



UNICA

UNIVERSITÀ
DEGLI STUDI
DI CAGLIARI



Università di Cagliari

UNICA IRIS Institutional Research Information System

This is the Author's *accepted* manuscript version of the following contribution:

Elisabetta Strazzerà, Daniela Meleddu, Rossella Atzori, *A hybrid choice modelling approach to estimate the trade-off between perceived environmental risks and economic benefits in Ecological Economics*, vol. 196 (2022), art. n. 107400.

The publisher's version is available at:

<https://doi.org/10.1016/j.ecolecon.2022.107400>

When citing, please refer to the published version.

© 2022. This manuscript version is made available under the CC-BY-NC-ND 4.0 license <https://creativecommons.org/licenses/by-nc-nd/4.0/>

A hybrid choice modelling approach to estimate the trade-off between perceived environmental risks and economic benefits

Elisabetta Strazzera, Daniela Meleddu, Rossella Atzori

Abstract

Hazardous facilities raise issues of public acceptance, largely driven by citizens' beliefs, which should be thoroughly understood to inform assessment of welfare changes and possible compensation measures for local populations impacted by their presence. Modelling the socio-psychological drivers of public acceptance would help such understanding, yet this approach is seldom used in project appraisal. The current paper aims at filling this gap, in a valuation study dealing with a military facility located in Sardinia (Italy). A hybrid choice model is applied to the data, which integrates a rich socio-psychological framework with the choice model, resulting in a complex multi-layer structure. Results show that place attachment, sense of community and trust in institutions influence the perception of environmental and health risks, and the perception of economic benefits. The latter factors are negatively correlated and directly influence the utility of the attributes characterising the alternatives, driving the preference toward the proposed scenarios. These findings have important practical implications, giving guidance to calibrate welfare compensations and to define policy measures aimed at socio-economic regeneration

Keywords: *Public acceptance Risk perception Benefit perception Hazardous facilities Military bases Hybrid choice model*

1. Introduction

Every decision regarding land use in a territory comes with costs and benefits, and this is especially true for the case of siting and management of hazardous facilities (HF). Power plants, chemical factories, waste disposal infrastructures and many other facilities are deemed essential for the economic growth of a country and, in some cases, can contribute to the achievement of important objectives for the society. However, the distribution of the costs and benefits of a HF is often perceived as unfair by residents in nearby areas: for example, large wind and solar plants are beneficial for the population at large, by producing green energy while contributing to reduce greenhouse gas emissions, but their construction is sometimes strongly opposed by locals because of adverse visual impacts and land use change in these areas. This phenomenon is often referred to as “Not In My Backyard” (NIMBY) (Dear, 1992) or “Locally Unwanted Land Use” (LULU) (Schively, 2007). The distinctive feature is that such contested land uses produce negative environmental and possibly health impacts at the local level and broadly distributed benefits at a more general level (Liu et al., 2018).

Previous literature has explored attitudinal motivations of opposition toward many types of HFs, such as industrial sites (e.g. petrochemical industries as in Hung et al., 2020, or chemical factories as in Li et al., 2019), nuclear power plants (Chung and Kim, 2009; Wang et al., 2020), waste-to-energy plants (Achillas et al., 2011; Liu et al., 2018), etc. Military facilities have received much less attention, possibly because hazardous activities (such as weapon testing and war simulations) are conducted in training areas relatively secluded from densely populated territories. However, their presence has relevant impacts on hosting communities. As other HFs, military installations entail an unequal distribution of costs and benefits over the territory: they serve to provide national security (general benefit) and may create development opportunities (both general and local benefit), but most social costs are localised. From an environmental and health perspective, there is a potential hazard of water and soil pollution due to residuals of military drills, with potential health impacts. Furthermore, important social costs are generated by a restricted use of land for other purposes, such as agricultural, industrial, residential, touristic and recreational uses. On the other hand, a military facility, just as any other industry, generates incomes, either directly or indirectly, and a closure or a downsizing of such infrastructures after a period of operation may have significant social impacts on the territory (see Droff and Paloyo, 2015 for an extensive review). It is our opinion that, even assuming that defence requirements are a non-negotiable priority for National security, getting insight on the perceived costs and benefits deriving from modifications of the status quo conditions should be regarded as a fundamental passage in the process. This knowledge would help to inform decision making, and ease conflicts and social tension that the proposed change may raise among the local population: for example, providing guidance on the definition of compensations for the affected citizens and territories.

Welfare assessment of HFs has been the object of many valuation studies, but we are not aware of any application dealing with military facilities. Furthermore, the valuation exercise is usually aimed at assessing the degree of acceptance of a new instalment, and associated monetary (and non monetary) compensations; while we could not find previous choice experiments surveys dealing with a proposed closure or downsizing of such facilities. The current paper aims at filling these gaps. We present an assessment study of a proposed change in a military facility, and more specifically the largest NATO experimental base in Europe, located in Sardinia, Italy (cf. Balletto et al., 2020; Calia et al., 2020). The change regards a possible downsizing of the infrastructure: so, our study is concerned with the valuation of the compensative variation associated with a decrease in environmental/health risk. In this context, the local population faces a trade-off between the loss of benefits generated by the facility (revenues directly or indirectly created by the military base) and gains in terms of reduced impacts on the environment, and reduced restrictions on land use. Our research is characterized by three main elements of novelty. First, from an empirical perspective, the assessment of a project dealing with a military facility represents a new application in environmental economics, as previous literature regarding acceptance and valuation of HFs has mostly focused on energy, waste, and other industrial infrastructures. Second, choice experiments studies aimed at project assessment mostly focus on the estimation of trade-offs between attributes of the proposed project, and associated welfare compensations, while the process leading to the choice behaviour has been scarcely investigated. However, understanding the factors

that drive the decision process can be helpful to improve communication between policy makers and the citizens, and to tailor compensation measures which effectively improve the perceived benefits and risks. As discussed by Hoyos et al. (2015), economists have been historically more interested in analysing the results of rational choice rather than the process of choice, but the psychological process underlying an observed willingness to pay (WTP) or to accept (WTA) response has been receiving increasing attention in the environmental economics literature.

As emphasised by Stern (2000), only attitudinal (psychometric) models can uncover the motivations behind a certain behaviour. Hybrid Choice Models (HCM) provide a framework to jointly model choice behaviour and the socio-psychological process leading to such behaviour. Mariel and Meyerhoff (2016) highlight the importance of the final use of an estimated model: if the primary interest of the study is simply to obtain central tendency measures of WTP or WTA to be plugged in a Cost Benefit analysis, a relatively simple model such as the Random Parameter Logit model can be an adequate choice. But if we are interested in learning something new from the model and disentangle the preference heterogeneity further than a standard RPL allows, then the authors point to HCM as a promising option. This opinion is also shared by Vij and Walker (2016, pp. 212): hybrid models allow for decomposition of the preference heterogeneity into a purely random part and a part related to attitudes, and “provide a mathematical framework for testing and applying complex theories of behaviour, and lend structure and meaning to underlying sources of heterogeneity.” This allows a deeper understanding of the role of socio-demographics, and, subsequently, better policy recommendations. This view diverges from Chorus and Kroesen (2014), and Bahamonde-Birke et al. (2017), who argue that since attitudinal variables are intrinsic characteristics of the individuals (like sex or age), they are not sensitive to changes in external circumstances, leaving little space for guidance on policy implications.

At the very least, a better understanding of the reasons behind a certain behaviour can help to develop information campaigns which are more finely targeted on the socioeconomic and psychological profiles emerged from the survey.

An element of novelty in the current paper is that we define a more complex model structure with respect to previous applications of hybrid choice models. Usually it is assumed that the latent constructs have simply a direct effect in the utility model (as in Faccioli et al., 2020; Grilli et al., 2018). Our model involves multiple layers with hierarchical relations and correlations among socio-psychological factors, with socioeconomic (observed) characteristics included as explanatory variables of latent factors, which in turn explain the choice behaviour. This allows to test different conceptual hypotheses, especially with reference to the relation between benefit perception and risk perception, which is at the core of the socio-psychological literature dealing with acceptance of HFs.

Finally, from a theoretical perspective, we tested a series of behavioural hypotheses which have not been considered in previous studies, although our results confirm standard relations identified by the literature on acceptance of HFs. The paper is organised as follows: Section 2 describes sociopsychological factors potentially related to acceptance of hazardous facilities and reviews previous studies relevant to this topic; Section 3 presents the case study and the research method; the econometric methods are described in Section

4; Section 5 contains the analysis and discussion of results; finally, Section 6 presents practical implications and conclusions.

2. Socio-psychological theory and hypotheses

Public acceptance of hazardous facilities, as well as other NIMBY or LULU installations, can be regarded as the result of an evaluation of costs (or risks) and benefits associated with the project. This point of view, consistent with the assumption of rational homo economicus of standard economic theory, is also shared by some socio-psychological theoretical frameworks such as the Theory of Planned Action by Ajzen (1985). The socio-psychological literature has delved in depth into the relation between risk and benefit perceptions, and their role as drivers of acceptability of hazardous objects (de Groot et al., 2020). Previous research has also emphasised the role of trust (Bronfman and Vázquez, 2011; Poortinga and Pidgeon, 2003; Siegrist et al., 2005), social influence (de Groot et al., 2020; Howell et al., 2017), place attachment (Devine-Wright, 2011; Strazzer et al., 2012; Van Veelen and Haggett, 2017) in influencing the public acceptance of controversial technologies or facilities, either directly or indirectly through the risk-benefit acceptability model. In the following we review the main findings in previous literature and present the model hypotheses to be tested in the empirical application.

2.1. Risk and benefit perception

Previous studies, especially in the field of risky energy technologies, have shown that risk play an important role in explaining acceptability (Contu et al., 2016; de Groot et al., 2020; de Groot et al., 2013; Dreyer et al., 2017; Greenberg and Truelove, 2011; Howell et al., 2017; Keller et al., 2012; Visschers et al., 2011). As pointed out by Fischhoff et al. (1993), risk perception can be interpreted as the subjective assessment of a hazard, which in turn can be influenced by many factors: physical characteristics of the hazard, and socio-psychological characteristics of the individual (previous experience, knowledge, social context, etc.) (López-Navarro et al., 2013; Sjöberg, 2000; Slovic, 2000). Two characteristics of the hazard, “dread risk” (characterized by catastrophic potential, lack of control and “inequitable distribution of risks and benefits”) and “unknown risk” (unobservable, new, and delayed in its effects) have been described as major determinants in risk perception, the former being more important than the latter (Slovic, 1987). The psychometric paradigm has been widely applied in the literature investigating which psychological factors influence risk perception and acceptance of potentially hazardous facilities, such as controllability, perceived benefits and trust (e.g. Chung and Kim, 2009; Janmaimool and Watanabe, 2014; López-Navarro et al., 2013; Visschers et al., 2011). A higher risk perception is generally associated with lower levels of acceptance of HFs (Liu et al., 2018; Mah et al., 2014; Wang et al., 2020; Wang and Li, 2016). On the other hand, HFs can also bring various economic benefits to the host communities, such as increasing local employment and creating opportunities for satellite activities, with a positive impact on the average income in the region in which they are located (Lopez-Navarro et al., 2013; Wang et al., 2020). Benefit perception is seen as positively associated with acceptance, by Bronfman et al. (2008) (various types of hazards); Chung and Kim (2009) (nuclear waste disposal); Wang et

al. (2020) and Frant' al and Malý (2017) (nuclear plants). Liu et al. (2017) indicate that local residents find more attractive those benefits related to local economic improvements, such as infrastructure development and job opportunities, rather than long-term and indirect social benefits. Many previous studies have also tested whether there is a relationship between benefit perception and risk perception. A strong negative correlation is generally found between perceived risk and perceived benefits of energy technologies (de Groot et al., 2020). Some have suggested that benefit perception plays a more important role than risk perception in acceptance of a hazardous technology (de Groot et al., 2020; Siegrist et al., 2007; Siegrist et al., 2000; Tanaka, 2004; Visschers et al., 2011; Wang and Li, 2016). Higher perceived benefits may reduce risk perception: when the activities of a hazardous facility or a technology are perceived as beneficial, people may perceive as less important the associated risks (Siegrist et al., 2007). This would imply that the acceptability of a HF might be increased by stressing its benefits (Siegrist et al., 2000). However, the same authors suggest that also the opposite direction of causality cannot be ruled out, i.e. perceived risks affecting negatively the perception of economic benefits (Siegrist et al., 2007; Siegrist et al., 2000). In this study we propose the following hypotheses:

H1a. Risk perception and Benefit perception are negatively correlated.

H1b. Risk perception directly influences preferences toward the hazardous facility.

H1c. Benefit perception directly influences preferences toward the hazardous facility.

H1d. Risk perception indirectly influences preferences toward the hazardous facility, through Economic benefit perception.

H1e. Benefit perception indirectly influences preferences toward the hazardous facility, through Risk perception.

2.2. Trust

Previous literature has explored the assumption that perceived benefits and risks may be both influenced by a third factor, and potentially correlated rather than causally linked (Siegrist et al., 2000). Social trust could serve as a third unmeasured factor and plays a key role in managing HFs. Many researchers have shown how trust influences acceptance of environmental and health hazards originating from various technologies (Bronfman et al., 2009; Flynn et al., 1992; Guti' errez et al., 2015) and many others have found empirical evidence of a link between trust and risk perception (Achillas et al., 2011; Chung and Kim, 2009; Liu et al., 2018; Visschers et al., 2011). A review of studies of trust in risk management in different contexts (e.g. genetically modified food, water supply, technological hazards, nuclear power and waste, others) revealed that trust generally reduces risk perception and is associated with higher levels of acceptance (Earle, 2010). Trust can be interpreted as a shortcut to manage social uncertainty and complexity (Poortinga and Pidgeon, 2003; Siegrist et al., 2000), since most citizens do not possess the knowledge required to assess a risk, nor its costs and benefits (Lo' pezNavarro et al., 2013). Siegrist and Cvetkovich (2000) observed strong correlations between social trust and perceived risks for hazards about which people were not knowledgeable, whereas correlation

was not significant for hazards about which people possessed more knowledge. Trust in authorities can also influence the perception of economic benefits, due to a potential information asymmetry (Lo'pez-Navarro et al., 2013): the positive impact of a HF on the local territory (e.g. induced economic activity) may be learnt through institutional communication. In such situation, trust may be positively related with perceived economic benefits: the higher the level of trust in public and private institutions, the greater the perceived benefits. In light of the above, we test the following:

H2a. Trust directly influences preferences toward the hazardous facility.

H2b. Trust indirectly influences preferences toward the hazardous facility, through Economic Benefit perception.

H2c. Trust indirectly influences preferences toward the hazardous facility, through Risk perception.

2.3. Sense of community

The role of community engagement in improving public acceptance toward hazardous infrastructures has been emphasised in many studies (Boyd, 2017; Liu et al., 2018; Mah et al., 2014; Wang et al., 2020). Such a role may be played through the causal links between civil engagement and trust (Anderson, 2010; Brehm and Rahn, 1997; Putnam et al., 1994; Uslaner, 2002). The theoretical framework adopted by Anderson (2010) posits that the causal relationship flows from sense of community to trust, arguing that there are many reasons why sense of community could influence trust: first, belonging to a community will generally require to build relationships with its members; second, it entails cooperation which in turn, according to Brehm and Rahn (1997) and Putnam (2000), leads to trust. In de Groot et al. (2020) it is hypothesized that social influence has a direct effect on risk perception and benefit perception: if individuals perceive higher support in their social network toward risky technologies they will consequently perceive more benefits and fewer risks. Alternatively, the influence may be indirect, through activation of trust, which in turn shapes the perception of risks and benefits. In conclusion, many alternative causal links between trust and civic participation or sense of community are possible and have been tested over the years. Here, we test the following hypotheses:

H3a. Sense of community directly influences preferences toward the hazardous facility.

H3b. Sense of community influences preference toward the hazardous facility by positively affecting trust in institutions.

2.4. Place attachment

Place attachment can be defined as the emotional involvement (bonds, affect, thoughts) between individuals and their socio-physical environment (Fornara et al., 2010). Devine-Wright (2009) proposed a framework to explain NIMBYism as a “form of place-protective action, which arises when new developments disrupt pre-existing emotional attachment and threaten place-related identity processes”. He suggests that individuals showing a stronger place attachment may experience the change as a “disruption” or a “threat” and this may trigger negative feelings or explicit opposition toward the new development.

Place attachment has been studied extensively to explain local opposition toward projects which generate impacts on the landscape. Some studies analyse the role of place attachment in influencing the acceptance of a controversial facility directly: for example, Strazzera et al. (2012), Scott and Powells (2020), and Hou et al. (2019). This literature confirms the Devine-Wright's hypothesis that place attachment intensifies opposition toward a HF.

Other works assume that place attachment may be related to acceptance through one or more mediating factors. For example, place attachment is associated with community participation (Kim and Kaplan, 2004; Lewicka, 2005). In this perspective, a sense of place identity could activate a sense of community, and indirectly influence acceptance through the mediating factors analyzed above, i.e. trust and risk and benefit perceptions. Thus, we propose:

H4a. Place attachment directly influences preferences toward the hazardous facility.

H4b. Place attachment influences preference toward the hazardous facility by positively affecting sense of community.

3. The econometric methods

Choice modelling has been extensively applied in many disciplines (transport, food, health and environmental economics) to study individual choices. It is based on the random utility theory proposed by McFadden (1974) and Luce's (1958) probabilistic utility theory. Utility can be disaggregated into a deterministic and a random component as in the following:

$$U_{int} = V_{int} + \varepsilon_{int} = \beta' x_{int} + \varepsilon_{int}$$

where V_{int} represents the component of utility that the individual n derives from choosing alternative i in the choice situation t . V_{int} is a function of preference parameters β' and explanatory variables x_{int} , whereas ε_{int} represents the stochastic component of utility. Depending on assumptions made on the distribution of this component, different econometric models can be estimated. For example, the multinomial logit (MNL) model is based on the assumption that errors are independently and identically distributed (IID) following a Gumbel distribution. Under this assumption, the probability that decision maker n chooses y_i in the scenario t is expressed as:

$$Prob(y_{int}|x_{nt}) = P_{nt} = \frac{\exp(\beta' x_{int})}{\sum_{j=1}^J \exp(\beta' x_{jnt})}$$

and the probability of observing a specific sequence of choices is calculated as the product of these probabilities:

$$P_n = \prod_{t=1}^T P_{nt} = \prod_{t=1}^T \frac{\exp(\beta' x_{int})}{\sum_{j=1}^J \exp(\beta' x_{jnt})}$$

The MNL model does not allow for heterogeneity in tastes across respondents.

In a mixed logit (MIXL) model the term $\beta' n$ is the vector of the unobserved taste parameters for respondent n . Since it is unknown, we may assume that it is IID over respondents with multivariate probability density

function $g(\beta | \theta)$, with θ being the vector of parameters of this distribution (e.g. mean and standard deviation). Therefore, the mixed probability of the n th respondent's chosen alternative in choice situation t is the integral of P_{nt} over the distribution of β :

$$P_n(\theta) = \int P_{nt} g(\beta | \theta) d\beta$$

where P_{nt} is usually assumed to be a logit choice probability conditional on β as in Eq. (2). Then, the probability of the sequence of choices is calculated as the product of P_{nt} (Revelt and Train, 1998):

$$P_n = \int \prod_{t=1}^T P_{nt} g(\beta | \theta) d\beta$$

This integral does not have a closed form and requires approximation. Recent developments have attempted to better address the issue of preference heterogeneity and to enrich the behavioural component of discrete choice models. Proposed by Ben-Akiva et al. (1999, 2002), Hybrid Choice Models (HCM) allow for the integration of latent constructs in the utility functions. Usually, a linear structural equation characterises the latent variable:

$$LV_n = \gamma' z_n + \eta_n$$

where z_n is a vector of socio-economic and demographic characteristics of the respondent and γ' is a vector of parameters capturing the effect of such characteristics on the latent variable LV_n , whereas η_n is a random disturbance component assumed to be normally distributed across respondents, i.e. $\eta_n \sim N(0,1)$. In its simplest formulation HCM integrates the latent variable through interaction with explanatory variables x_{int} in the deterministic component of utility, that is:

$$V_{int} = \beta' x_{int} + \lambda' LV_n x_{int}$$

where λ' is a vector of parameters capturing the impact of the latent variable on the preference for the characteristic x_{int} . This expression for V_{int} will substitute $\beta' x_{int}$ in equations (2) and (3). Latent constructs are based on attitudinal indicators, which usually employ Likert scales and can be modelled through measurement equations. Let I_n be a measurement variable, function of the latent variable LV_n and a random component ν_n , as in:

$$I_n = \zeta' LV_n + \nu_n$$

where ζ' is a vector of parameters measuring the association between the indicator I_n and the latent variable. Since I_n is not observed, we need to model the probability of observing the answers i_1, i_2, \dots, i_M indicated by individuals on a given Likert scale question. It is assumed that $i_1 < i_2 < \dots < i_M$, and

$$i = \begin{cases} i_1 & \text{if } -\infty < I_n \leq \tau_1 \\ i_2 & \text{if } \tau_1 < I_n \leq \tau_2 \\ \vdots & \\ i_M & \text{if } \tau_{M-1} < I_n < +\infty \end{cases}$$

where $\tau_1, \tau_2, \dots, \tau_{M-1}$ are threshold parameters to be estimated through an ordered probabilistic model. The probability of observing the specific answer i_m in a Likert scale is expressed as:

$$\begin{aligned} L_{i_m} &= Prob(i_m) = Prob(\tau_{m-1} < I_n < \tau_m) = Prob(\tau_{m-1} < \zeta'LV_n + \nu_n < \tau_m) \\ &= Prob(\tau_{m-1} - \zeta'LV_n < \nu_n < \tau_m - \zeta'LV_n) \\ &= F(\tau_m - \zeta'LV_n) - F(\tau_{m-1} - \zeta'LV_n) \end{aligned}$$

where F is the distribution function (e.g. logistic). Then, the probability of observing a sequence of answers from k psychometric items is calculated as follows:

$$PL_{i_n} = \prod_{k=1}^K L_{i_n^k}$$

Summing up, a HCM will consist of at least three model components: the structural equation model, the measurement equations, and the choice model. The joint log-likelihood of such model is expressed as:

$$\sum_{n=1}^N \ln \int_{\eta} (P_n \times PL_{i_n}) \times g(\eta) d\eta$$

where P_n is the probability of observing a specific sequence of choices in choice situations $t = 1, 2, \dots, T$, conditional on the preference coefficients β' and the latent variable LV_n ; whereas PL_{i_n} is the likelihood of observing the sequence of answers to a set of attitudinal questions, with τ' representing the vector of threshold parameters and ζ being the parameter capturing the association between the indicator and the latent construct LV_n . Of course, if more latent variables are included in the model, multiple integrals are involved and the computation becomes more complex, although feasible by means of simulation.

4. Case study

4.1. Context

This study focuses on the military base known as Poligono Interforze Salto di Quirra (henceforth, we will refer to this military facility as PISQ), located in South-East of Sardinia. It was installed in 1956 and was designated for different activities, including military training, war simulation, weapon testing and space research. It is the largest experimental site in Europe for the experimentation of new weapons and rocket launching. As shown in Fig. 1, the territory of the PISQ comprises both an inland and a coastal area. The first one involves lands pertaining to several municipalities, prominently Villaputzu, Perdasdefogu, Ulassai, whereas the coastal area of Capo San Lorenzo mainly includes territory of Villaputzu. Villagrande holds wide common land in both areas.

The installation of the military facility was initially welcomed with enthusiasm, as it brought technological innovation, jobs, services and infrastructures, allowing economic and social development for local communities. The perception of military bases in Sardinia gradually changed in the following decades and the public attention started to focus on risks related to military activities, ranging from air crashes and accidents

(especially in the last two decades of the 20th century) to environmental and health risks (from the early 2000s on), with the emergence of the phenomenon known as Quirra Syndrome (Esu and Maddanu, 2018). It refers to the apparent excess of morbidity in the area, mainly cancers to the lymphatic system (lymphomas) and natal genetic malformations, which may have multiple concurring causes (Zucchetti, 2006), ranging from exposure to Depleted Uranium, contamination of environmental matrices due to dispersion of metals from an abandoned arsenic mine, and atmospheric dispersion of nano-sized particles following explosion of weapons (Gatti et al., 2013). Recalling the determinants of risk perception analyzed by Slovic (1987) and discussed in Section 2.1, this is a type of hazard that may have characteristics of “dread risk” (individuals do not have a direct control of the risk, it may have lethal consequences, and the risks may overbalance the benefits); but also of “unknown risk” (the impacts are not well known, and delayed in time).

Another source of concern is represented by the socio-economic conditions of the territory. Many of the benefits associated with the military base have substantially diminished after 2005, when the military enrolment regime changed from mandatory to voluntary, leading to a shrinking effect on the military population (Calia et al., 2020), and a negative effect on the local economy. It will be seen that different perceptions of environmental risks and economic benefits may have an effect on the citizens’ stance regarding the military facility and in orienting preferences toward a potential downsizing.

4.2. The qualitative study

Our research entailed a preliminary qualitative study to investigate the relationship between the PISQ and the surrounding territory. First, a series of in-depth interviews was conducted with administrators and stakeholders operating in the area; afterwards, we carried out two focus groups with citizens from Perdasdefogu and Villaputzu, i.e. the two municipalities that are most affected by the presence of the PISQ. The interviews and the discussions highlighted several useful elements to identify the relevant elements to be included in the choice exercises, as well as some recurrent socio-psychological paths. More specifically, a trade-off between health and economy emerged clearly: those who were interested in economic benefits and praised the PISQ for its contribution to the local development were more prone to underestimate risks for health and environment and vice versa. For example, participants in the focus group from Perdasdefogu expressed a strong belief in the economic advantages generated by the PISQ and had a shared view that the local economy was dependent on it. Even the perspective of a partial downsizing was experienced as a threat, also in light of the poor alternative opportunities they believed their territory could offer. Therefore, the only viable policy for economic development was seen in new investments by the public sector. With reference to health issues, participants blamed the local press for the superficial reporting of inquiries concerning the “Quirra Syndrome”. Nevertheless, they deemed important that civil authorities could monitor the activities in the area, so as to control environmental and health risks.

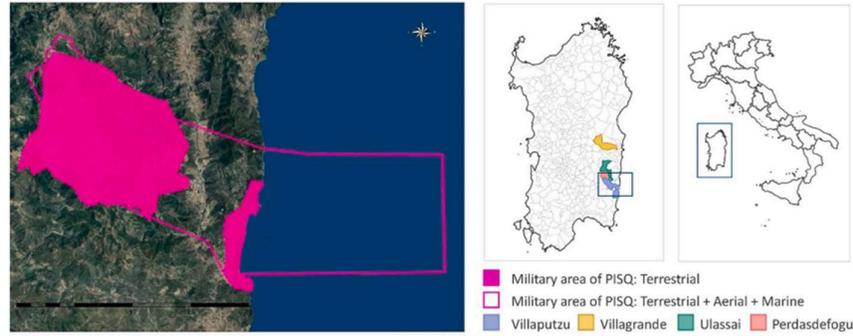


Fig. 1. PISQ area and municipalities affected (adapted from Balleto et al., 2020).

Table 1
Attributes and levels of the CE exercise.

Attribute	Levels
% of jobs lost due to downsizing	No reduction
	25% reduction
	50% reduction
Length of the break of military exercises	3 months
	4 months
	6 months
Alternative land uses	Neither tourism or agricultural uses
	Tourist services
	Tourist services and Agricultural use
Type of control over military activities	Public but limited by the military authority
	Public and independent
% annual increase in local taxes	No increase
	10% increase
	20% increase
	30% increase

On the other hand, citizens from Villaputzu were more sceptical about the contribution of the PISQ to local economic development, especially in the coastal area of Capo San Lorenzo. In general, there was a different perception of the opportunity cost associated with the military base. Most participants observed that the territory offers many opportunities insufficiently exploited, both in the agri-food and tourism sectors. The military easement (e.g. limited use of the beach) was seen as a strong hindrance to the development of the local economy. Furthermore, these citizens were worried about environmental and health risks associated with the activities carried out at the military facility without adequate control from the civilian institutions.

4.3. The survey

The survey was administered face-to-face between February and August 2015 to a total of 446 residents in four municipalities: 160 Villaputzu, 108 Villagrande, 106 Perdasdefogu and 72 Ulassai, with sample weighting accounting for population size and extension of land occupied by the military facility.

The questionnaire consisted of three sections. One contained Likert scale questions aimed at eliciting attitudes and beliefs. In particular, in order to test the behavioural hypotheses discussed in Section 2, we aimed at characterising the respondents in terms of the following attitudinal factors: Place attachment, Sense of community, Trust in institutions, environmental and health Risk perception and economic Benefits perception. Table A.1 in Appendix reports the Likert scales included in the questionnaire to elicit socio-psychological beliefs and perceptions. The reported Cronbach's alpha tests indicate a very high level of internal consistency and reliability for most scales.

Another section of the questionnaire contained the choice experiments carried out to evaluate alternative downsizing options for the PISQ military area. The project scenarios included social economic costs, expressed in terms of jobs lost due to downsizing; social economic benefits, expressed in terms of increased possibility of land use (beach use for tourism purposes; use of other land for agriculture, livestock and forestry); suspension of the military activities in summer or in vacation periods; control of environment and health risk by a civilian regional agency, proposed either in coordination with the military authority, or as a totally independent control; and a personal monetary cost, expressed in terms of an increase in local taxes. Such tax increase was plausible in the proposed scenarios since the municipalities under investigation receive some monetary compensation for the military constraints on their territory, to be spent for public works or social services. In case of a downsizing or closure of the military facility these compensations would be likely reduced, and the local governments may need to increase local taxes to provide the same level of goods and services.

The attributes and levels of the choice experiments are summarised in Table 1 (in italic, status quo levels).

The Choice Experiment was designed using the NGENE™ software. It was based on a MNL-d efficient design, with prior values obtained from a pilot survey with 24 individuals. The design consisted in 36 combinations divided into 6 blocks. Each respondent was presented with 6 choice cards, in which s/he was asked to choose between three alternatives: two downsizing scenarios and an opt-out alternative, consisting in the closure of the military facility.

The final part of the questionnaire contained questions aimed at collecting socio-economic characteristics of the respondents. Table A.2 in Appendix reports descriptive statistics of four main demographic variables, presenting a comparison between the sample and the reference population, and Table A.3 describes additional sample statistics of socio-economic characteristics relevant for the current study.

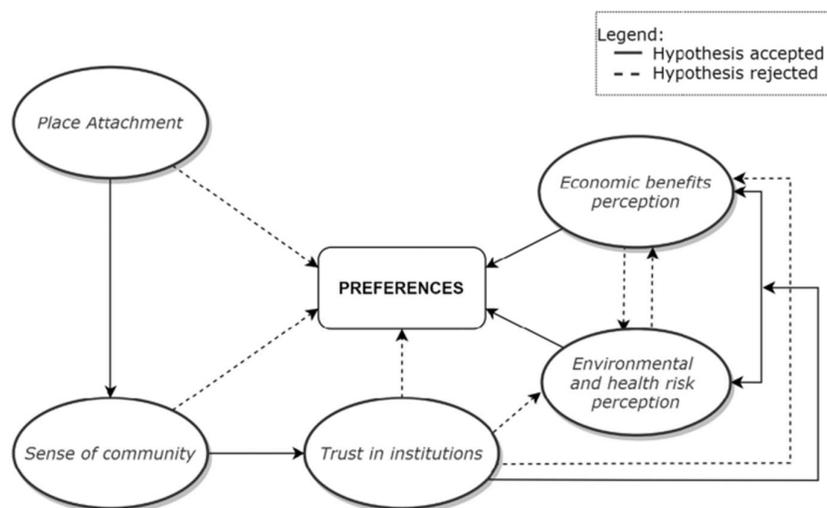


Fig. 2. Hypotheses tested in the structural equation model.

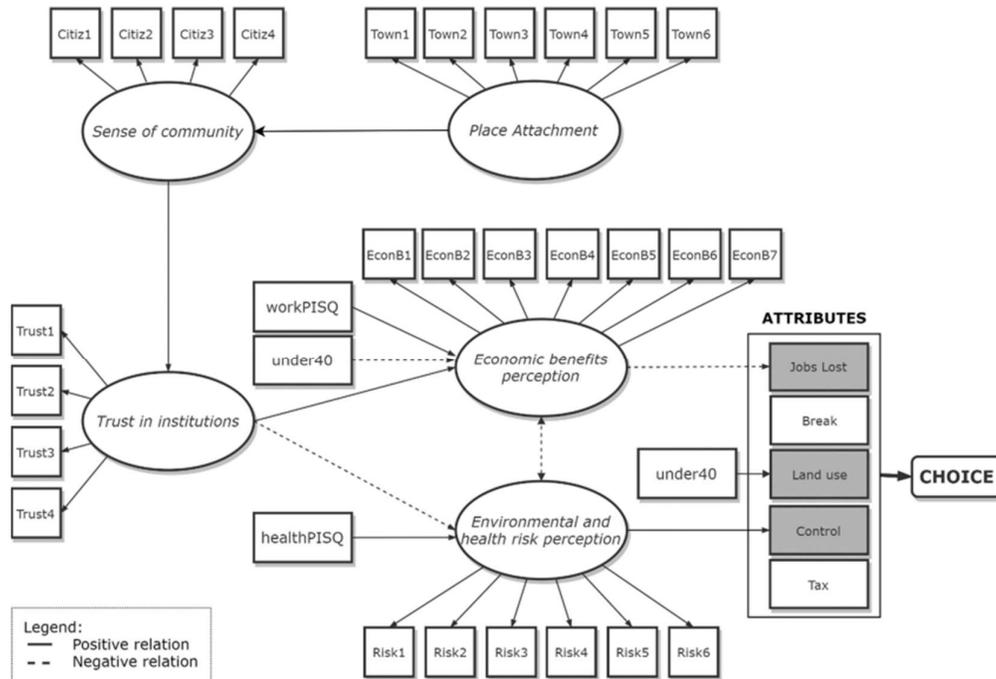


Fig. 3. Empirical hybrid model structure.

4. Model estimation and results

For estimating the model we employed the package Apollo (Hess and Palma, 2019a, 2019b), which operates in the free software environment R.

We adopted a sequential modelling approach as a preliminary step in the specification of the hybrid model. A graphical representation of the socio-psychological hypotheses is presented in Fig. 2, whereas Table A.4 in Appendix provides a summary of the hypotheses tested and the respective results. In the sequential approach, a SEM model is estimated to obtain the individual scores for the latent constructs, which are plugged into the choice model as if they were observed variables. The potential best alternative specifications were then estimated using the HMXL joint structure, as in the modelling approach proposed by Paulssen et al. (2014).

Based on Czajkowski and Budzinski (2019), 2000 scrambled Sobol draws were set for estimation of simulated likelihood. The final specification, reported in Fig. 3, was selected on the base of AIC and BIC indicators and the significance of coefficients.

The estimation results for the structural equation and the discrete choice components of the HMXL model are presented in Table 2.

The socio-psychological part of the model exposes how attitudes and beliefs guide the respondent's decision making in the choice between alternative project options. Respondents with stronger sense of attachment to their town tend to have higher sense of community, perceiving higher solidarity, collaboration and support among fellow citizens; in turn, these people tend to trust the institutions that are relevant for control of

environmental and health impacts from the activities of the facility: i.e. the municipal government, the military apparatus, the local health authority and the National Institute of Health. Next, it is found that trust in these institutions influences both the perception of economic benefits (positively) and the perception of health risk (negatively): the higher the level of trust in the relevant institutions, the larger the perceived benefits, and smaller the perceived risks. As regards the relation between perceived economic benefits and perceived health risks, three alternative relations have been tested: a hierarchical relation flowing from perceived risks to perceived benefits; a hierarchical relation flowing from perceived benefits to perceived risks; and a non-hierarchical relation. The latter hypothesis has been better supported by our data, both in SEM and in HMXL models; the relationship is negative, and the associated parameter is highly significant. Finally, it can be observed that the attitudinal model includes three observed individual characteristics: *workPISQ* indicates that either the respondent or some family member work at the facility; *healthPISQ* indicates that either the respondent or some family member experienced health problems potentially related to the activities carried out in the facility; while *under40* denotes respondents aged less than 40 years. Not surprisingly, the perception of environmental and health risks is higher if the respondent experienced health problems which could be ascribed to the activities carried out at the PISQ facility; while the perception of economic benefits is higher for individuals with a working relationship with the PISQ. It seems worth noting that younger respondents tend to perceive less the economic benefits generated by the facility: this may be in part explained by the fact that they did not experience the initial phase of economic growth, but also that the payrolls have decreased in the last years. We will return to this issue after examining the results obtained from the choice experiments.

In the choice model specification, the coefficients of the attributes *Jobs Lost*, *Break*, *Control* and *Land Use* are assumed to be random, following a Normal distribution; whereas the *Tax* coefficient has been estimated as a non-random parameter, i.e. its standard deviation has been constrained at zero, as it never proved significant in alternative model specifications. This model specification allows for heterogeneity of preferences across individuals, while maintaining the assumption of consistency of tastes over choice tasks for the same individual.

Table 2 shows the results of the choice and structural equation components of the HMXL model, while the measurement component is reported in Table A.5, in Appendix. The preference parameters are all significant at 1% level or better, and their sign is as expected. On average respondents perceive a disutility from the loss of jobs provided by the military facility, whereas the positive sign of the parameters *Break*, *Land Use* and *Control* indicates that all these attributes have, on average, a positive effect on utility. As regards the *Break* attribute, we recall that at the time of the interviews the military base observed a three months' summer break, from 20th June to 20th August. The results show that respondents favour the extension of this period of suspension of military activities. A longer break allows locals to use the territory for other purposes: citizens can enjoy the beach and the marine area (usually off-limits) and small businesses can profit from seaside tourism. The possibility of a co-use of the territory for recreational activities and for agriculture is generally appreciated by most respondents, as revealed by the low standard deviation of *Land Use*; while the *Control* coefficient indicates that individuals would, on average, favour an independent form of control

of civil authorities over the activities performed in the PISQ territory. Finally, the coefficient of *Tax* is negative, obviously implying that citizens would not be happy of an increase in local taxes. It is worth noting that the random coefficients *Jobs Lost*, *Break* and *Control* are characterized by large and significant standard deviations, implying that a relatively high proportion of respondents could have preferences that differ from the sample mean. The analysis of the conditional distributions (as in [Sillano and Ortúzar, 2005](#)) shows that there are very few outliers for the parameters *Break* (<5%), *Landuse* (<1%) and *Control* (<1%), whereas a higher proportion is observed for the parameter *Jobs lost*: for about 15% of respondents the posterior mean parameter is positive, in contrast with the negative sign observed for the rest of the sample. This result may be explained considering that there may be a portion of individuals who could consider jobs lost in the military sector not necessarily as a social loss, if they can be replaced in other economic sectors.

As depicted in [Fig. 3](#), the three latent variables Place attachment, Sense of community and Trust in institutions influence utility indirectly: these variables are hierarchically related, and trust enters as a regressor of both Risk perception (negative coefficient) and Economic benefit perception (positive coefficient). The perceptions of economic benefits and health risks enter the utility function through interaction with specific attributes. Two strong relations have been found: the interaction between perceived Economic benefits (*EconB*) and *Jobs Lost*, and the interaction between perceived environmental and health Risks (*Risk*) and *Control*. Individuals characterized by higher perception of economic benefits put more weight on the potential loss of jobs, whereas individuals with higher perception of environmental and health risks give more importance to the independent control of environmental impacts. No significant effects were found in the interactions between risk and benefit perceptions and the other project attributes, i.e. *Break*, *Land Use* and *Tax*. This implies that the valuation of these attributes is determined by other factors than the perception of risks and economic benefits generated by the facility. Nevertheless, these attributes will have a role in the selection of the preferred scenario, and more in general in the acceptance of the project, since the respondent will take account of their values and add them to the social costs and benefits associated with the *Jobs Lost* and *Control* attributes.

We did not find evidence of the effect of other covariates, either observed or latent, on the *Break* and *Tax* attributes, whereas the valuation of the attribute *Land Use* is significantly influenced by age. As pointed out by [Vij and Walker \(2016\)](#), the observed variables may have either direct and indirect effects on the utility function, so we tested both effects in several alternative specifications. The socio-economic variable *Under40* is included as a covariate in the structural equation of *EconB*: younger respondents perceive the presence of the military base as less beneficial than the rest of the population, and this has an indirect negative effect on the utility of the attribute *Jobs Lost*. *Under40* is also interacted with the attribute *Land Use* in the utility function (direct positive effect): younger people are more interested than their older counterparts in the possibility of co-using the territory under military easement to carry out economic enterprises in the agricultural or tourism sector.

6. Welfare assessment

In this section we explore more in detail the preferences of citizens in each municipality and see how different perceptions and attitudes have an impact on welfare valuations. Fig. 4 shows the posterior distributions of the estimated latent constructs (Place Attachment, Sense of Community, Trust, Risk and Benefit perceptions) by municipality (Villa-putzu, Villagrande, Ulassai, Perdasdefogu).

It seems clear that the four communities are characterized by different attitudes and perceptions: in particular, with respect to the others, citizens of Perdasdefogu feel a stronger sense of place identity, a higher sense of community with fellow citizens, trust more the local institutions, have lower perception of risks, and higher perception of economic benefits generated by the facility. According to the hypotheses discussed in [Section 2](#), this should lead to a lower acceptance of the proposed change, i.e. downsizing of the facility.

The patterns in the other three communities are closer to each other, with citizens of Villaputzu generally holding intermediate positions between those of Perdasdefogu and the other two towns, even though it can be noticed that place attachment is much weaker here than elsewhere.

The graphs reported in [Fig. 5](#) show how the different perceptions of Risk and Economic Benefits drive the citizens' preferences toward the attributes *Control* and *Jobs Lost*: the posterior distribution of the coefficients of *Jobs Lost* for Perdasdefogu is shifted toward the left with respect to the corresponding distributions of other towns, implying that this attribute is particularly important in this community; conversely, the *Control* attribute is especially relevant to Ulassai, and less to residents in Perdasdefogu.

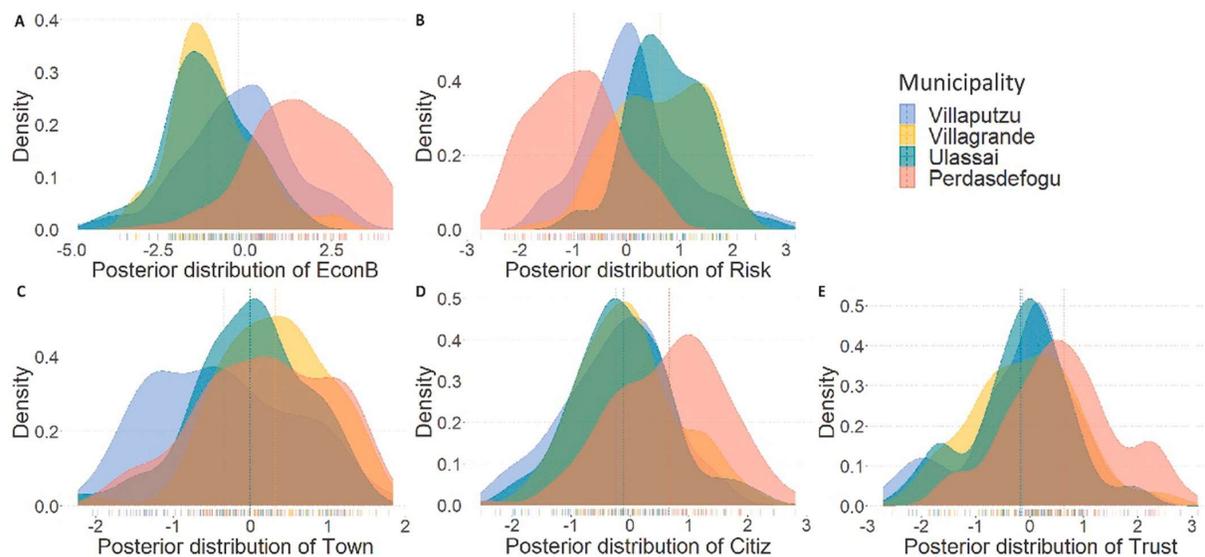


Fig. 4. Posterior distributions of estimated latent constructs by municipality.

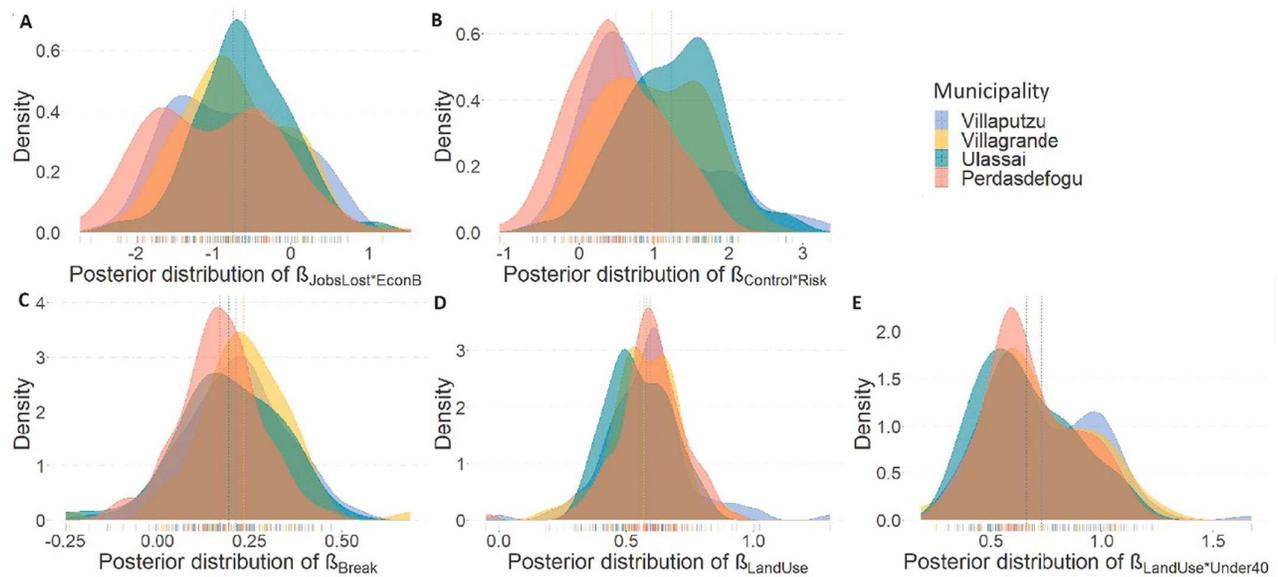


Fig. 5. Posterior distributions of estimated preference coefficients by municipality.

Table 3
Compensating variations by municipality: change in annual local taxes.

	Villaputzu	Villagrande	Ulassai	Perdasdefogu
% Change: mean (St.dev.)				
Jobs Lost	-15.7 (15.9)	-15.1 (14.2)	-12.4 (12.7)	-21.0 (17.4)
Break	4.5 (2.8)	4.9 (2.7)	4.1 (3.0)	3.6 (2.3)
Land Use	12.2 (3.6)	12.0 (2.7)	11.6 (2.5)	12.5 (2.9)
Land Use < 40	15.3 (5.1)	15.0 (4.9)	13.8 (4.5)	14.4 (4.2)
Control	18.5 (16.9)	20.4 (14.0)	25.8 (13.5)	10.3 (13.0)
Monetary values (€): mean (St.dev.)				
Jobs Lost	-46.98 (47.66)	-60.94 (57.19)	-32.18 (32.92)	-74.29 (61.57)
Break	13.41 (8.50)	19.95 (10.99)	10.59 (7.72)	12.60 (8.19)
Land Use	36.50 (10.79)	48.28 (10.97)	30.08 (6.52)	44.15 (10.09)
Land Use < 40	45.77 (15.43)	60.55 (19.72)	35.95 (11.64)	50.89 (15.02)
Control	55.46 (50.56)	82.45 (56.57)	66.99 (35.17)	36.48 (45.95)

The WTP values, i.e. the marginal rates of substitution between the utility coefficients of the project attributes and that of tax, provide a quantitative measure of preferences toward the attributes included in our choice experiments. Table 3 reports the estimated WTP measures by municipality as a percent change in local taxes. The monetary value is then calculated in relation to the average local tax actually paid by sampled individuals in each town: €300 in Villaputzu, €404 in Villagrande, €260 in Ulassai and €354 in Perdasdefogu.

It can be seen that Perdasdefogu is the only town where an increase in environmental and health safety would not be sufficient to compensate the welfare loss caused by a 25% job cuts. In all other cases, and most notably in Ulassai, the social gain from an increase in safety overcomes the social loss associated with this

level of downsizing. From another perspective, it can as well be said that people in Ulassai, but also in Villagrande and Villaputzu, would need to be compensated if no change in the status quo is made: the welfare loss perceived by these communities for the lack of an independent control over the environmental impacts of the experiments and other activities conducted in the facility is higher than the avoided perceived losses from downsizing.

If these were the only attributes of the project, the results regarding the acceptability of the change would be just as those predicted by the risk-benefit acceptability model discussed in Section 2: if the perceived benefit/risk ratio improves after a change, the change is accepted; otherwise, there will be public opposition to such a change. However, our scenarios included further project elements, i.e. Break and Land Use, whose valuation was not influenced by the perception of risks and benefits generated by the facility. Increasing the possibility of using the territory for tourism and agriculture is valued positively by residents in all municipalities; this is especially true for younger respondents, notably in Villaputzu and Villagrande, but also in Perdasdefogu and in a lesser extent in Ulassai. The extension of the period of suspension of the military activities is valued most by citizens in Villagrande and Villaputzu, followed by those in Ulassai and much less by citizens in Perdasdefogu. In any case, the inclusion of these project elements would increase the acceptability of a downsizing scenario even among citizens in Perdasdefogu. On the other hand, if no change is made, and jobs and control are left at the status quo level, the possibility of using the land both for tourism and agricultural activities, and the extension of the period of suspension of activities in the base could largely compensate citizens in Villaputzu and Villagrande, but barely those in Ulassai, for the lack of independent control against possible health and environmental impacts generated by the facility.

7. Conclusions

The socio-psychological literature has long debated on the nature of the relationship between perceived economic benefits and perceived health risks in driving acceptance of hazardous facilities or technologies. As discussed in Section 2, there are different views: either that benefits perception activates risk perception; or that the causal relationship is reversed, so that risk perception causes benefit perception; or that the two perceptions are correlated through a third factor which activates both. Our study validates the third hypothesis: trust in local institutions influences both risk and benefit perceptions. Moreover, it confirms that antecedents of trust are the sense of community and place attachment. The theory predicts that the stronger these attitudes, the harder will be to accept a change from the status quo. This is confirmed in our application: citizens of Perdasdefogu, who feel a strong sense of place attachment and strong relationships with fellow citizens and institutions, show lower perception of risks and higher perception of economic benefits, and are the least keen of a downsizing of the facility. In the other three towns attitudes and beliefs are more variegated, but a change from the status quo will be generally welcomed if this would lead to a higher level of environmental control, and to some co-use of the land under military easement.

The framework adopted in this study is particularly useful to identify which project elements are involved

in the risk-benefit acceptability model discussed in Section 2. Project elements whose valuation is not influenced by the perception of risks and benefits may work as a leverage to facilitate acceptance of the proposed change. For example, in our application it is seen that the evaluation of the attributes Break and Land Use is not affected by the perceptions of risks and benefits generated by the facility. Increasing the possibility of using the territory for tourism and agriculture, also expanding the period of suspension of the military activities, would increase the acceptability of a downsizing scenario, even among citizens in Perdasdefogu. This is especially true for younger people: either because they have a lower perception of benefits produced by the military base, and also because they are more interested in alternative uses of land. It seems important that restoration measures are designed so as to stimulate and sustain young people in the creation of private enterprises, possibly in, but not necessarily limited to, the agriculture and tourism sectors. Policy measures solely aimed at creating new payrolls in the public sector would perpetuate the conditions of dependence of the local economy (see Fortuna et al., 2021). Furthermore, allowing new generations to invest and operate in their territory could be helpful to overcome the sense of detachment from their place that is currently observed, especially in Villaputzu. The results of our work suggest that this should be a priority for any policy aimed at regenerating the economy in the PISQ area.

Finally, our work confirms that the HMXL model is a robust and flexible approach to analyse the role of latent constructs and socioeconomic variables integrated in a choice model which allows for heterogeneity in preferences by means of a random parameter specification. In contrast with previous valuation studies, we specified a sociopsychological model with multiple latent variables and multiple layers, which was estimated jointly with the choice model. Such complexity comes at a cost: the estimation procedure is extremely involved and time consuming. We suggest to employ a two-step procedure: a sequential model can be used in a first stage to identify potential candidates, which are then estimated through the joint model in order to select the best specification. In our empirical application the sequential and the joint models produced similar results, but we could see the superiority of the latter in terms of efficiency. Monte Carlo work should be required to further investigate on the comparative advantage between the two estimators.

Acknowledgements

This work was supported by Regione Autonoma della Sardegna [LR7/2007, Tender 2019, F24I19000360002].

Appendix

Table A.1

Descriptive statistics on socio-psychological factors used in this study.

Factor name	Item description	Villaputzu	Villagrande	Ulassai	Perdasdefogu
<i>Town</i>	I feel attached to this town	3.78	4.69	4.56	4.56
	I would be sorry to leave this town	3.56	4.30	4.26	4.12
	I miss this town when I am away	3.56	4.30	3.86	4.16
	I feel I belong to this town	3.71	4.57	4.44	4.39
<i>alpha = 0.88</i>	I like this town	3.60	4.58	4.57	4.58
<i>Citiz</i>	I identify with people living in this town	2.87	4.05	3.42	4.02
	People in this town do not respect the environment	3.47	3.56	2.08	2.33
	My fellow citizens are not supportive	3.28	3.76	3.22	3.96
<i>alpha = 0.72</i>	Residents seem to take care of the town	2.80	3.08	3.13	3.79
	My fellow citizens do not easily collaborate	3.43	3.10	3.19	2.47
<i>Trust</i>	The municipality	1.94	2.60	2.38	3.12
	Military apparatus	2.14	2.16	1.97	3.52
<i>alpha = 0.83</i>	The local health authority	2.52	2.61	2.63	3.28
	National Institute of Health	2.42	2.69	2.68	3.34
	Activities carried out by the PISQ pose a serious risk for me	3.25	3.37	3.46	1.57
<i>Risk</i>	Negative consequences of the activities carried out by the PISQ will also affect future generations	3.57	3.84	4.06	2.21
	I believe that the presence of the PISQ causes environmental degradation and pollution	3.40	3.97	3.97	1.47
	I believe that the activities carried out by the PISQ are not risky for health	2.41	1.87	1.89	3.97
<i>alpha = 0.93</i>	I am worried about what materials and substances have been used so far in the PISQ	3.69	4.28	4.39	1.85
	I believe the so called Quirra Syndrome does not exist	2.53	2.08	1.97	4.22
	I think that the PISQ could still represent an opportunity for the future of my town	2.90	2.93	2.71	4.36
<i>Eco</i>	The installation of the PISQ contributes to the development of my town	3.33	2.12	2.21	4.39
	I believe that, overall, the PISQ generates more disadvantages than advantages	3.20	3.33	3.50	1.66
	I believe that the presence of the PISQ is not so relevant for the economy of this territory	2.67	3.06	2.89	1.64
<i>alpha = 0.93</i>	I would like the PISQ to increase its activities	2.22	2.25	2.13	4.36
	I believe that if the PISQ were to close, the economy of my town would be strongly affected	2.77	2.11	2.17	4.53
	Given the choice, I would opt for the complete closure of the PISQ	2.79	3.29	2.86	1.26

Notes: Responses were given on a 5-step Likert scale, from "Completely disagree" to "Completely agree", with the only exception of the scale for Trust (ranging from "No Trust" to "Full Trust").

Table A.2

Descriptive statistics on demographic variables.

	Villaputzu	Villagrande	Ulassai	Perdasdefogu
Sample				
Age (Mean)	45.29	46.69	49.74	48.92
Family components (Mean)	3.12	3.44	2.93	3.01
Men (%)	51.2%	56.5%	56.9%	66.7%
HighEdu (%)	9.8%	24.9%	23.6%	4.6%
Population				
Age (Mean)	46.3	45.9	46.9	47.4
Family components (Mean)	2.15	2.45	1.91	2.31
Men (%)	49.7%	50.2%	49.1%	51.0%
HighEdu (%)	4.6%	10.3%	8.1%	4.6%

Table A.3

Descriptive statistics of variables used in this study.

Variable name	Variable description	Villaputzu	Villagrande	Ulassai	Perdasdefogu
under40	1 if the respondent is younger than 40 years old	41.3%	34.3%	33.3%	24.5%
workPISQ	1 if the respondent (or one of his/her relatives) works or worked at PISQ	31.3%	5.6%	16.7%	66.0%
healthPISQ	1 if the respondent has relatives or friends with health problems potentially related to the "Quirra Syndrome"	33.8%	12.0%	13.9%	3.8%

Table A.4
Hypotheses tested in the structural equation model.

Hypothesis	Path	Result
H1a	Risk perception ↔ Economic benefit perception	Accept
H1b	Risk perception → Preferences	Accept
H1c	Economic benefit perception → Preferences	Accept
H1d	Risk perception → Economic benefit perception → Preferences	Reject
H1e	Economic benefit perception → Risk perception → Preferences	Reject
H2a	Trust → Preferences	Reject
H2b	Trust → Economic benefit perception → Preferences	Accept
H2c	Trust → Risk perception → Preferences	Accept
H3a	Sense of community → Preferences	Reject
H3b	Sense of community → Trust	Accept
H4a	Place attachment → Preferences	Reject
H4b	Place attachment → Sense of community	Accept

Table A.5
Measurement component of the HMXL model.

Coefficients of the measurement equations					
	τ_1	τ_2	τ_3	τ_4	ζ
<i>Town01</i>	-10.041*** (1.164)	-8.100*** (0.940)	-5.317*** (0.670)	-1.814*** (0.378)	4.886*** (0.614)
<i>Town02</i>	-4.135*** (0.335)	-3.454*** (0.296)	-1.884*** (0.221)	-0.290 (0.181)	2.251*** (0.230)
<i>Town03</i>	-4.805*** (0.398)	-3.586*** (0.313)	-1.712*** (0.219)	0.346* (0.188)	2.458*** (0.242)
<i>Town04</i>	-7.353*** (0.706)	-6.172*** (0.621)	-3.869*** (0.446)	-1.181*** (0.298)	4.181*** (0.494)
<i>Town05</i>	-6.820*** (0.635)	-5.686*** (0.529)	-3.189*** (0.349)	-0.859*** (0.244)	3.193*** (0.340)
<i>Town06</i>	-3.436*** (0.289)	-2.386*** (0.233)	-0.642*** (0.172)	0.777*** (0.169)	2.031*** (0.216)
<i>Citiz01</i>	-2.187*** (0.193)	-0.442*** (0.132)	0.898*** (0.140)	2.152*** (0.190)	0.977*** (0.152)
<i>Citiz02</i>	-3.415*** (0.300)	-2.378*** (0.232)	-0.448*** (0.161)	1.861*** (0.213)	1.607*** (0.197)
<i>Citiz03</i>	-3.299*** (0.303)	-1.695*** (0.208)	0.407** (0.171)	2.857*** (0.275)	1.775*** (0.224)
<i>Citiz04</i>	-1.690*** (0.167)	-0.558*** (0.134)	0.645*** (0.137)	1.977*** (0.181)	0.998*** (0.148)
<i>Trust01</i>	-1.576*** (0.164)	0.092 (0.136)	1.502*** (0.161)	3.040*** (0.239)	1.125*** (0.131)
<i>Trust02</i>	-1.560*** (0.184)	-0.339** (0.162)	1.467*** (0.183)	3.156*** (0.258)	1.611*** (0.167)
<i>Trust03</i>	-4.452*** (0.518)	-1.007*** (0.315)	2.666*** (0.391)	6.125*** (0.671)	3.780*** (0.468)
<i>Trust04</i>	-3.877*** (0.436)	-1.188*** (0.297)	2.618*** (0.365)	5.308*** (0.556)	3.511*** (0.412)
<i>Risk01</i>	-1.518*** (0.190)	0.049 (0.166)	2.472*** (0.228)	4.228*** (0.329)	2.020*** (0.179)
<i>Risk02</i>	-2.029*** (0.204)	-1.048*** (0.175)	0.847*** (0.174)	2.388*** (0.225)	1.993*** (0.179)
<i>Risk03</i>	-2.161*** (0.287)	-0.431* (0.241)	2.330*** (0.300)	4.698*** (0.433)	3.516*** (0.316)
<i>Risk04</i>	-2.447*** (0.234)	-0.867*** (0.180)	0.970*** (0.182)	2.405*** (0.228)	2.187*** (0.185)
<i>Risk05</i>	-3.034*** (0.307)	-1.488*** (0.244)	0.897*** (0.230)	2.822*** (0.298)	3.163*** (0.279)
<i>Risk06</i>	-1.932*** (0.230)	-0.609*** (0.195)	1.507*** (0.214)	3.060*** (0.278)	2.569*** (0.223)
<i>Eco01</i>	-4.212*** (0.344)	-2.700*** (0.264)	-0.958*** (0.205)	0.978*** (0.204)	1.437*** (0.155)
<i>Eco02</i>	-2.946*** (0.259)	-1.980*** (0.222)	-0.595*** (0.186)	1.116*** (0.191)	1.259*** (0.133)
<i>Eco03</i>	-4.263*** (0.341)	-2.703*** (0.260)	-0.251 (0.199)	1.512*** (0.223)	1.468*** (0.146)
<i>Eco04</i>	-3.731*** (0.294)	-2.283*** (0.205)	-0.758*** (0.162)	0.885*** (0.166)	0.972*** (0.112)
<i>Eco05</i>	-2.542*** (0.247)	-1.384*** (0.208)	0.618*** (0.192)	1.732*** (0.220)	1.384*** (0.143)
<i>Eco06</i>	-3.694*** (0.353)	-2.188*** (0.286)	-0.481** (0.239)	1.385*** (0.255)	1.892*** (0.215)
<i>Eco07</i>	-6.150*** (0.544)	-4.072*** (0.361)	-1.781*** (0.245)	-0.599*** (0.217)	1.579*** (0.183)

References

- Achillas, C., Vlachokostas, C., Moussiopoulos, N., Baniyas, G., Kafetzopoulos, G., Karagiannidis, A., 2011. Social acceptance for the development of a waste-to-energy plant in an urban area. *Resour. Conserv. Recycl.* 55, 857–863.
- Ajzen, I., 1985. From intentions to actions: a theory of planned behavior. In: *Action Control*. Springer, pp. 11–39.
- Anderson, M.R., 2010. Community psychology, political efficacy, and trust. *Polit. Psychol.* 31, 59–84.
- Bahamonde-Birke, F., de Ortúzar, J.D.D., 2014a. Is sequential estimation a suitable second best for estimation of hybrid choice models? *Transp. Res. Rec.* 2429, 51–58.
- Bahamonde-Birke, F., de Ortúzar, J.D.D., 2014b. On the variability of hybrid discrete choice models. *Transp. A Transp. Sci.* 10, 74–88.
- Bahamonde-Birke, F.J., Kunert, U., Link, H., Ortúzar, J.D.D., 2017. About attitudes and perceptions: finding the proper way to consider latent variables in discrete choice models. *Transportation (Amst)*. 44, 475–493.
- Balletto, G., Milesi, A., Fenu, N., Borruso, G., Mundula, L., 2020. Military training areas as Semicommons: the territorial valorization of Quirra (Sardinia) from easements to ecosystem services. *Sustainability* 12, 622.
- Ben-Akiva, M., McFadden, D., Garling, T., Gopinath, D., Walker, J., Bolduc, D., Borsch-Supan, A., Delqui'e, P., Larichev, O., Morikawa, T., 1999. Extended framework for modeling choice behavior. *Mark. Lett.* 10, 187–203.
- Ben-Akiva, M., Walker, J., Bernardino, A.T., Gopinath, D.A., Morikawa, T., Polydoropoulou, A., 2002. Integration of choice and latent variable models. *Perpetual Mot. Travel Behav. Res. Oppor. Appl. Chall.* 431–470.
- Boyd, A.D., 2017. Examining community perceptions of energy systems development: the role of communication and sense of place. *Environ. Commun.* 11, 184–204.
- Brehm, J., Rahn, W., 1997. Individual-level evidence for the causes and consequences of social capital. *Am. J. Polit. Sci.* 999–1023.
- Bronfman, N.C., Vazquez, E.L., 2011. A cross-cultural study of perceived benefit versus risk as mediators in the trust-acceptance relationship. *Risk Anal. An Int. J.* 31, 1919–1934.
- Bronfman, N.C., Vazquez, E.L., Guti'erre, V.V., Cifuentes, L.A., 2008. Trust, acceptance and knowledge of technological and environmental hazards in Chile. *J. Risk Res.* 11, 755–773.
- Bronfman, N.C., Vazquez, E.L., Dorantes, G., 2009. An empirical study for the direct and indirect links between trust in regulatory institutions and acceptability of hazards. *Saf. Sci.* 47, 686–692.
- Calia, P.P., Sistu, G., Strazzer, E., 2020. The impact of military downsizing on two Italian communities: a counterfactual approach using the synthetic control method. *Def. Peace Econ.* 1–21.
- Chorus, C.G., Kroesen, M., 2014. On the (im-) possibility of deriving transport policy implications from hybrid choice models. *Transp. Policy* 36, 217–222.

- Chung, J.B., Kim, H.-K., 2009. Competition, economic benefits, trust, and risk perception in siting a potentially hazardous facility. *Landsc. Urban Plan.* 91, 8–16.
- Contu, D., Strazzer, E., Mourato, S., 2016. Modeling individual preferences for energy sources: the case of IV generation nuclear energy in Italy. *Ecol. Econ.* 127, 37–58. <https://doi.org/10.1016/j.ecolecon.2016.03.008>.
- Czajkowski, M., Budzinski, W., 2019. Simulation error in maximum likelihood estimation of discrete choice models. *J. Choice Model.* 31, 73–85.
- De Groot, J.I.M., Steg, L., Poortinga, W., 2013. Values, perceived risks and benefits, and acceptability of nuclear energy. *Risk Anal. An Int. J.* 33, 307–317.
- De Groot, J.I.M., Schweiger, E., Schubert, I., 2020. Social influence, risk and benefit perceptions, and the acceptability of risky energy technologies: an explanatory model of nuclear power versus shale gas. *Risk Anal.* 40, 1226–1243.
- Dear, M., 1992. Understanding and overcoming the NIMBY syndrome. *J. Am. Plan. Assoc.* 58, 288–300.
- Devine-Wright, P., 2009. Rethinking NIMBYism: the role of place attachment and place identity in explaining place-protective action. *J. Community Appl. Soc. Psychol.* 19, 426–441.
- Devine-Wright, P., 2011. Place attachment and public acceptance of renewable energy: a tidal energy case study. *J. Environ. Psychol.* 31, 336–343.
- Dreyer, S.J., Polis, H.J., Jenkins, L.D., 2017. Changing tides: acceptability, support, and perceptions of tidal energy in the United States. *Energy Res. Soc. Sci.* 29, 72–83.
- Droff, J., Paloyo, A.R., 2015. Assessing the regional economic impacts of defense activities: a survey of methods. *J. Econ. Surv.* 29, 375–402.
- Earle, T.C., 2010. Trust in risk management: a model-based review of empirical research. *Risk Anal. An Int. J.* 30, 541–574.
- Esu, A., Maddanu, S., 2018. Military pollution in no war zone: the military representation in the local media. *Journalism* 19, 420–438.
- Faccioli, M., Czajkowski, M., Glenk, K., Martin-Ortega, J., 2020. Environmental attitudes and place identity as determinants of preferences for ecosystem services. *Ecol. Econ.* 174, 106600.
- Fischhoff, B., Bostrom, A., Quadrel, M.J., 1993. Risk perception and communication. *Annu. Rev. Public Health* 14, 183–203.
- Flynn, J., Burns, W., Mertz, C.K., Slovic, P., 1992. Trust as a determinant of opposition to a high-level radioactive waste repository: analysis of a structural model. *Risk Anal.* 12, 417–429.
- Fornara, F., Bonaiuto, M., Bonnes, M., 2010. Cross-validation of abbreviated perceived residential environment quality (PREQ) and neighborhood attachment (NA) indicators. *Environ. Behav.* 42, 171–196.
- Fortuna, M.J.A., Teixeira, J.C.A., Silva, F.J.F., 2021. Gone with the winds of peace: the regional economic effects of military base downsizings and closures. *Def. Peace Econ.* 1–24.
- Frantal, B., Malý, J., 2017. Close or renew? Factors affecting local community support for rebuilding nuclear power plants in the Czech Republic. *Energy Policy* 104, 134–143. <https://doi.org/10.1016/j.enpol.2017.01.048>.

Gatti, A.M., Montanari, S., Capitani, F., 2013. The Quirra syndrome: matter of translational medicine. In: *Advanced Sensors for Safety and Security*. Springer, pp. 55–64.

Greenberg, M., Truelove, H.B., 2011. Energy choices and risk beliefs: is it just global warming and fear of a nuclear power plant accident? *Risk Anal. An Int. J.* 31, 819–831.

Grilli, G., Notaro, S., Campbell, D., 2018. Including value orientations in choice models to estimate benefits of wildlife management policies. *Ecol. Econ.* 151, 70–81.

Gutiérrez, V.V., Cifuentes, L.A., Bronfman, N.C., 2015. Factors influencing compensation demanded for environmental impacts generated by different economic activities. *Sustainability* 7, 9608–9627.

Hess, S., Palma, D., 2019a. Apollo: a flexible, powerful and customisable freeware package for choice model estimation and application. *J. Choice Model.* 100170.

Hess, S., Palma, D., 2019b. Apollo version 0.0.8, User Manual. www.ApolloChoiceModelling.com.

Hou, G., Chen, T., Ma, K., Liao, Z., Xia, H., Yao, T., 2019. Improving social acceptance of waste-to-energy incinerators in China: role of place attachment, trust, and fairness. *Sustainability* 11, 1727.

Howell, E.L., Li, N., Akin, H., Scheufele, D.A., Xenos, M.A., Brossard, D., 2017. How do US state residents form opinions about ‘fracking’ in social contexts? A multilevel analysis. *Energy Policy* 106, 345–355.

Hoyos, D., Mariel, P., Hess, S., 2015. Incorporating environmental attitudes in discrete choice models: an exploration of the utility of the awareness of consequences scale. *Sci. Total Environ.* 505, 1100–1111.

Hung, H.-C., Li, C.-F., Hung, C.-H., 2020. Risk communication and local perceptions of petrochemical pollution risk: a comparison of the petrochemical industry complexes at different development stages. *Environ. Sci. Pol.* 114, 549–559.

Janmaimool, P., Watanabe, T., 2014. Evaluating determinants of environmental risk perception for risk management in contaminated sites. *Int. J. Environ. Res. Public Health* 11, 6291–6313.

Keller, C., Visschers, V., Siegrist, M., 2012. Affective imagery and acceptance of replacing nuclear power plants. *Risk Anal. An Int. J.* 32, 464–477.

Kim, J., Kaplan, R., 2004. Physical and psychological factors in sense of community: new urbanist Kentlands and nearby Orchard Village. *Environ. Behav.* 36, 313–340.

Lewicka, M., 2005. Ways to make people active: the role of place attachment, cultural capital, and neighborhood ties. *J. Environ. Psychol.* 25, 381–395.

Li, W., Zhong, H., Jing, N., Fan, L., 2019. Research on the impact factors of public acceptance towards NIMBY facilities in China—a case study on hazardous chemicals factory. *Habitat Int.* 83, 11–19.

Liu, F., Lyu, T., Pan, L., Wang, F., 2017. Influencing factors of public support for modern coal-fired power plant projects: an empirical study from China. *Energy Policy* 105, 398–406.

Liu, Y., Sun, C., Xia, B., Cui, C., Coffey, V., 2018. Impact of community engagement on public acceptance towards waste-to-energy incineration projects: empirical evidence from China. *Waste Manag.* 76, 431–442.

Lopez-Navarro, M.A., Llorens-Monzonis, J., Tortosa-Edo, V., 2013. The effect of social trust on citizens’ health risk perception in the context of a petrochemical industrial complex. *Int. J. Environ. Res. Public Health* 10, 399–416.

- Luce, R.D., 1958. A probabilistic theory of utility. *Econom. J. Econom. Soc.* 193–224.
- Mah, D.N., Hills, P., Tao, J., 2014. Risk perception, trust and public engagement in nuclear decision-making in Hong Kong. *Energy Policy* 73, 368–390.
- Mariel, P., Meyerhoff, J., 2016. Hybrid discrete choice models: gained insights versus increasing effort. *Sci. Total Environ.* 568, 433–443.
- McFadden, D., 1974. Conditional logit analysis of qualitative choice behavior. In: *Frontiers in Econometrics*. Academic Press, pp. 105–142.
- Ortúzar, J.D.D., Willumsen, L.G., 2011. *Modelling Transport*. John Wiley & Sons.
- Paulssen, M., Temme, D., Vij, A., Walker, J.L., 2014. Values, attitudes and travel behavior: a hierarchical latent variable mixed logit model of travel mode choice. *Transportation (Amst.)* 41, 873–888.
- Poortinga, W., Pidgeon, N.F., 2003. Exploring the dimensionality of trust in risk regulation. *Risk Anal. An Int. J.* 23, 961–972.
- Putnam, R.D., 2000. *Bowling Alone: The Collapse and Revival of American Community*. Simon and Schuster.
- Putnam, R.D., Leonardi, R., Nanetti, R.Y., 1994. *Making Democracy Work: Civic Traditions in Modern Italy*. Princeton University Press.
- Raveau, S., Alvarez-Daziano, R., Yañez, M.F., Bolduc, D., Ortúzar, J.D.D., 2010. Sequential and simultaneous estimation of hybrid discrete choice models: some new findings. *Transp. Res. Rec.* 2156, 131–139.
- Revelt, D., Train, K., 1998. Mixed logit with repeated choices: households' choices of appliance efficiency level. *Rev. Econ. Stat.* 80, 647–657.
- Schively, C., 2007. Understanding the NIMBY and LULU phenomena: reassessing our knowledge base and informing future research. *J. Plan. Lit.* 21, 255–266.
- Scott, M., Powells, G., 2020. Towards a new social science research agenda for hydrogen transitions: social practices, energy justice, and place attachment. *Energy Res. Soc. Sci.* 61, 101346.
- Siegrist, M., Cvetkovich, G., 2000. Perception of hazards: the role of social trust and knowledge. *Risk Anal.* 20, 713–720.
- Siegrist, M., Cvetkovich, G., Roth, C., 2000. Salient value similarity, social trust, and risk/benefit perception. *Risk Anal.* 20, 353–362.
- Siegrist, M., Gutscher, H., Earle, T.C., 2005. Perception of risk: the influence of general trust, and general confidence. *J. Risk Res.* 8, 145–156.
- Siegrist, M., Cousin, M.-E., Kastenholz, H., Wiek, A., 2007. Public acceptance of nanotechnology foods and food packaging: the influence of affect and trust. *Appetite* 49, 459–466.
- Sillano, M., Ortúzar, J.D.D., 2005. Willingness-to-pay estimation with mixed logit models: some new evidence. *Environ. Plan. A* 37, 525–550.
- Sjoberg, L., 2000. Factors in risk perception. *Risk Anal.* 20, 1–12.
- Slovic, P., 1987. Perception of risk. *Science* (80) 236, 280–285.
- Slovic, P., 2000. *The Perception of Risk*. Earthscan, London (UK).

- Stern, P.C., 2000. New environmental theories: toward a coherent theory of environmentally significant behavior. *J. Soc. Issues* 56, 407–424.
- Strazzer, E., Mura, M., Contu, D., 2012. Combining choice experiments with psychometric scales to assess the social acceptability of wind energy projects: a latent class approach. *Energy Policy* 48, 334–347.
- Tanaka, Y., 2004. Major psychological factors determining public acceptance of the siting of nuclear facilities. *J. Appl. Soc. Psychol.* 34, 1147–1165.
- Uslaner, E.M., 2002. *The Moral Foundations of Trust*. Cambridge University Press.
- Van Veelen, B., Haggett, C., 2017. Uncommon ground: the role of different place attachments in explaining community renewable energy projects. *Sociol. Rural.* 57, 533–554.
- Vij, A., Walker, J.L., 2016. How, when and why integrated choice and latent variable models are latently useful. *Transp. Res. Part B Methodol.* 90, 192–217.
- Visschers, V.H.M., Keller, C., Siegrist, M., 2011. Climate change benefits and energy supply benefits as determinants of acceptance of nuclear power stations: investigating an explanatory model. *Energy Policy* 39, 3621–3629.
- Wang, Y., Li, J., 2016. A causal model explaining Chinese university students' acceptance of nuclear power. *Prog. Nucl. Energy* 88, 165–174.
- Wang, Y., Gu, J., Wu, J., 2020. Explaining local residents' acceptance of rebuilding nuclear power plants: the roles of perceived general benefit and perceived local benefit. *Energy Policy* 140, 111410.
- Zucchetti, M., 2006. Environmental pollution and health effects in the Quirra area, Sardinia island (Italy) and the depleted uranium case. *J. Environ. Prot. Ecol.* 7, 82–92.