + \lambda_{ij}^{(x)}\xi_j + \delta_i \tag{23}$$

$$y_{i}=\tau_i^{(y)} + \lambda_{ij}^{(y)}\eta_j + \epsilon_i \tag{24}$$

where ξ_j identifies exogenous constructs, and η_j endogenous constructs. Moreover, $\tau_i^{(x)}$ and $\tau_i^{(y)}$ symbolize constants whereas $\lambda_{ij}^{(x)}, \lambda_{ij}^{(y)}$ represent the loadings. δ_i and ϵ_i are error terms.

With regards to the structural equation, this entails estimating, for each endogenous latent factor, the following equation:

$$\eta_j = \beta_{ij}\xi_j + \gamma_{ij}\eta_j + \zeta_i \tag{25}$$

where β_{ij} and γ_{ij} are the parameters associated with the exogenous and endogenous latent factors, respectively; ζ_i are random disturbances. Factor analysis and structural equation modeling were conducted in STATA (version 13).

2.3.4 Notes on models' estimation

Across discrete choice models and structural equation models (and the software utilized, namely Limdep Nlogit, STATA, R), parameters' estimation requires the maximization of non-linear log likelihood functions. Different starting values were specified[20] to check for presence of local maxima, as the log-likelihood optimization is conducted by searches for

[20] For instance, for the mixed logit models, MNL model were the initial starting values, with variations from it produced with the inclusion of random disturbances, along with tests with randomly generated starting values. Similarly, for the Latent class models, variations from MNL estimates were produced, along with randomly generated starting values.

improvements iteratively, including a different set of parameters at each iteration; if the starting values are far from the global maximum and the improvement criteria is not stringent enough, iteration could stop at a local maxima[21].

Another important point pertains to the simulation draws when estimating mixed logit models, needed as the log-likelihood cannot be computed analytically. Following initial estimations with low number of draws to inspect the coefficients that were being obtained, a minimum number of at least 500 Halton draws was set for final model estimations. Also, stability checks were performed by inspecting results for different numbers of draws set.

Structural equation models were estimated post confirmatory factory analyses, which were run to confirm the measurement of the expected set of constructs. To ensure identification of latent scales, all means and intercepts in the structural models were fixed at 0. Also, one measurement loading per construct was set to 1. Non-fixed covariances between latent constructs were tested, and were kept in the Italy case study between the constructs 'Egoistic' and 'Confidence', as well as between the constructs 'Altruistic' and 'Bioshperic', as they resulted to be significant.

[21] The MNL model does not face this issue, having a single maximum.

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Chapter 3

Modeling individual preferences for energy sources: The case of IV generation nuclear energy in Italy[22]

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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.

3.1 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; Eiser et al. 1990; 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[23].

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). 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).

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

This work focuses on social acceptability and preferences for IV nuclear energy technology. This technology, currently under research and development, aims at minimizing the risks arising from nuclear energy. Italy has taken part in research efforts to develop a Lead-Cooled Fast Reactor, within the ELSY (European Lead System) research framework (Bortot et al. 2010; Bandini et al. 2011). This is one of the prototypes being developed with efforts coordinated by the Generation IV International Forum. 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, a structural equation modeling framework is implemented to further illustrate 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 work is structured as follows. The next section describes the data collection methods (i.e. choice experiments) as well as the data analysis methods used. Results are presented and discussed in Section 3. Section 4 contains the results of heterogeneity and sensitivity tests whereas conclusions are presented in Section 5.

3.2 Survey design

3.2.1 Choice experiments: Experimental design

Table 3.1 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 3.1 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, as the pre-test suggested that respondents were not responsive to these additional pieces of information.

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, we would expect a project including a nuclear plant further away to 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).

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[24].

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 3.1,

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

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.

[redacted]

Figure 3.1: Example of a choice task

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. 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. 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 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[25]. 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 3.1.

3.2.2 Questionnaire design and information provision

Beside the choice experiment, the questionnaire 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. The psychometric scales employed to measure egoistic, altruistic and biospheric values, as well as perceived risks and benefits, confidence and place attachment, are presented below in the tables 3.2, 3.3, 3.4 and 3.5. Also, as discussed in Chapter 2, a random sample of respondents were treated with information on Chernobyl and Fukushima as well as a map displaying nuclear plants in Europe. This was carried out before the choice experiment exercise in order to gather data to test preference sensitivity to information.

[25] Overlapping levels (equal between alternatives) were allowed, whereas no dominated alternatives were allowed. Full experimental design is available in Appendix, Table 3.A3.

Table 3.2. 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 3.3. 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 3.4. Confidence items

How confident are you that fourth generation technology goals will be achieved?								
		Very unconfident	Not confident	Somewhat unconfident	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 3.5. Perceived risks and benefits items

How likely are these risks/benefits stemming from the building 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							

3.2.3 Data collection

The questionnaire was programmed in Qualtrics and implemented online, during March and June 2014. In total, it was administered to a sample of 1,198 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. In particular, 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.

3.3 Statistical and econometric models

The choice experiment data was analyzed employing a multinomial logit model (MNL), a random parameters model with error components (RPL) and a latent class model. An overview of these models is available in Chapter 2. We detail here the implementation of the structural equation model employed to model psychometric data and, in addition, describe the bivariate probit model used in further analyses.

3.3.1 Analysis of psychometric variables[26]

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[27].

Before running the model, seven independent factor analysis were carried out in order to confirm the validity of each construct. For example, for the Egoistic latent factor we have a set of four regressions, as we used four statements to measure this construct (Table 2). The items of each construct, along with the scales according to which they were measured, ware presented in Tables 3.2, 3.3, 3.4, 3.5.

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

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:

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

$$x_{i=}\tau_i^{(x)} + \lambda_{i2}^{(x)}\text{Altruistic} + \delta_i, i = 1, \dots 4 \quad (2)$$

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

$$x_{i=}\tau_i^{(x)} + \lambda_{i4}^{(x)}\text{Confidence} + \delta_i, i = 1, \dots 5 \quad (4)$$

$$y_{i=}\tau_i^{(y)} + \lambda_{i1}^{(y)}\text{Benefits} + \epsilon_i, i = 1, \dots 6 \quad (5)$$

$$y_{i=}\tau_i^{(y)} + \lambda_{i2}^{(y)}\text{Risks} + \epsilon_i, i = 1, \dots 7 \quad (6)$$

$$y_{i=}\tau_i^{(y)} + \lambda_{i3}^{(y)}\text{Acceptance} + \epsilon_i, i = 1, \dots 4 \quad (7)$$

The structural equations are defined as follows:

$$\text{Acceptance} = \beta_{11}\text{Benefits} + \beta_{12}\text{Risks} + \beta_{13}\text{Confidence} + \zeta_1 \quad (8)$$

$$\text{Benefits} = \gamma_{11}\text{Egoistic} + \gamma_{12}\text{Altruistic} + \gamma_{13}\text{Biospheric} + \zeta_2 \quad (9)$$

$$\text{Risks} = \gamma_{21}\text{Egoistic} + \gamma_{22}\text{Altruistic} + \gamma_{23}\text{Biospheric} + \zeta_3 \quad (10)$$

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 (1)-(4) are the indicators of the exogenous constructs, whereas y_i in equations (5)-(7) represent the indicators of the endogenous latent variables. Moreover, $\tau_i^{(x)}$ and $\tau_i^{(y)}$ symbolize constants whereas $\lambda_{i1}^{(x)}, \lambda_{i1}^{(y)}$ 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.

3.3.2 Bivariate probit model

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[28]. The model is formally characterized as follows (Sajaia 2008). Given two latent variables, y_{1i}^* and y_{2i}^* , function of the matrices of explanatory variables X_{1i}' and X_{2i}' respectively:

$$\begin{cases} y_{1i}^* = X_{1i}'\beta_1 + \varepsilon_1 \\ y_{2i}^* = X_{2i}'\beta_2 + \varepsilon_2 \end{cases} \tag{11}$$

where 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:

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

[28] 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.

$$y_{2i} = \begin{cases} 0 \; if \; y_{2i}^* \leq c_{21} \\ 1 \; \; if \; y_{1i}^* > c_{21} \end{cases} \quad (13)$$

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:

$$\Pr(y_{1i} = j, y_{2i} = k) = \Phi_2(c_{1j} - X'_{1i}\beta_1,\ c_{2k} - X'_{2i}\beta_2),\ \rho) - \Phi_2(c_{1j-1} - X'_{1i}\beta_1,\ c_{2k} - X'_{2i}\beta_2), \rho) - \Phi_2(c_{1j} - X'_{1i}\beta_1, c_{2k-1} - X'_{2i}\beta_2), \rho) + \Phi_2(c_{1j-1} - X'_{1i}\beta_1, c_{2k-1} - X'_{2i}\beta_2), \rho) \quad (14)$$

Φ_2 represents the bivariate standard normal cumulative distribution function. 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. The model was estimated in STATA, with the command biprobit.

3.4 Descriptive statistics

3.4.1 Sample characteristics

Descriptive statistics for key socio-economic variables are presented in Table 3.6. 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 2004).

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 3.6. Socio-demographic characteristics

		OVERALL			INFO Treatment			No INFO Treatment		
Variable	*Statistic*	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.

3.4.2 Attitudes towards energy sources

Figure 3.2 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 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 3.3, 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.

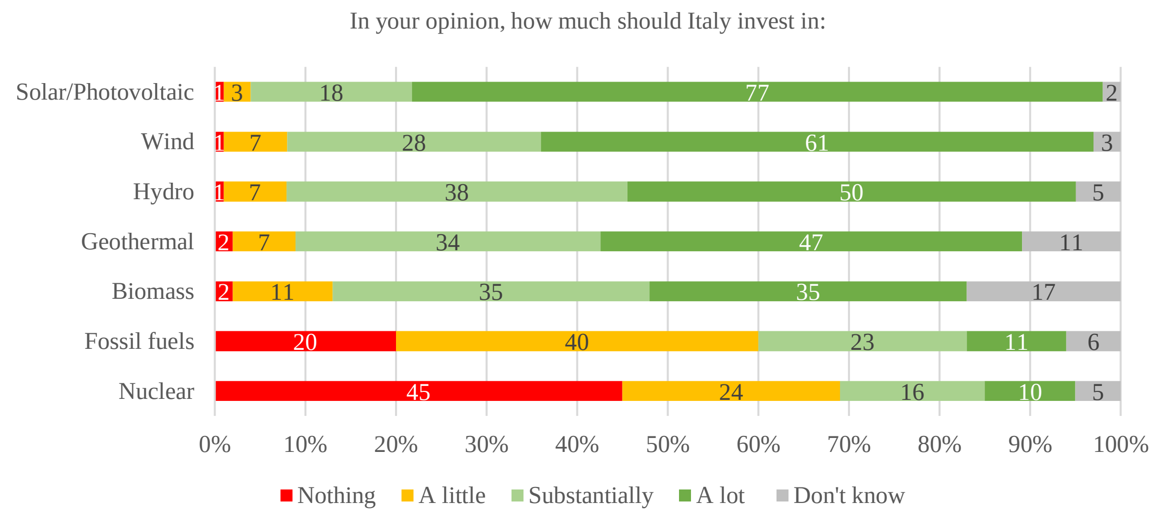

Figure 3.2: Views towards different energy sources

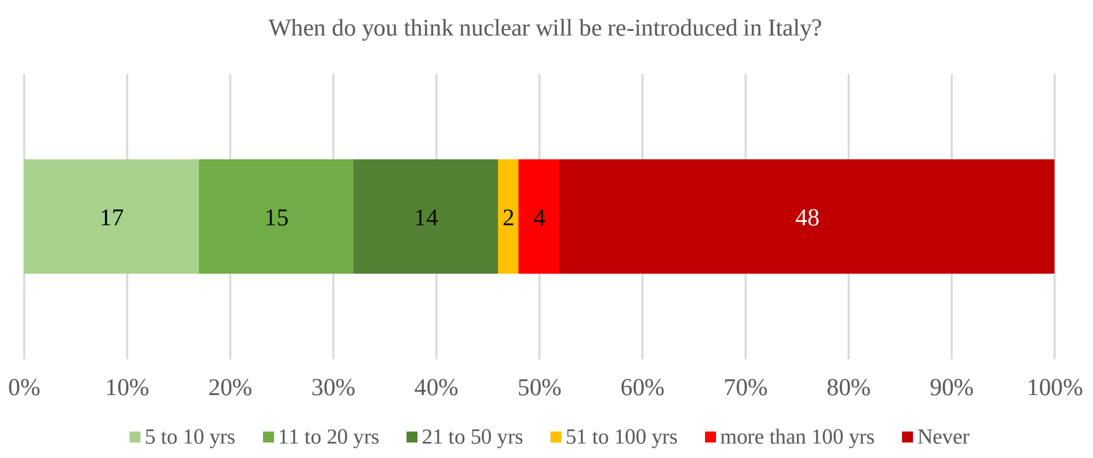

Figure 3.3: Views towards nuclear energy re-introduction in Italy

When it comes to views towards climate change (Fig. 3.4), more than 8 in 10 respondents seem to be agree that averages temperature would increase in Italy, that Italy's emission contribute to climate change. Also, 76% believe it is likely that climate change would have catastrophic impacts in Italy. Considering the respondents (132) who are undecided or believe all of the aforementioned points are unlikely, support towards nuclear energy seems higher: only 24% would not want Italy to invest anything in it, whereas 15% would want substantial investments. Instead, looking at the respondents (940) who believe all of the three possibilities are likely, almost 50% would not want any investment in nuclear. It does not seem that more concern towards climate change can be associated to greater support towards nuclear, among this sample of Italian respondents. With regards to 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.

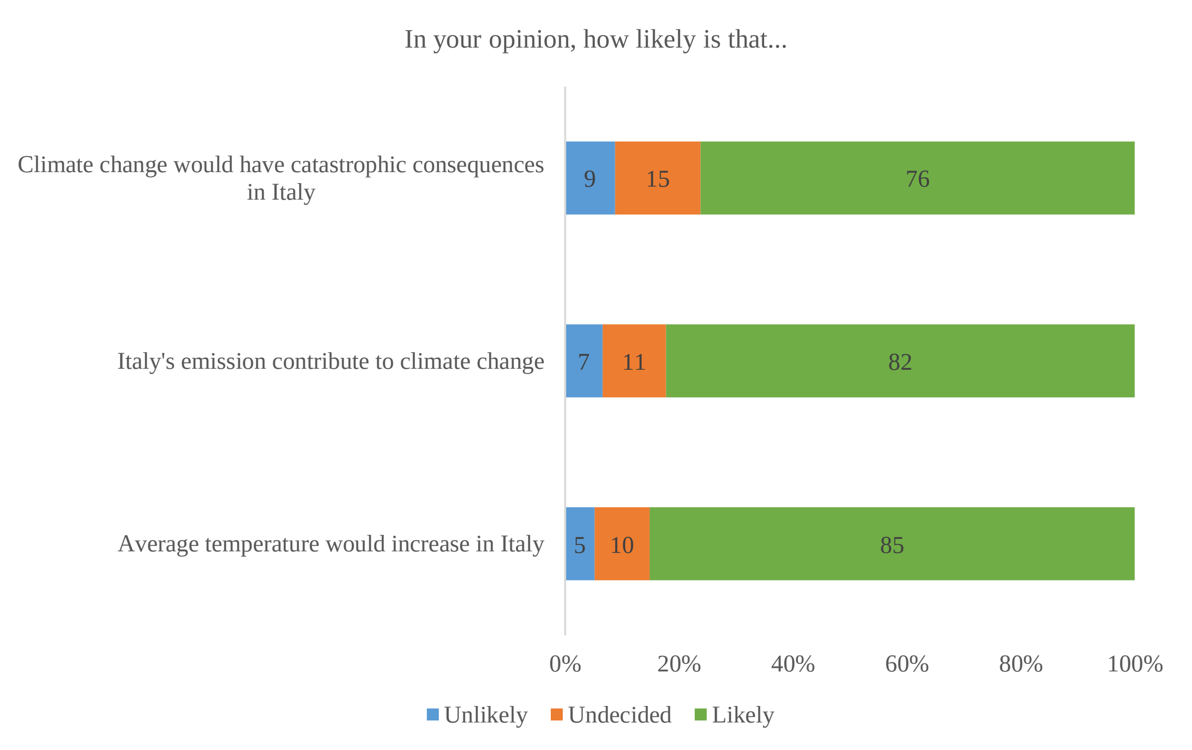

Figure 3.4: Views towards climate change

Table 3.7. Answers to the risks, benefits and confidence's statments (%)

Risks	*In your opinion, how likely are the following risks?*				
	Very/Extremely unlikely	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?*				
	Very/Extremely unlikely	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

Importance of goals of nuclear industry	*In your opinion, how important are the following goals of the 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

Confidence	*How confident are you that these goals will be reached?*				
	Not at all	*A little*	*Somewhat*	*Very*	*Extremely*
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

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 Table 3.7.

3.4.3 Views on fourth generation nuclear energy

Next, we investigate the level of confidence in fourth generation nuclear energy technology. 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 accomplishment 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 the next sections.

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 3.8 shows the corresponding findings. 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.

With regards to the construct Risk, 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 'building of nuclear plants in Italy is acceptable'. The structural equation model is presented in Figure 3.5. 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 3.9. 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.

Table 3.8. Factor loadings and uniqueness-Factor analysis

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

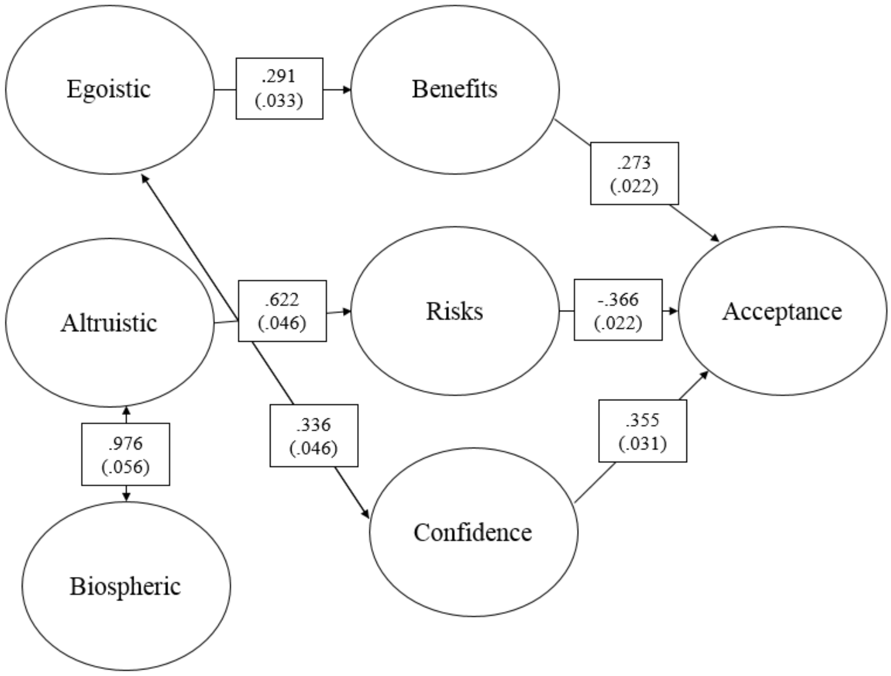

Figure 3.5: Structural equation model: Path diagram

In addition, estimated residuals are fairly low[29]. 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

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

egoistic. The measurement equations present all the coefficients statistically significant, consistent with the factor analysis shown in Table 3.8.

Table 3.9. Structural 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

Table 3.9. (continued) Structural measurement equations: coefficients

	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	2.4	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	0.9	0.024	/	/
$\tau_i^{(y)}$	5.7	0.04	4.6	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	/	/

3.5 Choice experiments results

3.5.1 MNL and RPL models

As a first step, respondents' choices were inspected to check for the presence of anomalies; the retained observations amount to 9107. The number of opt outs by respondent is presented in Figure 3.6. 23% always chose none of the options and the same share selected 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[30]:

$$V_{ij} = \beta_1 ASC + \beta_2 Distance_{200Km} + \beta_3 Distance_{100Km} + \beta_4 Distance_{50Km} + \beta_5 Waste_{30\%} + \beta_6 Waste_{20\%} + \beta_7 Waste_{10\%} + \beta_8 Emission + \beta_9 Hospitals + \beta_{10} Land + \beta_{11} Bill \quad (15)$$

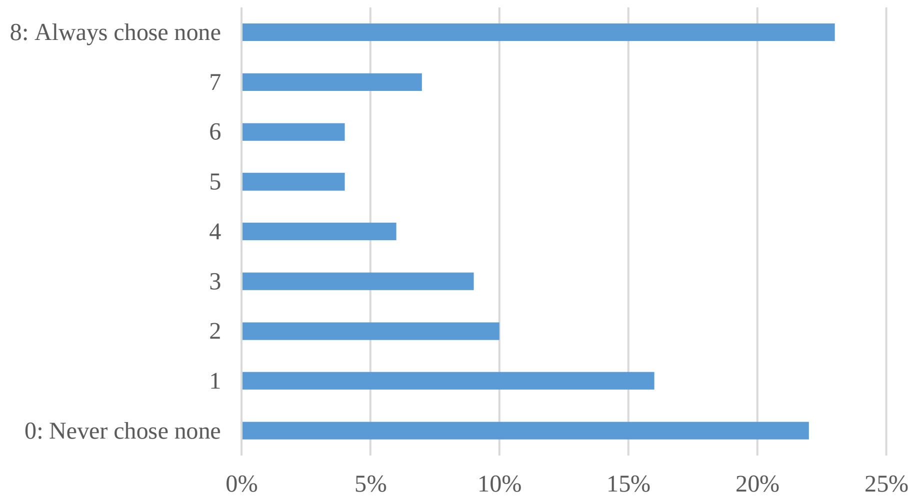

Figure 3.6: Frequency of ‘none’ option chosen

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.

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30 The code of the variables is presented in Appendix, Table 3.A1. Non-linearities were not found in correspondence of different distance and waste reduction levels.

Table 3.10. MNL and RPL models. Dependent variable: Choice

	MNL	RPL	RPL	MNL	RPL
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	-9188.82	-6882.1			
R squared	0.08	0.31			
Observations	9107	9107			

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

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'. 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). All the random parameters were set to be randomly distributed but the monetary attribute, assumed to be fixed (following Revelt and Train 1998). Table 3.10 shows the estimated coefficients and monetary valuations.

Starting with the analysis of the coefficients, RPL and MNL portrait an analogous picture (Table 3.10). 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 crucially representing FG technology in this experiment, 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 building 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 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 €).

The assumption of a fixed parameter associated to the monetary variable might be too stringent. Hence, a RPL model that allows for this parameter to follow a continuous distribution was estimated (Table 3.11). While all parameters' distribution associated with non-monetary attributes are still set to follow a normal distribution, in this additional model the distribution of the coefficient linked to the monetary attribute is assumed to be log-normal. This model is estimated in willingness to pay space, where the ratio of parameters are the output of the estimation rather than being derived post estimation.

Table 3.11. RPL model (WTP space). Dependent variable: Choice

Variable	Monetary Valuations (€)	T ratios	S.D.	T ratios
ASC	817.9	9.7	946.8	12.2
Distance: 200 Km	256.3	8.6	206.2	4.5
Distance: 100 Km	208.02	7.5	180.9	3.4
Distance: 50 Km	132.4	6.2	74.9	1.5
Waste Reduction: 30%	252.3	9.6	34.1	0.6
Waste Reduction: 20%	224.3	9.5	77.1	1.6
Waste Reduction: 10%	123.5	6.2	3.24	.05
Emission Reduction	103.4	9.4	103.4	.04
Hospitals	150.4	8.4	67.5	1.3
Land Recovery	201.4	9.6	51.4	1.1
Log-Likelihood	-6927.517			
R squared	0.31			
Observations	9107			

Distribution of the monetary attribute assumed to be (positive) log-normally distributed. S.D.: standard deviation. T ratio associated to the standard deviation of the monetary coefficient is 3.8

Compared to the RPL shown in Table 10, monetary valuations appear more conservative with respect to distance, waste and emission reductions, as well as land recovery measures. The compensations associated with distance levels are equal to 256 € for 200 Km, 208 € for 100 Km and 132 € for 50 km. Similarly, the valuations of 'waste reduction' are reduced, ranging from 123 to 252 €. The valuation of a 10% emission reductions is lowered to 103 €. Finally, the value associated to land recovery measures decreases to 201 €. Instead, the appraisal of new hospitals is stable at 150 €. Higher is the value associated to the 'None' option, representing a refusal of any project: this is estimated at 817 € in this model, as opposed to less than 670 € according to the previous RPL.

3.5.2 Latent class model

The latent class approach represents an alternative way to model preference heterogeneity (Boxall and Adamowicz 2002; Greene 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 a variable identifying whether a given individual received the information treatment, besides the individual score factors of the constructs 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 3.A2.

The utility function has been specified as follows:

$$V_{ij|s} = \beta_{1|s}ASC + \beta_{2|s}Distance_{200} + \beta_{3|s}Distance_{100} + \beta_{4|s}Distance_{50} + \beta_{5|s}Waste_{30} + \beta_{6|s}Waste_{20} + \beta_{7|s}Waste_{10} + \beta_{8|s}Emission + \beta_{9|s}Hospitals + \beta_{10|s}Land + \beta_{11|s}Bill \quad (16)$$

A three latent class specification, chosen on the basis of the goodness of fit and parameters' significance, is presented in Table 3.12. The pseudo R squared now equals .358. Inspecting the coefficients, it is indeed confirmed the presence of a great deal of preference heterogeneity. The goodness of fit has improved considerably compared to the analogous statistic for the MNL and the two RPL models. 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 models. These are strong indications in favour 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 to 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[31]. Unsurprisingly, although distance is

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

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. 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 greater 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 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[32].

[32]The computation of these monetary valuations 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 3.12. 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.

All in all, one segment of respondents, amounting to 33% of the sample, seem to be strongly against the building 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.

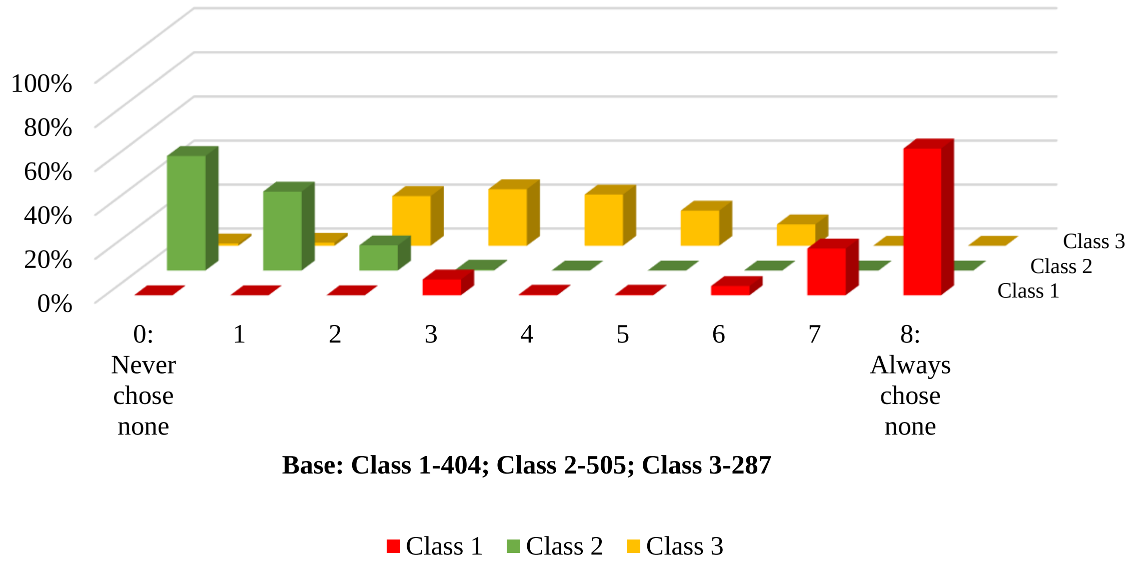

Figure 3.7: Frequency of 'none' chosen by segment

Posterior class probabilities have been computed so as to assign each respondent to a class, depending on the greatest class membership probability[33]. Individuals assigned to class 2 rarely chose none as shown in Figure 3.7. 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. 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%).

[33]It is worth remarking that the 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%.

In both class 1 and 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 favour 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%).

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.

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. The findings from this analysis, which are reported in detail in Tables 3.13 and 3.14, are supportive of the consistency of results with prior expectations.

Table 3.13. Bivariate Ordered probit model-Equation 1

Variable	Source	Coefficient	St. Error
Age	Q1	0.027	0.033
Male	Q2	-0.073	0.07
EU_Risk	Q3	-0.083***	0.032
Income	Q4	-0.005	0.024
Household size	Q5	-0.034	0.03
Right wing	Q6	-0.155*	0.096
Chernobyl Seriousness	Q7	0.019	0.07
Fukushima Seriousness	Q8	0.07	0.057
Never nuclear	Q9	0.171**	0.07
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	0.04
Investment_Geothermal	Q15	0.005	0.031
Investment_Biomass	Q16	-0.042	0.027
Importance_School	Q17	0.039	0.05
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	0.05
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	-0.11	0.09
Unemployed	Q27	0.057	0.099
Under 16 years old in the household	Q28	0.007	0.016
Degree	Q29	0.106	0.09
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 3.14. Bivariate Ordered probit model-Equation 2

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	0.02	0.074
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	-2836.02		
P	-0.061		
Observations	1111		

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

In terms of the determinants of opting-out (Table 3.13, 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 3.14, Equation 2), their profile is as follows: men, right-wing voters, higher income, and in favour 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.

Table 3.15.Bivariate ordered probit model: variables in Tables 3.13-3.14

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

We also used the bivariate ordered probit model to investigate the impact of the information treatment (Table 3.13, Equation 1). This 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, we looked at the effect of the information treatment on the choice experiments results. A latent class model was estimated including, within 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, Table 3.A2[34]. The key 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.

Furthermore, we looked at the effect of the information treatment in the RPL model[35] (Table 3.16). 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 findings of the latent class model just discussed.

[34]The preferences described in the three segments of the latent class model with the information treatment (Table 3.A2) are analogous to those of the model presented in Table 3.12, without considering the treatment in the class membership probability. However, the goodness of fit is inferior.

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

Table 3.16. RPL 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. All parameters assumed normally distributed.

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 3.17, 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 3.17, 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 in terms 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 3.17, panel C).

Table 3.17. 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 (***)	0.083	1.05	430	-0.048	0.919	752	-2.2521
Risks (***)	-0.095	1.05	430	0.059	0.92	752	2.6355
Confidence (***)	0.09	1.06	425	-0.047	0.925	743	-2.3274
Acceptance (***)	0.096	1.05	429	-0.057	0.934	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 (***)	-0.066	0.997	513	0.05	0.947	682	2.0638
Risks (*)	0.045	0.987	513	-0.03	0.97	682	-1.3273
Confidence (**)	-0.057	0.957	506	0.04	0.992	675	1.693
Acceptance (*)	-0.045	0.967	510	0.029	0.99	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 (**)	-0.02	1.05	170	0.15	1.05	258	1.6486
Risks	-0.087	1.1	170	-0.094	1.02	258	-0.0667
Confidence	0.027	1.02	168	0.127	1.08	255	0.9457
Acceptance (*)	0.007	1.05	170	0.146	1.06	257	1.3373
	HAVE NOT HEARD of FG						
Benefits	-0.083	0.971	334	-0.019	0.876	417	0.9486
Risks	0.106	0.922	334	0.023	0.919	417	-1.237
Confidence	-0.093	0.918	329	-0.011	0.931	413	1.2035
Acceptance	-0.065	0.936	332	-0.052	0.935	417	0.1981

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

3.6 Conclusions

In the aftermath of the Fukushima accident, Italy abandoned all plans that were made 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 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 approve 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 favour 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 on accident histories, in a country with no nuclear plants in operation, might lead instead to heightened opposition.

All in all, our results suggest the dependency of success of IV generation technology 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. 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, could foster opposition towards nuclear energy.

Appendix

Table 3.A1. Variables used in the CE econometric models

Choice Experiments-Utility function Variables	Type	Mean	S.D.	Min	Max
ASC	Dichotomous	0.33	0.47	0	1
Distance 20 Km	Dichotomous	0.49	0.49	0	1
Distance 50 Km	Dichotomous	0.17	0.37	0	1
Distance 100 Km	Dichotomous	0.17	0.37	0	1
Waste 30 %	Dichotomous	0.16	0.37	0	1
Waste 20 %	Dichotomous	0.17	0.37	0	1
Waste 10 %	Dichotomous	0.17	0.37	0	1
Emission Reduction	Discrete	0.62	0.79	0	2
Hospital	Dichotomous	0.27	0.44	0	1
Land Recovery	Dichotomous	0.27	0.44	0	1
Bill Reduction	€/household/year	68.35	78.61	0	203.73
Choice Experiments-Segment membership Variables					
Confidence	Score factors	2.71E-09	0.978	-1.82	2.151
Risk	Score factors	5.63E-09	0.977	-3.59	1.089
Benefits	Score factors	4.02E-10	0.969	-2.25	1.817

Notes: 1. Dichotomous variables were used to code the levels of 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 3.A2. Latent class model. Dependent variable: Choice

Variable	CLASS 1 Coeff. (S.e.)	CLASS 2 Coeff. (S.e.)	CLASS 3 Coeff. (S.e.)	CLASS 1 Monetary Valuations (€)	CLASS 2 Monetary Valuations (€)	CLASS 3 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 3.A3. Experimental Design

BLOCK	OPTION	Distance	Waste reduction	Emission Reduction	Hospitals	Land recovery measures	Bill reduction
1	A	100	0%	10%	NO	YES	0%
1	B	20	10%	10%	NO	NO	10%
1	A	50	20%	0%	YES	NO	0%
1	B	50	0%	20%	YES	NO	20%
1	A	50	10%	20%	YES	NO	20%
1	B	200	10%	0%	NO	YES	10%
1	A	200	30%	20%	NO	NO	10%
1	B	20	30%	0%	YES	NO	10%
1	A	200	20%	20%	NO	NO	20%
1	B	50	0%	0%	YES	YES	20%
1	A	20	30%	10%	NO	YES	10%
1	B	200	10%	10%	NO	NO	10%
1	A	20	30%	0%	YES	NO	30%
1	B	100	30%	20%	NO	NO	0%
1	A	200	10%	10%	YES	NO	20%
1	B	100	30%	0%	NO	NO	20%
2	A	50	30%	0%	NO	YES	30%
2	B	50	0%	10%	YES	YES	20%
2	A	20	30%	0%	YES	YES	20%
2	B	50	10%	10%	NO	NO	0%
2	A	100	20%	20%	NO	NO	20%
2	B	100	0%	0%	NO	YES	0%
2	A	20	0%	20%	NO	NO	30%
2	B	100	20%	20%	YES	YES	10%
2	A	200	0%	0%	YES	NO	0%
2	B	200	30%	10%	NO	YES	10%
2	A	100	10%	10%	NO	YES	30%
2	B	200	0%	0%	YES	NO	30%
2	A	100	10%	20%	NO	NO	10%
2	B	100	20%	0%	NO	YES	30%
2	A	100	30%	10%	NO	YES	30%
2	B	100	10%	10%	YES	NO	30%
3	A	50	0%	20%	YES	YES	20%
3	B	20	30%	0%	YES	NO	20%
3	A	20	20%	20%	NO	YES	10%
3	B	100	20%	10%	YES	NO	30%
3	A	20	20%	20%	YES	NO	0%
3	B	200	10%	20%	YES	YES	10%
3	A	100	30%	10%	NO	NO	20%
3	B	200	30%	10%	YES	NO	10%
3	A	100	0%	10%	NO	YES	10%
3	B	20	20%	20%	NO	YES	0%
3	A	50	0%	0%	YES	YES	10%

BLOCK	OPTION	Distance	Waste reduction	Emission Reduction	Hospitals	Land recovery measures	Bill reduction
3	B	20	30%	10%	YES	YES	0%
3	A	100	10%	10%	YES	YES	20%
3	B	20	30%	10%	YES	YES	0%
3	A	20	20%	10%	YES	YES	0%
3	B	200	20%	20%	YES	NO	20%
4	A	200	0%	0%	YES	YES	30%
4	B	100	10%	10%	NO	YES	30%
4	A	50	0%	10%	NO	NO	10%
4	B	20	10%	10%	YES	NO	10%
4	A	20	10%	0%	YES	YES	0%
4	B	50	0%	0%	NO	NO	20%
4	A	20	20%	20%	YES	YES	10%
4	B	100	0%	10%	NO	NO	0%
4	A	50	10%	10%	YES	NO	0%
4	B	100	30%	0%	NO	NO	20%
4	A	200	20%	0%	NO	NO	20%
4	B	50	0%	20%	NO	YES	30%
4	A	100	10%	10%	NO	NO	0%
4	B	50	30%	0%	YES	YES	30%
4	A	200	20%	0%	YES	NO	10%
4	B	200	20%	20%	NO	NO	30%
5	A	200	30%	20%	NO	NO	30%
5	B	50	30%	0%	YES	NO	30%
5	A	50	0%	0%	NO	NO	30%
5	B	20	20%	20%	NO	YES	20%
5	A	50	10%	10%	NO	YES	30%
5	B	20	10%	0%	NO	YES	0%
5	A	200	30%	0%	NO	YES	20%
5	B	20	0%	20%	YES	YES	0%
5	A	200	20%	10%	YES	YES	0%
5	B	20	20%	20%	NO	NO	0%
5	A	100	20%	20%	NO	NO	10%
5	B	200	30%	20%	NO	NO	0%
5	A	20	0%	20%	NO	NO	30%
5	B	50	20%	10%	NO	YES	10%
5	A	50	30%	0%	YES	NO	0%
5	B	50	0%	20%	NO	NO	30%

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Chapter 4

Complementing choice experiment with contingent valuation data: Individual preferences and views towards IV generation nuclear energy in the UK

Abstract

Nuclear energy represents an essential component of the UK energy mix. While most of the current nuclear plants are scheduled to be decommissioned, new reactors are expected to join the fleet. Looking ahead, IV generation nuclear energy technology is under research and development and aims to minimize some of the hazards of the current technologies. This work investigates social acceptance of IV generation nuclear energy, examining both the willingness to accept (WTA) new nuclear plants and the willingness to pay (WTP) for further research of IV generation technology. Choice experiments were employed to assess WTA, whereas contingent valuation questions were used to unveil WTP. Furthermore, an information treatment was given to a random sub-sample of the respondents. On the whole, the choice experiments results show the presence of four segments of respondents, whose preferences are aligned with the contingent valuation results. Segments'description is further enriched by the aid of contingent valuation data which shows that even among strong opposers of new nuclear plants there are individuals willing to pay for R&D of IV generation technology.

4.1 Introduction

Soon after becoming a net energy importer, in 2008 the UK made explicit its intention to increase investments in renewables and nuclear (BERR 2008)[36]. In 2016, the UK electricity mix was as follows: 42% Gas, 19% Nuclear, 14% Wind & Solar, 9% Coal, other renewables 8%, Hydro 2%, net imports 6% and Oil 2% (DECC 2017). The share of nuclear energy has experienced a minor drop since the late 1990s, when it made up 25% of the energy mix (WNA 2016). Out of the 15 nuclear plants in operation in the UK (WNA 2016), the majority will be soon decommissioned as approaching the end working life. This is why a decrease of 7.4 GW of nuclear capacity is planned by 2019 (OECD 2015). However, the share of nuclear is expected to increase in the future as new nuclear plants are scheduled. 12 new reactors are planned, equivalent to an electricity generation of up to 16 GW by 2030 (HM Government 2013a). Of these, 6.4 GW are planned at Hinkley point, 6.6 GW at Wylfa and Oldbury and up to 6.6 GW at Moorside (OECD 2015). On the whole, asset replacement and strong decarbonisation goals characterize the UK's capital needs, with both nuclear and renewables being more capital intensive than traditional fossil fuel plants. According to Blyth et al. (2015), current investments need to be sustained until 2020 and then will have to be increased substantially to reach the planned GHG reduction goals.

[36]It is worth mentioning that Scotland has opposed the building of new nuclear plants in its territory (The Scottish Government 2007) and aims to have 100% of electricity consumption generated by renewable energy by 2020 (Connolly et al.2016). The UK has committed to reduce its Greenhouse Gas (GHG) emission by 80% compared to 1990 levels by 2050 (Climate Change Act 2008), in line with the target set by the European Union (European Commission 2011).

The role of nuclear appears to be fundamental for the UK[37], given its current and planned energy policy coupled with the research and development in the areas of open fuel cycle and transition to closed fuel cycle (HM 2013b). Yet, the UK is currently a non-active member of the Generation IV Energy Forum (GIF), through which R&D towards the development of fourth generation reactors is coordinated. These prototypes under development are characterized by reduced risks and greater fuel efficiency compared to III and III+ generation reactors (Grape et al. 2014). Coincidentally, the IV generation goals are aligned with the set of social values that Demski et al. (2015) have found to be desirable for future energy systems in the UK.

Research on social acceptance of IV generation nuclear energy and, more in general, technologies under R&D, remains scant. The UK provides the opportunity to investigate this in a context where nuclear plants have been in operation for more than 50 years. In addition, since the technology under evaluation is mostly undeveloped, it appears crucial to assess the value respondents attach to R&D of IV generation technology. In order to estimate willingness to accept IV generation nuclear plant, this study employs choice experiments. Instead, the contingent valuation method is implemented in order to estimate willingness to pay for R&D of the same technology.

This work offers a combination of the two types of stated preference data. Furthermore, sensitivity to information is tested. Finally, the role of confidence towards the realization of IV generation technology's goals is explored. The reminder of the chapter is outlined as

[37] Acceptance of nuclear power in the UK did not seem to be affected negatively by the Fukushima accident (BBC 2011). More recently, according to the opinion tracker of the UK government, 38% of sampled respondents were in support of the use of nuclear energy, whereas 23% were against (DECC 2016).

follows: the next section presents the methodology employed; Section 3 describes the data collection and data analysis methods used; descriptive statistics are presented and discussed in Section 4; Section 5 shows the statistical and econometric models results; Section 6 contains additional multivariate analysis; finally, Section 7 concludes.

4.2 Methodology

The survey involved the administration of choice experiments, a contingent valuation exercise, as well as the collection of psychometric variables. Choice experiments and contingent valuation methods are presented below. The study does not aim at estimating the same economic value with two different stated preference techniques (as in, for instance, Mogas et al. 2006; Jin et al. 2006; Christie et al. 2007; Fearnley et al. 2008; He et al. 2016). Rather, two different economic values related to IV generation nuclear energy are assessed: WTP for further R&D and WTA for the building of nuclear plants. In terms of survey flow, respondents were first asked a series of questions regarding the perceived risks and benefits of nuclear energy, preferences towards energy source in general and views towards climate change. Subsequently, a sub-sample was presented with information on the Chernobyl and Fukushima accidents, together with a map indicating nuclear plants in operation, under construction, and shut down, in Europe[38]. Next, all respondents got introduced to the concept of IV generation nuclear energy. They were then asked their opinion on a set of statements regarding the likelihood of successful development, followed by a close-ended contingent valuation question. Finally, the choice experiment exercise was presented and the survey ended collecting socio-demographics data.

[38] Same information treatment as employed in the Italy case study, details in Chapter 2.

4.2.1 Choice Experiments

The choice experiments designed invited respondents to choose between a series of options regarding the construction of FG nuclear power plants in the UK. Attributes are the same as those employed in the case study presented in Chapter 3: atmospheric emission reductions, nuclear waste reduction, distance of city of residence from the nuclear power plant (levels expressed in Miles instead of Km in this study), public investments and electricity bill reductions. The monetary valuations that are obtained represent the estimated compensations for the building of new power plants. Table 4.1 depicts the attributes and their levels. A Bayesian-Efficient design (Ferrini and Scarpa 2007; Rose and Bliemer 2009) was generated, employing the choice experiments' results obtained from the Italian case study (Chapter 3) to derive priors. The output consisted in 5 blocks of 8 choice tasks each. One of the choice tasks is presented below in Figure 4.1. Alternatives were unlabeled (Project A versus Project B) and presented along with a 'none' option. The complete design is available in Appendix, Table 4.A3.

Table 4.1. Attributes and levels of the choice experiment

Attributes	Levels
Distance from the nuclear plant	15, 30, 60, or 120 Miles 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: Building of new hospitals	Yes or No
Public investments 2: Land recovery measures	Yes or No

[redacted]

Figure 4.1: Example of a choice task

4.2.2 Contingent Valuation

This study employs the CV method to assess the WTP for R&D of IV generation nuclear energy technology. All respondents were presented with a scenario introducing the topic of IV generation nuclear energy. This also explained the payment vehicle, consisting of extra income tax. Respondents were reminded to state an amount that they would really feel ready to pay (Lusk 2003; Carlsson et al. 2005). The contingent valuation scenario is reported in Table 4.2.

Table 4.2: Contingent valuation scenario

Introduction	Funding for research and development of energy sources such as fourth generation nuclear energy comes mainly from governments, and it is raised through income taxes. Please consider for a moment how much the development of fourth generation nuclear energy, and all its associated benefits, is worth to you, if anything. The money raised would be used in the context of UK-related fourth generation nuclear energy projects.
Question	What is the maximum you would be willing to pay, in extra income tax per year (one year only), for the research and development of fourth generation nuclear energy, and all its associated benefits? (Presented list of values from 0 to 300 GBP-**closed ended question**)
Cheap talk	Studies have shown that many people answering survey questions similar to this one, say they are willing to pay more than they would actually pay in reality. Please think about this question just as if it is a real decision. Please do not agree to pay an amount if you think you cannot afford it, if you feel you have paid enough already, or other things to spend your money on, and other ways to fund energy technology developments. Also, the question is just about fourth generation nuclear energy and not about other energy sources.

4.3 Statistical and econometric models

4.3.1 Analysis of contingent valuation data

Contingent valuation data was analysed by means of standard regression analysis and quantile regression (Koenker and Basset 1978; Koenker 2004). The ordinary least squares (OLS) method allows to obtain the average effect of a set of explanatory variables on the WTP for investment in R&D of IV generation nuclear energy. Formally, the following equation is estimated:

$$WTP_i = \sum_k \beta_k X_i' + \varepsilon_i \tag{4.1}$$

where β represents the vector of coefficients, X the matrix of the k explanatory variables, ε the error terms. Equation (4.1) is estimated by minimizing $\sum_i {\varepsilon_i}^2$. However, the estimated effects might be substantially different at different quantiles of the WTP's distribution[39]. What is more, in a contingent valuation context the dependent variable does not usually follow a normal distribution, being instead closer to a log-normal with substantial density at zero. When estimating the effect of the explanatory variables on different quintiles of WTP_i, (4.1) becomes:

$$WTP_i = \sum_k \beta_k^\theta X_i' + \varepsilon_i^\theta \tag{4.2}$$

with $\theta \in (0,1)$ representing the quantile chosen. The coefficients β_k^θ are obtained by minimizing the weighed sum of the absolute value of the residuals ε_i^θ. The model was estimated in STATA with the command qreg.

4.3.2 Analysis of psychometric variables[40]

In order to analyze the psychometric variables we estimated a structural equation model characterized by four latent factors: 'perceived benefits', 'perceived risks', 'confidence' and 'trust'. Prior to estimating this model we ran four independent factor analyses to confirm the validity of each latent factor. The same method was employed to investigate the presence of latent factors related to views towards climate change.

Once the constructs were confirmed, we proceeded to estimate the relationships between the latent constructs by means of a structural equation model. This was set such that the construct 'trust' affects the constructs 'perceived benefits', 'perceived risks' and 'confidence'. Hence, 'trust' is specified as an exogenous latent construct, whereas

[39] The added value of the quantile regression estimator was shown in O'Garra and Mourato (2006) in the context of WTP for hydrogen buses.

[40] This section draws on Bartholomew et al. (2008).

‘perceived benefits’, ‘perceived risks’ and ‘confidence’ are endogenous. The measurement equations are defined as follows:

$$x_{i=}\tau_i^{(x)} + \lambda_{i1}^{(x)}\text{Trust} + \delta_i,\ i = 1, \dots 5 \quad (4.3)$$

$$y_{i=}\tau_i^{(y)} + \lambda_{i1}^{(y)}\text{Benefits} + \epsilon_i, i = 1, \dots 6 \quad (4.4)$$

$$y_{i=}\tau_i^{(y)} + \lambda_{i2}^{(y)}\text{Risks} + \epsilon_i, i = 1, \dots 6 \quad (4.5)$$

$$y_{i=}\tau_i^{(y)} + \lambda_{i3}^{(y)}\text{Confidence} + \epsilon_i, i = 1, \dots 6 \quad (4.6)$$

Furthermore, the structural equations are specified below:

$$\text{Confidence} = \beta_{11}\text{Trust} + \zeta_1 \quad (4.7)$$

$$\text{Benefits} = \beta_{21}\text{Trust} + \zeta_2 \quad (4.8)$$

$$\text{Risks} = \beta_{31}\text{Trust} + \zeta_3 \quad (4.9)$$

The x_i in equation (4.3) are the indicators of the exogenous constructs, whereas y_i in equations (4.4)-(4.6) represent the indicators of the endogenous latent variables. $\tau_i^{(x)}$ and $\tau_i^{(y)}$ indicate constants and $\lambda_{i1}^{(x)}, \lambda_{i1}^{(y)}$ denote the loadings. The structural equations are described in equations (4.7), (4.8) and (4.9). β_{ii} represents the coefficients attached to endogenous constructs, which represent the effect of trust on confidence, perceived risks and benefits. ζ_i, δ_i and ϵ_i indicate the error terms.

4.3 Descriptive statistics

4.3.1 Sample characteristics

Data was collected online, in December 2014, targeting respondents aged 18 to 75 years old, residing in the UK. The total sample, provided by a market research company (Toluna), was equal to 887 respondents. Descriptive statistics for socio-economic variables are presented in Table 4.3. 68.5% of reside in England, 16% in Scotland, 11% in Wales and 4.5% in Northern Ireland[41]. Table 4.3 presents both socio-economic data at the overall level and by information treatment (individuals who received it versus those who did not). Socio-economic characteristics between these two samples do not appear to be substantially different when considering those residing in England. For the remaining respondents, there are differences in terms of marital status and age groups.

Table 4.3. Socio-demographic characteristics

		OVERALL		INFO Treatment		No INFO Treatment	
Variable	*Statistics*	England	Wales, Scotland, Ireland	England	Wales, Scotland, Ireland	England	Wales, Scotland, Ireland
Age	% Up to 24	6.4	11	7.9	7.9	4.9	14.2*
	% 25-39	24.2	38.7	22.7	44.9	25.5	32.6**
	% 40-54	32	34.7	31.7	32.6	32.4	36.8
	% 55+	37.3	15.4	37.6	14.4	37	16.3
Gender	% Male	45.8	48	46.2	48.5	45.5	47.5
Education	% Degree holders	40.7	39.7	41.9	40.6	39.7	39
Marital Status	% Single	21.3	33.7	20.8	28.2	21.9	39*
	% Married	51.6	40.1	48.1	44.2	55.1*	36.2
Observations		608	279	303	138	305	141

Level of significance: *10%, ** 5%. Test of proportions between shares. The groups considered are England with information treatment versus England without information treatment and Wales, Scotland, Ireland with information treatment versus Wales, Scotland and Ireland without information treatment.

4.3.2 Attitudes towards energy sources

[41] The population share of English to UK residents amounts to 83% (ONS 2014).

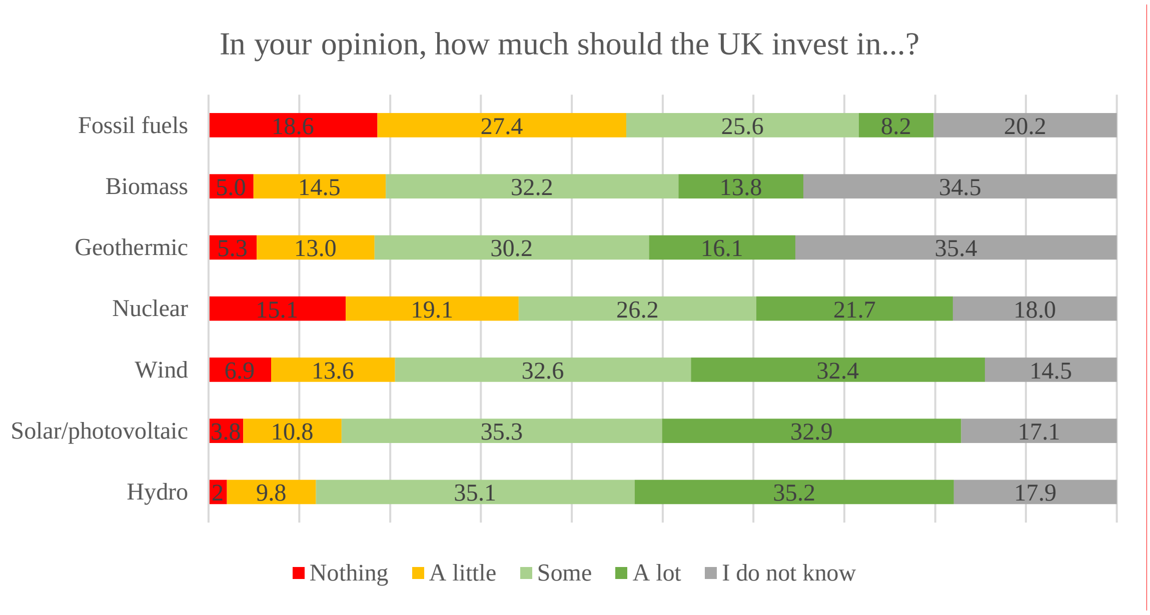

Figure 4.2: Views towards different energy sources

In this section we explore respondents' attitudes towards different energy sources. Figure 4.2 shows the answers given to the following question: 'In your opinion, how much should the UK invest in…'; seven different energy sources were in turn listed. Renewable energies seem to be widely endorsed. Instead, fossil fuels are clearly the least preferred energy option. Hydro, solar/photovoltaic and wind energy are the top three energy sources: a minimum of 30% would want the UK to invest a lot in any of them. Importantly, 21% indicated nuclear energy, more than the analogous share obtained by geothermic, biomass and fossil fuels. Nevertheless, 15% would not want the UK to invest anything in nuclear energy[42]. Finally, more than 1 in 3 selected 'I do not know' when evaluating biomass and geothermic.

Furthermore, respondents were invited to pick their preferred energy policy (Figure 4.3). The largest share, 44%, indicated 'gradually switching towards renewable energy sources'.

[42] An analogous question was asked to the sample of Italian respondents (Chapter 3). In that instance, nuclear was the least preferred option. 45% of respondents did not want the Italian government to invest anything in it. Similarly as observed in this study, the top three energy sources were solar/photovoltaic, wind and hydro.

31% opted for moving towards more advanced nuclear plants. Instead, 15% chose to progressively shut down all operating nuclear plants and 9% chose to invest in fossil fuels. All in all, a strong preference for renewable energy sources emerges, with nuclear energy considered as an additional option.

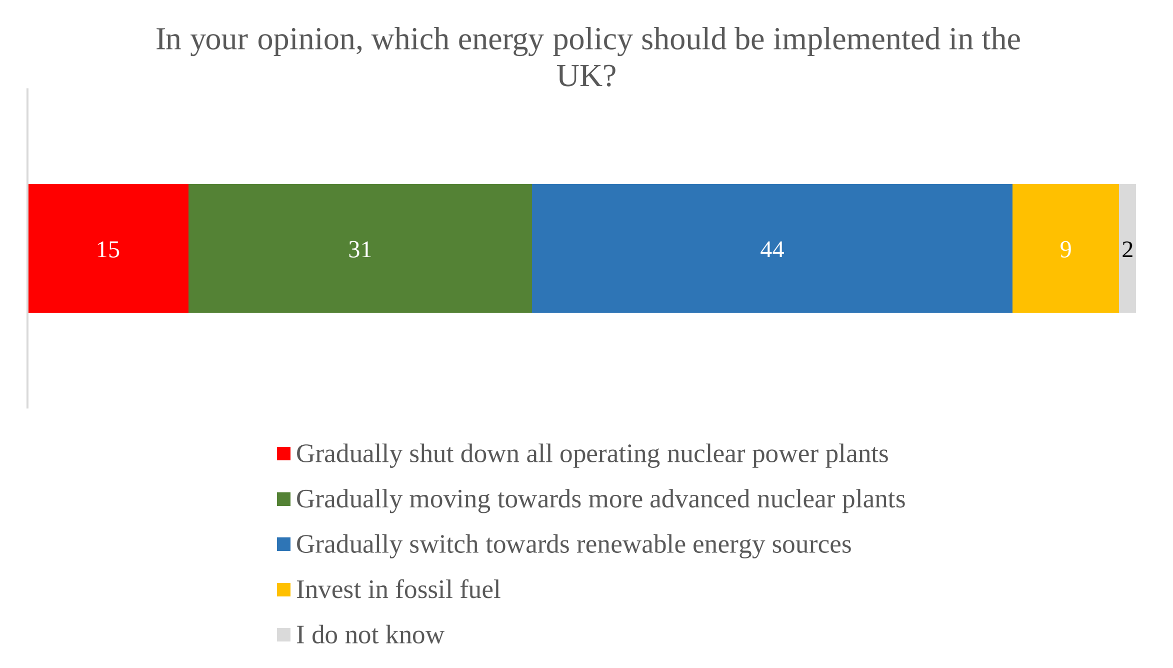

Figure 4.3: Opinion towards energy policy in the UK

Table 4.4. Answers to the risks, benefits and confidence's statements

Risks	*In your opinion, how likely are the following risks?*				
	Extremely/very unlikely	Somewhat unlikely	Neutral	Somewhat Likely	Very/Extremely likely
Damages/threats to the environment	11.8	13.4	27.5	25.4	21.9
Nuclear waste disposal accident	11.5	13.4	28.9	25.8	20.4
Terrorist attacks	12	12.5	32.5	22.7	20.1
Damage/threats to the human health	13.8	12.8	29.6	23.8	19.9
Military use of nuclear power	17.3	12.8	32	21	16.6
Risk of catastrophic accident	13.9	16.2	29.7	24.5	15.7

Benefits	*In your opinion, how likely are the following benefits?*				
	Extremely/very unlikely	Somewhat unlikely	Neutral	Somewhat Likely	Very/Extremely likely
Less reliance on fossil fuels	3.6	6.7	28	29.5	32
Less energy imports	5.4	8.2	31	27.4	27.9
Atmospheric emissions' reduction	6.5	9.3	39.5	23.5	21.1
More convenient energy prices	12	12.6	37.5	22.5	15.2
Economic Growth	6.4	9	44.9	28.6	10.9
Less unemployment	11.3	15.4	48.5	17.2	7.5

	In your opinion, how important are the following goals of the nuclear industry?				
Importance of goals of nuclear industry	Extremely/very unimportant	Somewhat unimportant	Neutral	Somewhat important	Extremely/Very important
Reduce the probability of catastrophic accidents	3.3	1.7	10.9	10.5	73.6
Minimize nuclear waste production	2.6	1.7	13.7	16.2	65.7
Increase passive security	2.7	2.5	13.7	17.3	63.7
Increased protection against terrorist attacks	2.8	2.7	13.7	18.4	62.3
Reduce the long-term stewardship burden of nuclear waste	3.1	3.3	7.2	21.9	54.3
Increase cost competitiveness compared to other energy sources	3.7	4.3	24.3	29.3	38.3

We then examine views on perceived risks and benefits of nuclear energy (Table 4.4). Only 1 in 5 see the following risks as 'extremely likely': damages/threats to the environment, nuclear waste disposal accidents, terrorist attacks and damage/threats to human health. Fewer respondents indicated the military use of nuclear power (16.6%) and the risk of catastrophic accidents (15.7%). These shares are much lower when compared to those obtained from the Italy case study (Chapter 3). In reference to the perceived benefits, 32% think it is extremely likely that reliance on fossil fuels would be reduced thanks to nuclear energy. 28% believe it is extremely likely that there would be less energy imports. Only 21% seem confident that atmospheric emission would be reduced. Few expect more convenient energy prices (15.2%) and economic growth (11%). Less unemployment is a very likely prospect for just 7.5%.

4.3.3 Views on fourth generation nuclear energy

The survey flow was designed such that respondents would be first asked to state the level of importance of goals of the nuclear energy industry. Until that point, there had been no reference to any specific nuclear energy technology. Next, it was explained those were actually the goals of the fourth generation. Respondents then stated how confident they were about the accomplishment of the research's goals. As observed in the first case study, the most important goal is the reduction of the probability of catastrophic accidents. This is extremely important for more than 7 in 10. Also, more than 60% perceive as extremely important the following: minimize nuclear waste production, increase passive security, and increase protection against terrorist attacks.

On the other hand, confidence towards the attainment of these goals is quite low. For instance, only 7.1% are extremely confident that IV generation nuclear energy will lead to a reduction of the nuclear waste produced. Data on knowledge of IV generation nuclear energy was also collected. Only 8.4% declared to have heard of this nuclear technology before. These respondents were also requested to elaborate on what they knew about it. The most frequent mentions were "new", "safer", "reactors" and "cleaner", showing FG appears to be associated to the perception of a better nuclear energy technology.

Table 4.5. Answers to the confidence and trust statements

Confidence	*How confident are you that these goals will be reached?*				
	Very unconfident/Not confident	Somewhat Unconfident	Undecided	Somewhat Confident	Confident/Very confident
Reduce the probability of catastrophic accidents	9	10.8	43.8	25	11.2
Minimize nuclear waste production	9.1	12.9	48.4	22.3	7.11
Increase passive security	6.7	7.7	44.5	26.2	14.8
Increased protection against terrorist attacks	9.5	7.9	43.8	23	15.9
Reduce the long-term stewardship burden of nuclear waste	9.8	12.8	47.1	22.8	7.4
Increase cost competitiveness compared to other energy sources	8.8	12.2	45.2	23.1	10.7
	Finally, to what extent are you confident that…?				
Trust	Very unconfident/Not confident	Somewhat Unconfident	Undecided	Somewhat Confident	Confident/Very confident
In the UK, the selection of the sites for new nuclear power plants is a fair process	13.6	10.37	43.5	20.3	12.1
In the UK, the decommissioning of old nuclear plants can be carried out effectively	11.5	11.8	31.9	26	18.7
In the UK, corporations operating nuclear power plants are aware of their responsibility	10.1	8.1	28.8	28.5	24.3
In the UK, legal regulations regarding the disposal of nuclear waste are sufficient	12.8	12.3	35.8	22.3	16.7
In the UK, responsible authorities accurately control whether legal regulations and restrictions are upheld in nuclear power plants	9.8	10.2	35.4	26.4	18.2

Additionally, respondents stated their level of trust towards stakeholders involved in the nuclear energy system in the UK (Table 4.5). Drawing on Siegrist et al. (2000), this work tests the following hypothesis: a greater level of trust positively affects perceived benefits and negatively impacts perceived risks. We also postulated that greater trust may be linked to greater confidence towards the success of the IV generation technology. Over 24% of the respondents are confident/very confident that in the UK corporations operating nuclear power plants are aware of their responsibility. Almost 19% are confident that the decommissioning of old nuclear plants would be carried out effectively and that the responsible authorities accurately control whether legal regulations and restrictions are upheld in nuclear power plants. Fewer are confident that legal regulations regarding the disposal of nuclear waste are sufficient and that the selection of the sites for new nuclear plants follows a fair process.

4.4.4 Views on climate change

Open ended data on top of mind association with climate change was collected. A sizable minority, amounting to 8%, appeared to be rather skeptic. For instance, some maintained that climate change is a lie. Others stated it is overrated, unproven, or even an excuse to enforce extra taxes[43]. A few respondents said it is a natural occurrence, a cyclical event[44]. On the other hand, the vast majority indicated 'global warming', 'ozone layer' and 'melting ice cap' as top of mind. Some individuals elaborated more in detail. For instance, a man residing in England, aged 70 to 74 years old, said '*The Planet is in trouble and there seems to be no serious political will to enforce the necessary changes. The human race is, at present, cutting off the branch we are sitting on'*. A woman from England, aged between 45 and 49 years old, commented '*Carbon dioxide emissions, increased risk of floods, sea*

[43] '*An EU excuse to up our taxes - not happening at the rate they say it is happening'*.

[44] '*The fiction that it is man-made when in reality it is a naturally occurring thing'*.

level rise, extreme weather'. Remarkably, only a handful expressed concerns towards the possibility of catastrophic events.

We then evaluated the respondents' opinion on a set of statements on climate change (Figure 4.4). 66% believe it is likely the UK's emissions contribute to climate change. More than 3 in 5 agree that average temperatures will increase in the UK. Fewer believe climate change will have catastrophic consequences in the UK in the short run. Also, 31% think it is likely the impacts of climate change are over emphasized, 42% that climate change is the result of natural climate variability and 34% that the Earth has a natural feedback that protects it from catastrophic impacts.

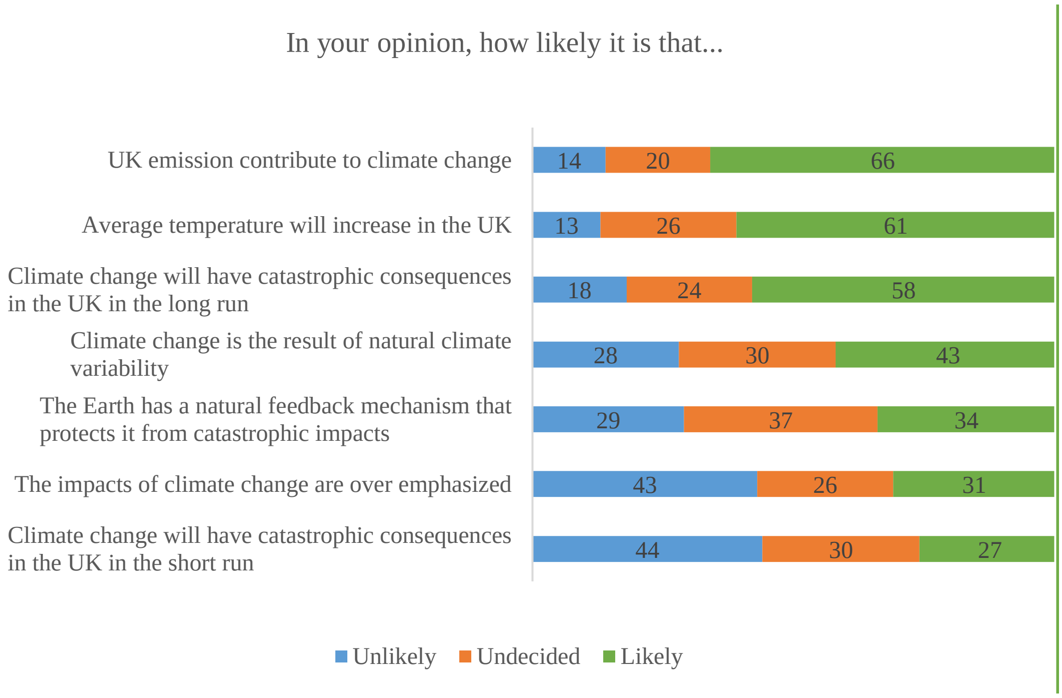

Figure 4.4: Views towards climate change

4.5 Statistical and econometric model results

4.5.1 Structural equation model

Four confirmatory factor analyses were estimated to validate the existence of the constructs employed in the structural equation model. The constructs are 'Perceived Risks', 'Perceived

Benefits', 'Confidence', and 'Trust'. Tables 4.6, 4.7 and 4.8 present the items employed for each construct, whereas Table 4.9 displays the factor loadings and uniqueness. The lower the uniqueness, the higher the proportion of variance explained by the construct. Considering the factor 'Perceived Risks', most of the variance in the item 'Damage/threats to human health' is explained by the construct. Instead, as far as the construct 'Perceived Benefits' is concerned, the item 'Less energy imports' has the lowest uniqueness: 64% of its variance is explained by the construct. For the third endogenous construct, 'Confidence', the lowest uniqueness is associated with the item 'Increase passive security'. Finally, with regards to 'Trust', the item 'In the UK, responsible authorities accurately control whether legal regulations and restrictions are upheld in nuclear power plants' has the lowest uniqueness. All factor loadings linked to this construct present a positive magnitude, greater than 0.79.

Table 4.6. Perceived risks and benefits items

We now focus on nuclear energy in the UK. In your opinion, how likely are these risks/benefits associated with nuclear energy?

		Very Unlikely	Unlikely	Somewhat Unlikely	Undecided	Somewhat likely	Likely	Very Likely
Risks	v_1	Risk of catastrophic accident						
	v_2	Damage/threats to the environment						
	v_3	Damage/threats to human health						
	v_4	Terrorist attacks						
	v_5	Military use of nuclear power						
	v_6	Nuclear waste disposal accident						
Benefits	v_1	Atmospheric emissions' reduction						
	v_2	Less reliance on fossil fuels						
	v_3	Less energy imports						
	v_4	Economic growth						
	v_5	Less unemployment						
	v_6	More convenient energy prices						

Table 4.7. Confidence items

		How confident are you that fourth generation technology goals will be achieved?						
		Very unconfident	Not confident	Somewhat unconfident	Undecided	Somewhat confident	confident	Very confident
Confidence	v_1	Minimize nuclear waste						
	v_2	Reduce the long term stewardship burden of nuclear waste						
	v_3	Increase the cost-competitiveness compared to other energy sources						
	v_4	Reduce the probability of catastrophic accidents						
	v_5	Increase passive security						
	v_6	Increase protection against terroristic attacks						

Table 4.8. Trust items

		To what extent are you confident that…						
		Very unconfident	Not confident	Somewhat unconfident	Undecided	Somewhat confident	Confident	Very confident
Trust	v_1	In the UK, the selection of the sites for new nuclear power plants is a fair process						
	v_2	In the UK, the decommissioning of old nuclear plants can be carried out effectively						
	v_3	In the UK, corporations operating nuclear power plants are aware of their responsibility						
	v_4	In the UK, legal regulations regarding the disposal of nuclear waste are sufficient						
	v_5	In the UK, responsible authorities accurately control whether legal regulations and restrictions are upheld in nuclear power plants						

Table 4.9. Factor loadings and uniqueness

Item	ξ: Risks		ξ: Benefits		ξ: Confidence		ξ: Trust	
	F.L.	UN.	F.L.	UN.	F.L.	UN.	F.L.	UN.
v_1	0.87	0.24	0.68	0.53	0.80	0.35	0.79	0.37
v_2	0.86	0.25	0.73	0.45	0.82	0.32	0.83	0.29
v_3	0.90	0.18	0.79	0.36	0.74	0.45	0.82	0.31
v_4	0.63	0.59	0.74	0.43	0.81	0.32	0.81	0.33
v_5	0.68	0.52	0.60	0.63	0.83	0.30	0.86	0.26
v_6	0.85	0.27	0.66	0.56	0.75	0.43	/	/

F.L.: Factor loadings. UN: Uniqueness

The coefficients of the structural equation model are displayed in Figure 4.5. The measurement equation's coefficients are presented in Table 4.10. This model has a comparative fit statistic (CFI) of .942 and a Tucker-Lewis Index of .936. All the coefficients of the structural equations and measurement equations are statistically significant at $\alpha<1\%$. In line with the hypothesis, the construct 'Trust' significantly affects 'Perceived Risks', 'Benefits' and 'Confidence'. The effect on 'Perceived Benefits' is positive, with a coefficient equal to .52. Whereas 'Perceived Risks' are affected in a negative way, with a coefficient of -.55. In addition, 'Confidence' is positively affected (.62): trust towards stakeholders of the nuclear energy sector in the UK seems to positively influence the extent to which people see the achievement of IV generation nuclear energy goals as obtainable.

Table 4.10. Structural Equation model-Measurement equations' coefficients

	Risks		Benefits		Confidence			Trust	
	Coeff.	Std. Err	Coeff.	Std. Err	Coeff.	Std. Err		Coeff.	Std. Err
$\lambda_{ii}^{(y)}$	1	c	1	c	1	C	$\lambda_{ii}^{(x)}$	1	C
$\tau_{i}^{(y)}$	4.11	0.049	4.48	0.044	4.01	0.038	$\tau_{i}^{(x)}$	4.03	0.046
$\lambda_{ii}^{(y)}$	1.02	0.028	1.07	0.052	1.02	0.037	$\lambda_{ii}^{(x)}$	1.10	0.038
$\tau_{i}^{(y)}$	4.38	0.050	4.93	0.044	4.01	0.039	$\tau_{i}^{(x)}$	4.27	0.048
$\lambda_{ii}^{(y)}$	1.07	0.027	1.18	0.054	0.95	0.039	$\lambda_{ii}^{(x)}$	1.10	0.038
$\tau_{i}^{(y)}$	4.28	0.050	4.72	0.045	4.12	0.039	$\tau_{i}^{(x)}$	4.51	0.048
$\lambda_{ii}^{(y)}$	0.70	0.034	0.91	0.047	1.12	0.040	$\lambda_{ii}^{(x)}$	1.07	0.038
$\tau_{i}^{(y)}$	4.30	0.049	4.29	0.038	4.15	0.041	$\tau_{i}^{(x)}$	4.14	0.048
$\lambda_{ii}^{(y)}$	0.83	0.035	0.77	0.050	1.08	0.039	$\lambda_{ii}^{(x)}$	1.07	0.036
$\tau_{i}^{(y)}$	4.06	0.053	3.91	0.041	4.34	0.040	$\tau_{i}^{(x)}$	4.32	0.045
$\lambda_{ii}^{(y)}$	0.97	0.028	0.99	0.057	1.08	0.044	$\lambda_{ii}^{(x)}$	/	/
$\tau_{i}^{(y)}$	4.35	0.049	4.15	0.047	4.26	0.044	$\tau_{i}^{(x)}$	/	/

c: constrained

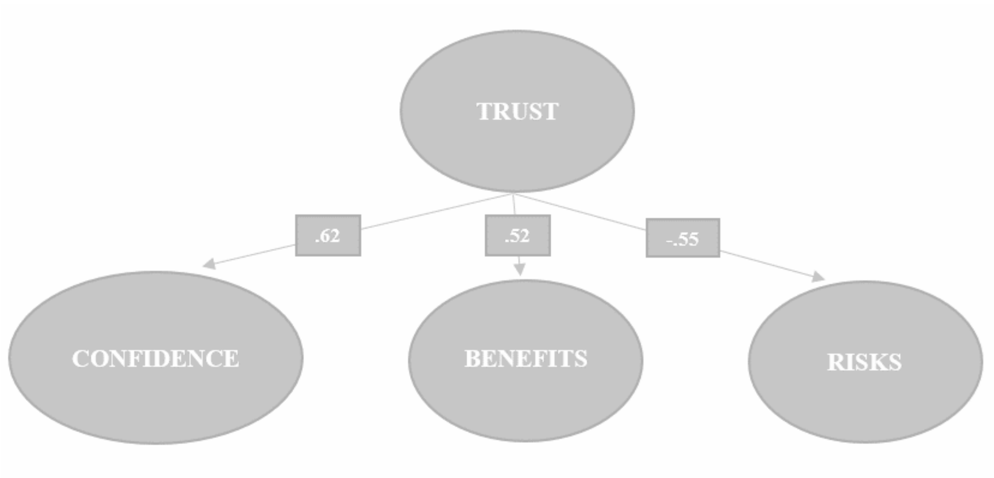

Figure 4.5: Structural equation model: Path diagram

4.5.2 Factor analysis applied to climate change statements

A separate factor analysis was applied to the set of statements concerning the views on climate change. Three latent factors were extracted, characterized as follows (Tables 4.11 and 4.12). Respondents who score high on the first factor are more worried about climate change. This is because the coefficients of the factor loadings associated to the following statements are positive: 'climate change will have catastrophic consequences in the UK in the short and in the long run'; 'UK emissions contribute to climate change; average temperature will increase in the UK'. The second factor, instead, represents the views of respondents who believe climate change is the result of natural climate variability and that its impacts are over-emphasized. Finally, the third construct presents factor loadings lower in magnitude compared to the other two factors; hence it was labelled as 'Not worried'.

Table 4.11. Climate change items

Climate change refers to drastic weather conditions and extreme events over long time periods. How likely do you think is that…?

	Extremely unlikely	Very unlikely	Somewhat unlikely	Undecided	Somewhat likely	Very likely	Extremely likely
v_1	Climate change will have catastrophic consequences in the UK in the short run						
v_2	Climate change will have catastrophic consequences in the UK in the long run						
v_3	UK's emission contribute to climate change						
v_4	Average temperature will increase in the UK						
v_5	The Earth has a natural feedback mechanism that protects it from catastrophic impacts						
v_6	Climate change is the result of natural climate variability						
v_7	The impacts of climate change are over emphasized						

Table 4.12. Factor loadings and uniqueness

Item	ξ: Worried	ξ: Sceptics	ξ: Not Worried	
	F.L.	F.L.	F.L.	UN
v_1	0.51	-0.12	0.16	0.68
v_2	0.71	-0.28	0.07	0.39
v_3	0.69	-0.21	-0.06	0.47
v_4	0.59	-0.06	-0.05	0.63
v_5	-0.12	0.58	0.02	0.63
v_6	-0.11	0.67	-0.00	0.52
v_7	-0.38	0.65	-0.02	0.41

F.L.: Factor loadings. UN: Uniqueness

4.5.3 Choice experiment data: MNL and RPL models

Prior to econometric model estimation, checks were performed so as to evaluate the presence of non-trading behavior. Potential non-traders can be detected by assessing the number of option 'none' chosen by respondent. As shown in Figure 4.6, 11.9% always chose none of the options, whereas more than 56% always picked either A or B. On the whole, there seems to be a satisfactory degree of trading. Summary statistics for attributes and variables employed in the choice experiment analysis are shown in Appendix, Table 4.A1. Table 4.13 presents the estimated coefficients of the MNL and RPL models. Following a specification search, the deterministic portion of utility was specified as additive, non-linear with respect to the attributes 'distance' and 'waste reduction'. As a 'none' option was also available, we estimated the effect attached to it. This entailed including a dichotomous variable, defined as ASC (alternative specific constant), taking value 1 in correspondence of the 'none' option, 0 otherwise. The econometric model estimation started with a MNL. This model shows all attributes were significantly valued. Furthermore, the signs of the estimated coefficients are in line with expectations.

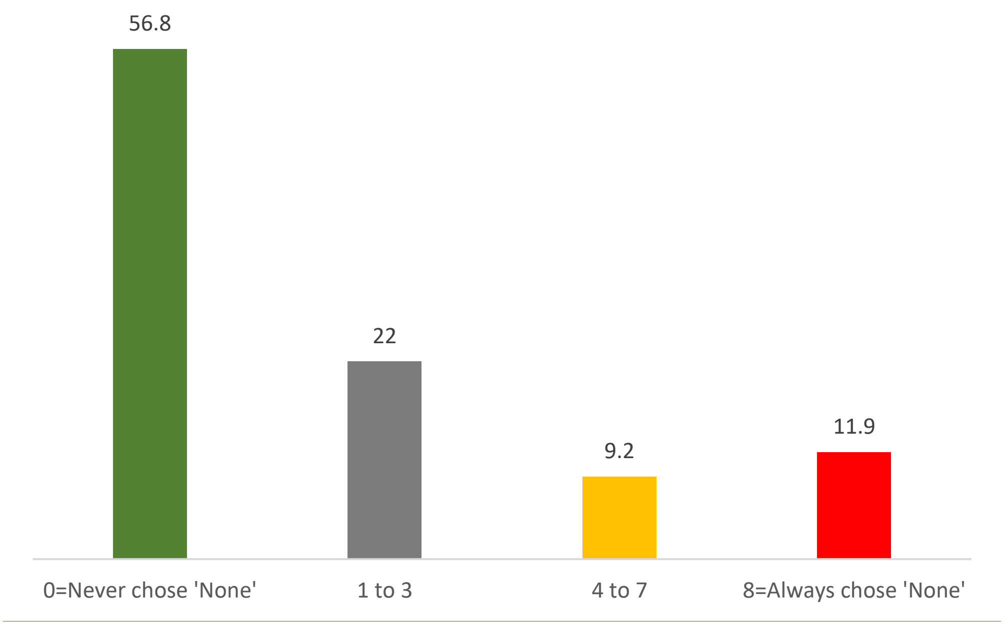

Figure 4.6: Share of 'None' chosen

Table 4.13. MNL and RPL models. Dependent variable: Choice

	MNL	RPL	RPL	MNL	RPL
Variable	Coeff. (S.e.)		S.D.	Monetary Valuations (£)	
ASC	1.48*** (.087)	.178 (.270)	5.22*** (.296)	550.6	→0
Distance: 120 Miles	.843*** (.054)	1.31*** (.090)	1.23*** (.101)	311.6	282.8
Distance: 60 Miles	.432*** (.061)	.785*** (.096)	.949*** (.144)	159.9	169.1
Distance: 30 Miles	.409*** (.053)	.641*** (.076)	.257 (.239)	151.3	138.2
Waste Reduction: 30%	.645*** (.053)	1.05*** (.074)	.508*** (.130)	238.4	227.7
Waste Reduction: 20%	.462*** (.054)	.779*** (.075)	.051 (.345)	170.9	167.7
Waste Reduction: 10%	.343*** (.058)	.456*** (.085)	.122 (.345)	127	98.3
Emission Reduction	.384*** (.023)	.559*** (.039)	.560*** (.054)	142.1	120.5
Hospitals	.545*** (.041)	.888*** (.071)	1.04 (.093)	201.4	191.3
Land Recovery	.199*** (.036)	.319*** (.057)	.661*** (.086)	73.6	68.7
Bill Reduction (£)	.0027*** (.000)	.004***[b] (.000)	/	/	/
Log-Likelihood	-7210.90	-5379.6			
R squared	0.053	0.31			
Observations	7096	7096			

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

The coefficient attached to the ASC is positive, indicating that, overall, respondents would require a compensation for the introduction of new nuclear plants. Furthermore, they preferred scenarios with proposed nuclear plants distant from their area of residence. Considering environmentally-related benefits, emissions' reductions are positively valued, as well as nuclear waste reductions. Finally, both public and private benefits, namely the building of hospitals, the provision of land recovery measures and electricity bill reduction, are positively valued.

The presence of preference heterogeneity is assessed estimating a RPL. Attributes were specified to be normally distributed, except for the monetary attribute held fixed. All estimated mean coefficients are significant but that of the ASC. Its estimated standard deviation is significant and with a large magnitude, signaling the presence of notable heterogeneity among respondents. Significant deviations from the mean are also observed with respect to 'distance', 'emission reductions', building of new hospitals and land recovery measures.

The monetary valuations denote the willingness to accept (WTA) a compensation for a worse level of a given attribute. For instance, this is the case for a closer nuclear plant, or less nuclear waste reduction, less or no emission reduction, or for no public benefits. At the same time, WTA is in theory equivalent to the willingness to pay (WTP) for an improvement in the levels of a given attribute[45]. Moving to the RPL model results, respondents would be willing to forgo on average of 282 £ per household per year for a nuclear plant located 120 Miles away. Instead, they value 169 £ for a new nuclear plant built 60 Miles away and 138 £ if it is 30 Miles away. Waste reduction is valued between 98

[45] Yet, for reasons including loss aversion (Kahneman and Tversky 1979), disparities between WTP and WTA are expected (Brown and Gregory 1999).

£, for a 10% reduction, and 227 £ for a 30% reduction. Emission reductions are valued at 120 £, less than the building of new hospitals (191£). The least valued attribute is the provision of land recovery measures (68 £).

An additional RPL model with the cost attribute specified as normally distributed as well, was estimated. Results are presented in Table 4.14. The resulting monetary valuations are aligned with the RPL estimates previously discussed. However, the value attached to distance (274 £ for 120 Miles), emission reductions (116 £), hospitals (187 £) seem more conservative. Instead, a slightly higher valuation is attached to land recovery measures (80 £).

Table 4.14. RPL model. Dependent variable: Choice

Variable	Monetary Valuations (£)	T ratios	S.D.	T ratios
ASC	120.5	1.87	1132.6	6.16
Distance: 120 Miles	274.7	9.69	370.3	5.7
Distance: 60 Miles	174.7	7.41	306	7.07
Distance: 30 Miles	138.6	8.17	89.2	2.94
Waste Reduction: 30%	241.5	11.9	44.7	0.66
Waste Reduction: 20%	163	8.7	54.1	0.99
Waste Reduction: 10%	92.7	4.6	65.3	1.36
Emission Reduction	116.5	11.3	82.8	2.09
Hospitals	187.6	11.6	148.3	2.20
Land Recovery	80.8	7.63	89.1	2.56
Log-Likelihood	-5317.614			
R squared	0.31			
Observations	7096			

Distribution of the monetary attribute assumed to be normally distributed. S.D.: standard deviation. T ratio associated to the standard deviation of the monetary coefficient is 8.94. The coefficient of the S.D. is equal to .0024, which coupled with a mean coefficient of .0053 ensures the absence of sign reversal.

4.5.4 Choice experiment data: Latent class model

Preference heterogeneity was further modeled in a latent class framework. This assumes the presence of a finite number of segments characterized by preferences homogenous within and different between them (Boxall and Adamowicz 2002; Greene and Hensher 2003). Besides, this model allows to condition the class membership probability on a set of variables (specifically score factors) linked to acceptance of nuclear energy: perceived risks, perceived benefits and confidence towards the achievement of IV nuclear energy goals. Different specifications were tested, as well as different number of segments. Based on goodness of fit, significance and magnitude of estimated coefficients, a 4-segments specification was selected. This is characterized by including ‘perceived benefits’, ‘risks’ and ‘confidence’ in the class membership function.

A different specification of the latent class model was also estimated. Within the class membership probability, this one included a variable coded 1 if the respondent received the information treatment, 0 otherwise (Appendix, Table 4.A2). However, this variable was not associated to any significant effect, nor did lead to a substantial improvement in model fit. Hence, it was subsequently omitted from the final model, presented in Table 4.15. The pseudo R squared equals .32 and the Log-Likelihood amounts to -5291.885, with 48 parameters. As noticed with the RPL, allowing for preference heterogeneity has led to a considerably better goodness of fit compared to the MNL.

The four segments resulting from the analysis present the following characteristics. Segment 1, associated to an average class probability of 46.9%, presents preferences favourable towards the construction of new nuclear plants. In this class the ASC variable has a significant and negative coefficient. This indicates that these respondents were more likely to choose one of the projects rather than ‘none’. Moreover, ‘distance’ does not seem to be of relevant importance. Finally, they value ‘waste reduction’, ‘emissions reduction’ and both private and public benefits.

Table 4.15. Latent class model. Dependent variable: Choice

	CLASS 1	CLASS 2	CLASS 3	CLASS 4	CLASS 1	CLASS 2	CLASS 3	CLASS 4
Variable	Coeff. (S.e.)				Monetary Valuations (£)			
ASC	-.934*** (.202)	6.30*** (.466)	1.67*** (.291)	2.68*** (.152)	-200.8	2797.2	461	947.3
Distance: 120 Miles	.187** (.089)	2.24*** (.361)	4.55*** (.221)	1.30*** (.101)	40.3	996.9	1253	459.7
Distance: 60 Miles	.026 (.100)	.798* (.416)	3.30*** (.178)	.902*** (.101)	→0	354.5	908	318
Distance: 30 Miles	.277*** (.079)	.054 (.501)	1.75*** (.149)	.648*** (.108)	59.6	→0	483	229.1
Waste Reduction	.297*** (.027)	.361*** (.080)	.520*** (.049)	.237*** (.030)	63.8	160.6	143	83.9
Emission Reduction	.478*** (.041)	.402*** (.140)	.666*** (.062)	.373*** (.041)	102.7	178.6	183	131.9
Hospitals	.698*** (.070)	.458*** (.211)	1.12*** (.105)	.701*** (.065)	150.1	203.7	309	247.6
Land Recovery	.269*** (.056)	-.098 (.226)	.405*** (.087)	.446*** (.062)	57.8	→0	111	157.7
Bill Reduction	.004*** (.000)	.002*** (.000)	.003*** (.000)	.002*** (.001)				
Class membership function								
Constant	.900*** (.116)	-.511*** (.151)	.074 (.140)	0[a]	/	/	/	/
Confidence	.293** (.144)	-.435*** (.152)	.186 (.170)	0[a]	/	/	/	/
Risks	-.353*** (.127)	.305** (.155)	.050 (.149)	0[a]	/	/	/	/
Benefits	.180 (.146)	-.442*** (.166)	.094 (.171)	0[a]	/	/	/	/
Average class probability	0.47	0.16	0.193	0.178	0.47	0.16	0.193	0.178
Log-Likelihood	-5291.885							
Pseudo R^2	0.321							
Observations	7096							

Robust standard errors estimated. [a]: constrained values. [b]: not defined.

The remaining three segments are associated to a size of 53.1%. They all have a positive and significant coefficient associated to the ASC variable. Segment 2 presents the highest level of compensation required to build new nuclear plants, totaling 2797 £ per year. Respondents linked to this class do not value land recovery measures. Instead, those more likely to belong to segment 3 and 4 would require a much lower compensation, amounting to 461 and 947 £ respectively. Across the four segments, the third one values ‘emissions reduction’ and the building of new hospitals the most, whilst being highly concerned about ‘distance’. Instead, segment 2 seems to particularly value ‘nuclear waste reductions’.

The inspection of the class membership function allows to further characterize these segments. Segment 1 has the largest and positive magnitude of the coefficients attached to the score factors of the constructs ‘confidence’ and ‘perceived benefits’. At the same time, it is linked to the largest and negative magnitude of the coefficient attached to the score factors of ‘perceived risks’. Those more likely to belong to this segment can be defined as moderate supporters of the IV generation technology. Instead, respondents more likely to be assigned to segment 2 are characterized by a lessened degree of confidence and less perceived benefits, whilst envisaging more risks. Although open to receive compensations, they seem to strongly oppose the building of new nuclear plants. Finally, segment 3 and 4 appear to be portray moderate opposers. They are associated with smaller coefficients when it comes to ‘confidence’ and ‘perceived benefits’. A greater coefficient is attached to perceived risks compared to segment 1, although to a lower extent if compared to the segment of the strong opposers. Segments 3 and 4 differ with respect to the compensation required at varying distance levels. In the following sections, we will be referring to respondents belonging to segment 3 as moderate opposers type A, willing to forgo 1252 pounds for a nuclear plant 120 miles away. Individuals belonging to segment 4 will be labeled moderate opposers type B, associated with a valuation of 459 pounds as far as the same distance is considered. Type A respondents value waste reductions, emission reductions and building of new hospitals to a greater extent than type B respondents do.

The characterization of the segments appears to be validated by the inspection of the number of the "none" alternative chosen by segments. For this purpose, we considered the highest individual class membership probability across segments in order to allocate respondents. The vast majority (84%) of those allocated to segment 1, the moderate supporters, always chose one of the projects (either A or B). On the contrary, we find that 70% of respondents belonging to segment 2, the strong opposers, chose 'none' of the projects. Moderate opposers type A instead, belonging to segment 3, have a share of 'none' very similar to segment 1. Finally, moderate opposers type B, mostly chose 'none' between 2 and 4 times (85%).

4.5.5 Analysis of contingent valuation data

We begin the analysis of CV data by inspecting the distribution of the amounts stated, presented in Figure 4.7. First, a large cluster is observed in correspondence of the value zero. 50% of the respondents stated a zero WTP for supporting further research and development of IV generation nuclear energy. Considering positive WTP only, the average amounts to 33.75 GBP, whereas the median is equal to 10 GBP. We also asked these respondents to state to what extent they were certain that they would have really paid the amount stated. 13.3% declared to be 'not certain at all', whereas 54.4% were 'somewhat certain' and 32.1% 'very certain'. Average WTP increases with the degree of certainty in committing to the payment, ranging from GBP 19.1 for those not certain to 45.8 GBP for those most certain.

With regards to the motivations of respondents with a positive WTP, 30% stated to be in favour of the IV generation technology. 28% declared to be in favour of nuclear energy in general. However, for 13.7% warm glow seems to be behind the positive WTP, believing 'it is a good cause like many other'. Among those with a zero WTP, almost half (47%) said they could not afford it. 34.5% think the industry should pay for this development, 25.7% believe existing tax funds should be used and 23% stated to be against nuclear energy in general. Fewer respondents (7.6%) said not to be concerned about climate change and 13.5% indicated to prefer other energy sources.

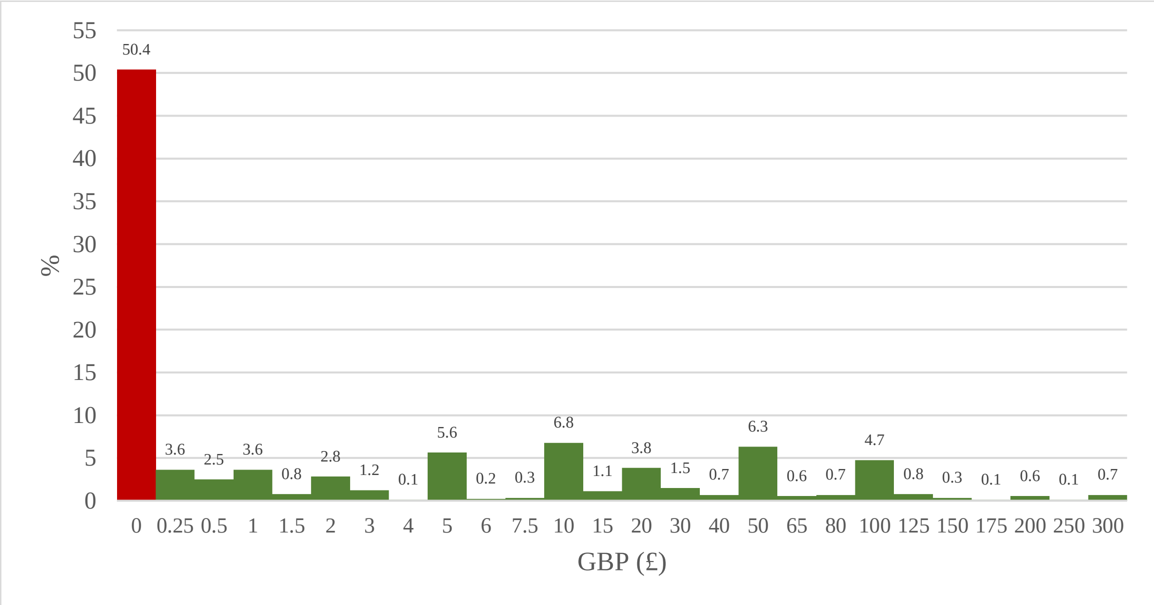

Figure 4.7: Distribution of stated WTP (close ended)

Given the (expected) highly asymmetrical distribution of the stated WTP, it was applied the following logarithmic distribution: WTP=log(WTP+1). This represents the dependent variable included in both the models specified in equations (1) and (2). The following models were estimated: OLS applied to all the sampled respondents (model OLS (1) in Table 4.16), OLS applied to sampled respondents excluding those deemed to have stated a positive WTP due to warm glow and those saying to be 'Not certain at all' (model OLS (2) in Table 4.16). Similarly, two quantile regressions have been applied to these two samples (QR (1) and (2) in Table 16), in both cases for the quantiles θ=0.5 and 0.75.

Across the six equations a significant positive effect is associated to those in favour of investing in nuclear, worried about climate change[46] and those who stated to have heard before of IV generation technology. Furthermore, there is evidence of a positive coefficient associated to confidence and perceived benefits, whereas a negative effect is attached to perceived risks. Yet, these effects are not significant across all the six equations considered. Confidence becomes not significant when considering sample (2). Furthermore, the effect attached to perceived risks is not significant when taking into account the quantile regressions applied to the full sample. Also, views towards benefits of nuclear energy are only significant when considering the full sample. Additional findings emerge with respect to a few socio-demographic attributes: older age groups and respondents with income greater than 20K (reference category) are more likely to state a positive WTP.

[46] Individuals more worried about climate change are more favourable towards IV generation nuclear, wind energy and solar, whilst being less favourable towards current nuclear energy technology, in line with Corner et al. (2011).

Table 4.16. Contingent valuation data: OLS and QR models

Variable	OLS (1)	OLS (2)	QR (1) Q(.5)	QR (1) Q(.75)	QR (2) Q(.5)	QR (2) Q(.75)
	Coeff. (S.e.)					
Confidence	.174*** (.063)	.077 (.099)	.121** (.047)	.206** (.100)	-.064 (.121)	.062 (.121)
Perceived Risks	-.224*** (.067)	-.343*** (.095)	-.066 (.051)	-.130 (.114)	-.305** (.121)	-.291** (.120)
Perceived Benefits	.123*** (.068)	.004 (.109)	.088* (.051)	.252** (.108)	.178 (.136)	.101 (.139)
Invest in Nuclear	.180 *** (.042)	.113* (.062)	.152*** (.031)	.451*** (.072)	.186** (.078)	.126 (.081)
Income: 20K to 40K	.440*** (.119)	.687*** (.175)	.114 (.090)	.934*** (.198)	.597*** (.223)	.703*** (.208)
Income: 40K to 60K	.424*** (.159)	.397* (.216)	.220* (.121)	.603** (.262)	.244 (.275)	.461* (.264)
Income: More than 60K	.473** (.201)	.657** (.274)	.147 (.152)	.385 (.338)	.551* (.342)	.376 (.335)
Gender	.041 (.110)	-.175 (.153)	.065 (.083)	-.115 (.182)	-.268 (.193)	-.180 (.188)
Age: 50+	.001 (.123)	.455*** (.176)	-.141 (.093)	-.014 (.207)	.561** (.223)	.383* (.209)
Degree holders	.087 (.106)	-.088 (.146)	.023 (.046)	.033 (.176)	-.149 (.185)	-.059 (.179)
Kids in household	.064 (.060)	.042 (.083)	.023 (.046)	.144 (.101)	.134 (.104)	.005 (.096)
England	-.166 (.149)	-.216 (.208)	-.014 (.112)	.036 (.249)	-.225 (.264)	-.026 (.253)
Scotland	-.109 (.182)	-.045 (.257)	-.086 (.137)	.023 (.307)	-.078 (.325)	-.034 (.307)
Conservative & Liberal	.177 (.139)	-.159 (.191)	.219* (.106)	.267 (.229)	-.334 (.241)	-.159 (.231)
Labour Party	.271* (.139)	.164 (.197)	.135 (.105)	.399 (.229)	.368 (.248)	.096 (.239)

Fukushima accident: very and extremely serious	.186* (.109)	.284* (.150)	.092 (.082)	.118 (.184)	.256 (.190)	.398** (.183)
Heard of IV G	.944*** (.191)	.575** (.230)	1.67*** (.145)	1.37*** (.323)	.806*** (.292)	.713** (.290)
Info_T	.009 (.103)	.005 (.143)	-.004 (.078)	-.036 (.171)	-.203 (.182)	-.027 (.178)
Worried	.243*** (.069)	.227** (.100)	.134*** (.052)	.280** (.114)	.296** (.124)	.182 (.122)
Constant	.287 (.279)	1.89*** (.400)	-.068 (.209)	.343 (.449)	1.83*** (.502)	2.83*** (.467)
R squared	.197	.204	.088	.193	.136	.107
Observations	871	384	871	871	384	384

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

Table 4.17. Analysis of CV data: Variables employed in Table 4.16

Source	Question	Scale/ Levels
Confidence	Score factor	Continuous
Perceived Risks	Score factor	Continuous
Perceived Benefits	Score factor	Continuous
Invest in Nuclear	How much should the UK government invest in nuclear energy?	0: Do not know, 1: Nothing, 2: A little, 3: Some, 4: A lot
Income: 20K to 40K	Annual household income before tax	1: 20K to 40K, 0: otherwise
Income: 40K to 60K	Annual household income before tax	1: 40K to 60K, 0: otherwise
Income: More than 60K	Annual household income before tax	1: more than 60K, 0: otherwise
Gender	What is your gender?	1: Male, 2: Female
Age: 50+	Age group:	1:50+ years old, 0: otherwise
Degree holders	Has university degree:	1: has university degree, 0: otherwise
Kids in household	How many children under the age of 16 live in your household?	1: 0, 2:1, 3:2, 4:3, 5:4, 6:5 or more
England	Where is your normal place of residence?	1: England, 0: otherwise

Scotland	Where is your normal place of residence?	1: Scotland, 0: otherwise
Conservative & Liberal	What is your favourite political party?	1: Conservative and liberal, 0: otherwise
Labour Party	What is your favourite political party?	1: labour party, 0: otherwise
Fukushima accident: very and extremely serious	How serious was the Fukushima accident?	1: very or extremely serious, 0: otherwise
Heard of IV G	Have you ever heard of IV generation nuclear energy?	1: Yes, 0: No/DK
Info_T	Information treatment	1: Has received the information treatment, 0: otherwise
Worried	Score factor	Continuous

4.6 Multivariate analysis

4.6.1 Correspondence between CE and CV data

This section aims to assess whether the choice experiments and contingent valuation results are aligned and to explore the latent CE segments further. Four segments were detected after applying a latent class estimator to the CE data. It was suggested the presence of moderate supporters, strong opposers and moderate opposers. Moderate supporters are characterized by a negative coefficient attached to the 'none' option. Hence, we expect them to be associated with the greatest stated willingness to pay for R&D of the same technology. At the same time, strong opposers should present the largest share of zero WTP and the lowest stated positive WTP. Finally, moderate opposers type A and B should be positioned somewhere in the middle.

Table 4.18 shows overall mean WTP and standard deviation, the share of zero WTP as well as the mean WTP and S.D. when excluding zero bids. Overall, results conform to expectations. Moderate supporters have the highest mean WTP and the lowest share of zero WTP. Conversely, strong opposers stated the lowest WTP, with almost 8 in 10 indicating a zero WTP. Opposers of type A and B are located in the middle, with the former associated with a lower overall bid. This is in line with the greater valuation attached to each level of distance considered.

Table 4.18: Stated WTP by segment (£ unless % specified)

Class	Label	Overall Mean £[a]	Overall S.D. £[a]	% Zero WTP	Mean positive WTP	S.D. Positive WTP
1	Moderate Supporters	21.9	42.6	41%	37.2	50.2
2	Strong opposers	6.1	30.5	79%	29.0	61.9
3	Opposers A	12.8	33.7	48%	24.7	43.7
4	Opposers B	17.5	46.0	48%	33.9	59.6

[a]Includes zero WTP. Moderate supporters: Respondents allocated with highest probability to class 1. Strong Opposers: Respondents allocated with highest probability to class 2. Opposers A: Respondents allocated with highest probability to class 3. Opposers B: Respondents allocated with highest probability to class 4. Given that the allocation to the segments is probabilistic, a proper statistical test cannot be performed.

All in all, higher WTP is observed among the following individuals: those who heard of IV generation prior to the study, more confident towards the fulfilment of the technology's goals, more concerned with the risks, wanting the UK to invest in nuclear and more worried about climate change. In consonance with this, the segment of the moderate supporters has the largest share of respondents with prior knowledge of IV generation (11%). Finally, it includes the greatest share of respondents favouring investments in nuclear energy[47].

4.6.2 Stated WTP by increasing concern towards climate change

Previous research found acceptance of nuclear energy in the UK to be negatively related to concerns towards climate change (Corner et al. 2011). Accordingly, in this section it is tested whether the mean of the score factor for the construct 'Worried' is significantly different when considering preferences for different energy sources. We found that individuals more concerned towards climate change, namely presenting a greater score factor, are more likely to state a positive WTP to support further IV generation R&D. Table 4.19 shows the significantly higher mean for score factor of the construct 'Worried' among respondents with a positive WTP. Yet, those supporting investment in current nuclear energy technology seem less concerned about climate change, in line with previous research. This is also the case of individuals who support investments in fossil fuels. These are associated with lower means of the score factor of 'Worried'. Conversely, respondents favouring wind and solar energy are associated to a significantly greater mean of the score factor, indicating a heightened degree of concern towards climate change.

[47] 30% would want the UK to invest a lot in nuclear energy, as opposed to 4.8% among the strong opposers, 17.1% among opposers type A and 20.3% among opposers type B.

Table 4.19. Mean and S.D. of the score factors of the construct 'Worried' by preference for energy source and WTP

T statistic[a]	Mean of score factor 'Worried'	S.D.	Base	Mean of score factor 'Worried'	S.D.	Base
	Respondents with Positive WTP for IV gen			*Respondents with Zero WTP for IV gen*		
-2.779	0.078	0.847	438	-0.0782	0.825	440
	Support investment in Nuclear			*No support for investment in Nuclear*		
4.368	-0.1501	0.8891	351	0.0999	0.789	527
	Support investment in Wind			*No support for investment in Wind*		
-5.808	0.1718	0.799	412	-0.1519	0.845	466
	Support investment in Solar			*No support for investment in Solar*		
-6.136	0.169	0.793	442	-0.171	0.85	436
	Support investment in Fossil Fuels			*No support for investment in Fossil Fuels*		
1.89	-0.084	0.842	252	0.033	0.836	626

S.D.: Standard Deviation. [a]T-test employed.

4.6.3 Sensitivity to information

In this section it is briefly discussed the impact of information provision in terms of CE and CV results. Starting with the CE, it was noted in section 4.5.4 that the information treatment variable included in the class membership probability of a latent class model specification has no significant impact in influencing segment allocation. In addition, we estimated a RPL model with heterogeneity decomposition, presented in Table 4.20. In this model, all parameters were assumed to be normally distributed.

Table 4.20. RPL-Information Treatment. Dependent variable: Choice

Variable	β	β*Info_T	S.D.
		Coeff. (S.e.)	
ASC	.334 (.301)	.585 (.391)	5.03*** (.248)
Distance: 120 Miles	1.28*** (.119)	.024 (.164)	1.03*** (.099)
Distance: 60 Miles	1.00*** (.121)	-.224 (.167)	.543*** (.169)
Distance: 30 Miles	.617*** (.102)	.056 (.142)	.363** (.147)
Waste Reduction	.385*** (.035)	-.080* (.048)	.196*** (.051)
Emission Reduction	.591*** (.054)	-.062 (.075)	.524*** (.056)
Hospitals	1.02*** (.092)	-.233* (.126)	.917*** (.090)
Land Recovery	.358*** (.074)	-057 (.105)	.619*** (.101)
Bill Reduction (€)	.005*** (.000)	-.0007 (.0005)	.003*** (.000)
Log-Likelihood		-5386.753	
R squared		0.309	
Observations		7096	

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

Besides the mean and the standard deviation of the random parameters, it was also estimated a series of interactions between the mean and the dichotomous variable representing the provision of the information treatment (=1), or otherwise (=0). When inspecting the significance of these interactions, it appears that only two out of nine are significant. In particular, it seems individuals that received the information treatment value the construction of hospitals and the reduction of nuclear waste to a lower extent. However, there is no indication that the treatment has led to greater opposition towards nuclear energy, as instead observed in the Italy case study. Furthermore, CV results appeared not be influenced by the information treatment either (see Table 4.16).

4.7 Conclusion

With the aim of reaching the GHG emission target and gradually reducing fossil fuels consumption, the UK envisages a future with a focus on renewable energy sources and nuclear energy. The decommissioning of most of the existing nuclear reactors is scheduled to happen soon. At the same time, investments in new nuclear plants are planned to at least maintain the current share of nuclear in the energy mix. Focusing on IV generation nuclear energy technology, this study adds to the literature on social acceptance of nuclear energy. Moreover, this work investigates the role of confidence towards the achievement of IV generation's aims, as well as the role of information provision. Furthermore, it offers a joint implementation of CE and CV methods.

The surveyed respondents live in a country with nuclear plants in operation. This provided the opportunity to test whether trust towards corporations and authorities in the field of nuclear energy positively affects confidence towards the IV generation technology objectives. Results suggest evidence in support of this hypothesis. We employed a structural equation model, where we postulated trust affects the following endogenous constructs: perceived risks, benefits, and confidence. A greater level of trust is linked to a lower level of perceived risks on one hand, and to heightened perceived benefits on the other one. As found by Ansolabehere and Konisky (2009), Greenberg (2009), Siegrist and Cvetkovich

(2000), Greenberg and Truelove (2011), Bronfman et al. (2012), there is evidence of the importance of the role of corporations and authorities in affecting social acceptance of nuclear energy. This work has shown that this kind of trust helps to cast a positive light on a nuclear energy technology under R&D.

The score factors of the constructs 'perceived benefits', 'risks' and 'confidence' were included in the class membership function of the latent class estimator applied to the choice experiment data. These constructs were previously investigated in de Groot et al. (2013), where their links with egoistic, altruistic and biospheric values were discussed. Four distinct segments of preferences were found: moderate supporters, strong opposers, opposers type A and type B. Moderate supporters are characterized by a negative coefficients attached to the 'none' option. That is, they were more likely to choose one of the projects presented instead of opting out. Respondents who are more confident towards the achievement of the IV generation technology goals are more likely to be allocated to this class. At the same time, they tend to score higher on 'perceived benefits' and lower on 'perceived risks' score factors. On the other hand, strong opposers present the lowest level of 'confidence' and 'perceived benefits', whilst highly focusing on the risks. In between we find opposers of type A and B, with the latter group characterized by a lower monetary compensation required for any level of distance. Results appear to be fairly aligned to the findings of Chapter 3, where three segments were found: moderate supporters, opposers and strong opposers. As in that study, a segment of respondents seem to favour the construction of IV generation nuclear plants, provided the R&D goals are achieved. However, in this case none of the segments appear to refuse monetary compensations. This is in line with previous research suggesting that respondents from countries with nuclear plants in operation tend to be more supportive towards nuclear energy (OECD 2010).

A key difference between the UK and Italy study is found with respect to the impact of the information treatment. This did not affect preferences measured in the choice experiment or the willingness to pay elicited through the contingent valuation exercise. As far as the CE data is considered, it was not found a significant effect of the information treatment on class allocation. Neither was found a substantial effect when estimating a random parameters logit model with heterogeneity decomposition. Similarly, there are no significant differences in willingness to pay comparing the group of treated versus non treated respondents, either in terms of average WTP or share of zero WTP. In contrast, it was found a higher opposition among information-treated Italian respondents (Chapter 3). This was expressed in a significantly greater ASC and in information-treated respondents who were more likely to be allocated into the class of the strong opposers. It is worth mentioning that research has highlighted the medium of communication may be more important than the message itself (Schulz et al. 2011; Utz et al. 2013). Further research could investigate whether this matters in the context of social acceptance of nuclear energy.

Choice experiments results appear to be aligned with the contingent valuation results. Perceived risks, benefits and confidence affect both willingness to accept new nuclear plants and willingness to pay for further R&D of IV generation technology. Respondents with prior knowledge of IV generation, whose largest share is found within the class of the moderate supporters, present a higher WTP for further R&D. What is more, as observed in the CE results with regards to WTA, the information treatment seems not to have affected stated WTP. A correspondence between class allocation and stated WTP was also found. Moderate supporters stated 21 GBP on average, whereas opposers type A and B stated 12 and 17 GBP respectively, and strong opposers only 6 GBP. Even among strong opposers there are individuals willing to support the funding of further R&D, although to a substantially lower extent than compared to moderate supporters. At the same time, a sizable share of moderate supporters stated zero WTP. This is an example of how segments' characterization can be further explored and validated by means of such complementary information, linking CE with CV data.

The preferred energy sources are hydroelectric, solar, photovoltaic, and wind (as previously shown in Fimereli 2011, Pidgeon et al. 2008, Upham et al. 2009). As found in Pidgeon et al. (2008), views towards current nuclear energy technology in the UK continue to be mixed. When looking at IV generation nuclear energy technology the picture is similar: almost half of the respondents seem to be favourable towards this option. We found greater social acceptance among individuals who feel more confident the IV generation technology's goals will be achieved, as observed in the Italy case study. Besides heightening confidence trough nurturing trust, linking future projects with their resulting benefits is crucial to foster social acceptance. Previous research has suggested these benefits should be both public, such as a lower GHG emission or the construction of hospitals, as well as private ones, for instance electricity bill's reductions (Strazzera et al. 2012).

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Appendix

Table 4.A1. Variables used in the CE econometric models

Choice Experiments-Utility function Variables	Type	Mean	S.D.	Min	Max
ASC	Dichotomous	0.33	0.47	0.00	1.00
Distance 120 Miles	Dichotomous	0.17	0.37	0.00	1.00
Distance 60 Miles	Dichotomous	0.17	0.37	0.00	1.00
Distance 30 Miles	Dichotomous	0.17	0.37	0.00	1.00
Waste 30 %	Dichotomous	0.17	0.37	0.00	1.00
Waste 20 %	Dichotomous	0.17	0.37	0.00	1.00
Waste 10 %	Dichotomous	0.17	0.37	0.00	1.00
Emission Reduction	Three levels	0.66	0.80	0.00	2.00
Hospital	Dichotomous	0.30	0.45	0.00	1.00
Land Recovery	Dichotomous	0.30	0.45	0.00	1.00
Bill Reduction	£/household/year	116.4	134.4	0.00	349.2
Choice Experiments-Segment membership Variables					
Confidence	Score factors	-9.41e-10	.957	-2.96	2.68
Risk	Score factors	-2.35e-09	.970	-2.39	1.99
Benefits	Score factors	-1.82e-09	.934	-3.19	2.26

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 4.A2. Latent class model. Dependent variable: Choice

Variable	CLASS 1	CLASS 2	CLASS 3	CLASS 4	CLASS 1	CLASS 2	CLASS 3	CLASS 4
	Coeff. (S.e.)				Monetary Valuations (£)			
ASC	-.941*** (.203)	6.30*** (.466)	1.69*** (.295)	2.67*** (.153)	-202.2	2797.7	463.7	946.2
Distance: 120 Miles	.191** (.090)	2.24*** (.361)	4.60*** (.224)	1.30*** (.101)	41.1	997.7	1262.1	462
Distance: 60 Miles	.028 (.100)	.800*** (.415)	3.33*** (.180)	.903*** (.102)	→0	355.2	914.9	320.1
Distance: 30 Miles	.277*** (.079)	.061 (.500)	1.77*** (.151)	.650*** (.107)	59.5	→0	487.6	230.3
Waste Reduction	.297*** (.027)	.361*** (.080)	.523*** (.050)	.237*** (.030)	63.8	160.7	143.7	84
Emission Reduction	.477*** (.041)	.401*** (.140)	.670*** (.063)	.373*** (.041)	102.6	178.5	183.9	132.2
Hospitals	.697*** (.070)	.463*** (.211)	1.13*** (.106)	.696*** (.066)	149.8	205.6	312.7	246.7
Land Recovery	.267*** (.056)	-.099 (.226)	.416*** (.087)	.444*** (.062)	57.5	→0	114.2	157.4
Bill Reduction	.004*** (.000)	.002*** (.000)	.003*** (.000)	.002*** (.001)				
Class membership function								
Constant	.929*** (.160)	-.549*** (.206)	.175 (.186)	0[a]	/	/	/	/
Info_T	-.064 (.221)	.060 (.268)	-.231 (.263)	0[a]	/	/	/	/
Confidence	.292 (.144)	-.440*** (.152)	.179 (.169)	0[a]	/	/	/	/
Risks	-.354*** (.128)	.309** (.155)	.040 (.149)	0[a]	/	/	/	/
Benefits	.179 (.169)	-.439*** (.166)	.094 (.171)	0[a]	/	/	/	/

Average class probability	0.469	0.161	0.191	0.178	0.469	0.161	0.191	0.178
Log-Likelihood	-5291.193							
Pseudo R^2	0.321							
Observations	7096							

Robust standard errors estimated. [a]: constrained values. [b]: not defined.

Table 4.A3. Experimental Design

BLOCK	OPTION	Distance	Waste reduction	Emission Reduction	Hospitals	Land recovery measures	Bill reduction
1	A	15	30%	10%	YES	NO	0%
1	B	15	0%	20%	YES	YES	10%
1	A	15	0%	10%	NO	YES	10%
1	B	120	20%	0%	NO	NO	0%
1	A	60	10%	0%	NO	NO	0%
1	B	60	30%	10%	YES	NO	20%
1	A	15	10%	20%	NO	NO	30%
1	B	30	10%	10%	NO	YES	30%
1	A	120	0%	10%	YES	YES	0%
1	B	15	0%	0%	YES	YES	10%
1	A	120	20%	10%	YES	YES	0%
1	B	30	0%	10%	NO	NO	10%
1	A	60	30%	10%	YES	YES	0%
1	B	120	0%	10%	YES	NO	20%
1	A	60	30%	20%	YES	NO	0%
1	B	60	20%	20%	NO	YES	0%
2	A	30	20%	20%	NO	YES	0%
2	B	120	10%	10%	NO	NO	10%
2	A	120	30%	0%	YES	YES	10%
2	B	15	20%	0%	NO	YES	30%
2	A	120	20%	10%	YES	NO	20%
2	B	30	30%	20%	YES	NO	10%
2	A	30	10%	20%	NO	NO	10%
2	B	30	10%	10%	NO	YES	0%
2	A	60	10%	20%	NO	YES	10%
2	B	30	30%	10%	NO	YES	20%
2	A	15	0%	20%	YES	YES	0%
2	B	30	10%	0%	NO	NO	30%
2	A	15	0%	20%	NO	NO	30%
2	B	60	0%	20%	NO	NO	0%
2	A	60	20%	0%	YES	YES	10%
2	B	120	20%	0%	NO	YES	30%
3	A	60	10%	0%	NO	YES	30%
3	B	30	20%	0%	NO	NO	0%
3	A	120	30%	0%	NO	YES	0%
3	B	15	0%	0%	YES	NO	0%
3	A	120	0%	0%	NO	YES	10%
3	B	15	20%	20%	NO	NO	20%
3	A	60	30%	0%	YES	NO	10%
3	B	60	10%	20%	NO	YES	30%
3	A	30	0%	0%	YES	NO	20%

BLOCK	OPTION	Distance	Waste reduction	Emission Reduction	Hospitals	Land recovery measures	Bill reduction
3	B	120	0%	20%	YES	NO	10%
3	A	30	30%	20%	YES	NO	20%
3	B	60	20%	20%	NO	YES	20%
3	A	15	0%	10%	YES	YES	20%
3	B	60	20%	10%	NO	NO	30%
3	A	15	30%	10%	YES	NO	20%
3	B	120	20%	0%	YES	NO	10%
4	A	15	20%	0%	NO	NO	30%
4	B	30	0%	20%	YES	NO	20%
4	A	15	20%	10%	NO	NO	30%
4	B	15	30%	0%	NO	NO	30%
4	A	60	20%	20%	YES	NO	10%
4	B	15	30%	0%	YES	YES	30%
4	A	30	10%	0%	YES	NO	20%
4	B	15	30%	0%	NO	YES	10%
4	A	60	10%	20%	NO	NO	30%
4	B	30	0%	20%	YES	YES	0%
4	A	120	30%	20%	NO	NO	10%
4	B	30	10%	10%	NO	YES	30%
4	A	30	0%	0%	NO	YES	30%
4	B	120	30%	10%	YES	NO	20%
4	A	120	0%	0%	NO	NO	30%
4	B	120	10%	20%	YES	NO	20%
5	A	30	20%	10%	NO	YES	20%
5	B	60	0%	10%	YES	NO	20%
5	A	120	0%	10%	NO	NO	20%
5	B	60	10%	0%	YES	YES	10%
5	A	30	10%	20%	YES	YES	0%
5	B	15	20%	10%	NO	YES	0%
5	A	15	20%	10%	YES	YES	30%
5	B	15	10%	0%	YES	YES	20%
5	A	30	10%	0%	YES	NO	20%
5	B	60	10%	20%	NO	NO	0%
5	A	120	10%	10%	NO	NO	30%
5	B	120	30%	20%	NO	YES	10%
5	A	30	20%	20%	NO	NO	20%
5	B	120	30%	10%	YES	NO	0%
5	A	60	30%	10%	NO	YES	10%
5	B	15	30%	10%	NO	NO	30%

Chapter 5

Individual preferences for nuclear energy in the UAE: Exploring the effect of transient residency and life satisfaction[48]

[48] I acknowledge and greatly value the constructive discussions and comments received from Ozgur Kaya, American University of Sharjah, UAE.

Abstract

The United Arab Emirates (UAE) is going to be the first Arab state to have nuclear energy for electricity generation. A great deal of studies have investigated the importance of social acceptance of nuclear energy to guarantee a successful implementation of nuclear projects. The UAE is characterized by a high share of expatriates who live only part of their lives in the country. This distinctive population structure offers the opportunity to investigate the effect of transient residency on acceptance of and preferences towards nuclear energy. We conducted this investigation by designing a choice experiment-based survey, targeting an online nation-wide sample. In addition, the survey collected information on respondents' perception of benefits and risks of nuclear energy. Further, data on life satisfaction was gathered. Results show that transient individuals, and even more if satisfied with their life in the UAE, are significantly less likely to oppose the construction of new nuclear plants. These individuals are characterized by an amplified positive perception of benefits over risks arising from nuclear energy.

5.1 Introduction

The UAE's decision to invest in nuclear is supported by the forecasted growth in energy demand and associated GHG emissions. The nation has been enjoying one of the world's largest reserve of hydrocarbon (Masdar/IRENA 2015). Yet, it saw its population tripling in the last 15 years. This, together with a sustained economic growth, has expanded energy demand (Mezher et al. 2012; Jayaraman et al. 2015). Demand for electricity increased more than twofold with an average annual growth rate of about 9% during the last decade and it is estimated to double by 2020 (Early 2010; Mokri et al. 2013). Almost 98% of the current electricity generation in the UAE is based on natural gas-powered plants, leading to an increased production of GHG emissions (Omri 2013; Jayaraman et al. 2015). The CO_2 emissions level in the UAE has more than doubled between 1990 and 2008 (Kazim, 2007; Qader 2009; Arouri 2012; AlFarra and Abu-Hijleh 2012) and since then it has increased further, from 143.89 Mt in 2008 to 167.61 Mt in 2013 (IEA 2016). The UAE has committed to the Kyoto Protocol and planned to reduce CO_2 emissions by 30% by 2030 (Sbia et al. 2014). In light of these considerations, it is necessary to modify the energy mix, which should shift to energy sources with zero or next to zero emissions. This means increasing the share of renewable energy sources and considering nuclear energy. Incidentally, a number of simulation studies suggest the inclusion of nuclear energy in the UAE's mix to be a promising strategy to tackle GHC emissions (AlFarra and Abu-Hijleh 2012; Jayaraman et al. 2015; Betancourt-Torcat and Almansoori 2015).

With the aim of developing a highly successful nuclear program, the UAE signed bilateral nuclear-cooperation agreements with the US, Korea and France. In addition, it took on memoranda of understanding with the UK and Japan, consulted leading nuclear suppliers and made clear its willingness to forsake a full nuclear cycle[49] (Early 2010; Strategic Comments 2010). This strategy has made the UAE the first Arab state on its way to possess nuclear power for electricity generation. A successful implementation of a nuclear energy programme usually requires social acceptance of nuclear energy. This is of particular relevance in countries where citizens can request referenda and potentially veto government's choices in terms of energy policy. For example, this has been the case of Italy after both the Chernobyl and the Fukushima accidents. Yet, even in countries where a referendum is not a possibility, opposition to nuclear energy may raise costs of project's implementation, for instance by causing delays. These, in turn, can lead to cost escalation (Khatib and Difiglio 2016). Costs from opposition may also be of a less direct type. For instance, negative views towards nuclear energy either from the public or international organizations, could result in negative international media coverage. This, in turn, may hinder future influxes of expatriates and tourists[50]. Importantly, the entity responsible for the deployment and operation of the UAE nuclear energy programme, Emirates Nuclear Energy Corporation (ENEC), acknowledges the importance of public opinion, as demonstrated by polls commissioned (ENEC 2011) and open public forums hosted (ENEC 2014).

The total population in the UAE is over 9 million and non-nationals make up more than 80% of the total population (Koch 2016). This particular setting represents a great opportunity to investigate social acceptance of nuclear energy in the context of transient

[49] Besides, spent fuel is planned to be stored in dry storage systems after a phase of storage in spent fuel pools (Al Saadi and Yi 2015).

[50] The mental picture individuals build about a destination is likely to be negatively affected by negative media coverage (Konecnik 2004). The Emirate of Dubai has been defined as a model for destination branding (Balakrishnan 2008).

residents, namely individuals who spend only part of their life in the country. There is currently no access to citizenship nor unconditional permanent residency for non-UAE nationals: at some point, expatriates would most likely have to leave the country. This trait is common across all of these individuals. However, expatriates in the UAE constitute a highly heterogeneous group. For instance, it comprises individuals with different backgrounds, nationalities, culture and social status (Hills and Atkins 2013), as well as facing different challenges and rewards in the workplace (Koch 2016).

This study employs a stated preference technique, choice experiments, in order to estimate willingness to accept (WTA) nuclear power plants in the UAE. We surveyed a representative sample of the online population in terms of age, gender and nationality group. To the best of our knowledge, this is the first study employing choice experiments in this country in order to investigate social acceptance of nuclear energy. There does not seem to be evidence of such methodology applied to investigate social acceptance of other energy sources either. Besides, the nuclear energy option seems to be economically attractive for the other Gulf Cooperation Council (GCC) countries as well, namely Saudi Arabia, Kuwait, Bahrain, Qatar and Oman (Sultan 2013), which also have substantial shares of transient residents. Hence, the results of this study can also contribute towards research on social acceptance of nuclear power in the GCC. The rest of the chapter is organized as follows: section 2 presents background information on public attitudes towards nuclear energy and life satisfaction in the UAE; section 3 describes the methodology employed; section 4 contains the descriptive statistics; section 5 describes the CE results; finally, section 6 concludes.

5.2 Public attitudes towards nuclear energy and life satisfaction in the UAE

Research on social acceptance of nuclear energy in the UAE has considerable scope for improvement. Two face-to-face polls were conducted in 2011 and 2012 by the market research company TNS for ENEC. It is argued that in 2011 more than 8 in 10 individuals believed that a peaceful nuclear energy program is important for the nation (ENEC 2011). This share grew to almost 9 in 10 in 2012 (WNN 2013). Interestingly, views presented in the 2012 study appeared to be even more in favour of a nuclear plant being built in their emirate of residence (89%, up from 67% in 2011). Our research question is highly related with this support among the UAE residents. Similarly as other GCC countries, the UAE is characterized by a demographic structure where a high share of expatriates make up the highest share of the total resident population. This study aims to investigate the impact of transiency of residence on attitudes and preferences towards nuclear energy.

Transient residents might lack shared hopes and desires for the future of the society (Forstenlechner and Rutledge 2011). Yet, as discussed in Koch (2016), nationalism is frequently exhibited by non-citizens in the UAE. This is linked to the concept of place attachment which, albeit defined in a great deal of ways and multidimensional (Scannell and Gifford 2010), appears to stem from the place dependence and place identity individuals develop over time (Anton and Lawrence 2014). Place attachment can foster acceptance or opposition towards a proposed project depending on how this is evaluated by the public, namely as a threat or an opportunity (Devine-Wright 2011). A place that allows individuals to satisfy their needs and reach their goals, besides being evaluated in a positive way compared to the alternatives, is more likely to foster place dependence. In turn, place dependence tends to precede place identity and should develop in transient residents who came to the country in search for, and found, better opportunities. Hence, expatriates who are more satisfied with their life in the UAE should be more likely to develop a sense of place dependence towards the country[51].

Life satisfaction is one of the subjective measures of welfare denoted with the term 'subjective well-being', employed to assess experienced utility (Kahneman and Krueger 2006) and value non-market goods (Van den Berg and Ferrer-I-Carbonell 2007; Dolan and Metcalfe 2012; Levinson 2012; MacKerron 2012; MacKerron and Mourato 2013). In addition, life satisfaction is of substantial policy relevance for the UAE: the 2021 UAE vision includes fostering happiness among the residents. According to the World Happiness Report (WHR 2016), in 2016 the UAE ranked 28th among 157 countries, first among Arab countries[52]. In this study, we include life satisfaction into our analysis to assess whether expatriates experienced an overall improvement in their lives after coming to the UAE and whether this improvement, or lack of it, affects the respondents' views on nuclear acceptance.

5.3 Methodology

5.3.1 Experimental design

The choice experiment scenarios asked respondents to imagine they had a chance to choose between a series of options regarding the construction of current generation nuclear power plants in the UAE. The selection of attributes and levels was informed by previous studies conducted in Italy and the UK, as well as by literature review. The four attributes chosen were: 'atmospheric emission reductions', 'distance from the nuclear power plant',

[51] Nationalism is here viewed as a broader place attachment (see Bonaiuto et al. 1996).
[52] GCC countries: Qatar 36th, Kuwait 41st, Bahrain 42nd, Saudi Arabia 118th, Oman not included in the ranking.

‘construction of parks or other recreational spaces’ and ‘water, gas and electricity bill reductions’. Table 5.1 shows the attributes and their levels.

Table 5.1. Attributes and levels of the choice experiments

Attributes	Levels
Distance from the nuclear plant	20, 50, 100, or 200 Km from the city of residence/house
Atmospheric emission reduction	20%, 10% or no reduction
Construction of parks/recreational spaces	Yes or No
Water, Gas and Electricity bill reduction	30%, 20%, 10% or no reduction

The attributes ‘distance from the nuclear plant’ and ‘emission reductions’ proved to be of significant relevance in analogous studies carried out in Italy and UK. Distance is a key element considering the nuclear plants pose potential threats to the environment (Beheshti 2011) and human health (Fairlie 2013). ‘Construction of parks and other recreational spaces’ was included as an attribute so as to introduce the potential public benefits typically associated with the construction of nuclear plants (Yamane et al. 2011; Gregory et al. 1991; Mansfield et al. 2002). Finally, ‘water, gas and electricity bill reduction’ was incorporated as the monetary attribute (Strazzera et al. 2012). A combination of water, gas and electricity bill reduction, as opposed to a simple electricity bill reduction, was included due to the relatively low prices of electricity bill in the UAE (Mezher et al. 2012; Griffiths and Mills 2016).

Respondents were presented with a series of four choice tasks consisting of pairs of nuclear energy scenarios. These were characterized by combinations of the attributes’ levels depicted in Table 5.1. Each exercise required to choose the most preferred scenario in each comparison presented. There was also a 'none' option. That is, it was possible to choose neither of the two options. Hence, these choice experiments presented two unlabeled alternatives (Project A and Project B) and a labelled alternative (None). An example of such choice tasks is displayed in Figure 5.1. Given four attributes and their levels, with two options per choice task, the total number of possible experimental choice task combinations is 9216[53]. This is clearly excessive and it was therefore necessary to reduce the number of choice tasks to present by means of an experimental design. A Bayesian efficient design (Sándor and Wedel 2001; Rose and Bliemer 2009) was prepared. Priors were derived from analogous CE studies conducted in Italy and UK. The final design consists of 8 blocks of 4 choice tasks each (Appendix, Table 5.A2).

[redacted]

Figure 5.1: Example of choice task

[53] 4 distance levels * 3 emission reduction levels * 4 bill reduction levels * 2 public investments = 96 scenarios. As each choice card comprises a pair of scenarios, the total number of all possible pairs is 96*96=9216.

5.3.2 Questionnaire design and data collection

The questionnaire was administered online between June and July 2015. We made use of respondents provided by a market research company (YouGov), who voluntarily sign up to be members of the panel and receive surveys. Respondents could complete the survey either in English or Arabic, based on their preference.

In addition to the choice experiment, the survey collected extensive information on socio-economic characteristics and attitudes, including views on climate change, views on different energy sources, perceived risks and benefits of nuclear energy and awareness of nuclear accidents. The survey flow was designed to incentivize the respondents to think carefully about energy and climate change issues before taking part in a CE focused on nuclear energy. At the start of the survey, respondents were also asked to state their level of life satisfaction. As shown in Figure 5.2, individuals were invited to think about their life in general and in the UAE specifically. In this way, it is possible to compute a measure of relative life satisfaction. That is, the extent to which individuals are more, less, or as much as satisfied in the UAE as opposed to in general. Individuals associated with higher values of this measure, meaning more satisfied in the UAE, are expected to be more likely to develop place attachment.

Please think for a moment about **how satisfied you are with your life**. On a scale from 1 to 10, where 1 means "Not at all satisfied" and 10 means "Extremely satisfied",

-How satisfied are you overall with your life **in general**?

-How satisfied are you overall with your life **in the UAE**?

Figure 5.2: Life Satisfaction question

5.4 Descriptive statistics

5.4.1 Sample characteristics

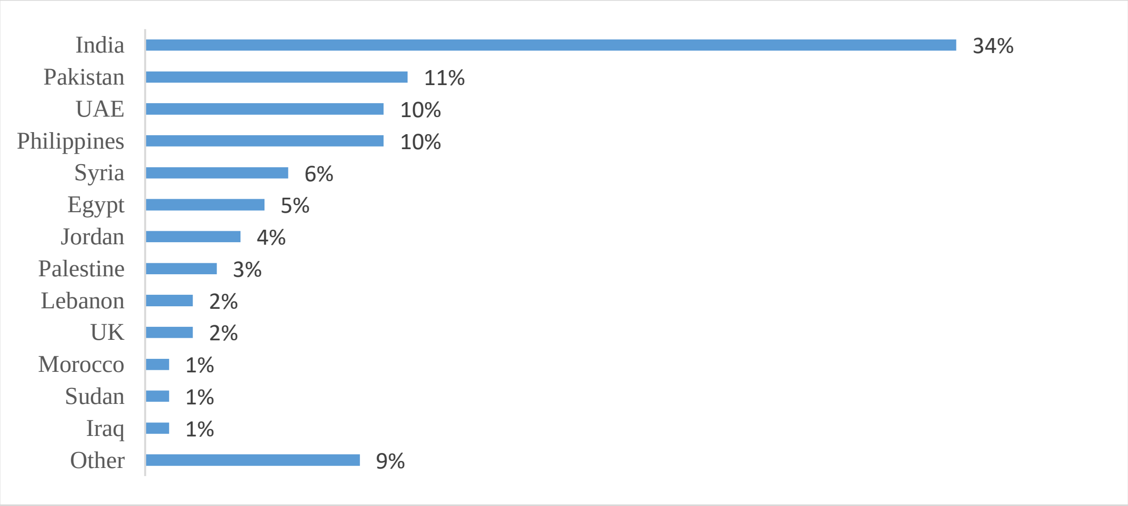

Figure 5.3: Sample % by nationality

The questionnaire was completed by 1,961 respondents residing in the UAE. Quotas on age, gender and nationality group were set so as to be in line with the target population: UAE residents aged 18 and more. 62 different nationalities took part in the survey, the majority belonging to India (34%), Pakistan (11%), Philippines (10%) and UAE (10%), as depicted in Figure 5.3. In order to define the segment of transient expat residents, we rely on stated intention to leave the country. We consider as transient those who intend to leave within the next ten years. Overall, they constitute 38% of the total sample and 42% of the expatriates. Other expatriates, who do not plan to leave the UAE in the next ten years, make up 52% of the sampled respondents.

Table 5.2 presents summary statistics at the total level, and for the following segments considered throughout the study: UAE nationals, transient and other expats. A considerable difference is found with respect to the emirate of residence: transient respondents are associated with the lowest share of Abu Dhabi residents (20%), whereas 57% reside in

Dubai. In line with the population's structure of the UAE, only 20% of the sampled respondents were born in the UAE.

Table 5.2. Sample structure by socio-demographic variables

	All	Transient	Emirati	Other expats
	N=1961	N=738	N=197	N=1026
Gender				
Male	64.7	67.3	70.1	61.8
Female	35.3	32.7	29.9	38.2
Emirate of residence				
Dubai	49.8	57.5	51.8	44
Abu Dhabi	24.2	19.6	30.5	26.3
Sharjah	17.4	16	9.1	20
Other	8.6	6.9	8.6	9.7
Marital status				
Single-never married	34.5	37.1	32.5	33
Married without kids	15.8	17.6	13.7	14.8
Married with kids	47.4	43	49.2	50.2
Divorced	2	2	4.6	1.6
Widow/widower	0.3	0.3	0	0.4
Employment				
Working full time	70	78.2	58.4	66.4
Working part time	8.7	8.5	19.8	6.6
Full time student	4.8	3.4	8.6	5.2
Retired	0.8	0.7	2.5	0.6
Full-time home-maker or housewife	8.3	4.2	5.1	11.8
Unemployed	6.6	4.6	4.6	8.5
Other	0.8	0.4	1	1
Were you born in the UAE?				
Yes	20.2	6.1	64	21.9
No	79.8	93.9	36	78.1
For how many years have you been living in the UAE				
Less than 1 year	8	10.7	2.5	7
1-2 years	11.4	18	3.6	8.2
3-4 years	12.1	17.8	4.6	9.5
5-6 years	9.8	11.1	5.6	9.6
7-8 years	10.7	11	5.1	11.5
9-10 years	6.7	6.9	3.6	7.1
11-15 years	10.1	10.7	5.6	10.6
16-20 years	8.7	6.5	10.2	9.9
21-30 years	12.7	5	23.9	16.2
More than 30 years	9.8	2.3	35.5	10.3

How long are you planning to stay in the UAE				
Less than 3 months	1.6	4.1	1	0
3 – 6 months	1.2	2.7	1.5	0
6 – 12 months	1.5	3.7	1.5	0
1 – 2 years	7.1	17.2	6.6	0
3 – 4 years	10.5	26	7.1	0
5 – 6 years	9.9	25.1	4.6	0
7 – 10 years	8.4	21.3	3.6	0
More than 10 years	12.5	0	11.2	21.8
I do not plan to move out of the UAE	28.1	0	54.3	43.4
Do not know	19.1	0	8.6	34.8

This share grows substantially among UAE nationals (64%). The lowest share of those who were born in the country is found among transient expats (6%). UAE nationals are also, unsurprisingly, the group of respondents who have been living longer in the country: 6 in 10 have stayed for more than 20 years. Instead, only 7% of transient residents have stayed in the country for so long. Considering employment, almost 8 out of 10 transient residents work full time. This is the highest share across the groups considered, whereas Emiratis have the lowest share (58%). Emiratis and transient expats share the lowest level of unemployed (4.6%). With regards to marital status, gender and average age, no remarkable differences across groups are noticed. More than half of the respondents (65%) are male and average age is 33.8 years. Furthermore, almost half of the sample consists of respondents who are married with children (47%), while 35% are single. Finally, with regards to monthly personal income, the highest share is observed for the category AED 5,001-AED 10,000 (22%), followed by AED 2,001-AED 5000 (19%)[54]. More transient

[54] The UAE dirham is pegged to the US dollar (fixed at a rate of AED 3.67 to US $1) since 1997 to date. So AED 5,001- 10,000 is equivalent to US $1360 - $2720. Also, note that as of September 2017 there is no income tax in the UAE.

residents have a lower income: 38% up to 5000 AED; whereas Emiratis are the richest, with 35.5% indicating an income of 25000 AED or more (Table 5.3).

Table 5.3. Descriptive statistics: Income

	ALL	Transient	Emirati	Other expats
	N=1961	N=738	N=197	N=1026
Up to 5000 AED	28.8	33.6	18.3	27.4
AED 5,001 to 10,000	22.2	23.4	14.7	22.7
AED 10,001 to 15,000	12	13.7	10.7	11
AED 15,001 – 20,000	6.7	6.6	4.1	7.2
AED 20,001 – 25,000	4.2	5.4	5.6	3.1
AED 25,001 and more	13.3	11.1	35.5	10.5
Don't know/prefer not to say	12.9	6.1	11.2	18

5.4.2 Views towards climate change

The majority of the sampled respondents indicated to be concerned about climate change (Table 5.4). In particular, on a scale from 1 'Not at all concerned' to 10 'Very concerned', 21% stated to be very concerned. Among Emiratis the share of those very concerned decreases to 19%. The survey contained also statements on climate change in order to unveil traits of potential skepticism and extent of concern (Table 5.5). The majority of individuals (59%) believe that 'average temperature will increase in the UAE'. Furthermore, a substantial share (48%) sees as likely or very likely that 'climate change will have catastrophic consequences in the UAE in the long run'. Fewer believe that catastrophic consequences will be seen in the short term (36%).

Table 5.4. How concerned are you, as individual, about climate change?

	All	Transient	Emirati	Other expats
	N=1961	N=738	N=197	N=1026
1:Not concerned at all	3.1	1.8	3.6	3.9
2	1.1	0.7	2.5	1.1
3	1.5	2.2	1	1.2
4	2.3	1.6	3	2.6
5	10.5	7.9	16.8	11.2
6	14	15.6	14.2	12.9
7	19	19.4	22.8	17.9
8	17.2	17.9	10.7	17.9
9	10.1	12.9	6.6	8.9
10:Very concerned	21.2	20.2	18.8	22.4

Table 5.5. Attitudes towards climate change

	All	Transient	Emirati	Other expats
	N=1961	N=738	N=197	N=1026
Climate change will have catastrophic consequences in the UAE in the short term				
Very unlikely	8.1	7.3	15.7	7.2
Unlikely	17.3	16.3	13.2	18.8
Neutral	38.9	36.4	46.7	39.1
Likely	28.8	32	16.2	28.8
Very likely	6.8	7.7	8.1	5.8
Climate change will have catastrophic consequences in the UAE in the long run				
Very unlikely	5	4.7	9.6	4.4
Unlikely	11.1	11.9	15.2	9.7
Neutral	35.8	31.4	41.6	37.8
Likely	32.2	34.4	22.8	32.4
Very likely	15.6	17.1	10.7	15.4
UAE's emission contribute to climate change				
Very unlikely	4.2	2.3	11.7	4.1
Unlikely	10.3	10	11.2	10.3
Neutral	39.8	35.4	47.2	41.5
Likely	33.5	37.3	21.3	33
Very likely	11.7	14.5	8.1	10.4
Average temperature will increase in the UAE				
Very unlikely	4	3.1	9.6	3.6
Unlikely	8.3	8.8	9.6	7.6
Neutral	28.7	26.4	36	28.8
Likely	40.6	42.8	31	40.8
Very likely	17.6	17.8	12.7	18.5

The Earth has a natural feedback mechanism that protects it from catastrophic impacts				
Very unlikely	6.2	6	10.2	5.6
Unlikely	12.2	13.6	11.7	11.3
Neutral	44.9	43.2	44.2	46.3
Likely	26.8	27.5	19.8	27.6
Very likely	9.3	9.5	12.7	8.6
Climate change is the result of natural climate variability				
Very unlikely	6.8	6.8	9.6	6.3
Unlikely	14	14.1	11.7	14.4
Neutral	39.3	37.3	43.7	40
Likely	29.5	31.4	21.3	29.7
Very likely	9.7	9.9	13.2	8.9
The impacts of climate change are over emphasized				
Very unlikely	11.3	10.3	14.2	11.5
Unlikely	17.6	18.6	12.2	17.9
Neutral	40.4	37.8	44.7	41.4
Likely	22.9	24.5	20.3	22.3
Very likely	7	8	8.6	6

Transient respondents see catastrophic events associated with climate change to be more likely as opposed to UAE nationals, both in the short term (40% versus 24%) and in the long run (51% versus 33.5%). Fewer Emiratis believe ‘UAE’s emission are likely to contribute to climate change’ (29%) when compared to transient residents (52%) and other expats (43.5%). According to 6 in 10 expats, which include transient residents and other expats, it is likely that average temperature will increase in the UAE; instead, only 44% of Emiratis believe so. Yet, 4 in 10 transient expats think it is likely that ‘climate change is the result of natural climate variability’. This share drops to 34.5% among UAE nationals.

Respondents were also asked whether the risks of nuclear energy are justified by its benefits and contribution to decreasing the impact of climate change. At the overall level, only 3 in 10 believe it is the case. A slightly higher share of transient residents believe so (36.6%), as opposed to UAE nationals (30%) and other expats (28%). The share of those agreeing with the possibility of nuclear energy helping to tackle climate change decreases to just 22% among women, as opposed to 36.7% among men.

5.4.3 Preferences towards different energy sources

In this section we discuss preferences towards different energy sources, including nuclear energy (Table 5.6). Solar/photovoltaic seems to be the most favoured energy source. On the opposite end we find coal. For both traditional and 'clean' coal it is found the greatest share of dislikes. Behind renewable energy we find nuclear. Although 11% of the respondents would not want the UAE to invest anything on nuclear energy, 26% would like the nation to invest a lot on it. A similar share, 24%, selected 'I do not know'. This indicates that a substantial part of the respondents do not have a clear stance on the matter. A greater share of respondents are not sure about clean coal (31%), geothermal (32%) and biomass (35%). A few differences emerge when comparing UAE nationals with expats. More Emirati would like the UAE to invest in nuclear as opposed to transient residents (57% versus 52%). Instead, transient respondents prefer investments in solar/photovoltaic to a higher extent compared to Emiratis (75% versus 67%). Finally, a greater share of transient respondents (71%) prefer investments in oil compared to Emiratis (62%).

Table 5.6. In your opinion, how much should the UAE invest in?

	All	Transient	Emirati	Other expats
	N=1961	N=738	N=197	N=1026
Wind				
Nothing	5.6	5.1	8.1	5.5
A little	11.5	13	10.7	10.6
Some	26.5	30.5	24.9	23.9
A lot	36.6	36	37.6	36.7
Do not know	19.8	15.3	18.8	23.3
Solar/Photovoltaic				
Nothing	3.8	4.3	6.1	2.9
A little	6.2	8.3	9.1	4.2
Some	17.8	21.1	19.8	15.1
A lot	55.3	53.9	47.2	57.9
Do not know	16.8	12.3	17.8	19.9

Geothermal				
Nothing	7.5	8	7.6	7.1
A little	10.3	12.2	11.2	8.8
Some	24.8	30.2	24.4	21
A lot	25.4	23.2	29.4	26.3
Do not know	32	26.4	27.4	36.8
Nuclear				
Nothing	10.9	12.5	10.2	9.9
A little	13.7	16	12.2	12.4
Some	25.3	29	21.8	23.3
A lot	25.9	23.4	35	25.8
Do not know	24.2	19.1	20.8	28.6
Biomass				
Nothing	7.4	7.9	8.6	6.8
A little	10.8	13.6	10.7	8.9
Some	25.1	29.9	21.3	22.4
A lot	22	20.9	27.4	21.7
Do not know	34.7	27.8	32	40.2
Oil				
Nothing	5.5	6	7.6	4.8
A little	12	14.5	10.2	10.6
Some	26.7	30.6	27.9	23.7
A lot	41.4	40.7	34	43.3
Do not know	14.4	8.3	20.3	17.6
Gas				
Nothing	4.6	4.6	7.6	4
A little	12.4	16.7	13.2	9.3
Some	28.1	30.2	21.8	27.8
A lot	38.1	37.9	36	38.7
Do not know	16.7	10.6	21.3	20.3
Traditional coal				
Nothing	11.9	12.3	10.2	12
A little	14.4	17.1	14.7	12.5
Some	26.3	29.5	24.9	24.2
A lot	16.8	18.4	21.8	14.7
Do not know	30.5	22.6	28.4	36.6
Clean coal				
Nothing	19.4	19.9	17.3	19.5
A little	16.6	18.8	15.7	15.2
Some	23.5	27.6	20.8	21
A lot	11.3	11.2	16.8	10.2
Do not know	29.2	22.4	29.4	34.1

5.4.4 Perceived risks and benefits of nuclear energy

We now examine answers on a list of potential risks and benefits associated with nuclear energy. For each risk and benefit enumerated, respondents were probed to think about nuclear energy in the UAE and nuclear energy in general. The answers to these statements are presented in Table 5.7 and 5.8. The sum of 'likely' and 'very likely' statements is presented in figures 5.4 and 5.5. All in all, the UAE is associated with significantly lower perceived risks, whereas no significant difference is found when considering benefits. When invited to think about nuclear energy in general, respondents indicated the risk of 'nuclear waste disposal accident' as the most likely (58%). This is followed by 'damages/threats to human health' (55%) and 'damages/threats to the environment' (53%). Instead, when requested to think about the UAE, they most frequently selected 'threats to human health' (45%) and 'nuclear waste disposal accidents' (44%). On the opposite end 'Terrorist attacks' and 'military use of nuclear power', which emerge as the least likely risks. With regards to perceived benefits, 'energy source diversification' and 'technology development' were selected most often, both when considering nuclear energy in general and in the UAE. Fewer respondents stated 'atmospheric emission reductions'.

Table 5.7. How likely are the following risks associated with nuclear energy…?

	All	Transient	Emirati	Other expats	All	Transient	Emirati	Other expats
	N=1961	N=738	N=197	N=1026	N=1961	N=738	N=197	N=1026
	…in general?				**…in the UAE?**			
Risk of catastrophic accidents								
Very unlikely	6.3	6.2	12.2	5.3	6.1	5	13.2	5.6
Unlikely	10.9	12.1	11.2	10	13.4	12.6	15.2	13.5
Neutral	30.8	27.9	34	32.3	40	38.8	37.6	41.4
Likely	32.6	34.8	27.4	32	27.4	29.7	23.4	26.5
Very likely	19.4	19	15.2	20.5	13.1	14	10.7	13
Damage/threats to the environment								
Very unlikely	4.6	3.9	8.6	4.4	5.9	5.1	9.1	5.8
Unlikely	11.6	12.7	14.7	10.2	14.4	14.1	18.3	13.8
Neutral	30.9	29.3	33	31.7	36.3	33.6	37.6	37.9
Likely	32.2	34.1	27.4	31.7	29	32.1	22.3	28
Very likely	20.7	19.9	16.2	22	14.5	15	12.7	14.4
Damage/threats to human health								
Very unlikely	4.4	3.8	8.6	4.1	6.7	5.8	10.7	6.5
Unlikely	10.2	12.3	10.7	8.7	12	11.9	11.7	12.2
Neutral	29.8	27.1	38.1	30.2	35.8	32.1	41.6	37.3
Likely	31.8	33.5	24.9	32	29.5	33.1	20.8	28.7
Very likely	23.7	23.3	17.8	25	16	17.1	15.2	15.3
Terrorist attacks								
Very unlikely	7.7	5.3	11.2	8.8	10.7	8.9	13.2	11.5
Unlikely	11.3	13.1	12.7	9.7	16.4	17.2	13.7	16.3
Neutral	31.2	29.3	33	32.3	36	33.1	34.5	38.4
Likely	29.7	32.4	28.9	27.9	24	27.5	25.9	21.1
Very likely	20.1	19.9	14.2	21.3	13	13.3	12.7	12.8
Military use of nuclear power								
Very unlikely	5.9	4.2	12.2	5.8	10.9	8	16.2	12
Unlikely	8.7	10	10.7	7.4	14.6	14.6	12.2	15
Neutral	33	31.8	33.5	33.7	37.2	35.4	34.5	39.1
Likely	30.6	33.1	23.9	30.2	25	29	22.8	22.6
Very likely	21.8	20.9	19.8	22.8	12.2	13	14.2	11.3

	Nuclear waste disposal accidents							
Very unlikely	5	3.7	9.1	5.3	7.2	4.6	10.2	8.5
Unlikely	8.1	8.5	11.2	7.1	12.2	11.7	16.2	11.9
Neutral	29.4	27.1	29.9	30.9	36.5	34.1	34	38.7
Likely	31.9	35.2	30.5	29.7	28.5	33.2	23.9	25.9
Very likely	25.7	25.5	19.3	27	15.6	16.4	15.7	15

A difference in ratings given to risks and benefits in the UAE emerges comparing different segments of respondents. When compared to UAE nationals, transient residents attach a greater likelihood to both risks and benefits. Looking at the perceived benefits of nuclear energy, more transient residents are optimistic about them, followed by other expats (Figure 5.4). In particular, almost 6 in 10 transient respondents believe that nuclear energy will contribute to 'energy source diversification'; fewer indicated as likely 'atmospheric emission reduction' (45%).

Table 5.8. How likely are the following benefits associated with nuclear energy…?

	All	Transient	Emirati	Other expats	All	Transient	Emirati	Other expats
	N=1961	N=738	N=197	N=1026	N=1961	N=738	N=197	N=1026
	…in general?				**…in the UAE?**			
	Atmospheric emission reduction							
Very unlikely	6.9	6.8	14.7	5.5	5.8	5.4	12.7	4.7
Unlikely	10.4	11.8	10.2	9.4	8.9	9.1	10.2	8.6
Neutral	45.4	41.3	43.1	48.7	43.2	40.2	40.6	45.9
Likely	28.1	31.3	19.3	27.5	30.1	32.4	23.4	29.8
Very likely	9.3	8.8	12.7	9	11.9	12.9	13.2	11
	Less reliance on fossil fuels							
Very unlikely	3.9	2.4	10.2	3.7	3.9	3.1	8.1	3.6
Unlikely	7.5	9.2	10.7	5.8	9.2	8.8	11.7	9
Neutral	39.1	37	37.6	40.9	40	37	40.6	42
Likely	34	35.5	27.4	34.2	30.7	34.3	23.4	29.6
Very likely	15.5	15.9	14.2	15.4	16.2	16.8	16.2	15.8

Economic growth								
Very unlikely	3.7	3.3	9.6	2.9	3.6	3.1	7.6	3.2
Unlikely	6	6.6	7.6	5.3	7.5	8.3	8.6	6.7
Neutral	39.5	39.7	38.1	39.7	36.8	35.2	38.6	37.5
Likely	34.6	34.3	25.9	36.5	32.7	34.6	26.9	32.5
Very likely	16.1	16.1	18.8	15.6	19.4	18.8	18.3	20.1
Energy sources diversification								
Very unlikely	3.2	2.4	8.1	2.7	3.4	2.6	8.1	3
Unlikely	6.5	7	10.7	5.3	6.9	6.2	9.1	6.9
Neutral	36.4	33.6	31.5	39.3	36.9	34.4	37.6	38.6
Likely	36.8	39.4	28.9	36.5	33.8	36.7	24.4	33.4
Very likely	17.2	17.5	20.8	16.3	19.1	20.1	20.8	18
Convenient energy prices								
Very unlikely	4.5	3.5	11.7	3.8	5.2	4.7	10.2	4.6
Unlikely	9.1	12.2	9.1	6.9	9	8.8	10.7	8.9
Neutral	39.7	36.4	36	42.7	38.9	36.6	40.6	40.2
Likely	32.2	31.8	26.9	33.4	31.6	33.6	21.8	32
Very likely	14.5	16	16.2	13.2	15.3	16.3	16.8	14.4
Technology innovation/development								
Very unlikely	3.8	3.3	10.2	3	3.9	3.3	8.6	3.4
Unlikely	5.7	6.2	7.6	4.9	6.3	6.8	8.1	5.6
Neutral	36.9	33.9	34.5	39.6	36.6	34.3	40.1	37.5
Likely	34.7	37.5	29.4	33.7	33.1	35.4	24.9	33.1
Very likely	18.9	19.1	18.3	18.8	20.1	20.3	18.3	20.4

Instead, other expatriates indicated most frequently ‘technology development/innovation’ (56%). Among Emiratis, ‘economic growth’ and ‘energy source diversification’ are perceived to be more likely (45%). With regards to perceived risks, ‘terrorist attacks’ and ‘military use of nuclear power’ are the least likely according to non-transient expats. UAE nationals are the segment attaching the lowest likelihood to the remaining risks listed, namely ‘risks of catastrophic accidents’, ‘damage/threats to the environment’, ‘damage/threats to human health’, ‘nuclear waste disposal accidents’.

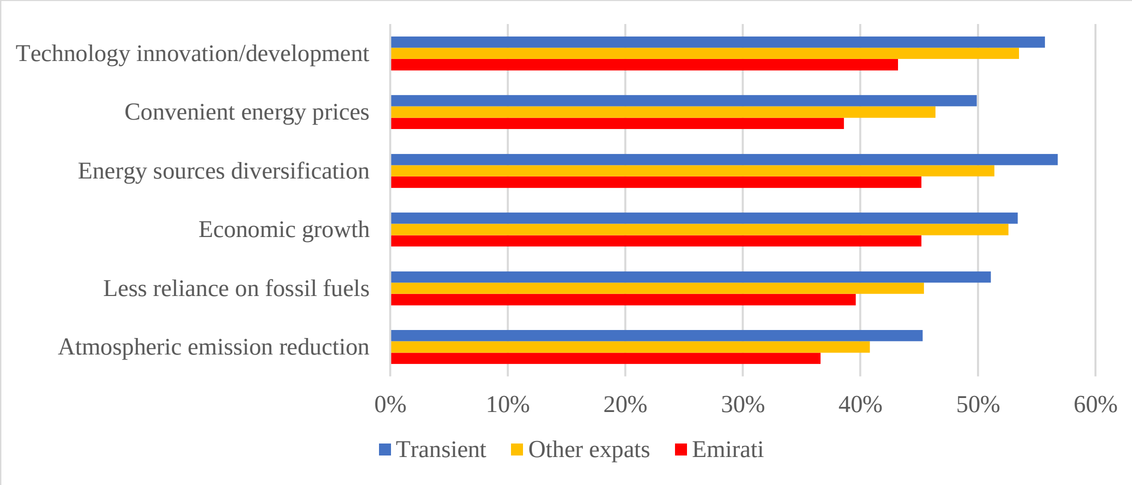

Figure 5.4: Perceived benefits of nuclear energy in the UAE-sum of likely & very likely

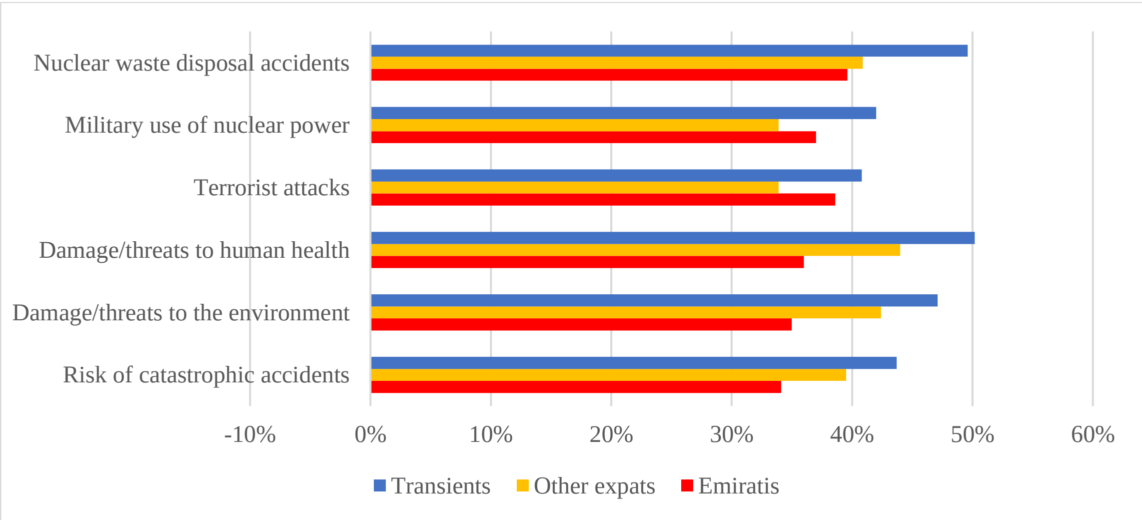

Figure 5.5: Perceived risks of nuclear energy in the UAE-sum of likely & very likely

5.4.5 Life satisfaction

Overall life satisfaction in the UAE is greater among Emirati respondents, with an average score of 7.6 out of 10 (as opposed to 6.7 for the remaining sample). 35% of UAE nationals selected a score of 10 (Very satisfied), as opposed to just 7.3% of transient residents and 16.4% of other expats. Across the whole sample, average life satisfaction amounts to 6.8. According to the World Happiness Report (2016), the UAE average score on a similar question is 6.6[55]. Considering only expatriates, we computed the difference between life satisfaction in general and life satisfaction in the UAE. Results are presented in Figure 5.6 and 5.7. 1 in 4 expatriates stated to be more satisfied in the UAE. This is the group of respondents expected to have a higher level of place dependence. Unsurprisingly, fewer of those with a greater life satisfaction in the UAE would intend to leave the country in the near future. 29% of other expats are less satisfied in the UAE, as opposed to 40% of the transient respondents. Also, 22% of transient residents declared to be more satisfied in the UAE as opposed to 28% of other expats.

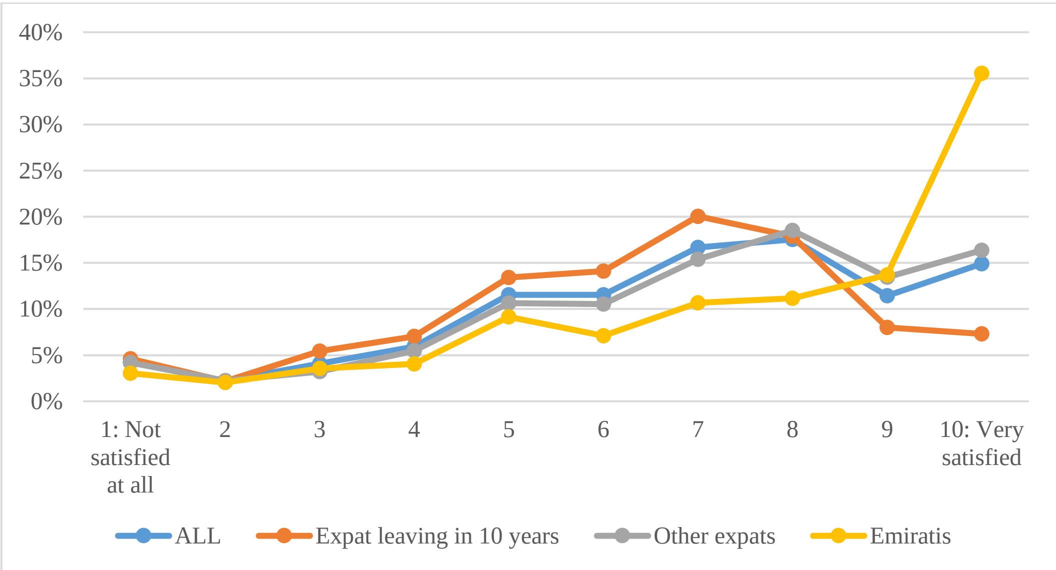

Figure 5.6: How satisfied are you, overall, with your life in the UAE?

[55] 'Please imagine a ladder, with steps numbered from 0 at the bottom to 10 at the top. The top of the ladder represents the best possible life for you and the bottom of the ladder represents the worst possible life for you. On which step of the ladder would you say you personally feel you stand at this time?'

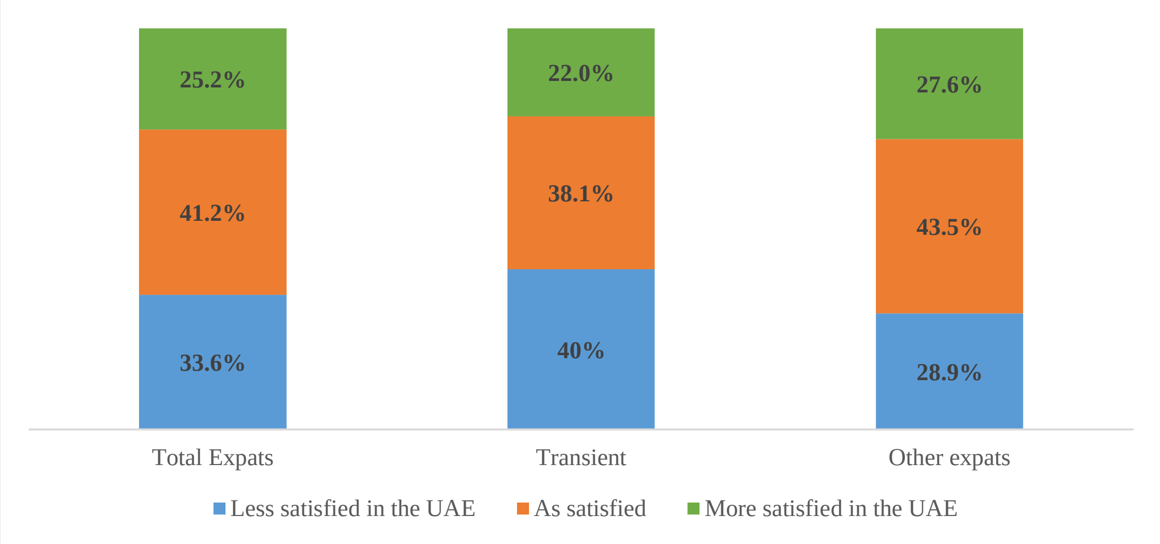

Figure 5.7: Difference between life satisfaction in general and in the UAE-Expatriates

5.5 Statistical and econometric model results

5.5.1 Factor analysis

Two independent factor analyses were run to assess the existence of the latent factors 'Perceived risks' and 'Perceived benefits'. One latent construct was derived from each analysis. Table 5.9 presents the resulting factor loadings and uniqueness' values. Considering perceived risks, most of the variance in the question 'threats to human health' is explained by the construct. Instead, with regards to perceived benefits, the item 'economic growth' has the smallest uniqueness. Given the factor loadings shown in Table 5.9 and the answers to each of the items, it is possible to compute a score for each latent factor for each respondent. In particular, the greater the factor loading associated with one item, the greater its weight in the computation of the individual scores. As it was observed that expats tended to give higher ratings to both perceived benefits and risks, we computed the differences between benefits and risks' score factors. We refer to this measure as net perceived benefits. This allows to determine whether a given respondent scores greater on the benefits or on the risks. A greater positive difference between benefits and risks is assumed to be associated with a higher degree of acceptance, all else equal.

Table 5.9. Perceived Risks and Benefits: Factor loadings and uniqueness by question

	ξ: Risks			ξ: Benefits	
	Factor Loadings	Uniqueness		Factor Loadings	Uniqueness
Catastrophic accidents	0.83	0.30	Atmospheric emission reduction	0.68	0.53
Threats to the environment	0.87	0.24	Less reliance on fossil fuels	0.73	0.45
Threats to the human health	0.88	0.21	Economic growth	0.79	0.36
Terrorist attacks	0.77	0.40	Energy source diversification	0.74	0.43
Military use of nuclear power	0.75	0.43	Stable/convenient energy prices	0.60	0.63
Risk of nuclear waste disposal accident	0.83	0.30	Technology development	0.66	0.56

A series of t-tests have been performed with the aim of assessing whether these differences are significantly higher by specific groups (Table 5.10). The groups considered are 1) expatriates less satisfied in the UAE, 2) expatriates who indicated the same level of satisfaction in the UAE and in general and 3) expatriates who stated to be more satisfied in the UAE. Also, we repeated the tests with the subset of expatriates planning to leave the country in the next 10 years (i.e. transient), leading to additional 3 groups according to the level of life satisfaction (bottom three rows in Table 5.10). Expatriates more satisfied in the UAE and stating to be leaving within the next 10 years are associated with the greatest and positive mean score factor of the net perceived benefits. Instead, expatriates less satisfied in the UAE display a negative value of the difference between the score factors of benefits and risks.

Table 5.10 Mean and S.D. of net perceived benefits by group

Segment	Mean	S.D.	Base	**Comparison group**	Mean	S.D.	Base	T-statistic
Total Expatriates less satisfied	-.154	1.240	592	Else	.066	1.31	1369	3.85
Total Expatriates as satisfied	.025	1.120	727	Else	-.014	1.19	1234	-.726
Total Expatriates more satisfied	.190	1.140	445	Else	-.055	1.17	1516	-3.91
Transient less satisfied	-.174	1.230	295	Else	.062	1.13	443	2.67
Transient as satisfied	-.046	1.140	281	Else	-.022	1.20	457	.265
Transient more satisfied	.252	1.100	162	Else	-.112	1.19	576	-3.49

5.5.2 MNL and RPL models

We start the analysis by examining how often the option 'none' was chosen. The share of respondents choosing the 'none' option is such that no particular concerns arise in terms of non-trading behavior. Only 10% of always chose none of the options, whereas 67.4% always chose either project A or B.

In the following econometric analysis, the deterministic component of the utility function is specified as follows[56]:

$$V_{ij} = \beta_1 ASC + \beta_2 Distance_{200\ Km} + \beta_3 Distance_{100\ Km} + \beta_4 Distance_{50\ Km} + \beta_5 Emission_{20\%} + \beta_6 Emissions_{10\%} + \beta_7 Parks + \beta_8 Bill$$

ASC refers to the alternative specific constant indicating which of the alternatives is the 'none' option. Therefore, the coefficient attached to it, β_1, describes whether respondents are more or less likely to choose none of the project. This is an indication of broad acceptance (β_1 negative) or opposition (β_1 positive) towards nuclear energy. Yet, the 'none' option could be chosen due to reasons other than acceptance or opposition, such as lack of preferred alternative, difficulty of the tasks.

Econometric analysis of choice experiment data started with a MNL model and a RPL model with all parameters assumed to be normally distributed, but the monetary attribute's coefficient held fixed. Estimated coefficients and monetary valuations are presented in Table 5.11. Although both models portray an analogous set of preferences, the RPL model seems to be preferable in terms of model fit as it reveals a substantial amount of preference heterogeneity. On the whole, these models show the presence of a positive attitude towards the nuclear option, as indicated by the negative and significant coefficient attached to the alternative specific constant (ASC). In addition, in line with expectations, respondents prefer nuclear projects located further away from their city of residence. They positively

[56] Variables' code is presented in Appendix, Table 5.A1.

value emission reductions, the building of parks and bill reductions. According to both models all estimated coefficients are significant, with the exception of β_4 (nuclear plant located 50 Km away). While there are non-linear effects attached to distance, no significant difference is present when comparing 20 and 50 Km.

Table 5.11. MNL and RPL models. Dependent variable: Choice

	MNL	**RPL**	**RPL**	**MNL**	**RPL**
Variable	Coeff. (S.e.)		S.D.	Monetary Valuations (AED)	
ASC	-.312*** (.065)	-2.46*** (.179)	4.10*** (.186)	-610.1	-4004.7
Distance: 200 Km	.495*** (.048)	.674*** (.055)	.536*** (.165)	966.4	1094.1
Distance: 100 Km	.317*** (.051)	.471*** (.057)	.023 (.113)	619.9	764.8
Distance: 50 Km	.000 (.047)	.073 (.054)	.325* (.184)	→0	→0
Emission Reduction: 20%	.157*** (.042)	.191*** (.045)	.044 (.133)	308.3	310.2
Emission Reduction: 10%	.125*** (.037)	.166*** (.039)	.011 (.115)	245.8	270.3
Parks	.114*** (.026)	.179*** (.032)	.008 (.082)	224.4	291.2
Bill Reduction (AED)	.0005*** (.000)	.0006*** (.000)	/	/	/
Log-Likelihood	-8143.71	-7009.40			
R squared	0.05	0.18			
Observations	7844	7844			

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

The monetary valuations, shown in the last two columns of Table 5.11 for the MNL and RPL respectively, represent the willingness to accept a compensation for a worse level of the attribute considered. At the same time they denote the willingness to forgo the same compensation so as to assure an improvement of the same attribute. Given that the monetary attribute, electricity bill, is expressed in terms of reductions' levels, the resulting monetary valuation are willingness to accept (WTA). Considering RPL estimates, it is found that respondents would prefer nuclear plants built away from their area of residence, as they would be willing to forgo over 1300 AED (US $354) a year for a nuclear plant located 200 Km away. This reduces to almost 900 AED (US $245) for a distance of 100 Km. On the whole, distance seems to be a key attribute for the respondents. Emission reductions are positively valued too, but not more than 380 AED (US $103) for 20% emissions reduction. Similarly, the building of parks is valued around 340 AED (US $93).

We then estimate a RPL model in willingness to pay space (Table 5.12), where the monetary attribute is assumed to be distributed according to a positive log-normal distribution; remaining coefficients assumed to be normally distributed. When allowing for heterogeneity in the cost parameter, monetary valuations appear to be substantially lower. Individuals seem to be willing to forgo only 578 AED (US $ 157) for a nuclear plant built 200 Km away, 482 AED if 100 Km away. Furthermore, emission reductions are not valued more than 62 AED (for a 10% decrease). Finally, the building of parks is valued 122 AED (US $ 33). This model with an additional parameter does not present a superior goodness of fit as opposed to the previous RPL where the cost parameter was set fixed.

Table 5.12. RPL model (WTP space). Dependent variable: Choice

Variable	Monetary Valuations (AED)	T ratios	S.D.	T ratios
ASC	-1318.2	1.09	28.8	0.39
Distance: 200 Km	578.2	1.1	85.5	0.32
Distance: 100 Km	482.9	0.8	64.6	0.16
Distance: 50 Km	77.5	4.2	19.3	0.18
Emission Reduction: 20%	51.3	0.46	67.4	2.3
Emission Reduction: 10%	62	1.36	13.0	0.16
Parks	122.4	76.9	3.37	0.23
Log-Likelihood	-7365.105			
R squared	0.15			
Observations	7844			

Distribution of the monetary attribute assumed to be (positive) log-normally distributed. S.D.: standard deviation. T ratio associated to the standard deviation of the monetary coefficient is 2.05.

5.5.3 RPL model with heterogeneity decomposition

We previously noticed that expatriates likely to leave the UAE within 10 years and more satisfied with their life in the UAE are associated with a greater net perceived benefit score. In order to further assess the effect of these variables on the choices, an RPL model with heterogeneity decomposition was estimated. This includes, for each utility's coefficient[57], two sets of interactions. The first one with a dummy variable identifying whether the respondent is an expatriate likely to leave within 10 years, namely a transient resident. The second interaction is with a dichotomous variable identifying whether the respondent is an expatriate more satisfied with his/her life in the UAE (regardless of whether he or she classifies as transient or not). The results belonging to this model that simultaneously

[57] All utility's coefficients are assumed normally distributed in this model.

incorporates these effects are presented in Table 5.13. For both sets of interactions, a significant effect is found with respect to the ASC: transient respondents and those more satisfied with their lives in the UAE are associated with a lower coefficient, translating into a lower probability of choosing none of the projects. In addition, respondents intending to leave are also associated with significantly lower coefficients for the attribute 'distance', thereby confirming a lessened degree of opposition.

Table 5.13. RPL model with heterogeneity decomposition. Dependent variable: Choice

	β	**β*Transient**	**β*Expat_MS**	**S.D.**
Variable	Coeff. (S.e.)			
ASC	-1.90*** (.205)	-1.03*** (.260)	-.666** (.305)	3.99*** (.183)
Distance: 200 Km	.711*** (.069)	-.197** (.100)	.031 (.114)	.497** (.163)
Distance: 100 Km	.469*** (.067)	-.108 (.100)	.008 (.115)	.046 (.108)
Emission Reduction: -30%	.210*** (.064)	-.022 (.091)	-.041 (.106)	.157 (.125)
Emission Reduction: -20%	.256*** (.056)	-.179** (.081)	-.055 (.093)	.005 (.101)
Parks	.171*** (.045)	-.074 (.066)	-.083 (.076)	.006 (.082)
Bill Reduction (AED)	.0005** (.0002)	.0001 (.0002)	.0002 (.0004)	.001*** (.0004)
Log-Likelihood	-6991.641			
R squared	0.188			
Observations	7844			

Level of significance: *10%, **5%, ***1%. Robust standard errors estimated. Model with monetary attribute set as log-normal failed to converge.

5.5.4 Latent class model

The latent class approach represents an alternative way to model preference heterogeneity (Boxall and Adamowicz 2002; Greene and Hensher 2003). As opposed to the RPL model according to which heterogeneity is modelled in a continuous fashion, the LC model assumes the existence of a given number of segments of preferences, different between and same within. The deterministic component of the utility function, conditional on each segment s, is as follows:

$$V_{ij|s} = \beta_{1|s}ASC + \beta_{2|s}Distance_{200\ Km} + \beta_3 Distance_{100\ Km} + \beta_{4|s}Emission_{20\%} + \beta_{5|s}Emissions_{10\%} + \beta_{6|s}Parks + \beta_{7|s}Bill$$

Different specification with increasing number of classes were prepared for estimation. However, models with more than two classes seemed to have issues in converging to a global optimum. Hence, a two class model is considered and presented in Table 5.14. This is a two classes' specification, with class membership function of whether expats are considering to leave the UAE within the next 10 years and whether respondents belong to the group of expatriates who declared to be more satisfied in the UAE. These two variables entering the class membership probability were also included as interactions within the RPL model with heterogeneity decomposition.

Table 5.14. Latent class model. Dependent variable: Choice

Variable	CLASS 1 Coeff. (S.e.)	CLASS 2 Coeff. (S.e.)	CLASS 1 Monetary valuation (AED)	CLASS 2 Monetary valuation (AED)
ASC	-1.82*** (.089)	2.31*** (.108)	-2644.4	3606.6
Distance: 200 Km	.643*** (.048)	.196*** (.103)	929.9	306.4
Distance: 100 Km	.462*** (.049)	-.143 (.119)	668.8	→0
Emission Reduction: 20%	.182*** (.045)	.056 (.109)	263.9	→0
Emission Reduction: 10%	.156*** (.039)	-.045 (.105)	225.9	→0
Parks	.159*** (.032)	.256*** (.083)	229.9	400.9
Bill Reduction (AED)	.0006*** (.0001)	.0006*** (.0002)	/	/
Class membership function				
Constant	1.15*** (.079)	0[a]	/	/
Transient	.438*** (.129)	0[a]	/	/
Expat_MS	.329*** (.151)	0[a]	/	/
Average class probability	0.8	0.2	0.8	0.2
Log-Likelihood	-7021.78			
Pseudo R^2	0.184			
Observations	7844			

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

The two segments are characterized as follows. The first class presents a negative value attached to the ASC. That is, individuals more likely to be associated with this class are more in favour of nuclear energy in the UAE. In addition, they would prefer nuclear plants away from their city of residence. Furthermore, they value emission reductions and the construction of parks and other recreational spaces, besides valuing water, gas and electricity bill's reductions. Those more likely to belong to the class 1 are more likely to leave the UAE within the next 10 years and to be more satisfied with their life in the UAE. Instead, the second class is characterized by a positive coefficient attached to the ASC, indicating a less favourable stance towards nuclear energy for individuals allocated to this segment. This segment groups individuals who do not value the reduction of atmospheric emissions to a significant extent. Yet, they do value significantly the building of parks and the provision of private benefits, namely water, gas and electricity bill reductions.

After the choice experiment exercise, respondents were directly asked to state their view towards the building of nuclear plants in the UAE. A 10 points scale was employed where 1 meant 'absolutely oppose nuclear plants in the UAE' and 10 'absolutely in favour of nuclear plants in the UAE'. This allows to validate the extent of support and opposition within each segment. Results are displayed in Figure 5.8. In line with expectations, class 2 has a higher share of clear nuclear energy opposers (25% selecting option 1, meaning 'absolutely oppose nuclear plants in the UAE'), a higher share of neutrals (47%) and less individuals in favour of nuclear energy in the country. Notably, in both segments, the share of neutral responses is substantial. All in all, segment 1 seems to be consisting of respondents more favourable towards nuclear energy. Instead, in segment 2 around half of the respondents are indifferent and almost 2 in 5 indicate an opposing attitude.

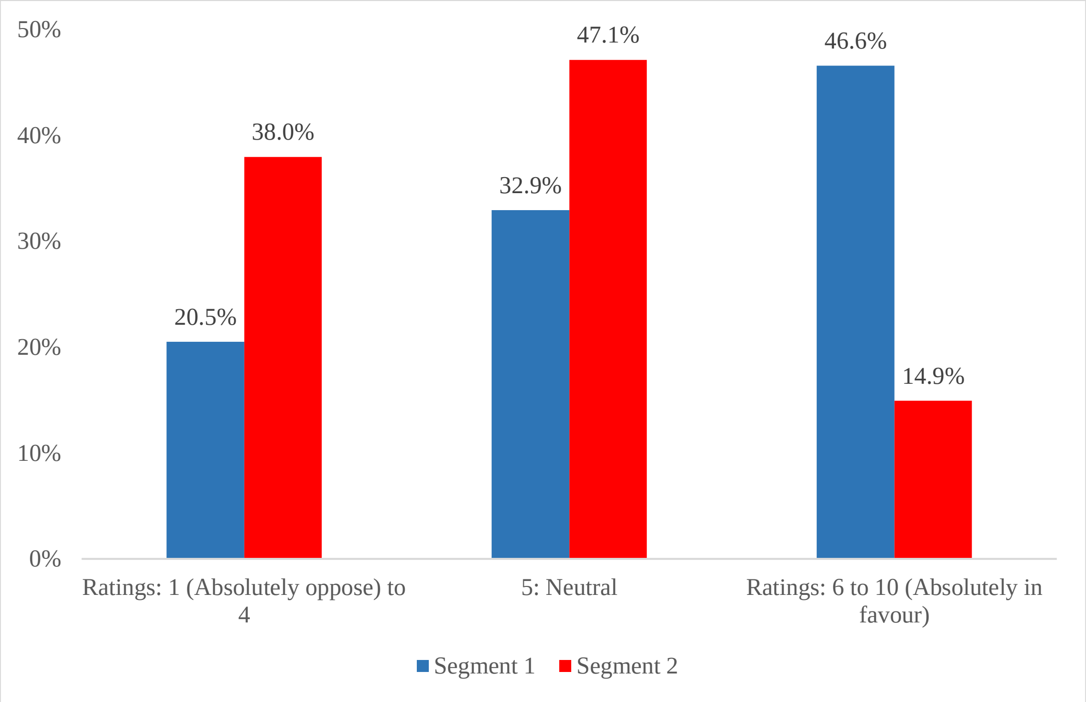

Figure 5.8: Views towards nuclear energy in the UAE by segment

5.6 Conclusion

The UAE's nuclear power program will see the first reactor completed by 2017 and 5.6 GWe are expected to be produced by 2020. This is a crucial step in the direction of dealing with increasing energy demand and moving towards decarbonizing the energy mix. The UAE has the advantage of learning from past disasters and having resources to aim to world class technology (Sultan 2013). This study investigated whether the UAE has an additional asset, namely favourable social acceptance of nuclear energy, and whether this can be linked to the high share of transient residents who are expected to be less likely to show opposition towards the building of nuclear plants in the country.

Part of the findings reveal the presence of support towards nuclear energy implementation in the UAE. First, only 11% would not want the UAE to invest in nuclear. This share is lower if compared to the analogous one found for UK (15%) and substantially lower when considering the case of Italy (45%) in the previous chapters. In addition, when asked to think about risks of nuclear energy in the UAE as opposed to risks of nuclear energy in general, respondents associated significantly lower risks to nuclear energy implementation in the UAE.

However, additional results suggest a more cautious stand towards acceptance of nuclear energy. Only 32% of respondents believe that the risks of nuclear energy are justified by its benefits and contribution to tackle climate change. In addition, renewable energy sources obtained a greater share of preferences, with solar and photovoltaic coming top. This shows support towards other plans and investments the government is also undertaking such as the development of a sustainable eco-neighbourhood, Masdar City (Reiche 2010), or Abu Dhabi's goal to generate 7% of its electricity from renewables by 2020 (Reiche 2010), and Dubai's 15% by 2030 (Griffiths and Mills 2016).

Respondents took part in a choice experiment exercise aimed at unveiling to what extent they value selected attributes of hypothetical nuclear energy projects, with no specific reference to the Barakah site, where the UAE is building four reactors. The resulting economic valuations are in line with those in the stated preference literature. It was found that the potential for nuclear energy to reduce GHG emissions is positively valued, as it is greater distance from the energy facility (Fimereli 2011) and the provision of public and private benefits (Strazzera et al. 2012). The latent class model findings depict a situation characterized by two distinct segments of preferences: one seems more in favour of nuclear and the other one more in opposition. Segment 1, the more nuclear prone one, is characterized by a negative and significant coefficient attached to the 'none' alternative (ASC variable), indicating respondents more likely to belong to this group were more likely to choose one of the projects rather than opting out. Instead, respondents associated with segment 2, the more opposing one, were more likely to choose none of the projects, thereby indicating less support towards nuclear energy. Interestingly, respondents who declared to to leave the UAE within 10 years seem more likely to be associated to the more nuclear energy prone segment. A similar positive effect in terms of segment 1's membership probability is also linked with life satisfaction: those who appear to be more satisfied with their life in the UAE tend to be allocated to segment 1. These findings are supported by a RPL model with heterogeneity decomposition, in which attributes were interacted with a dichotomous variable indicating whether the respondent is an expatriate likely to leave the country in the next 10 years and an additional variable specifying whether he/she is more satisfied with his/her life in the UAE. A significantly lower coefficient attached to the 'none' option is associated with transient respondents, and even lower if these are also more satisfied with their life in the UAE. These individuals are the least likely to opt out at any given choice task, therefore signaling a heightened level of acceptance.

The choice experiments results show the presence of two segments which both value private benefits, in the form of electricity bill reductions, as well as public benefits, namely the building of parks and other recreational spaces. Remarkably, UAE transient residents seem to be even more supportive of this energy policy's direction, being associated with the segment favouring nuclear to a greater extent. In addition, respondents who are more satisfied with their life in the UAE perceive more benefits as opposed to risks arising from nuclear energy implementation. In a nutshell the study suggests that transiency of residence, and to a greater extent if combined with life satisfaction, fosters acceptance of nuclear energy. Further research is envisaged to investigate social acceptance of nuclear energy in other GCC countries. In particular, it appears relevant to assess views and preferences in

Saudi Arabia and Qatar, given their closeness to the Barakah site and the presence of a substantial share of expatriates.

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Appendix

Table 5.A1. Variables used in the CE econometric models

Choice Experiments-Utility function Variables	Type	Mean	S.D.	Min	Max
ASC	Dichotomous	0.30	0.46	0.00	1.00
Distance 200 Km	Dichotomous	0.17	0.38	0.00	1.00
Distance 100 Km	Dichotomous	0.17	0.37	0.00	1.00
Distance 50 Km	Dichotomous	0.15	0.36	0.00	1.00
Emission Reduction: -20 %	Dichotomous	0.20	0.40	0.00	1.00
Emission Reduction: -10 %	Dichotomous	0.26	0.44	0.00	1.00
Parks	Dichotomous	0.34	0.47	0.00	1.00
Bill Reduction	AED/household/year	86.9	140.3	0.00	900
Choice Experiments-Segment membership Variables					
Transient	Dichotomous	.38	.48	0.00	1.00
Expat_MS	Dichotomous	.23	.42	0.00	1.00

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 AED/household/year unit.

Table 5.A2 Experimental Design

BLOCK	OPTION	Distance	Emission Reduction	Parks	Bill reduction
1	A	200	20%	NO	30%
1	B	20	10%	YES	20%
1	A	100	10%	YES	10%
1	B	50	No reduction	NO	20%
1	A	100	10%	NO	30%
1	B	100	20%	NO	10%
1	A	50	20%	YES	No reduction
1	B	200	20%	NO	10%
2	A	100	10%	NO	20%
2	B	50	No reduction	YES	No reduction
2	A	50	No reduction	YES	20%
2	B	50	20%	NO	30%
2	A	20	20%	NO	30%
2	B	200	No reduction	YES	20%
2	A	50	10%	NO	10%
2	B	100	No reduction	YES	30%
3	A	20	10%	NO	20%
3	B	200	20%	YES	10%
3	A	50	10%	NO	30%
3	B	100	10%	NO	No reduction
3	A	200	10%	YES	10%
3	B	50	10%	YES	30%
3	A	200	20%	YES	10%
3	B	200	No reduction	NO	20%
4	A	100	No reduction	NO	No reduction
4	B	20	10%	YES	30%
4	A	200	20%	YES	No reduction
4	B	100	10%	NO	10%
4	A	200	No reduction	YES	No reduction
4	B	200	20%	NO	No reduction
4	A	20	No reduction	YES	20%
4	B	20	10%	YES	10%
5	A	50	No reduction	NO	20%
5	B	20	20%	YES	10%
5	A	50	No reduction	NO	No reduction
5	B	20	20%	NO	No reduction
5	A	200	10%	NO	No reduction
5	B	50	No reduction	YES	No reduction
5	A	200	No reduction	YES	20%
5	B	200	10%	NO	No reduction
6	A	200	10%	NO	30%
6	B	50	10%	NO	10%
6	A	20	20%	YES	10%
6	B	20	No reduction	YES	30%
6	A	50	No reduction	YES	3%
6	B	50	10%	NO	20%

BLOCK	OPTION	Distance	Emission Reduction	Parks	Bill reduction
6	A	200	No reduction	NO	20%
6	B	100	No reduction	YES	10%
7	A	100	10%	YES	30%
7	B	200	No reduction	NO	30%
7	A	200	10%	NO	No reduction
7	B	20	No reduction	NO	20%
7	A	50	10%	YES	10%
7	B	100	20%	YES	No reduction
7	A	100	20%	NO	20%
7	B	200	10%	YES	10%
8	A	20	20%	NO	30%
8	B	200	20%	YES	20%
8	A	100	10%	YES	30%
8	B	100	20%	NO	10%
8	A	100	No reduction	YES	10%
8	B	50	10%	YES	20%
8	A	20	20%	YES	10%
8	B	100	10%	NO	20%

Chapter 6

Salient attributes in choice experiments: empirical applications in the context of preferences towards nuclear energy

Abstract

Standard econometric models employed to analyze choice experiment data are based on the assumption that respondents effectively compare the attributes' levels between the options shown. Yet, individuals might not conform to a fully compensatory behavior (i.e.: trading-off all attributes' levels between the options presented). This is especially relevant when dealing with the preferences towards nuclear energy, in scenarios where some attributes or levels may capture the attention of the respondents, for instance evoking fears, worries, concerns. In light of this, this work formulates the following hypothesis: whilst choosing an option, respondents might overly focus on some key attributes which are salient for them; in turn, salient attributes play a major role in determining his or her final choice. To empirically test this hypothesis, we first elicit information on the most important attribute through a ranking exercise presented after the completion of the choice experiments tasks. This information is then included into a latent class model, which estimates the probability that the decision is driven by the salient attribute. We present three empirical applications in the context of preferences towards nuclear energy, conducted in three countries: Italy, the UK and the UAE.

6.1 Introduction

The modeling of discrete choice experiment data was built around the Random Utility Theory (Thurstone 1927) and the Lancaster's theory of value (Lancaster 1966). According to this framework individuals choose the option that maximizes their utility. This is in turn decomposed into the features, or attributes, of the good under evaluation. Also, it contains a stochastic component. Arguably, respondents taking part in choice experiments used to be treated as homines oeconomici at the model estimation stage. That is, perfectly able to evaluate the options proposed, trade off the attributes' levels and make their choice. Aspects such as learning and fatigue (Bradley and Daly 1994; Campbell et al. 2015), information overload (Simon 1955), framing (Tversky and Kahneman 1981), anchoring (Ryan et al. 2006), are not taken into account in a standard modeling framework[58]. Yet, especially in the last decade, a great deal of research has been conducted within the choice modeling literature with the aim of unveiling and modeling different attribute processing strategies (Hensher et al. 2012; Hensher 2014). Hensher (2014 p.2) remarked that '*What we do not yet have enough accumulated wisdom on is the identification of a small set of processing rules that might be the best descriptors of the way in which individuals process information in hypothetical (via choice experiments) and real markets.*'

This research has been focused on departures from a fully compensatory decision process. Individuals might fail to compare all the levels of the attributes defining each of the alternatives presented. Instead, they might adopt different processing strategies whilst making their choice. A reason is the simplification of the decision process (Heiner 1983;

[58] This work focuses on potential biases arising from respondents not choosing according to a fully compensatory behavior, within the context of a Random Utility Theory model. Research suggests individuals may process choice situations according to a random utility model, while others' behavior might be more closely described by a random regret model (Chorus et al. 2008, 2014; Boeri et al. 2012).

Payne 1976; Payne et al. 1993). Individuals might rationally choose to make choices considering only a sub-set of the information provided (De Palma et al. 1994; DeShazo and Fermo 2004). Alternatively, they could resort to heuristics due to limited cognitive capabilities or information overload (Simon 1955; Miller 1956; Loewenstein and Lerner 2003). The importance of the 'human' aspect of the respondents taking part in choice experiments has led to a number of studies investigating the impact of a greater complexity of choice exercises (quantifiable in terms of the number of attributes, choice tasks and alternatives) to the resulting error variance arising from respondents' choices (Mazzotta and Opaluch 1995; Dellaert et al. 1999; Swait and Adamowicz 2001; DeShazo and Fermo 2002; Caussade et al. 2005; Carlsson et al. 2012; Czajkowki et al. 2014; Meyerhoff et al. 2015).

There are situations in which departures from fully compensatory behavior can be expected due to the nature of the good under evaluation. This is, for instance, the case of preferences towards nuclear energy, as this energy source is generally identified as intrinsically controversial. This is a case in which respondents may overly focus on attributes that they particularly like or dislike. What is more, some options may trigger an emotional response. Some respondents might fail to compare all the attributes between the options presented because one attribute is particularly worrying for them, captures their attention and influences their choice. Formally, the hypothesis tested in this work is as follows: in some choice situations, respondents use a simplifying strategy, or more broadly fail to compare all attributes' levels between options, and base their choices on the presence (or absence) of the attribute's level that they consider to be the most relevant or that captures their attention. These attributes and/or levels that receive a higher attention are likely to be salient in subsequent choices made by the respondents (Taylor and Thompson 1982).

Information on the most important attribute is elicited through a ranking exercise presented after the completion of the choice experiments tasks (Balcombe et al. 2014). This information is then included into a constrained latent class model. This estimates the probability that individuals choose according to a regular utility model or, instead, focusing exclusively on the most important (salient) attribute, up to a certain probability. We present three empirical applications. All are in the context of preferences towards nuclear energy. Importantly, we considered three different countries, characterized by different energy policies with respect to nuclear energy: Italy, the UK and the UAE. The reason to provide a three-countries comparison is twofold. First, as the relevance of the saliency strategy in this context is assumed to depend on the concern/worries that nuclear energy might evoke, it is worth considering a set of respondents with different attitudes towards nuclear energy. Second, the application of the model to three different datasets is beneficial in terms of the robustness of the findings. While previous literature has employed information on attribute stated importance, employing the full ranking as additional input in the model, this work empirically tests the following hypothesis: the top attributes in terms of importance, which we define as salient, might be key in driving the decision process.

The original contribution of this work is that of eliciting the salient attributes via an attribute ranking process that enables analysts to use an endogenous switching latent class model in which it is possible to segregate probabilistically whose choice sequence is best approximated by a fully compensatory model, or otherwise. Furthermore, this study offers a comparison across three different countries, in the context of preferences towards nuclear energy. The reminder of the paper is outlined as follows. Section 2 presents a background of different choice processing strategies in the context of choice experiments; Section 3 introduces the salient attribute modeling strategy; Section 4 describes the three case studies; Section 5 shows descriptive statistics; Section 6 presents the empirical results. Finally, section 7 concludes.

6.2 Background

Individuals taking part in choice experiments might form consideration sets and focus on subsets of attributes, rather than trading off all of those presented (Louviere et al. 2005). According to this framework, individuals evaluate the costs and benefits of processing the information presented in a given choice set. Furthermore, Cameron and DeShazo (2010) suggest individuals might allocate different levels of attentions to attributes in choice experiments; in turn, differences in attention might bias marginal utilities and monetary valuations. From a conceptual point of view, our work is closely related to this area of research. It postulates individuals might overly focus on salient attributes, and this higher level of attention to such attributes might lead to distorted monetary valuations.

The research conducted with respect to lexicographic behavior is also relevant for this work (Sælensminde 2001; Scott 2002; Rosenberger et al. 2003; Rizzi and Ortúzar 2003; Gelso and Peterson 2005; Campbell et al. 2006; Lancsar and Louviere 2006; Hess et al. 2010; Scarpa et al. 2013). In the stated preferences context, choices tend to be labelled as lexicographic when respondents choose repeatedly the option containing the best level of a particular attribute. In turn, this may hinder the estimation of the other attributes' preferences (Sælensminde 2001); yet, as Scott (2002) remarks, it may be rare to empirically observe a pure lexicographic ordering, according to which no degree of substitution between the attributes is present. Studies have employed a constrained latent class model to deal with lexicographic preferences: respondents can be probabilistically allocated to a class where only one of the attributes has its taste parameter estimated, whereas the other attributes' coefficients are constrained to zero (Scarpa et al. 2013; Hess et al. 2012).

More recently, attention has been given to the stated importance of attributes. This can be derived by asking respondents to rank the attributes following the choice tasks. Balcombe et al. (2014) have proposed to model the stated ranking within a mixed logit framework, including a contraction factor that takes into account this complementary information. Accordingly, the less important the attribute is, the greater the contraction factor that may be attached to the mean and standard deviation of the associated coefficients. Stated attribute importance is a measure of explicit attributes ranking, as opposed to the implicit ranking given by the marginal rate of substitutions or monetary valuations. In this sense, it can also be used to test for internal consistency of choice experiments (Azevedo et al. 2009).

Further research has suggested that attributes and/or levels that respondents consider whilst making their choices may be affected by thresholds and cut-offs (Swait 2001; Cantillo et al. 2006; Cantillo and Ortúzar 2006; Mørbak et al. 2010; Campbell et al. 2011, 2012, 2014; Erdem et al. 2014). Namely, the decision process employed by the respondents may be dependent on the attributes' levels presented in the survey. For instance, individuals might not consider alternatives whose attributes' levels are outside given thresholds. Alternatively, individuals' choices may be influenced by reference points (Hensher and Collins 2011; Hess et al. 2012); that is, their decision process in successive choice tasks might be affected by what was presented in earlier comparisons. Respondents might evaluate gains or losses based on levels that were shown to them in earlier instances.

Another stream of research has focused on attribute non-attendance (ANA) (Hensher et al. 2005). According to this framework, respondents evaluate only a subset of the attributes presented in each choice task, whilst failing to evaluate one or more of the attributes presented. It is argued that failure to take ANA into account might lead to significantly different monetary valuations and/or parameters' estimates (Hensher 2006; Hensher and Rose 2009; Hess and Hensher 2010; Hole 2011; Scarpa et al. 2009; Scarpa et al. 2010; Campbell et al. 2011; Puckett and Hensher 2008; Puckett and Hensher 2009; Kehlbacher et al. 2013; Lagarde 2013; Kravchenko 2014; Erdem et al. 2015; Nguyen et al. 2015).

Evidence suggests that the higher the level of knowledge of the attributes constituting the good under evaluation, the lower the chances of these not being attended to during the decision process (Sandorf et al. 2016). Non-attendance has been usually identified by directly asking respondents to state whether and which of the attributes they have not considered (Hensher et al. 2005). It has been questioned as the information obtained seems to pose concerns in terms of its reliability (Campbell and Lorimer 2009; Carlsson et al. 2010; Hess and Hensher 2010; Hess 2012; Hess et al. 2013; Kaye-Blake et al. 2009; Kragt 2013). Therefore, it may be a risky strategy that of associating respondents indicating a given attribute as non-attended to a zero marginal utility for the attribute considered (as in Saelensminde 2001, Hensher et al. 2005, Campbell et al. 2008, Scarpa et al. 2010). Hence, it is advisable to test for the validity of the zero marginal utility assumption (Balcombe et al. 2011). Also, it has been suggested to gather more in depth information on attendance (Alemu et al. 2013; Colombo et al. 2013; Scarpa et al. 2013).

ANA has been also derived without the aid of additional information obtained from the respondents. Two main modeling strategies have been proposed in this context, namely the inferred ANA approach. The constrained latent class approach allows to model a mixture of fully compensatory, semi-compensatory and complete non-attendance behaviors. For any given attribute assumed not to have been attended, its preference's coefficients are constrained to be equal to zero (Scarpa et al. 2009; Scarpa et al. 2013). ANA can be also inferred within a mixed logit framework. In this context, random parameters are estimated, providing values for means and variances of the estimated distributions. Attributes more likely not to have been attended should be associated with a greater ratio of the variance over mean (Hess and Hensher 2010; Scarpa et al. 2013). On the whole, it appears undecided whether stated attribute non-attendance is a valid indication of not attended attributes or whether we should prefer and trust attribute non-attendance that is inferred via modelling.

This debate is highly important for the current work, as it raises a parallel debate on the validity of attribute stated importance, as opposed to inferred attribute importance. This is a limitation that the current work shares with previous literature on attribute non-attendance.

Finite mixture models have been widely applied in the aforementioned studies to model decision process heterogeneity, where the class membership probability is estimated either unconditionally (Hess et al. 2012; Scarpa et al. 2013), or conditional on socioeconomic covariates (Araña et al. 2008; Boeri et al. 2012). The finite mixture model framework, with specific constraints imposed on the coefficients, is also implemented in this work. Furthermore, we make use of information obtained from the respondents in order to determine which attribute is the salient one for each individual. In this work attribute saliency is assessed by asking respondents to provide a unique ranking (without ties) of the attributes at the end of the choice experiments. The model we put forward further allows for a mixture of compensatory and non-compensatory behavior, in line with research suggesting the same individuals may in some instances choose according to a fully compensatory model, while on other occasions might adopt one or many simplifying strategies (Araña et al. 2008; Leong and Hensher 2012; Balbontin et al. 2017). The goal of this work is to assess whether it can be detected an initial evidence of the saliency strategy, which further research could explore in further applications and modelling explorations. In particular, the investigation of potential integrations and identification issues with additional decision processing strategies is left for further research.

6.3 Econometric models

6.3.1 Salient attributes: a mixture model

We employ the latent class model to set the utility of the respondents as function of different variables, in each segment considered. Recalling from Chapter 2 that in this framework, utility for individual i, conditional on segment s, is given by:

$$U_{ij|s} = V_{ij|s} + \varepsilon_{ij|s} \tag{6.1}$$

The deterministic component of the utility function is now specified so as to allow for the influence of saliency. The way we operationalize attribute saliency is hereby explained. As mentioned earlier, saliency is captured with the aid of stated information on attribute's importance, following the choice experiment exercise. Given the individual ranking of the attributes, which are all present across the options, and given that the levels of the attributes in this study are all ordered (presence or absence of a level, higher or lower % or distances), it is then possible to detect which alternative j, amongst option A, B or None, contained the best level of the most important attribute. Since in some choice situations t there are overlapping levels between pairs of attributes, saliency in that instance would be captured by the better level of the second most important attribute.

Formally, we extend the deterministic component of the utility function so as to include a variable which indicates the presence of the best level of the salient attribute amongst the alternatives, and estimate the associated effect:

$$V_{ij|s} = \mathbf{x}'_{it,j}\boldsymbol{\beta}_{\boldsymbol{s}} + W_{\boldsymbol{it,j}}\gamma_{\boldsymbol{s}} \tag{6.2}$$

where $W_{\boldsymbol{it,j}}$ represents a dichotomous variable which takes value 1 if alternative j, in choice situation t, for individual i, contains the saliency influence; $\gamma_{\boldsymbol{s}}$ represents instead the coefficient associated to the presence of the saliency influence. In a context where an alternative that contains a better level of the salient attribute is more likely to be chosen, we expect γ to present a positive sign.

In addition, we constrain the coefficients entering $V_{ij|s}$ to test our behavioral assumption. We identify the segments where the choice is assumed to be purely driven by saliency with the notation h, whereas the segments assumed to be driven by a standard utility function with c, where h+c=S. Specifically, we isolate the impact of attribute saliency setting the vector $\boldsymbol{\beta}_{\boldsymbol{s=h}} = 0$, producing a saliency-led segments where $V_{ij|s=h} = W_{\boldsymbol{it,j}}\gamma_{\boldsymbol{s=h}}$. Furthermore, additional segments are set so that a standard utility function is in place, where $\gamma_{\boldsymbol{s=c}} = 0$, so that $V_{ij|s=c} = \mathbf{x}'_{it,j}\boldsymbol{\beta}_{\boldsymbol{s=c}}$. This is the reason why refer to this as a constrained latent class model. Such models may present limitations in terms of confounding effects between pure taste heterogeneity and decision process heterogeneity (Collins et al. 2013; Hess et al. 2013). This is indeed an important area of research which encompasses a substantial amount of literature concerned with heuristics in choice modeling.

According to our framework, the simplest version of the model consists of two segments, one for each constrain to be imposed. In addition, we allow for some degree of taste heterogeneity to be unleashed by estimating a greater set of classes. In terms of choice probabilities, these are derived in line with the formulation presented in Chapter 2. The probability of individual i choosing option j in choice tasks t, conditional on belonging to the segment h is given by:

$$P_{it,j|s=h} = \frac{\exp(W_{\boldsymbol{it,j}}\gamma_{\boldsymbol{s=h}})}{\sum_j \exp(W_{\boldsymbol{it,j}}\gamma_{\boldsymbol{s=h}})} \tag{6.3}$$

Instead, the probability of individual i choosing option j in choice tasks t, conditional on belonging to the segment c is as follows:

$$P_{it,j|s=c} = \frac{\exp(\mathbf{x}'_{it,j}\boldsymbol{\beta}_{\boldsymbol{s=c}})}{\sum_j \exp(\mathbf{x}'_{it,j}\boldsymbol{\beta}_{\boldsymbol{s=c}})} \tag{6.4}$$

In turn, assuming T independent choices, the joint probability is given by:

$$P_{i|s} = \prod_t^T P_{it|s} \quad (6.5)$$

Whereas the class assignment, $\mathrm{H_{is}}$, is set to be constant ($\mathrm{H_{is}} = \alpha_{is}$), and the resulting unconditional choice probability is given by:

$$P_i = \sum_s^S \alpha_{is} P_{i|s} \quad (6.6)$$

It is worth noting that $\alpha_{is=h}$ will then identify the size of the saliency segment, providing a direct measure of the impact of saliency in respondents' choices.

6.4 Empirical applications: Introduction of case studies

6.4.1 Case study 1-Italy

The case study 1 refers to a nation-wide online choice experiment survey. It was conducted in March and May 2014, with the goal of investigating preferences towards nuclear energy in Italy after the Fukushima's accident. In 2011, following this accident in Japan, the Italian population voted against the construction of nuclear plants in Italy. A similar referendum was held in Italy in 1987 after the Chernobyl's accident. Also in that occasion it was expressed opposition towards nuclear energy. There is an undergoing research in the field of nuclear energy and it is argued that in 20 years-time might be available a new nuclear energy technology, so called fourth generation nuclear energy. The aim is that of reducing some of the controversies that characterize the current technology (Locatelli et al. 2013). The attributes and levels, chosen after reviewing the literature and pre-tests, are presented in Table 6.1. These include the distance from the hypothetical nuclear plants, expressed in Kilometers (Km). In addition there are attributes that should be perceived as benefits by the respondents. Namely, the amount of nuclear waste reduction compared to the level produced by standard nuclear plants, and the reduction of atmospheric emissions. Also, the construction of public hospitals and the land recovery measures. Finally, the private benefit and payment vehicle is represented by annual electricity bill reductions.

Table 6.1. Case study 1-Italy: Attributes, levels and variables' code

Attributes	Levels	Variables' code
Distance (Distance of the nuclear plant from the area of residence)	200 Km away	1 if 200 Km away, 0 otherwise
	100 Km away	1 if 100 Km away, 0 otherwise
	50 Km away	1 if 50 Km away, 0 otherwise
	20 Km away	1 if 20 Km away, 0 otherwise
Waste (Nuclear waste reduction)	30% reduction	3 if 30% reduction
	20% reduction	2 if 20% reduction
	10% reduction	1 if 10% r eduction
	No reduction	0 if no reduction
Emissions (Atmospheric emissions' reduction)	20 % reduction	2 if 20% reduction
	10 % reduction	1 if 10% reduction
	No reduction	0 if no reduction
Bill reduction (Electricity bill reduction)	30% reduction	3 if 30% reduction
	20% reduction	2 if 20% reduction
	10% reduction	1 if 10% reduction
	No reduction	0 if no reduction
Hospitals (Construction of public hospitals)	Yes or No	1 if Hospitals are built, 0 otherwise
Land recovery (Implementation of land recovery measures)	Yes or No	1 if land recovery measures are planned, 0 otherwise

6.4.2 Case study 2-UK

The case study 2 is part of a nation-wide online choice experiment survey conducted in December 2014, with aim of investigating preferences towards nuclear energy in the UK after the Fukushima accident. We considered IV generation nuclear energy technology in this context as well. Respondents surveyed for this study live in a country with nuclear plants in operation and with further developments planned in the near future, as opposed to the case of Italy with no nuclear plants in operation nor planned. The attributes and levels are presented in Table 6.2. These are the same as in case study 1, with the exception of the distance's levels, which are expressed in Miles rather than Km (1 Mile=1.609 Km).

Table 6.2. Case study 2-UK: Attributes, levels and variables' code

Attributes	Levels	Variables' code
Distance (Distance of the nuclear plant from the area of residence)	120 Miles away	1 if 120 Miles away, 0 otherwise
	60 Miles away	1 if 60 Miles away, 0 otherwise
	30 Miles away	1 if 30 Miles away, 0 otherwise
	15 Miles away	1 if 15 Miles away, 0 otherwise
Waste (Nuclear waste reduction)	30% reduction	3 if 30% reduction
	20% reduction	2 if 20% reduction
	10% reduction	1 if 10% reduction
	No reduction	0 if no reduction
Emissions (Atmospheric emissions' reduction)	20 % reduction	2 if 20% reduction
	10 % reduction	1 if 10% reduction
	No reduction	0 if no reduction
Bill reduction (Electricity bill reduction)	30% reduction	3 if 30% reduction
	20% reduction	2 if 20% reduction
	10% reduction	1 if 10% reduction
	No reduction	0 if no reduction
Hospitals (Construction of public hospitals)	Yes or No	1 if Hospitals are built, 0 otherwise
Land recovery (Implementation of land recovery measures)	Yes or No	1 if land recovery measures are planned, 0 otherwise

6.4.3 Case study 3-UAE

The final case study is also a nation-wide online choice experiment focusing on preferences towards nuclear energy. Yet, in this study there was no mention of IV generation technology. Rather, respondents were presented with hypothetical scenarios concerning current nuclear energy technology. The country considered is the United Arab Emirates (UAE), which presently does not have nuclear plants in operation but it is in the process of building them. Four reactors are planned to start operations by 2020, in the Emirate of Abu Dhabi. The list of attributes and levels, partly different compared to the other two case studies, is presented in Table 6.3.

Table 6.3. Case study 3-UAE: Attributes, levels and variables' code

Attributes	Levels	Variables' code
Distance (Distance of the nuclear plant from area of residence)	200 Km away	1 if 200 Km away, 0 otherwise
	100 Km away	1 if 100 Km away, 0 otherwise
	50 Km away	1 if 50 Km away, 0 otherwise
	20 Km away	1 if 20 Km away, 0 otherwise
Emissions (Atmospheric emissions' reduction)	20 % reduction	2 if 20% reduction
	10 % reduction	1 if 10% reduction
	No reduction	0 if no reduction
Bill reduction (Water, Electricity and Gas bill reduction)	30% reduction	3 if 30% reduction
	20% reduction	2 if 20% reduction
	10% reduction	1 if 10% reduction
	No reduction	0 if no reduction
Parks (Construction of parks, recreational spaces)	Yes, No	1 if Parks are built, 0 otherwise

The attribute 'distance' is included in this study as well, with levels expressed in Km. Also, the attribute 'atmospheric emission reduction' was part of the choice tasks. Instead, as the study does not mention IV generation nuclear energy technology, the attribute 'nuclear waste reduction' was not included. With regards to attributes representing public benefits, we included 'construction of parks or other recreational spaces'. Finally, the monetary attribute is in this study represented by reductions of the water, electricity and gas bills.

6.5 Empirical applications: Descriptive statistics

6.5.1 Case study 1-Italy

A total of 765 respondents are considered in this case study. The reduced sample size compared to the total of 1198 respondents as seen in Chapter 3 is due to fact that the ranking exercise was not mandatory for the respondents to complete (the ranking exercise is depicted in Appendix, Figure 6.A1). This was considered a pilot for this particular ranking exercise, which was later scheduled to be conducted in the subsequent UK and UAE studies as well. 65% of the respondents spontaneously completed the ranking task. Each one of these respondents also took part in eight choice tasks with two unlabeled alternatives, plus a 'none' option. Importantly, the sample structure does not differ significantly when comparing respondents who complete the ranking exercise, versus those who did not (Table 6.4). For the subsequent studies, we enhanced the description of the task required, altered the display and made the response mandatory.

Table 6.4. Case study 1. Socio-demographic characteristics

Variable	*Statistics*	ALL	Did the ranking	Did not do the ranking
Age	Mean	43.7	43.2	44.7
	S.D.	13.8	13.9	13.7
Household size	Mean	3.1	3.1	3.1
	S.D.	1.2	1.2	1.1
Gender	% Male	46	46	46
Education[a]	% Before high school	12.4	11.5	13.9
	% High school	54.3	54.1	54.6
	% Degree	19.2	17.8	16.3
Observations		1198	765	433

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

The complete attributes' rankings are presented in Figure 6.1. The attributes are ordered from right to left, sorted by decreasing share of top importance. Overall, the attribute 'distance' is indicated as the most important one more often, by 33% of the surveyed respondents. Next, the attributes 'waste' and 'emissions reduction' are rarely placed at the bottom of the ranking whereas they have been frequently ranked as second. On the opposite end we find the attributes 'hospitals' and 'land recovery measures', ranked as the most important only by 7.6% and 9% respectively.

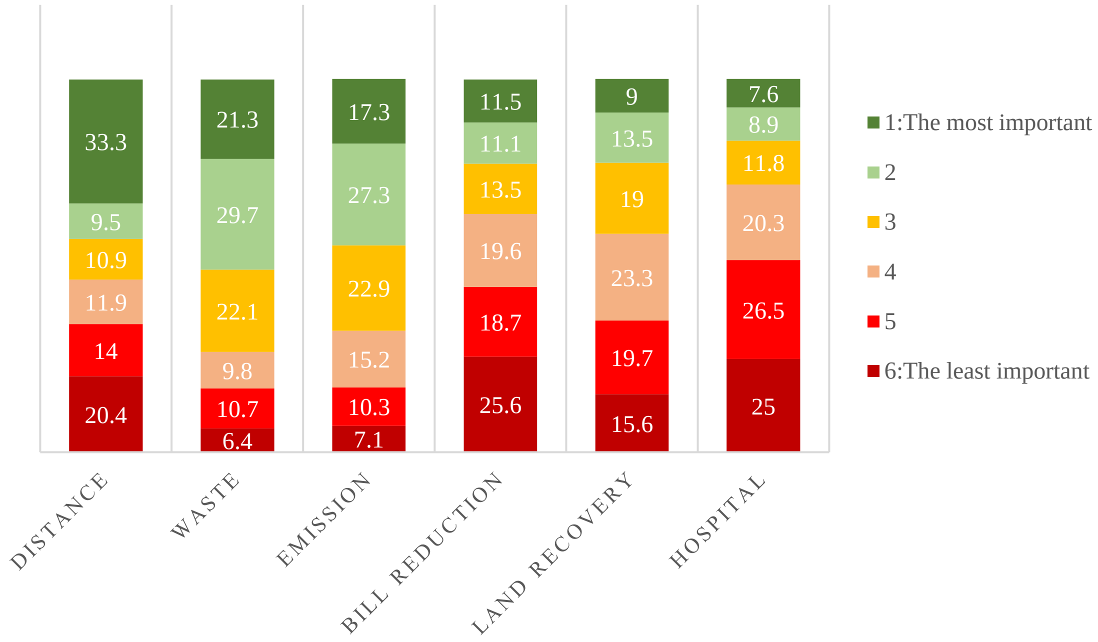


Figure 6.1: Frequency of top importance by attribute-Case study 1 Italy

6.5.2 Case study 2-UK

The sample size for case study 2 consists of 887 respondents. As in case study 1, each individual completed eight choice tasks characterized by two unlabeled alternatives, besides a 'none' option. 53% of the sampled respondents are women, with an average age of 46 years. Almost 7 in 10 reside in England, 16% Scotland, 10% Wales and 4.6% Northern Ireland. 27% have a college/university degree, whereas almost 29% have a higher degree. The ranking exercise that respondents took part in is shown in Appendix, Figure 5.A2. In this case, they were also given the option to specify whether they did not consider some, or even all, of the attributes.

The entire set of answers to the attributes' rankings are presented in Figure 6.2. 'Distance' is, again, the most important attribute by far (44%). This is followed by 'waste reduction' (19%) and 'bill reduction' (16%). As in case study 1, the least important attributes are 'hospitals' and 'land recovery measures'. The latter attribute was the most important one for only 2% of respondents. In line with this, over 36% stated to have not considered at all this attribute. A quarter of the sample specified not to have considered the attribute 'distance'.

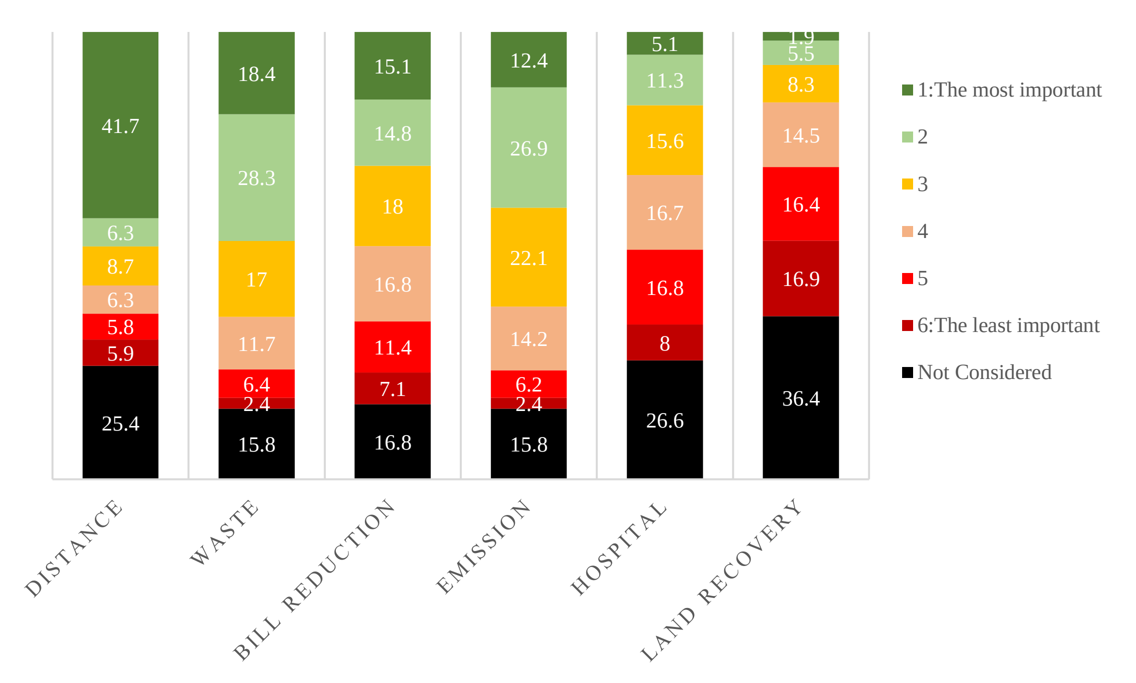


Figure 6.2: Frequency of top importance by attribute-Case study 2 UK

6.5.3 Case study 3-UAE

The total sample size for case study 3 amounts to 1961 respondents. They completed 4 choice tasks, with two generic options plus a 'none' alternative. The reduced number of choice tasks was motivated by the lower number of attributes and corresponding main effects to estimate. The majority of the sampled individuals are men (65%), with an average age of 34 years. Most respondents reside in Dubai (50%), while 24% live in Abu Dhabi and 17% in the Emirate of Sharjah. In line with the population structure of the UAE (Koch 2016), the sample is rich of individuals of different nationalities, the greater shares being Indians (34%), Pakistani (11%), Philipino nationals (10%), and UAE nationals (10%).

The entire ranking by attribute is available in Figure 6.3. In this study, respondents were allowed to provide partial rankings, for instance indicating only the most important attribute. As in the other two case studies, the attribute ‘distance’ seems to be the most important attribute overall. It comes on top of the ranking in almost half of the instances (46%). Next, the attribute ‘water, electricity and gas bill reduction’, as well as ‘emissions reduction’, were indicated as the most important in less than 1 out of 4 occasions. Finally, ‘the construction of parks’ was indicated as the most important one by only 15% of respondents.

Figure 6.3: Frequency of top importance by attribute-Case study 3 UAE

6.6 Empirical applications: Results

For each case study, unless a model did not converge, the following models were estimated: a standard multinomial logit (MNL), a standard latent class model with two classes (LC 2), a standard latent class model with three classes (LC 3). In addition, constrained latent class models that allow for a mixture of fully compensatory behavior and attribute’s saliency in driving choice. Practitioners are advised to check the correlation between the options chosen by the respondents and the dichotomous variable ($W_{it,j}$) in order to detect potential issues in estimation. Whilst we would expect some degree of correlation, a value too close to the boundaries of 1 or -1 would prevent the estimation of the coefficient attached to $W_{it,j}$. It is worth noting that this correlation is strictly linked to the size, in terms of class membership probability, of the 'salience' segment. Namely, the greater the correlation in absolute terms, the larger the size of the saliency segment, or the number of saliency segments that can be identified.

Particular attention is required when estimating and interpreting the resulting monetary valuations. At the overall level, the constrained latent class model with attribute's saliency provides a set of monetary valuations for segments of respondents who seemed to have valued more than one attribute. In the segment where choices appear to be fully driven by saliency, the deterministic component of the utility function presents all attributes' coefficients equal to zero. Hence, the ratios of coefficients are non-defined. Yet, posterior class probabilities can be employed to define individual level coefficients, from which monetary valuations can be derived. At the individual level, the ratio of coefficients is not defined only in the event that a given individual belongs with certainty to the saliency segment. By definition though, this is a model which allocates individuals to classes up to a certain probability.

6.6.1 Case study 1-Italy

The econometric results pertaining to the case study 1 are presented in Table 6.5 to 6.10. Across the estimated models the utility function includes non-linarites with respect to the attributes 'distance' and 'emissions reduction'. The MNL model's results show respondents prefer nuclear plants away from their area of residence (Tables 6.5 and 6.6). In addition, individuals positively value nuclear waste and emission reductions, as well as the building of new hospitals and land recovery measures. Furthermore, they significantly value electricity bill reductions. Also, the coefficient associated to the ‘none’ option is positive. This indicates that, overall, respondents were more likely to choose none of the projects. While the attribute ‘distance’ is the most important one according to the greatest share of respondents, it is not associated with a greater monetary valuation.

Table 6.5: Parameters’ estimates-Case study 1 (Italy). MNL & saliency

	MNL	MNL with saliency	
Variables		Class 1	Class 2
$w_{it,j}$	/	/	.524*** (.020)
ASC_NONE	1.55*** (.080)	6.43*** (.733)	0
DISTANCE 200 Km	.538*** (.050)	.741*** (.028)	0
DISTANCE 100 Km	0.360*** (.054)	-.112 (.036)	0
NUCLEAR WASTE REDUCTION	0.232*** (.019)	0.452*** (.125)	0
EMISSIONS -20%	0.545*** (.51)	1.791*** (.524)	0
EMISSIONS -10%	0.538*** (.52)	2.060*** (.518)	0
HOSPITALS	0.323*** (.043)	0.569** (.281)	0
LAND RECOVERY	0.530*** (.042)	1.045*** (.265)	0
BILL REDUCTION (€)	0.002*** (.000)	0.0006 (.000)	0
Class Probabilities	/	0.35	0.65
Log Likelihood	-6179.68	-5073.957	

We then present a model that incorporates attribute saliency (Table 6.5, third and fourth column). This consists of two latent classes. In one segment the decision process is assumed to be driven by the most important attributes, whereas in the other one a standard utility function is specified.

Table 6.6: Monetary valuations-Case study 1 (Italy). MNL & saliency

	MNL	MNL with saliency	
Variables		Class 1	Class 2
$W_{it,j}$	/	/	.524*** (.020)
ASC_NONE	745.6	n.s.	0
DISTANCE 200 Km	258.5	n.s.	0
DISTANCE 100 Km	173.2	n.s.	0
NUCLEAR WASTE REDUCTION	111.6	n.s.	0
EMISSIONS -20%	261.9	n.s.	0
EMISSIONS -10%	258.5	n.s.	0
HOSPITALS	155.5	n.s.	0
LAND RECOVERY	254.7	n.s.	0
BILL REDUCTION (€)	/	/	0
Class Probabilities	/	0.35	0.65
Log Likelihood	-6179.68	-5073.957	

65% of the respondents are allocated to the saliency segment with the highest likelihood, where the coefficient γ_s is positive and significant. This indicates that they were more likely to choose the option containing the better level of the saliency attribute[59]. Furthermore, the magnitude of the remaining coefficients increases considerably, with the exception of the non-significant coefficient attached to a distance of 100 Km from the hypothetical nuclear plant.

When comparing monetary valuations between the MNL and the MNL & Saliency model, it emerges that the latter does not lead to significant monetary valuations as the denominator is not-significant (Table 6.6). However, it is of paramount importance to note that there could be confounding effects in this specification, potentially inflating the probabilistic allocation to the saliency class. For this reason, additional models were estimated to allow for heterogeneity, introducing additional latent segments. Table 6.7 and 6.8 present a standard LC with two classes (LC 2) and a constrained latent class with two standard segments and two saliency segments.

In the standard LC 2 model emerges a clear distinction between a segment of respondents not willing to accept electricity bill reductions (class 1) and, instead, a segment of respondents whose preferences mirror those shown by the MNL model (class 2). The latter group represents the majority, accounting for 61% of the sample. In both segments, the alternative specific constant attached to refusing any of the projects, δ, is positive and significant. In class 1 its magnitude is significantly higher, in line with the refusal of monetary compensations (the coefficient attached to the attribute 'electricity bill reduction' is not significant). The LC 2 model represents a substantial improvement over the MNL, as

[59] The sign of the coefficient attached to $W_{it,j}$ is linked to the correlation between the preferred option chosen and the $W_{it,j}$ variable. The higher the number of respondents choosing an option based on their stated most important attribute, the closer to 1 the correlation coefficient should be. In cases where respondents avoid the option with the highest level of the most important attribute, the correlation would tend to -1. If both behaviors are present in the data with similar occurrence, the coefficient will tend towards 0. In case study 1, this correlation is negative and equal to -.04. The option containing the best level of the most important attribute was chosen in just 3 out of 10 instances.

indicated by the better goodness of fit and the significant degree of preference heterogeneity that allows to arise.

Table 6.7: Parameters' estimates-Case study 1 (Italy). LC 2 & saliency

	LC 2		LC 2 & saliency			
Variables	Class 1	Class 2	Class 1	Class 2	Class 3	Class 4
$W_{it,j}$	/	/	-.473*** (.137)	1.70*** (.105)	0	0
ASC_NONE	4.89*** (.39)	0.225*** (.065)	0	0	.330*** (.083)	6.37*** (.425)
DISTANCE 200 Km	.644*** (.199)	.690*** (.041)	0	0	.851*** (.052)	.628*** (.180)
DISTANCE 100 Km	0.039 (.24)	0.499*** (.041)	0	0	.655*** (.056)	-.244 (.216)
NUCLEAR WASTE REDUCTION	0.310*** (.084)	0.264*** (.015)	0	0	.337*** (.019)	.416*** (.086)
EMISSIONS -20%	0.957*** (.26)	0.628*** (.041)	0	0	.745*** (.052)	1.78*** (.290)
EMISSIONS -10%	1.22*** (.253)	0.634*** (.044)	0	0	.813*** (.056)	2.06*** (.281)
HOSPITALS	0.539*** (.188)	0.401*** (.036)	0	0	.539*** (.047)	.436** (.177)
LAND RECOVERY	0.879*** (.185)	0.593*** (.042)	0	0	.780*** (.046)	1.17*** (.178)
BILL REDUCTION (€)	0.008 (.001)	0.003*** (.000)	0	0	.003*** (.000)	.0006 (.001)
Class Probabilities	.39	.61	0.12	0.06	0.46	0.36
Log Likelihood	-4648.1		-4590.814			

Table 6.8: Monetary valuations-Case study 1 (Italy). LC 2 & saliency

	LC 2		LC 2 & saliency			
Variables	Class 1	Class 2	Class 1	Class 2	Class 3	Class 4
$W_{it,j}$	/	/	-.473*** (.137)	1.70*** (.105)	0	0
ASC_NONE	n.s.	74.5	0	0	82.9	n.s.
DISTANCE 200 Km	n.s.	227.9	0	0	213.9	n.s.
DISTANCE 100 Km	n.s.	164.7	0	0	164.6	n.s.
NUCLEAR WASTE REDUCTION	n.s.	87.2	0	0	84.7	n.s.
EMISSIONS -20%	n.s.	207.3	0	0	187.3	n.s.
EMISSIONS -10%	n.s.	209.2	0	0	204.4	n.s.
HOSPITALS	n.s.	132.3	0	0	135.5	n.s.
LAND RECOVERY	n.s.	195.9	0	0	195.9	n.s.
BILL REDUCTION (€)	/	/	0	0	/	n.s.
Class Probabilities	.39	.61	0.12	0.06	0.46	0.36
Log Likelihood	-4648.1		-4590.814			

In addition to two standard latent classes, we also incorporate attribute saliency. The model presented is characterized by two classes which assume the decision process to be driven by the most important attributes, and two classes where $V_{ij|s=c} = \mathbf{x}'_{it,j}\boldsymbol{\beta}_{s=c}$. 6% of the respondents are probabilistically allocated to the saliency class, and the attached coefficient is positive. These respondents seem to have made their chosen the options containing the best level of the most important attribute. The correlation between the choice and the

$W_{it,j}$ variable decreases to -.12 among respondents who indicated ‘distance’ as the most important attribute. In line with this, 12% of the respondents are allocated with the highest probability to the class where the coefficient attached to $W_{it,j}$ is significant and negative. 43% of the respondents assigned with the highest probability to this class indicated the attribute distance as the most important one. For them, choosing the option ‘none’ represented a preferable choice if compared to either project A or B. This is an example of how an attribute may be outside a range that is considered acceptable, and in turn can be associated with a negative preference. The remaining two classes, where individuals are assumed to follow a standard utility function specification, present a preference’s structure in line with that displayed by the standard LC 2. Namely, one class seems not to be willing to accept any monetary compensation, whereas the other one values emissions’ and nuclear waste reductions, as well as the construction of new hospitals and land recovery measures. Finally, individuals allocated to this segment prefer nuclear plants located away from their area of residence. On the whole, it is remarkable the decrease in size of the saliency segments, totaling 18%, as opposed to the 65% obtained without preference heterogeneity in place.

When inspecting the monetary valuations obtained from the LC 2 versus LC 2 & Saliency model, a number of similarities emerge. First, in both models one class is associated to non-significant monetary valuations as the coefficient attached to the bill reduction is non-significant. Second, class 2 of the standard latent class model and class 3 of the model that incorporates saliency present strikingly similar valuations. Yet, the two classes differ markedly in size: 46% (class 3 of LC2 & Saliency) versus 61% (class 2 of LC 2).

In order to test the stability of the results obtained, we introduced an additional model with three standard segments and a model with three standard and two saliency segments (Table 6.9). The total class membership probability of individuals belonging to the saliency segments amounts in this instance to 11%. This is a further reduction compared to the previous models, where it totaled 18% and 65% respectively. However, it is constant the size of the saliency segment where the coefficient attached to $W_{it,j}$ is significant and positive, still amounting to 6%. In terms of the preferences depicted, the models with three standard latent classes allow for an additional segment of respondents more prone to choose the 'None' option (class 3 in LC 3, class 4 in LC 3 & saliency), who would still value monetary compensations. This additional segment took away part of the respondents previously allocated in the model LC 2 & saliency, within the saliency segment with negative γ_s.

Remarkably similar are the monetary valuations in class 2 of LC 3 model and class 5 of the LC 3 & saliency model, as well as those emerged in class 3 of the LC 3 model and in class 4 of the LC 3 & saliency model (Table 6.10). Besides, in both models, one segment of individuals presents non-significant monetary valuations as the coefficient attached to the bill reduction is not significant.

Table 6.9: Parameters' estimates-Case study 1 (Italy). LC 3 & saliency

	LC 3			LC 3 & saliency				
Variables	Class 1	Class 2	Class 3	Class 1	Class 2	Class 3	Class 4	Class 5
$W_{it,j}$	/	/	/	-.583*** (.112)	1.71*** (.108)	0	0	0
ASC_NONE	7.68*** (1.27)	-0.399*** (.081)	2.30*** (.146)	0	0	7.23*** (1.08)	3.37*** (.208)	-0.292*** (.092)
DISTANCE 200 Km	-.045 (.572)	.631*** (.047)	.995*** (.087)	0	0	.005 (.53)	1.19*** (.108)	.730*** (.053)
DISTANCE 100 Km	0.087 (.584)	0.484*** (.051)	0.608*** (.099)	0	0	.060 (.545)	.742*** (.124)	.579*** (.057)
NUCLEAR WASTE REDUCTION	0.238 (.218)	0.260*** (.017)	0.312*** (.033)	0	0	.238 (.205)	.466*** (.044)	.302*** (.019)
EMISSIONS -20%	1.46* (.913)	0.610*** (.047)	0.826*** (.093)	0	0	1.23 (.782)	1.29*** (.122)	.664*** (.053)
EMISSIONS -10%	2.06*** (.867)	0.610*** (.047)	0.875*** (.088)	0	0	1.79*** (.727)	1.39*** (.118)	.726*** (.058)
HOSPITALS	0.872* (.495)	0.628*** (.051)	0.544*** (.078)	0	0	.767* (.455)	.809*** (.092)	.457*** (.047)
LAND RECOVERY	1.607*** (.603)	0.397*** (.040)	0.544*** (.078)	0	0	1.48*** (.528)	1.29*** (.104)	.675*** (.046)
BILL REDUCTION (€)	-0.004 (.003)	0.000*** (.000)	0.002*** (.000)	0	0	-.003 (.003)	.004*** (.000)	.0003*** (.000)
Class Probabilities	0.31	0.47	0.21	0.05	0.06	0.31	0.17	0.4
Log Likelihood	4503.97			4471.98				

Table 6.10: Monetary valuations-Case study 1 (Italy). LC 3 & saliency

	LC 3			LC 3 & saliency				
Variables	Class 1	Class 2	Class 3	Class 1	Class 2	Class 3	Class 4	Class 5
$W_{it,j}$	/	/	/	-.583*** (.112)	1.71*** (.108)	0	0	0
ASC_NONE	n.s.	-122.6	810.6	0	0	n.s.	808.8	-76.3
DISTANCE 200 Km	n.s.	193.8	349.7	0	0	n.s.	285.8	190.5
DISTANCE 100 Km	n.s.	148.7	213.9	0	0	n.s.	178	151.1
NUCLEAR WASTE REDUCTION	n.s.	79.9	109.7	0	0	n.s.	112	78.9
EMISSIONS -20%	n.s.	187.4	290.5	0	0	n.s.	311.1	173.3
EMISSIONS -10%	n.s.	193.1	307.5	0	0	n.s.	334.9	189.4
HOSPITALS	n.s.	122.1	191.2	0	0	n.s.	194.2	119.4
LAND RECOVERY	n.s.	174.7	320.8	0	0	n.s.	309.4	176.3
BILL REDUCTION (€)	/	/	/	0	0	/	/	/
Class Probabilities	0.31	0.47	0.21	0.05	0.06	0.31	0.17	0.4
Log Likelihood	4503.97			4471.98				

6.6.2 Case study 2-UK

The econometric results pertaining to case study 2 are presented in Table 6.11 to 6.16. Non-linearities are included with respect to 'distance' and 'nuclear waste reductions'. The results obtained from the MNL estimator applied to the UK choice experiment data are aligned with Italy's findings. Overall, a significant and positive effect is associated to the

ASC_NONE. Also, nuclear plants located away from the area of residence are preferred. Furthermore, respondents significantly value electricity bill reductions, the building of hospitals, land recovery measures, as well as emission and nuclear waste's reduction. In terms of stated importance, 'distance' was indicated as the most important attribute with the highest frequency. In line with this, it is associated with the highest monetary valuation: 222 GBP for a nuclear plant located 120 miles away from the area of residence.

Table 6.11: Parameters' estimates-Case study 2 (UK). MNL & saliency

	MNL	MNL & saliency	
Variables		Class 1	Class 2
$W_{it,j}$	/	/	-0.560*** (.030)
ASC_NONE	1.04*** (.075)	-0.64*** (.155)	0
DISTANCE 120 Miles	.604*** (.043)	.722*** (.057)	0
DISTANCE 60 Miles	0.275*** (.046)	0.517*** (.065)	0
NUCLEAR WASTE REDUCTION: 30%	0.422*** (.044)	0.693*** (.060)	0
NUCLEAR WASTE REDUCTION: 20%	0.257*** (.045)	0.510*** (.062)	0
EMISSIONS REDUCTION	0.358*** (.023)	0.450*** (.030)	0
HOSPITALS	0.528*** (.041)	0.813** (.058)	0
LAND RECOVERY	0.170*** (.035)	0.244*** (.045)	0
BILL REDUCTION (£)	0.002*** (.000)	0.004*** (.000)	0
Class Probabilities	/	0.68	0.32
Log Likelihood	-7270.614	-6376.08	

Conversely, the attribute 'land recovery' was selected as the most important one by only 2% of the respondents. Accordingly, its monetary valuation is the lowest, amounting to 62

GBP (Table 6.12). We then compare the MNL versus MNL & saliency model. The latter model presents all the coefficients, but the one attached to the ASC_NONE, characterized by a greater magnitude. The segment where the choice is assumed to be driven entirely by attribute saliency (class 2 of MNL & saliency model) has a class membership size equal to 32%. Furthermore, the γ_s coefficient is significant and negative.

Table 6.12: Monetary valuations-Case study 2 (UK). MNL & saliency

	MNL	MNL & saliency	
Variables		Class 1	Class 2
$W_{it,j}$	/	/	-0.560*** (.030)
ASC_NONE	384.5	-148.4	0
DISTANCE 120 Miles	222.6	165.7	0
DISTANCE 60 Miles	101.5	118.6	0
NUCLEAR WASTE REDUCTION: 30%	155.7	159.1	0
NUCLEAR WASTE REDUCTION: 20%	94.8	116.9	0
EMISSIONS REDUCTION	132.2	103.3	0
HOSPITALS	194.5	186.6	0
LAND RECOVERY	62.6	56.1	0
BILL REDUCTION (£)		/	0
Class Probabilities	/	0.68	0.32
Log Likelihood	-7270.614	-6376.08	

Next, preference heterogeneity is introduced by means of a standard two-latent classes model (LC 2). One group of individuals would require a much higher compensation for any given level of distance. However, none of the classes seem to oppose monetary compensations as instead emerged in case study 1. Subsequently, we estimate a model that incorporates attribute saliency (Table 6.13). The model we consider first consists of three classes, of which two assume fully compensatory behavior and one assumes choice driven by attribute saliency (LC 2 & saliency). 37% of the sampled respondents are allocated to class 1 with the highest probability. This segment is associated with a significant and positive coefficient γ. In line with this, the correlation between choices and $W_{it,j}$ is positive, equal to .30. The remaining two classes have preferences in line with the standard LC 2. In particular, class 3 of the LC 2 & Saliency model is aligned to class 1 of the standard LC 2, and the same goes for class 2 of both models. In the constrained latent class model, valuations seem higher or with a minor drop in magnitude at most, with the exception of 'distance'. This is the attribute which was indicated as the most important one most frequently, and it is associated with a marked reduction in the associated monetary valuations.

Table 6.13: Parameters' estimates-Case study 2 (UK) LC 2 & Saliency

	LC 2		LC 2 & saliency		
Variables	Class 1	Class 2	Class 1	Class 2	Class 3
$W_{it,j}$	/	/	1.38*** (0.053)	0	0
ASC_NONE	-.010 (.102)	5.24*** (.259)	0	-1.37*** (.159)	6.73*** (.396)
DISTANCE 120 Miles	.636*** (.049)	1.77*** (.135)	0	.496*** (.048)	2.06*** (.191)
DISTANCE 60 Miles	0.420*** (.055)	0.777*** (.154)	0	.375*** (.053)	.909*** (.207)
NUCLEAR WASTE REDUCTION: 30%	0.559*** (.051)	0.874*** (.138)	0	.815*** (.054)	1.30*** (.180)
NUCLEAR WASTE REDUCTION: 20%	0.387*** (.053)	0.536*** (.150)	0	.652*** (.058)	.721*** (.203)
EMISSIONS -10%	0.405*** (.026)	0.383*** (.077)	0	.501*** (.026)	.599*** (.109)
HOSPITALS	0.691*** (.049)	0.654*** (.123)	0	1.07** (.052)	.793*** (.165)
LAND RECOVERY	0.220*** (.040)	0.205*** (.116)	0	.283*** (.039)	.315** (.163)
BILL REDUCTION (£)	0.003*** (.000)	0.003*** (.000)	0	.004*** (.000)	.004*** (.000)
Class Probabilities	0.79	0.21	0.37	0.45	0.18
Log Likelihood	-5729.81		-5436.903		

Table 6.14: Parameters' estimates-Case study 2 (UK) LC 2 & Saliency

	LC 2		LC 2 & saliency		
Variables	Class 1	Class 2	Class 1	Class 2	Class 3
$W_{it,j}$	/	/	1.38*** (.053)	0	0
ASC_NONE	n.s.	1677.9	0	-291	1583.8
DISTANCE 120 Miles	175.5	568.6	0	105	486.6
DISTANCE 60 Miles	115.9	248.4	0	79.4	213.8
NUCLEAR WASTE REDUCTION: 30%	154.2	279.4	0	172.5	306.6
NUCLEAR WASTE REDUCTION: 20%	106.9	171.6	0	138	169.7
EMISSIONS -10%	111.8	122.5	0	106.1	140.9
HOSPITALS	190.7	209.4	0	228.3	186.5
LAND RECOVERY	60.7	65.7	0	59.9	74.3
BILL REDUCTION (£)	/	/	0	/	/
Class Probabilities	0.79	0.21	0.37	0.45	0.18
Log Likelihood	-5729.81		-5436.903		

Next, we estimate models with three standard latent classes (LC 3) and an additional one with three standard classes and two saliency segments (LC 3 & saliency), shown in Table 6.15. When inspecting the LC 3 model, it is evident the presence of a class (class 1) with a significant and negative coefficient associated to the 'none' alternative. Individuals more likely to belong to this class are also associated with coefficients with a lower magnitude attached to distance. This class displays the largest class membership size across the three segments, amounting to 65%. With regards to the LC 3 & saliency model, we firstly notice that the total class membership probability associated to the two saliency segments amounts to 37%, as obtained with the LC 2 & saliency model. This is a noteworthy sign of stability achieved in the sizing of the saliency segments after having estimated an additional latent class. On the whole, stable are also the majority of the monetary valuations obtained. Remarkable similarities are found comparing: class 3 of model LC 3 with class 3 of model LC 3 & saliency; class 1 of model LC 3 and class 5 of model LC 3 & Saliency. Yet, class 4 of model LC 3 & Saliency is quite peculiar. This is characterized by individuals not valuing distance from the hypothetical nuclear plant and presenting the highest valuation for nuclear waste reduction, emission reductions, hospitals and land recovery measures.

Table 6.15: Parameters' estimates-Case study 2 (UK) LC 3 & Saliency

	LC 3			LC 3 & saliency				
Variables	Class 1	Class 2	Class 3	Class 1	Class 2	Class 3	Class 4	Class 5
$W_{it,j}$	/	/	/	.616*** (.044)	2.57*** (.072)	0	0	0
ASC_NONE	-1.192*** (.166)	2.01*** (.121)	7.92*** (.657)	0	0	7.26*** (.741)	-1.08** (.284)	-1.18** (.196)
DISTANCE 120 Miles	.619*** (.056)	1.04*** (.068)	2.35*** (.337)	0	0	2.33*** (.394)	-.210*** (.116)	.777*** (.061)
DISTANCE 60 Miles	0.440*** (.065)	0.611*** (.077)	0.828*** (.385)	0	0	1.10*** (.430)	-.417*** (.136)	.637*** (.077)
NUCLEAR WASTE REDUCTION: 30%	0.659*** (.060)	0.422*** (.078)	1.47*** (.292)	0	0	1.41*** (.309)	.946*** (.122)	.798*** (.070)
NUCLEAR WASTE REDUCTION: 20%	0.487*** (.062)	0.190*** (.081)	1.03*** (.330)	0	0	.818*** (.357)	.602*** (.135)	.695*** (.072)
EMISSIONS -10%	0.417*** (.030)	0.394*** (.039)	0.631*** (.179)	0	0	.662*** (.188)	.635*** (.060)	.510*** (.032)
HOSPITALS	0.772*** (.059)	0.627*** (.063)	0.826*** (.269)	0	0	.828*** (.296)	2.01*** (.138)	.814*** (.066)
LAND RECOVERY	0.219*** (.045)	0.311*** (.060)	0.204*** (.280)	0	0	.192*** (.320)	.844*** (.095)	.146*** (.052)
BILL REDUCTION (£)	0.004*** (.000)	0.002*** (.000)	0.004*** (.001)	0	0	.004*** (.001)	.001*** (.000)	.006*** (.000)
Class Probabilities	0.65	0.19	0.16	0.20	0.17	0.17	0.14	0.32
Log Likelihood	-5515.66			-5340.4				

Table 6.16: Parameters' estimates-Case study 2 (UK) LC 3 & Saliency

	LC 3			LC 3 & saliency				
Variables	Class 1	Class 2	Class 3	Class 1	Class 2	Class 3	Class 4	Class 5
$W_{it,j}$	/	/	/	.616*** (.044)	2.57*** (.072)	0	0	0
ASC_NONE	-283.9	872.4	1731	0	0	1721.4	-600.6	-195.2
DISTANCE 120 Miles	147.4	449.5	515.4	0	0	552.9	-116.2	128.3
DISTANCE 60 Miles	104.9	264.3	181	0	0	260.9	-230.6	105.3
NUCLEAR WASTE REDUCTION: 30%	157	182.4	321.6	0	0	335.6	522.3	131.8
NUCLEAR WASTE REDUCTION: 20%	115.9	82.4	226	0	0	193.9	332.3	114.7
EMISSIONS -10%	99.4	170.6	137.9	0	0	156.9	350.5	84.3
HOSPITALS	183.8	270.8	180.5	0	0	196.3	1114.3	134.5
LAND RECOVERY	52.2	134.4	n.s.	0	0	45.7	465.7	24.2
BILL REDUCTION (£)				0	0	/	/	/
Class Probabilities	0.65	0.19	0.16	0.20	0.17	0.17	0.14	0.32
Log Likelihood	-5515.66			-5340.4				

6.6.3 Case study 3-UAE

The case study 3 offers some important differences compared to case study 1 and 2. That is, respondents were asked to consider current nuclear energy technology instead of a technology under research and development. In addition, the number of attributes and choice tasks was halved. The attributes 'distance' and 'emission reductions' were included in this study as well. The attribute 'Parks' was introduced in this study and represents hypothetical public benefits. Whilst trying to estimate different specifications within a latent class framework, it was found that only a MNL & Saliency could be estimated as additional classes lead to convergence failure. In addition, a global optimum is found constraining to zero the parameter attached to the alternative 'None'.

Table 6.17: Parameters' estimates-Case study 3 (UAE). MNL & Saliency

Variables	MNL	MNL & saliency Class 1	Class 2	Class 3
$W_{it,j}$	/	/	2.11*** (.079)	-1.02*** (.060)
ASC_NONE	0	0	0	0
DISTANCE 200 Km	0.660*** (.040)	1.69*** (.092)	0	0
DISTANCE 100 Km	0.506*** (.042)	1.60*** (.087)	0	0
DISTANCE 50 Km	0.177*** (.042)	0.931*** (.080)	0	0
EMISSION REDUCTION: 10%	0.129*** (.028)	0.424*** (.032)	0	0
PARKS	0.190*** (.028)	0.500*** (.047)	0	0
BILL REDUCTION (AED)	0.0007*** (.000)	0.0002*** (.000)	0	0
Class Probabilities	/	0.55	0.16	0.29
Log Likelihood	-8146.68	-7592.55		

The MNL model & MNL & Saliency are shown in Table 6.17 and 6.18, where coefficients and monetary valuations are displayed, respectively. According to the MNL model, all attributes are significantly valued. Further distance from the nuclear plants is preferred, with an estimated monetary valuation of 863 AED for 200 Km away from the area of residence. This reduces to 661 AED for 100 Km away. Emissions' reductions are valued up to 168.5 AED, whereas the construction of parks and other recreational spaces is valued up to 248.5 AED. The MNL & Saliency model presents two saliency classes, totaling 45% of the class membership probability. One saliency class, representing 16% of the sample, is characterized by a positive coefficient associated to $W_{it,j}$. The second saliency class, amounting to 29%, has instead a significant and negative γ coefficient.

Table 6.18: Monetary valuations-Case study 3 (UAE). MNL & Saliency

	MNL	MNL & saliency		
Variables		Class 1	Class 2	Class 3
$W_{it,j}$	/	/	2.11*** (.079)	-1.02*** (.060)
ASC_NONE	0	0	0	0
DISTANCE 200 Km	863.01	588.6	0	0
DISTANCE 100 Km	661.3	556.1	0	0
DISTANCE 50 Km	231.1	322.8	0	0
EMISSION REDUCTION: 10%	168.5	147.1	0	0
PARKS	248.58	173.4	0	0
BILL REDUCTION (AED)	/	/	0	0
Class Probabilities	/	0.55	0.16	0.29
Log Likelihood	-8146.68		-7592.55	

The remaining 65% of the respondents are more likely to be allocated to a class where 200 Km of distance from the nuclear plant are valued 588 AED, whereas 100 Km of distance are valued 556 AED. Further, the construction of parks is linked to a value of 173 AED, whereas emissions' reduction are valued up to just 17 AED. These estimates appear much more conservative as opposed to those derived from the standard MNL. Indeed, this model might present confounding effects between saliency and heterogeneity, which could not be disentangled within a constrained latent class framework.

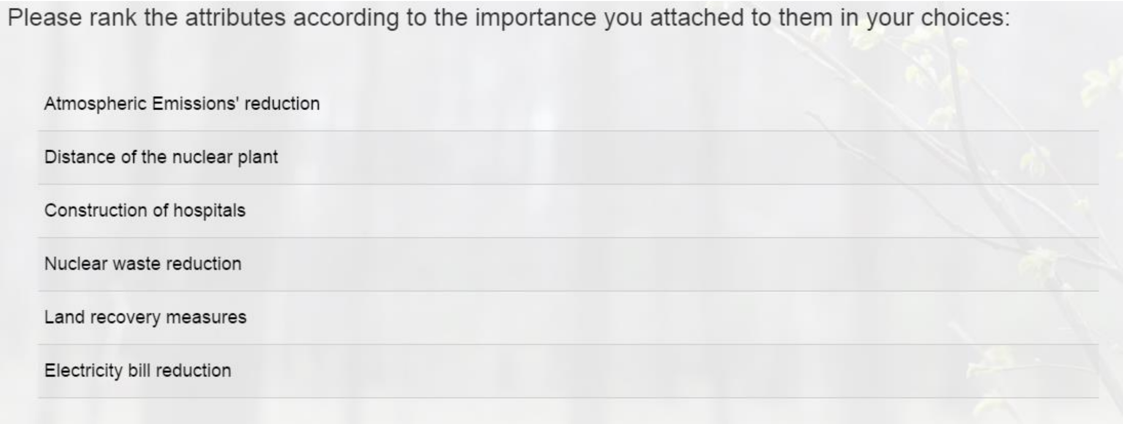
6.7 Conclusion

Across the three studies considered, respondents who seem to have traded-off the attributes whilst making the choice represent the majority. However, a substantial shares seem to focus on salient attributes when picking the preferred option. This evidence appears to be robust across the three case studies considered. On the whole, the empirical findings further confirm the relevance of identifying potential decision rules respondents might be following when taking part in choice experiments. What is more, this work provides a modeling framework for eliciting preferences towards energy sources that a considerable share of individuals are expected to perceive as problematic, such as nuclear energy and fossil fuels (Visschers and Siegrist 2014). More empirical applications would be certainly beneficial, also exploring areas outside of the energy economics realm.

The three case studies presented in this work provide evidence of a number of interesting findings arising from the implementation of the constrained latent class model in the context of attribute saliency. In case study 1 (Italy), a substantial share of respondents chose the 'none' option even when the best level of the most important attribute was shown in either option A or B. This seems to stem from opposition towards the construction of nuclear plants. This is a case in which the most important attribute might present levels which are not in a range such that some of the respondents are willing to trade off. Such instances might lead to the presence of a negative γ_s coefficient among the saliency segments. A negative value of this coefficient was observed in case study 3 (UAE) as well; however, no additional classes could be estimated and confounding effects might be impacting this coefficient. Instead, no such occurrence was observed in the case study 2 (UK), where all γ_s coefficients, across different specifications, were found to be positive. Finally, it was noted in the case study 1 and 2 that when preference heterogeneity was modelled together with attribute saliency, the size of the saliency segments tended to reduce substantially. Failing to allow for preference heterogeneity might lead to an over attribution of the saliency effect.

On the whole, we suggest to employ the constrained latent class model with inclusion of attribute saliency to aid the detection of non-fully compensatory respondents and quantify the extent to which they might focus on a subset of attributes. This may be helpful both at the final estimation stage as well as when piloting the choice experiment to select the final list of attributes and levels of these. In particular, results might highlight issues in terms of the experimental design chosen, for instance suggesting researchers to include additional or different trade-offs. Practitioners need to take into account that the complexity of the design may increase if one is to estimate additional classes to model saliency. For instance, a greater number of choice tasks may be required. Finally, it needs to be remarked that stated importance may lack accuracy, in that the stated most important attribute might not actually be the truly salient one. However, other strategies that do not require statements from respondents, such as mouse or eye-tracking, could be implemented (Balcombe et al. 2015). Further research could explore different model specifications, which depart from modelling heterogeneity in a discrete-only fashion, with particular attention to situations in which the goods under evaluation may contain 'problematic' attributes or levels.

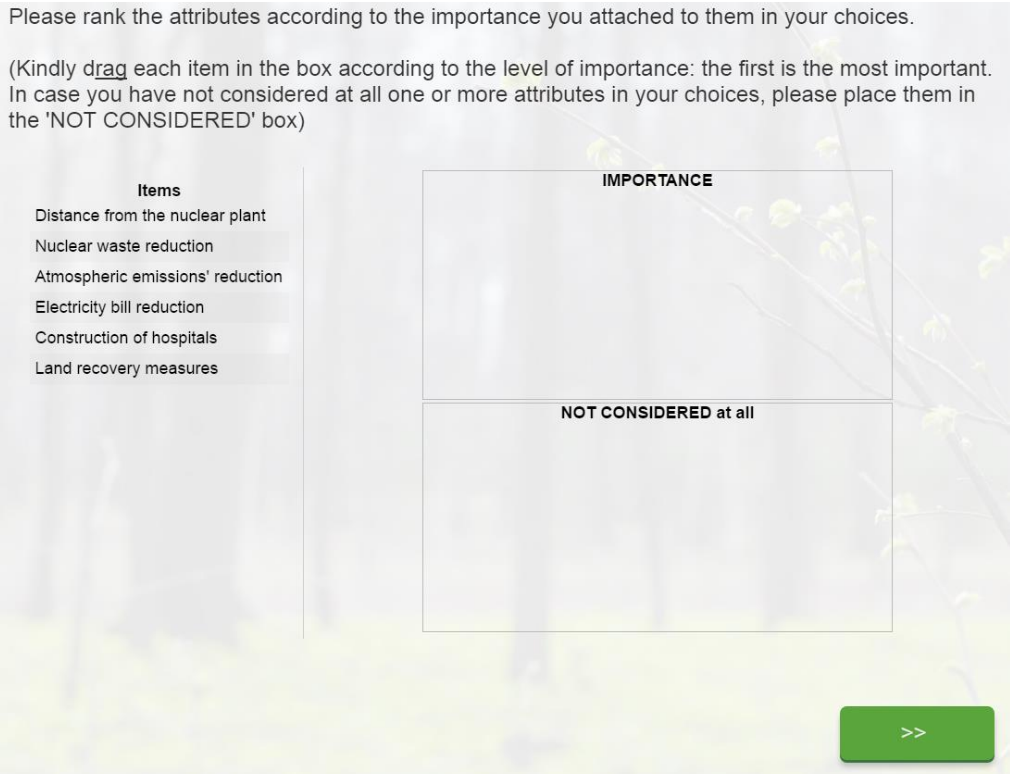
Appendix



Please rank the attributes according to the importance you attached to them in your choices:

Atmospheric Emissions' reduction
Distance of the nuclear plant
Construction of hospitals
Nuclear waste reduction
Land recovery measures
Electricity bill reduction

Figure 6.A1: Ranking question-Case study 1



Please rank the attributes according to the importance you attached to them in your choices.

(Kindly drag each item in the box according to the level of importance: the first is the most important. In case you have not considered at all one or more attributes in your choices, please place them in the 'NOT CONSIDERED' box)

Items
Distance from the nuclear plant
Nuclear waste reduction
Atmospheric emissions' reduction
Electricity bill reduction
Construction of hospitals
Land recovery measures

IMPORTANCE

NOT CONSIDERED at all

>>

Figure 6.A2: Ranking question-Case study 2

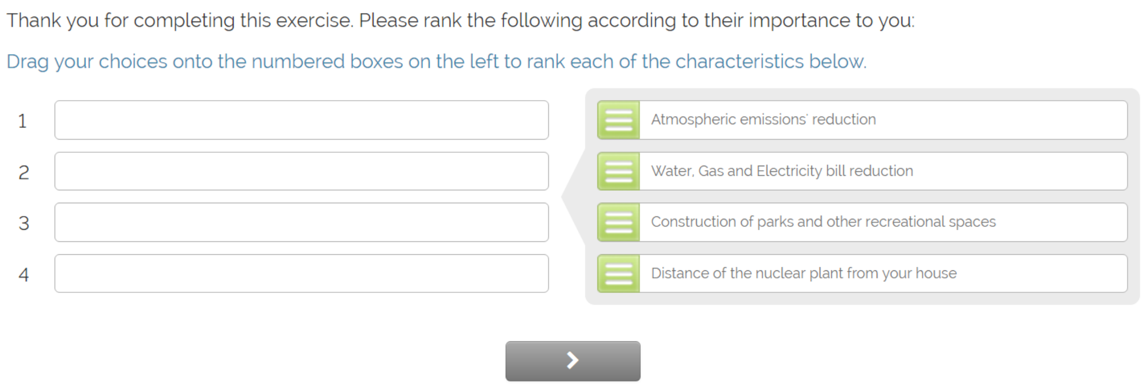


Figure 6.A3: Ranking question-Case study 3

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Chapter 7

Concluding remarks

This chapter concludes the thesis. Findings from the empirical studies are discussed and compared. Section 7.1 discusses results on preferences towards different energy sources; Section 7.2 compares results pertaining the perception of risks and benefits of nuclear energy; Section 7.3 compares the monetary valuations obtained from the three empirical studies; Section 7.4 discusses sensitivity to information; Section 7.5 summarizes the findings about the role of saliency in choice experiments; finally, Section 7.6 concludes.

7.1 Views on nuclear energy

7.1.1 Nuclear versus other energy sources

Preferences towards different energy sources vary substantially across the three case studies. We asked respondents to state the extent to which their country of residence should invest in different energy sources. Results are summarized in Table 7.1. The Italy case study displays the highest level of opposition towards nuclear energy: 45% would not want any investment in it. This share drops to 15% among UK respondents, and to 11% considering the UAE study. Further, only 10% of Italy's respondents would want the country to invest a lot on nuclear, as opposed to 22% in the UK, and 26% in the UAE. While views towards nuclear energy differ markedly when comparing Italy versus the UK and the UAE, renewable energy sources seem to be endorsed across all of the three studies. In Italy and the UAE, solar/photovoltaic appears to be greatly favoured. In the UK, hydroelectric receives the greatest endorsement, yet solar/photovoltaic and wind energy follow closely. Also, across all the three case studies, a substantial share selected 'I do not know' when it comes to biomass and geothermal energy, thereby signaling a certain degree of unfamiliarity with these two energy sources.

Table 7.1. In your opinion, how much should (COUNTRY) invest in…? (% reported)

ITALY	Nothing	A little	Some	A lot	Don't know
Solar/Photovoltaic	1	3	18	77	2
Wind	1	7	28	61	3
Hydro	1	7	38	50	5
Geothermal	2	7	34	47	11
Biomass	2	11	35	35	17
Fossil fuels	20	40	23	11	6
Nuclear	45	24	16	10	5
UK	**Nothing**	**A little**	**Some**	**A lot**	**Don't know**
Solar/Photovoltaic	4	11	35	33	17
Wind	7	14	33	32	15
Hydro	2	10	35	35	18
Geothermal	5	13	30	16	35
Biomass	5	15	32	14	35
Fossil fuels	19	27	26	8	20
Nuclear	15	19	26	22	18
UAE	**Nothing**	**A little**	**Some**	**A lot**	**Don't know**
Solar/Photovoltaic	4	6	18	55	17
Wind	6	12	27	37	20
Hydro[a]					
Geothermal	8	10	25	25	32
Biomass	7	11	25	22	35
Fossil fuels[b]	7	13	27	32	21
Nuclear	11	14	25	26	24

[a]Not asked in the UAE study. [b]Average of oil, gas and coal. Sample size: Italy= 1198; UK=887; UAE=1961.

7.1.2 IV generation nuclear energy

Views on IV generation nuclear energy were collected as part of the Italy and UK case studies. Stated awareness of this particular technology under R&D amounts to 37% of the Italian respondents and just 8.4% of the UK respondents. They were prompted to evaluate the importance of the IV generation energy goals, shown to them as generic goals of the nuclear industry. Unsurprisingly, ‘reducing the probability of catastrophic accidents’ turned out to be the most important goal, followed by ‘reducing nuclear waste production’ and ‘increasing passive security’, in both the countries considered. However, in both cases, the level of confidence towards the achievement of all the goals appears to be quite low, especially when it comes to the Italy study. For instance, while 63% of Italians respondent judged the goal of reducing the probability of catastrophic accidents to be extremely important, only 7% were extremely confident that this goal would be reached. There is, indeed, a substantial confidence gap arising from both the two studies.

7.2 Perceived risks and benefits of nuclear energy

Respondents’ views towards potential benefits and risks of nuclear energy are reported in Tables 7.2 and 7.3. It is worth noticing that some of the options were not displayed across all the case studies, being country specific. In line with the vast share of respondents not wanting Italy to invest anything in nuclear energy, more than 6 in 10 believe the following risks are very/extremely likely: public investments in Italy, nuclear waste related risks, and risks for the environment. Instead, considering the UK case study, threats for the environment is considered the most likely risk, although only 22% judge this as very/extremely likely. Considering the UAE, the top risk is believed to be nuclear waste disposal accidents, indicated by 26% as very likely.

Table 7.2. Perceived risks of nuclear energy (% reported)

ITALY	**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
UK	**Not at all/a little**	**Somewhat unlikely**	**Neutral**	**Somewhat Likely**	**Very/ Extremely likely**
Damages/threats to the environment	12	13	28	25	22
Nuclear waste disposal accident	12	13	29	26	20
Terrorist attacks	12	13	33	23	20
Damage/threats to the human health	14	13	30	24	20
Use of nuclear for military purposes	17	13	32	21	17
Risk of catastrophic accident	14	16	30	25	16
UAE[a]	**Very unlikely**	**unlikely**	**Neutral**	**likely**	**Very likely**
Nuclear waste disposal accidents	5	8	29	32	26
Damage/threats to the human health	4	10	30	32	24
Use of nuclear for military purposes	6	9	33	31	22
Damage/threat to the environment	5	12	31	32	21
Terrorist attacks	8	11	31	30	20
Risks of catastrophic accidents	6	11	31	33	19

[a]A 5 points scale was employed in the UAE case study. Sample size: Italy=1198; UK=887; UAE=1961.

On the whole, the risk of catastrophic accidents is not perceived to be the most likely of the risks considered in any of the three countries, although considerable heterogeneity across countries is observed. Namely, more than half of Italian respondents believe it to be very/extremely likely, whereas this share falls to 16% in the UK study; among the UAE respondents, 19% indicate this risk to be very likely. The Italy and UK case studies share similar results in terms of perceived benefits. In both instances, less energy imports and less reliance on fossil fuels are the top two benefits. Also similar are the views on less unemployment, which is seen as the least likely benefit. With regards to the UAE, a sizeable share of respondents appears neutral when considering all the potential benefits listed; also, the possibility of atmospheric emissions reduction is perceived as the least likely benefit.

Table 7.3. Perceived benefits of nuclear energy (% reported)

ITALY	**Not at all/a little**	**Somewhat unlikely**	**Neutral**	**Somewhat Likely**	**Very/ Extremely likely**
Less energy imports	11	8	18	29	34
Less reliance on fossil fuels	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
UK	**Not at all/a little**	**Somewhat unlikely**	**Neutral**	**Somewhat Likely**	**Very/ Extremely likely**
Less reliance on fossil fuels	4	7	28	30	32
Less energy imports	5	8	31	27	28
Atmospheric emissions' reduction	7	9	40	24	21
More convenient energy prices	12	13	38	23	15
Economic growth	6	9	45	29	11
Less unemployment	11	15	49	17	8

UAE[a]	Very unlikely	unlikely	Neutral	likely	Very likely
Technology innovation	4	6	37	35	19
Energy source diversification	3	7	36	37	17
Economic growth	4	6	40	35	16
Less reliance on fossil fuels	4	8	39	34	16
More convenient energy prices	5	9	40	32	15
Atmospheric emissions' reduction	7	10	45	28	9

[a]A 5 point scale was employed in the UAE case study. Sample size: Italy= 1198; UK=887; UAE=1961.

7.3 Monetary valuations

7.3.1 Monetary valuations: overview

The monetary valuations obtained from the three case studies are compared in this section. It is worth noticing that these comparisons are conducted in absolute terms, not accounting for purchasing power parity. All the values displayed are reported in USD per household per year. Italy and the UK have the same set of attributes and were presented in the context of IV generation nuclear energy. Instead, in the UAE case study there was no reference to such particular energy technology; also, the set of attributes differs slightly. Specifically, the attributes ‘waste reduction’, ‘hospitals’ and ‘land recovery measures’ were dropped from the experimental design of the UAE case study, whilst the attribute ‘construction of parks’ was included. The attributes ‘distance’ and ‘emission reductions’ are common across all the three studies. In addition, in all the choice experiments conducted, respondents were presented with three options: option A, option B, or None. Across all the choice situations, both option A and B represented a nuclear project implementation[60]. Hence, the alternative specific constant (ASC) associated with the option 'None' (i.e. none of the nuclear projects presented) provides an indication of the extent of opposition, or acceptance, towards nuclear energy implementation.

Results are summarized in Table 7.4. For each country, monetary valuations obtained from the MNL, RPL and LC models are displayed. A few common indications emerge when inspecting MNL/RPL models: 1) a greater distance from nuclear plants is preferred, 2) environmental benefits (nuclear waste reduction and emission reduction) are positively valued, 3) public benefits (hospitals, land recovery measures, parks) are valued too. Moreover, it emerges that both Italy and UK are associated with positive values of the ASC, indicating that overall respondents would not prefer the building of new power plants; instead, this value is negative when considering the UAE, showing a tendency to choose one of the projects rather than none. With regards to distance, in line with expectations, values marginally fall with decreasing distance across the three case studies. In addition, compared to the UAE case study, Italy and the UK present greater monetary valuations for each level considered. Nuclear waste reductions are more valued by Italian respondents, whereas emissions reductions received the highest valuations from the UK respondents.

[60]In the Italy and the UK case studies there were 8 such choice situations, whereas they were halved to 4 to in the UAE case study.

Table 7.4. Monetary valuations (USD per household per year) across the three case studies

	ITALY					UK						UAE			
	MNL	RPL	LC1	LC2	LC3	MNL	RPL	LC1	LC2	LC3	LC4	MNL	RPL	LC1	LC2
ASC (option none)	961	1043	→+∞	-282	958	871	154	-318	4426	730	1499	-218	-1048	-1539	801
Distance: 200 Km	431	327	→+∞	310	548	493	350	64	1577	1982	727	384	286	461	100
Distance: 100 Km	349	265	→+∞	280	398	253	223	n.s.	561	1437	503	245	200	301	n.s.
Distance: 50 Km	257	169	→+∞	177	267	239	177	94	n.s.	765	363	n.s	n.s.	n.a.	n.a.
Waste Reduction	339	255	→+∞	259	374	283	214	101	254	226	133	n.a.	n.a.	n.a.	n.a.
Emission Reduction	165	132	→+∞	141	196	225	149	163	283	290	209	109	76	118	n.s.
Hospitals	195	192	n.d.	159	306	319	239	238	322	488	392	n.a.	n.a.	n.a.	n.a.
Land Recovery	309	257	→+∞	206	418	116	103	91	n.s.	176	250	n.a.	n.a.	n.a.	n.a.
Parks	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	94	76	98	71
Segment size	n.a.	n.a.	33%	42.6%	24.4%	n.a.	n.a.	46.9%	16.1%	19.3%	17.8%	n.a.	n.a.	80%	20%

Monetary valuations (MV) are computed as the ratio between non-monetary coefficients over the monetary coefficient. The monetary attribute is represented by % of annual electricity bill reduction for the household, applied to the vector of the average stated electricity bill expenditure. The non-monetary attributes are welfare improving benefits (greater distance, emission reductions, etc). The monetary attribute is a compensation: bill reduction. So the higher the benefit, the lower should the compensation required be, i.e. the higher the WTP (in terms of foregone compensation). In line with expectations, negative signs are only observed in correspondence of some of the ASCs, indicating a positive attitude towards the building of nuclear power plants. These monetary valuations are expressed in USD. The exchange rate employed are from https://www.irs.gov/individuals/international-taxpayers/yearly-average-currency-exchange-rates. The average of the year 2014 was considered for case studies 1 and 2, whereas the average of the year 2015 was considered for case study 3. n.d.: not defined. n.a.: not applicable. n.s.: not significant at α<10%.MNL: Multinomial Logit Model. RPL: Random Parameters Logit Model (WTP space estimation for Italy & UK, parameter space estimation with fixed cost parameter for the UAE). LC: Latent class model, one column per segment. In the UK study, distance was expressed in Miles, in the Italy's and UAE's study it was expressed in Km.

Finally, in terms of public benefits, land recovery measures are associated with a higher monetary valuation in the Italy study. Instead, the construction of hospitals seem to be valued to a greater extent in the UK study.

A great deal of heterogeneity in preferences was detected across the studies. When assessing the monetary valuations derived from the LC estimators, one segment of Italian respondents (LC1) would not accept any monetary compensations, as they do not significantly value electricity bill reductions within the range presented. This is a unique finding across the three studies. This segment of respondents was labelled ‘strong opposers’, and amounts to 33% of the sample. A segment of opposers (LC2) was also found in the UK case study, representing 16% of the sample. Yet, in this instance monetary compensations seem acceptable. These individuals would require compensations of over 4400 USD per household per year for the construction of new power plants. No segment of strong opposers was identified in the UAE case study.

Other segments display a more positive stance towards the implementation of nuclear energy projects: LC2 in the Italy case study, LC1 in the UK case study, and LC1 in the UAE case study. In all these segment the ASC coefficient is negative and statistically significant, indicating respondents were more likely to opt for one of the nuclear energy projects. The largest of these segment is in the UAE case study, amounting to 80% of the respondents. Instead, the share drops to 46.9% in the UK study, and to 42.6% in the Italy case study. These individuals seem open towards compensations, yet they are not necessarily supportive of nuclear energy when inspecting their CV answers. This aspect was explored in chapter 4, where we complemented choice experiment data with contingent valuation data on the willingness to contribute towards further R&D of IV generation technology. Among those UK respondents deemed to be more supportive (allocated to the segment LC1), over 40% stated a zero WTP.

7.3.2 Latent Class models-class membership probability

When estimating the LC models, the class membership probabilities were set as function of key variables. In the Italy and UK studies, these variables were the score factors of the following latent constructs: perceived benefits, perceived risks and confidence towards the achievement of IV generation technology goals. These constructs were shown to significantly affect acceptance of nuclear energy within a structural equation model, presented in Chapter 3. With regards to the Italy case study, the segment LC2 (more likely to choose one of the nuclear projects over none) is associated with a higher score on confidence and a lower score on perceived risks. Instead, the segment LC1 (more likely to choose none of the nuclear projects) is significantly linked to a lower score on perceived benefits. Similarly, UK respondents more likely to belong to the segment LC1 (more likely to choose a nuclear project over none) score lower on the risks and higher on the confidence levels; whereas those associated with LC2 (highest probability of choosing none of the nuclear projects across all of the segments) score lower on confidence and perceived benefits, whilst scoring higher on perceived risks.

A different set of variables was instead included as part of the LC estimator applied to the UAE's choice experiment data. Namely, these variables are: 1) a dichotomous variable that indicates whether a given respondent is transient or not, 2) a dichotomous variable that specifies whether a given individual is an expatriate more satisfied with his/her life in the UAE. Transients and those more satisfied with their life are more likely to belong to LC1, the segment associated with a negative ASC (and therefore more likely to choose a nuclear project).

7.4 Sensitivity to information

In the Italy and UK case studies we presented a random sub-set of respondents with information on Chernobyl and Fukushima's accidents (Table 7.5), besides showing a map with nuclear plants operating, shut down, and under construction in Europe (Figure 7.1). This information treatment was given right before the start of the choice experiment exercise. Italian respondents were significantly affected by this treatment, making them more prone to oppose nuclear energy projects. Instead, UK respondents, residing in a country with a long history of nuclear plants in operation, were not significantly impacted by these additional pieces of information.

Table 7.5: Information on Chernobyl and Fukushima

Chernobyl (1986)	**Fukushima (2011)**
The accidents 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 explosion 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 a 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 thyroid cancer among those who were children or adolescents at the time of the accident.	Long term effects: too soon to tell.

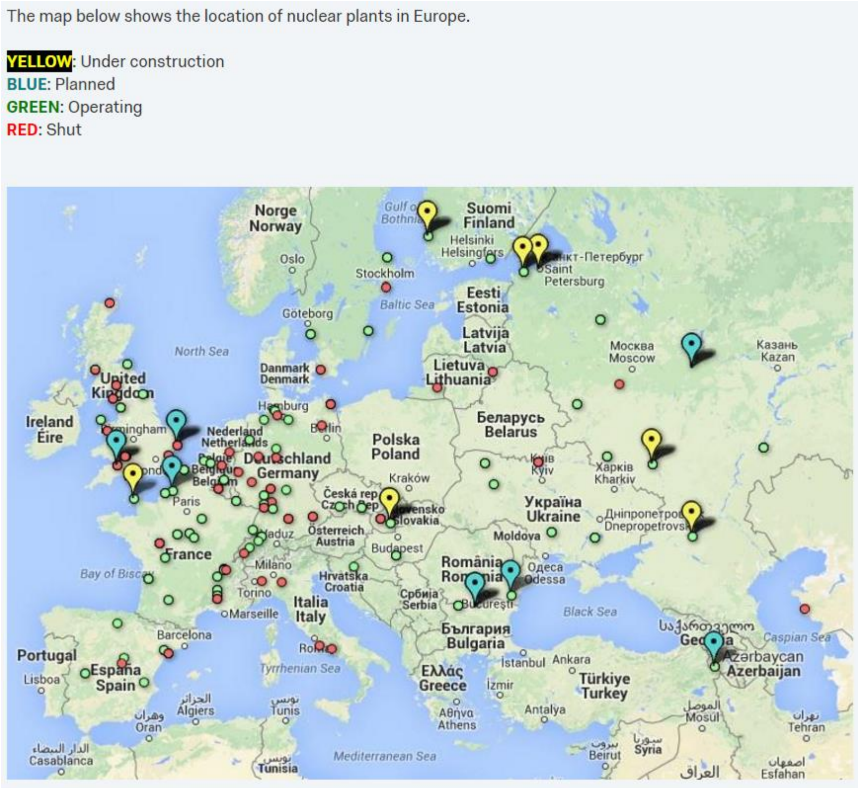

Figure 7.1: Map showing the location of nuclear plants in Europe

This finding is of noteworthy relevance, as it presents a key difference between respondent who live in country with nuclear plants in operation as opposed to individuals who live in a country without nuclear plants. We also examined secondary data to further contextualize these findings. In particular, we considered Google trends data. This allows us to compare the volume of UK-based searches and Italy-based searches, versus other European countries, of the term 'Fukushima'. The time frame considered ranges from March 2011, during which the disaster happened, until June 2011. Data is randomly drawn from the set of Google searches for the time selected and duplicate searches are removed (Google 2016). Data points are indexed from 0 to 100. Results, displayed in Figure 7.2, show the UK is associated with the lowest number of searches, reaching a value of 13 on the 13th of March. On the same day Germany is associated with the highest volume of searches (100), followed by Switzerland (82) and Italy (39). Grippingly, according to the analysis of Kepplinger and Lemke (2016), in the aftermath of the Fukushima disaster the media in Germany and Switzerland stressed the importance of the accident and its links with their domestic nuclear programme. Instead, in the UK, the coverage was focused more on the tsunami, hence on the natural aspect of the disaster. All in all, the much lower level of 'Fukushima' searches typed in the UK is aligned with the lack of sensitivity to information emerged in the empirical case study presented in this thesis.

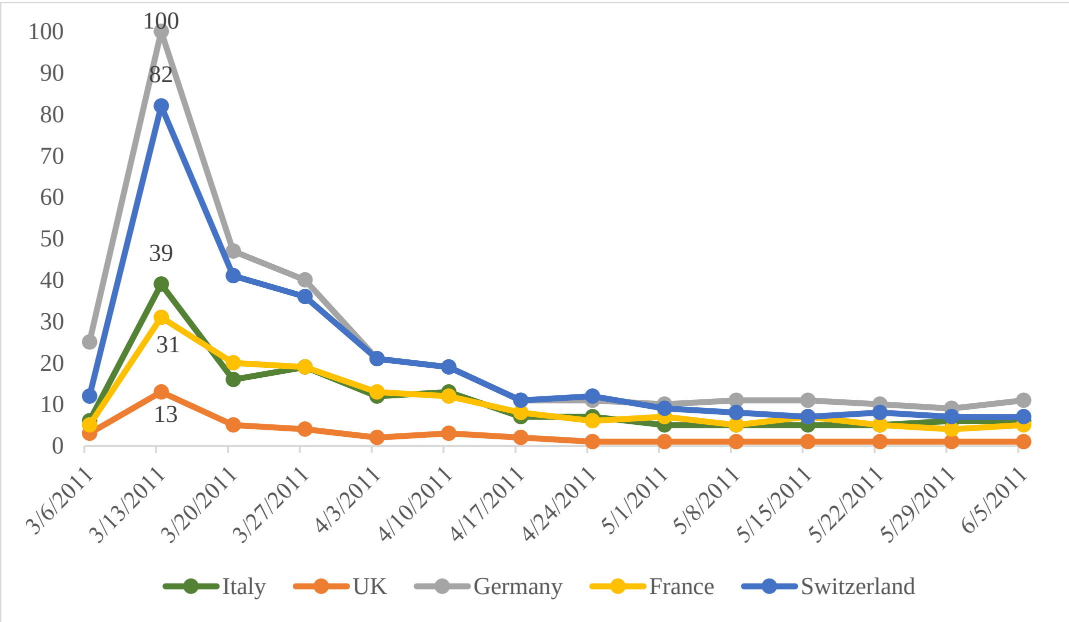

Figure 7.2: Google searches of the term "Fukushima" by Country-Google Trends data

7.5 Salient attributes

Standard econometric models used to analyse choice experiment data are rooted on the assumption that respondents successfully compare and trade-off the attributes' levels between the options shown. However, this might not be the case when dealing with preferences towards nuclear energy, in scenarios where specific attributes or levels may capture the attention of the respondents. Drawing on previous literature on choice set formation, lexicographic preferences, attribute non-attendance and stated attribute importance, this thesis tested the following hypothesis: whilst choosing an option, respondents might overly focus on some key attributes which are salient for them; in turn, salient attributes play a major role in determining his or her final choice. Saliency was operationalized by eliciting information on the most important attributes through a ranking exercise presented after the completion of the choice experiments tasks. This information was then included into a constrained latent class model, which estimates the probability that the decision is driven by the salient attribute or according to a standard utility function. Across the three studies considered, evidence was found that a substantial share of respondents seem to focus on salient attributes when choosing the favourite option. The constrained latent class model with inclusion of attribute saliency can be implemented to quantify the extent to which individuals might focus on a subset of attributes. Yet, it is crucial to test whether the inclusion of additional (standard) latent segments affects the size of the saliency segments, hence signaling the presence of confounding effects between preference heterogeneity and decision process heterogeneity.

7.6 Summary of conclusions

This thesis puts forward a number of policy contributions. First, it provides empirical evidence on views towards IV generation nuclear energy which represents, according to its proponents, the chance for a better, safer, even revolutionary nuclear energy technology. We have seen from both the Italy and UK case study that social acceptance of IV generation nuclear energy appears to depend on the confidence individuals have towards the achievement of the IV generation technology goals. In addition, it is affected by the individuals' perceived risks and benefits of nuclear energy, in line with the framework set out by de Groot et al. (2013). In the UK case study, individuals who show greater trust towards corporations and authorities in the field of nuclear energy are more prone to show greater confidence; this conforms to the positive effect of trust documented by Ansolabehere and Konisky (2009), Greenberg (2009), Siegrist and Cvetkovich (2000), Greenberg and Truelove (2011), Bronfman et al. (2012). On the whole, whilst the vast majority of respondents would agree the goals of IV generation technology are of prominent importance, very few are confident they that they will be achieved. There is a considerable confidence gap which, for the advocates of nuclear energy, seems to be worth addressing.

The thesis provides empirical evidence of willingness to accept estimates for the case of Italy (IV generation), the case of the UK (IV generation), and the case of the UAE (current generation technology). Given the limitation in terms of representation due to the use of panels and absence of post-stratification, the monetary valuations cannot be used to describe those of the Italy, UK and the UAE population; however, they provide indications for the policy makers to be further investigated and validated in terms of precise magnitude for each country. Also, caution is required when inferring to the broader population the sizing of segments of preferences.

With regards to the Italy case study, a country with no nuclear plants in operation, a segment of respondents would not accept monetary compensations to put up with nuclear energy. Instead, no such barrier was found when considering the case of the UK, country with operating nuclear plants. In addition, Italian respondents presented with information on past accidents and the location of nuclear plants in Europe displayed a heightened level of opposition, whereas UK respondents were not significantly affected. When focusing on the UAE cases study, we found that transiency of residence seems to foster acceptance of nuclear energy. This is especially the case among individuals who stated to have greater life satisfaction. We also found comparative evidence on views towards different energy sources. Across the three country considered, renewable energy sources receive ample support, confirming a trend previously found in studies addressing the case of Italy (Bigerna and Polinori 2014; Bollino 2009; Cicia et al. 2012; Strazzera et al. 2012b) and the UK (Fimereli 2011, Pidgeon et al. 2008, Upham et al. 2009). In line with the willingness to accept estimates, nuclear energy obtains the greatest share of dislikes in the Italy case study, whereas UAE respondents appear more favourable towards it.

With regards to methodological contributions, the thesis has found what follows. Structural equation modeling of psychometric data can successfully complement the analysis of choice experiment data. It allows for internal validity tests and deeper analysis of factors affecting they key attitudes which are in turn dependent on other latent constructs. We found that perceived benefits, risks, and confidence significantly affect both stated preferences, measured via choice experiments, and acceptance, measured via a set of agreement/disagreement statements. Moreover, we were able to show the role of egoistic, altruistic and biospheric values (Italy study), as well as the impact of trust (UK study) by means of structural equation modeling.

Contingent valuation data can be successfully employed to investigate further willingness to accept results, in terms of alignment of findings and further enriching the description of the latent segments obtained from the analysis of CE data. Individuals who tend to show a heightened level of opposition according to the CE data, also exhibited a lower inclination to contribute in the CV question. At the same time, among individuals who might be deemed as moderate supporters when inspecting CE data, a substantial share would not be willing to pay for further R&D of IV generation nuclear energy.

Finally, this thesis has formulated and tested the saliency hypothesis in the context of modeling choices when the good under valuation might affect the decision strategy of the respondents. The constrained latent class model employed allows to segregate respondents into standard utility function segments, and segments driven by saliency instead. Yet, it is key to simultaneously test for the presence of preference heterogeneity, due to the possibility of cofounding effects, as noticed with the modeling of other heuristics (Hess et al. 2013). Hence, practitioners should be wary of potential confounding effects that may lead to an over-attribution to the saliency segment. Further research could explore additional model specifications in a continuous effort to improve the way we approximate individual choices, especially in contexts where controversial goods are being evaluated.

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