Journal of Cleaner Production 387 (2023) 135964

Contents lists available at ScienceDirect

Journal of Cleaner Production

journal homepage: www.elsevier.com/locate/jclepro

Do environmental attitudes affect public acceptance of key enabling technologies? Assessing the influence of environmental awareness and trust on public perceptions about nanotechnology

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ARTICLE INFO

Handling Editor: Genovaite Liobikiene

Keywords:
Key enabling technologies
Nanotechnology
Public acceptance
Environmental attitudes
Cognitive miser model
Sustainable development

ABSTRACT

Key Enabling Technologies (KETs) play a crucial role in modern societies due to their substantial contribution to cleaner production, sustainable development, and societal well-being across industrial sectors. However, to prompt the successful deployment of such technologies in diverse societal and market contexts, public acceptance constitutes a crucial requirement. As public knowledge of KETs is often limited, "cognitive shortcuts" – such as attitudes and personal beliefs – play a crucial role in shaping public opinion about enabling technologies. Drawing on the case of nanotechnology, the paper advances that environmental attitudes contribute to shape layman's perceptions about novel enabling technologies. Based on data collected from a survey of Italian citizens, the study investigates the influence of environmental awareness on public perceptions of benefits and risks of nanotechnology. By means of hierarchical regression equations, the study also tests the moderation of public trust in the environmental commitment of societal actors deemed responsible for nanotechnology development – i.e. high-tech companies, governmental agencies and research universities. The results show that environmental awareness positively relates with both perceived benefits and risks of nanotechnology, while the different effects of trust are contingent upon the actor in which trust is put. The contribution of the study point to the role of public trust in shaping perceptions of novel technology: the study's implications for practice thus inform the development of information strategies aimed at supporting the acceptance of KETs among the larger public.

1. Introduction

Since their inception in late 2000s, Key Enabling Technologies (KETs) have increasingly played a crucial role in the European Union's (EU) strategy for sustainable competitiveness and growth, fostering technological advancements in a variety of sectors and industries, and supporting technology leaders in devising solutions to the most pressing societal challenges (Miller et al., 1997). According to the European Commission (EC), KETs are "*knowledge intensive and associated with high R&D intensity, rapid innovation cycles, high capital expenditure and highly skilled employment*". Furthermore, KETs *"enable process, goods and service innovation throughout the economy and are of systemic relevance"* (European Commission, 2012). In line with this definition, the EC's strategy for KETs identifies six technologies as the EU's main enabling technologies: namely, micro and nanoelectronics, nanotechnology, industrial biotechnology, advanced materials, photonics, and advanced manufacturing technologies (European Commission, 2012). Such technologies indeed enable a wide range of product and process applications, including those required for developing low carbon energy production technologies, and improving energy and resource efficiency of production processes and supply chains (John et al., 2022; Bag et al., 2021; Birkel and Müller, 2021; Páez-Avilés et al., 2018).

Despite extensive institutional support and vocal endorsement from the scientific community, the successful deployment of KETs is contingent upon their acceptance among the larger public (Gupta et al., 2012; Todt, 2011). In the last decade, the issue of public acceptance of technological innovations has indeed highlighted the crucial role of public opinion in determining the success of new technologies and in guaranteeing their future development (Lee et al., 2022; Irfan et al., 2021; Yuen et al., 2020; Arning et al., 2020; Bögel and Upham, 2018). Drawbacks of

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https://doi.org/10.1016/j.jclepro.2023.135964
Received 15 September 2022; Received in revised form 29 December 2022; Accepted 6 January 2023
Available online 6 January 2023

public opposition to novel or emerging technologies may include market failures such as the limited uptake of an innovation, as well as discontinued public investments and lack of political and regulatory endorsement. Similar drawbacks can be found in the controversial case of public opposition to genetically-modified organisms (GMOs) in the agricultural sector (Blancke et al., 2015), anti-nuclear energy movements in major EU countries (Jahn and Korolczuk, 2012; Gong et al., 2022), as well as vaccine opposition during the COVID-19 pandemic (Bonnevie et al., 2021; Escario et al., 2022).

Similar cases of public opposition to novel technologies has brought to the attention of social scientists the need to understand the dynamics underlying the development of public opinion in relation to new or emergent technologies, in order to devise information strategies aimed at supporting the introduction of technological innovations in society (Porcari et al., 2019). However, despite the strategic relevance of KETs for EU's sustainable competitiveness, the current understanding of public perceptions about enabling technologies among EU citizens is still limited.

Being on the forefront of EU's investment strategy for KETs, nanotechnology is at the centre of this debate (Boholm and Larsson, 2019; van Dijk et al., 2017). Nanotechnology is often broadly defined as heterogeneous group of technologies applied to, or using systems, at the nanoscale (Fleischer and Grunwald, 2008). The spread of nano-applications has led to a public debate about the potential environmental and health risks that the dispersion of nanomaterials in ecosystems entail (Babatunde et al., 2019), thus generating concerns about social acceptance of nanotechnology (Hannah and Thompson, 2008; Sas and Suarez, 2014; Besley, 2010; Morose, 2010; Fleischer and Grunwald, 2008; Glenn, 2006; Reijnders, 2006). Nanoparticles are directly applied in the environment (as for environmental remediation or water filtration) or end up in the environment through indirect pathways (as in the case of nano additives used in some biodiesel fuels) (Rai et al., 2021; Bartolozzi et al., 2020). While beneficial to the environment, similar applications cause humans to be exposed to risks of inhaling, ingesting or dermally absorbing nanoparticles, whose impacts on health are partially known (Díaz-Soler et al., 2019; Hull and Bowman, 2018).

Several surveys have been conducted to examine perceptions about risks and benefits of nanotechnology in diverse contexts. Similar studies have often highlighted a lack of knowledge of nanotechnology among the public, and a limited understanding of potential benefits and risks (Cobb and Macoubrie, 2004; Sheetz et al., 2005; Burri and Bellucci, 2008; George et al., 2014; Handford et al., 2015; Zhou and Hu, 2018; Larsson et al., 2019; Porcari et al., 2019). However, assuming that limited knowledge of a new technology hinders the development of public opinion is a simplistic conception. Scholars indeed claim that public opinion about emerging technologies is not only based on knowledge of the technology itself. When confronted with complex issues (such as science, technology and economics), individuals rely on "cognitive shortcuts", such as stereotypes, personal values, ideology or religious beliefs, to formulate judgments about phenomena they know little about (Lee and Scheufele, 2005; Besley, 2010; Upham et al., 2020). In this perspective, previous contributions have investigated heuristics like cultural cognition, religious beliefs, scepticism and altruism as determinants of individuals' perceptions about nanotechnology (Siegrist et al., 2007; Kahan et al., 2009; Ho et al., 2011; Ganesh Pillai and Bezbaruah, 2017).

Similarly, perceptions of the social, commercial and regulatory contexts in which technologies are introduced contribute orientating public opinion (Gupta et al., 2012). Scholars have investigated preconceptions about the societal actors responsible for advancing technological development (such as research centres and universities), regulating technological applications (i.e. governmental agencies) and commercializing technological products or services (such as hi-tech business enterprises) (Besley, 2010; Sastry et al., 2010; Arora et al., 2014). Specifically, trust in societal actors like scientists, business leaders, regulators and other authorities have been examined as predictors of views on nanotechnology (Cobb and Macoubrie, 2004; Macoubrie, 2006; Siegrist et al., 2007).

Due to the increasing public environmental awareness, several scholars have suggested that personal views on the relation between science, technology and nature may play a role in shaping perceptions about enabling technologies (Grunert et al., 2003; Siegrist et al., 2007; Siegrist, 2008; Vandermoere et al., 2011; Matin et al., 2012; Ganesh Pillai and Bezbaruah, 2017). However, despite the relevance of KETs for EU's sustainable development, and concerns for backlashes in response to societal concerns about their environmental and health impacts, current understanding on the relation between environmental attitudes and public acceptance of modern enabling technologies is still limited.

To address this gap, the present study draws on the cognitive miser model of information processing and decision-making to investigates the role of environmental attitudes as key cognitive heuristics in relation with enabling technology (Fiske and Taylor, 1991). In contrast with traditional scientific literacy models (Miller, 1998), the cognitive miser perspective indeed shifts the focus from knowledge and information towards heuristics and preconceptions as main factors in opinion formation processes and judgements.

By drawing on data from a survey on Italian citizens, the present study focuses on nanotechnology as a proxy of EU's KETs to examine the relations between environmental awareness and laymen's perceptions of both benefits and risks of enabling technologies. Specifically, in environmental psychology literature, diverse psychometric scales have been used to examine cognitive features like environmental attitudes, ecological beliefs and pro-environmental norms. In particular, the "New Environmental Paradigm" scale has been largely utilised to measure individuals' endorsement of environmental sustainability principles (Dunlap, 2008). The New Environmental Paradigm denotes an eco-centric worldview, which conceives "natural limits" to the exploitation of natural resources and hopes for a more harmonic relation between human activity and nature (Dunlap et al., 2000). In addition, the study draws on the concept of "green trust" (Chen, 2010; Chen and Chang, 2013) to test the moderation of public trust in the environmental responsibility and credibility of societal actors responsible for the development, commercialization and regulation of nanotechnology – i.e. government agencies, high-tech business enterprises, universities and research centres – on the relations between environmental awareness and perceived benefits and risks of nanotechnology.

The contribution of the study is twofold. First, the study contributes advancing the understanding of environmental attitudes as influential heuristics in perceptions about benefits and risks of enabling technology. By examining the effects of environmental awareness on both risk and benefit perceptions, the study contributes to a more nuanced understanding of the relation between ecological worldviews and views on technological development, suggesting a complementarity between ecological beliefs and acceptance of novel enabling technologies (Lee et al., 2022). Second, the study contributes to research on public trust and acceptance of enabling technologies (Lee et al., 2005). By acknowledging public trust as a multi-faceted construct that varies across domains and societal actors, the study focuses on trust about the environmental commitment and credibility (i.e. green trust) of diverse societal actors (i.e. business companies, government and research centres), shedding light on the differential effects of diverse green trust constructs on the relation between environmental awareness and perceptions about enabling technology.

2. Theoretical background and hypothesis development

2.1. *Cognitive miser model of information processing about novel technology*

The cognitive miser model is frequently utilised to explain individuals' information processing and decision-making behaviours

(Fiske and Taylor, 1991). According to theorists of this model, people are cognitive misers as they only collect as much information about a given issue as they think is sufficient to elaborate a personal opinion or take a decision. This behaviour often imply that people make decisions with insufficient amounts of information: people indeed invest efforts to process extensive amounts of information on a given issue only when pay-offs are reasonable, while they save on information-seeking when returns from taking an informed decision are not enough (Popkin, 1993).

This is especially relevant with regard to complex issues (such as science and technology), where developing an in-depth understanding requires substantial efforts on the part of ordinary citizens and pay-offs in terms of making informed risk judgments may not be enough (Kunreuther, 2001). When pay-offs from information-seeking are unsatisfactory, it makes rational sense for people to rely on heuristics, or "cognitive shortcuts" (e.g. stereotypes, ideologies, religious beliefs etc.), to elaborate opinions about issues they know little or nothing about.

In the domain of novel technologies, where most people have limited direct experience, numerous studies have demonstrated that cognitive factors and heuristics are highly influential in shaping perceptions about benefits and risks of technology (Wang et al., 2021; Que et al., 2019; Ganesh Pillai and Bezbaruah, 2017; Kahan et al., 2009). According to this view, heuristics like value predispositions, attitudes and beliefs provide a perceptual filter through which people form opinion about a novel technology, irrespective of their actual knowledge of the technology (Ho et al., 2019). This perspective contrasts with traditional scientific literacy models, according to which public support of novel technologies is contingent upon scientific information and factual understanding of the technology (Miller et al., 1997). As a result, scholars have increasingly emphasised the need to understand how individuals' cognitive and affective predispositions relate with perceptions about novel technologies, in order to tailor scientific communication strategies and messages to heuristics (e.g. values, beliefs etc.) that can stimulate positive attitudes among the public (Ho et al., 2019).

In this perspective, previous studies have examined the effect of diverse affect heuristics on perceptions about novel technologies, such as trust and environmental attitudes (Kamarulzaman et al., 2020; Liu et al., 2021). Trust occurs when societal actors are perceived as credible, competent, fair and reliable, and when their values are acknowledged and shared by the public (Mah et al., 2014). When individuals lack knowledge of a novel technology, trust functions as a "cognitive shortcut" for opinion formation, by leading individuals towards positive or negative evaluations depending on their level of trust in societal actors associated with the technology (Ho et al., 2019). Similarly, environmental awareness and ecological worldviews have been found to influence individuals' evaluations of new or controversial technologies (Lee et al., 2022), especially when such technologies' implications for environmental quality or environmental impacts are uncertain or debated. Environmental attitudes have been found to substitute factual knowledge with "illusory" knowledge about complex environmental issues, thus shaping individuals' opinion irrespective of their actual understanding of the specific issue (Zhu et al., 2016; Yang et al., 2020).

Based on these theoretical considerations, the following paragraph discusses the hypothesis of the study in greater detail.

2.2. Environmental attitudes and perceptions of risk and benefits of nanotechnology

Concerns for environmental quality and attitudes towards the natural environment have been often investigated as influential affect heuristics of public acceptance of novel technologies (Lee et al., 2022; Wu et al., 2019; Taufik and Dagevos, 2021). Previous research has indicated that environmental attitudes correlate significantly with risk perceptions with regard to diverse technological innovations. For instance, according to Siegrist (2008), strong ecological beliefs are related with opposition to gene technology. More recently, Hobman and Ashworth (2013) found that pro-environmental beliefs relate to support for alternative energy-related technologies. Jenkins-Smith et al. (2011), Lee et al. (2022) and Gong et al. (2022) found environmental concerns to be related with opposition to nuclear power energy. Arning et al. (2020) found environmental risk perceptions to be negatively related with acceptance and utilisation of carbon capture technology.

In the domain of key enabling technologies, previous studies have investigated the influence of environmental attitudes and beliefs on general support for nanotechnology in terms of benefit-risk ratio (Vandermoere et al., 2011; Matin et al., 2012). In examining general support for nanotechnology as a unique outcome variable, similar contributions fall short of detecting the effect of environmental attitudes on perceptions of both benefits and risks of nanotechnology. Therefore, the current understanding of the relation between environmental attitudes and perceived benefits and perceived risks of nanotechnology is still limited.

The present study aims at shedding light on the dynamics that shape both risks and benefits perceptions of nanotechnology, by investigating the relation between environmental awareness and two outcome variables, i.e. perceived benefits and perceived risks of nanotechnology. To this aim, the present study adopts the New Environmental Paradigm scale to measure endorsement of environmental sustainability principles as a proxy of individuals' environmental awareness. The New Environmental Paradigm denotes an eco-centric worldview (as opposed to an anthropocentric worldview), which places intrinsic value on natural resources, hopes for a more balanced use of limited natural resources and expresses concerns for the fragility of eco-systems (Dunlap, 2008).

Previous studies on the relation between environmental attitudes and acceptance of nanotechnology have often demonstrated a negative relation between the two. For instance, Vandermoere et al. (2011) found that people with strong eco-centric worldviews are less likely to support nanotechnology. Similarly, Matin et al. (2012) found that eco-centric beliefs are negatively related with support for nanotechnology applications in the food sector. Similar studies suggest that environmental awareness imply scepticism towards the societal benefits of technological progress. In this perspective, people with strong beliefs regarding the need to preserve natural resources appear to oppose to the use of nanotechnologies. Based on previous considerations, the following hypothesis is formulated.

Hypothesis 1. (a) Environmental awareness negatively influences perceived benefits of nanotechnology and (b) positively influences perceived risks of nanotechnology.

The perceived trustworthiness of societal actors and institutions responsible for technological progress play a crucial role in public opinion about nanotechnology (Lee et al., 2005; Besley, 2010; Kamarulzaman et al., 2020; Joubert et al., 2020). Public trust in scientists, governmental agencies and business leaders indeed denotes the perceived ability of similar institutions to minimize and manage risks related with the diffusion of nanotechnology (Siegrist et al., 2007). Trust in similar institutions helps people to reduce uncertainty about novel technologies and makes information processing more efficient (Liu et al., 2021).

Previous studies have examined a variety of trust measures to investigate the influence of public trust on acceptance of nanotechnology. Cobb and Macoubrie (2004) investigated public trust in business leaders, and found that a lack of trust in business leaders is positively related with perceptions of risks of nanotechnology. Lee et al. (2005) found that public trust in scientists play an important role in shaping perceptions of benefits of nanotechnology. Vandermoere et al. (2011) demonstrated that trust in governmental agencies relates with opposition to nanotechnology. Matin et al. (2012) found that individuals' natural inclination to trust others is only weakly related with support for nanotechnology.

Similar contributions found differential effects of public trust on perceptions about nanotechnology, depending on the type of trust that was examined. Given the study's focus on the influence of environmental attitudes on perceived benefits and risks of nanotechnology, the present study relies on the concept of green trust to investigate public trust in the commitment of institutions (i.e. business companies, governmental bodies, research centres or universities) to protect the environment and provide reliable claims about environmental issues. While previous research has measured public trust in diverse institutions by utilising generic trust constructs, without referencing to a specific issue or domain of science, technology or society, green trust specifically denotes public trust in institutions' environmental commitment and responsibility (Chen, 2010; Chen and Chang, 2013).

The study aims at exploring the interplay between environmental attitudes and public trust, by testing the moderation of green trust in the relations between environmental awareness and the perceived benefits and risks of nanotechnology. Drawing on previous insights, the study advances that high trust in the environmental commitment of business companies, governmental agencies and universities reduces the influence of environmental awareness on both perceptions of benefits and risks of nanotechnology. In this perspective, individuals characterised by high environmental awareness have a higher perception of benefits of nanotechnology and a lower perception of risks of nanotechnology as a result of the moderation of green trust. Accordingly, the following hypothesis are tested.

Hypothesis 2. (a) Green trust in companies positively moderates the relation between environmental awareness and perceived benefits of nanotechnology, and (b) it negatively moderates the relation between environmental awareness and perceived risks of nanotechnology.

Hypothesis 3. (a) Green trust in government positively moderates the relation between environmental awareness and perceived benefits of nanotechnology, and (b) it negatively moderates the relation between environmental awareness and perceived risks of nanotechnology.

Hypothesis 4. (a) Green trust in universities positively moderates the relation between environmental awareness and perceived benefits of nanotechnology, and (b) it negatively moderates the relation between environmental awareness and perceived risks of nanotechnology.

A graphical representation of the conceptual model is provided in Fig. 1.

3. Method

3.1. Data collection

Data were collected by means of a self-administered online questionnaire developed by authors of the study. Procedural remedies were included in the questionnaire design to reduce bias that might affect survey research, such as social desirability bias. First, an introductory message guaranteed respondent anonymity, and questions regarding the name of the respondent were avoided (Chung and Monroe, 2003). Second, all questions were based on categorical Likert scales with verbal labels on the endpoints of the scale. Most importantly, all questions were kept simple, concise and specific by design in order to avoid ambiguity or vagueness (Podsakoff et al., 2003). To verify the clarity of the questions and reduce risk of misinterpretations, a pre-test was carried out on six respondents. As a result of the test, some items were rephrased to improve clarity.

The online questionnaire was promoted by means of a paid advertising campaign on the online social media channels of the authors' university between July and September 2018. The campaign was targeted at Italian citizens, without any specific restriction with regard to gender, age, or occupation. To foster participation in the survey, the university offered a reward for the completion of the questionnaire. Accordingly, respondents who completed the questionnaire were included in a prize draw for awarding a wireless audio speaker.

At the end of the data collection period, 370 respondents participated in the survey. After uncompleted questionnaires were discarded, 264 questionnaires were retained for the analysis.

3.2. Sample description

Respondents' demographics were collected through a dedicated section of the questionnaire.

The sample is mostly composed by young Italian citizens. Specifically, 57.5% of the respondents is less than 30 years old, while only the 4.2% of the sample is over than 60 years old. A detailed breakdown of the sample by age is provided in Table 1.

In terms of gender, the sample is almost equally composed by male and female respondents. Specifically, 52.5% of the respondents in the sample are male, while 47.5% are female.

With regard to the level of education, 16.9% of the respondents concluded their academic studies with a lower secondary school diploma, while the 38.1% achieved a high school diploma. Respondents with a bachelor's degree (BA or BSc) are the 16.8% of the sample, while

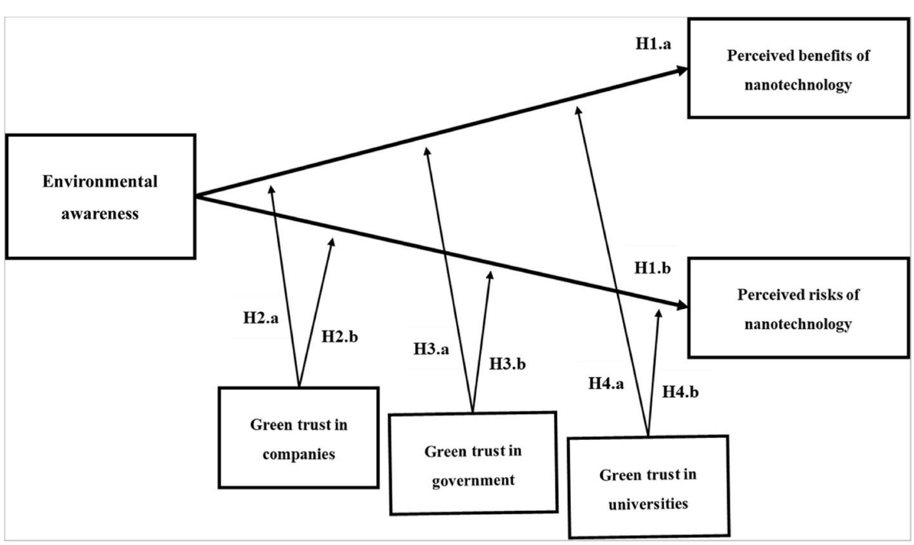

Fig. 1. Conceptual model.

Table 1
Sample breakdown by age of the respondents.

Age	Percentage of respondents	Age	Percentage of respondents
<20 years old	16.9%	41–50	11.4%
21–30	40.8%	51–60	10%
31–40	16.7%	>60 years old	4.2%

the 22.5% hold a master's degree (MSc). Respondents holding a higher-level academic qualification – such as a doctor of philosophy (PhD) or second-level master degree (MA) – constitute the 5.3%. Only the 0.4% of the sample did not continue their studies after primary school.

The entirety of respondents in the sample are Italian citizens. All Italian regions are represented in the sample, with very similar distributions among North, Centre and South Italy. Specifically, the 36.5% of the respondents reside in North Italy, the 38.3% resides in Centre Italy, and the 25.2% resides in South Italy.

Lastly, the questionnaire asked respondents to rate their level of information with regard to nanotechnology on a 1–5 Likert scale, where 1 corresponds to "not informed at all" and 5 to "very informed". Not surprisingly, only the 3.5% of the respondents rated themselves as "very informed", while the majority of the respondents rated themselves as "poorly informed" (i.e. 37.1%) or as "mildly informed" (25.8%). Accordingly, the mean value of this variable is 2.05 and standard deviation of 0.227. Table 2 breakdowns the sample according to the level of information about nanotechnology.

3.3. Measurements

3.3.1. Environmental awareness

To operationalise environmental awareness, the study utilises a short version of the New Environmental Paradigm scale proposed by Zhu and Lu (2017). By employing item-response theory technique to analyse responses to a large-scale New Environmental Paradigm survey, Zhu and Lu (2017) note that the multidimensionality problem affecting the New Environmental Paradigm scales developed by Dunlap et al. (2000) stems from the negatively worded items included in the scales. Main criticism to the original New Environmental Paradigm scale by Dunlap et al. (2000) regarded the multidimensionality issue caused by the imbalance between negatively worded items requiring reverse scoring (denoted as "anti-NEP" items) and positively worded items. Specifically, only four out of twelve items were worded negatively. Accordingly, Dunlap (2000) revised the New Environmental Paradigm scale to include seven negatively worded items and eight positive items.

However, according to the analysis by Zhu and Lu (2017), using a balanced set of negatively and positively worded items is not an effective method to reduce multidimensionality: the negatively worded items indeed have poorer measurement precision compared to positively phrased items and are often redundant in regard to the information obtained. Based on their analysis, Zhu and Lu (2017) claim that a short version of the revised New Environmental Paradigm scale consisting of only eight positive items perform as well as the scale by Dunlap et al. (2000).

As suggested by Zhu and Lu (2017), the present study utilises the short version of the revised New Environmental Paradigm scale. Accordingly, respondents were asked to rate their level of agreement on a 1–5 Likert scale with eight positively worded items. The results indeed support Zhu and Lu (2017): the construct exhibits satisfactory convergent validity. All items load on a single factor with loading higher than 0.6, average extracted variance is equal to 0.5 and composite reliability is 0.7. Cronbach's alpha reliability coefficient is 0.85.

3.3.2. Perceived benefits and perceived risks of enabling technologies

Previous surveys on public perceptions of benefits and risks of novel technologies have mostly investigated whether perceived benefits outweighs perceived risks (Cobb and Macoubrie, 2004; Kahan et al., 2009). Similar surveys usually develop measures that rely on a subjective self-assessment of the relative importance of risks against benefits, by asking questions like *"To what extent do you believe that risks of nanotechnology outweigh its benefits?"* (Kahan et al., 2009). This approach has been criticised when used in relation to respondents with little knowledge about potential risks and benefits of a specific technology (Lee et al., 2005). Alternatively, previous contributions have assessed perceived benefits and risks of technological innovations to measure opposition or support in terms of benefits-risks ratio (Vandermoere et al., 2011; Matin et al., 2012). However, these approaches do not allow differentiating constructs of perceived risks and perceived benefits to investigate the diverse effects of cognitive antecedents on perceived risks and perceived benefits.

The present study adopts a different approach for measuring perceptions of benefits and risks with the aim to separate constructs of perceived benefits and perceived risks of nanotechnology. Drawing on previous literature on public perceptions about technological innovations, two distinct measures were constructed:

Perceived benefits of nanotechnology – six items were created based on the most recurring potential benefits in literature, including (1) fostering economic growth; (2) improving people daily lives; (3) creating new job opportunities; (4) improving public health; (5) fostering innovation; (6) benefiting the natural environment (Cobb and Macoubrie, 2004; Lee et al., 2005; Scheufele and Lewenstein, 2005). Respondents were asked to rate each item on a 1–5 Likert scale according to their level of agreement with the possibility that nanotechnology can bring such benefit. The benefit with the highest score is creating new job opportunities (mean is 4.06), while the benefit with the lowest score is improving public health (mean is 3.70). The mean value of whole construct is 3.90. The Cronbach's alpha reliability coefficient of this construct is 0.88.

Perceived risks of nanotechnology – six items were created to represent the most recurring risks of nanotechnology in literature, specifically (1) breathing nanoparticles; (2) ingesting nanoparticles; (3) developing diseases (such as tumors, cardiovascular pathologies, allergies etc.); (4) air pollution; (5) water pollution; (6) producing hazardous waste (Cobb and Macoubrie, 2004; Scheufele and Lewenstein, 2005). Respondents were asked to rate the perceived magnitude of each risk on a 1–5 Likert scale, where 1 corresponded to "null" and 5 to "very high". The risk with the highest score is producing hazardous waste (mean is 3.94), while the risk with the lowest score is polluting air (mean is 3.40). The mean of the overall measure is 3.58. The Cronbach's alpha reliability coefficient is 0.91.

3.3.3. Green trust in companies, government and universities

The study draws from the concept of green trust to develop three distinct measures of public trust in (1) business companies, (2) government agencies at various levels (i.e. local, regional, national and European levels) and (3) universities and research centres, in the domain of environmental protection (Chen, 2010; Chen and Chang, 2013).

Table 2
Sample breakdown by level of information about nanotechnology.

Level of information	1 Not informed at all	2 Poorly informed	3 Mildly informed	4 Fairly informed	5 Very informed
Percentage of respondents	17.5%	37.1%	25.8%	16.1%	3.5%

Previous contributions have examined public trust in institutions responsible for technological development (such as scientists, regulators and business leaders) as an influential factor in public acceptance of nanotechnology (e.g. Macoubrie, 2004; Siegrist et al., 2007; Lee and Scheufele, 2005; Vandermoere et al., 2011). Most studies have measured trust as a generic construct with limited relevance to a specific domain of science, technology or society (Brown et al., 2015). Few studies have measured trust as a domain-specific construct, but with limited focus on institutions' willingness or capability to manage nanotechnology-related risks (e.g. Cobb and Macoubrie, 2004).

However, public trust is a multi-faceted construct that can greatly vary across domains. Consequently, diverse kinds of domain-specific public trust may have different influences on perceptions of benefits and risks of nanotechnology. Accordingly, too broad formulations of public trust may make it difficult to examine the specific role of trust in public acceptance of new technologies (Lee and Scheufele, 2005). Specifically, to the best of our knowledge, previous contributions have overlooked public trust in the domain of environmental protection.

For each of the three constructs – *Green trust in companies, Green trust in government, Green trust in universities* – green trust is a function of (1) perceived commitment to environmental protection, (2) perceived reliability of environmental claims and (3) perceived priority of environmental protection over economic interests. Accordingly, each construct is composed by three items (Table 3). Respondents were asked to rate each item on a 1–5 Likert scale according to their level of agreement. The Cronbach's alpha reliability coefficients are 0.82, 0.79 and 0.85 for *Green trust in companies, Green trust in government, Green trust in universities*, respectively.

3.3.5. Control variables

Drawing on previous contributions, three variables have been identified as control variables in the study, i.e. respondents' age, gender and level of information about nanotechnology.

Age – Age is often considered to be influential in shaping perceptions of emerging technologies. However, empirical studies have provided mixed results at this regard. For instance, according to Vandermoere et al. (2011), younger people are more likely to support nanotechnology applications in the food sector compared to older people. Similarly, Matin et al. (2012) found age to be negatively related with support of nanotechnology. On the other hand, according to Lee et al. (2005), age is not a significant predictor of support for nanotechnology, when variables like level of information and education are considered. For the sake of the present study, respondents have been asked to indicate their age on a 6-point categorical scale, ranging from "less than 20 years old" to "more than 60 years old" (Table 1).

Gender – As in the case of age, gender is a demographic variable often accounted for playing a role in risk perceptions and risk judgements (Finucane et al., 2000; Kahan et al., 2009; Kahan et al., 2009). Studies like Finucane et al. (2000) and Kahan et al. (2009) have indeed suggested that male individuals tend to underrate societal risks compared to women, displaying the so-called "white-male" effect. However, subsequent studies on risk perceptions about nanotechnology have denied a similar relation, claiming that previous findings are not yet generalizable across cultural and demographic groups and technological contexts (Brown et al., 2015). In the present study, gender is treated as a dummy variable.

Level of information – The cognitive miser model assumes that individuals are capable of elaborating risk judgements based on little or no

Table 3
Questionnaire items and factor loadings.

Construct	Operationalisation	Factor loadings	Uniqueness
Environmental awareness	We are approaching the limit of the number of people the Earth can support	0,65	0,47
	When humans interfere with nature it often produces disastrous consequences	0.71	0,37
	Humans are severely abusing the environment	0,80	0,32
	Plants and animals have as much right as humans to exist	0,67	0,48
	Despite our special abilities, humans are still subject to the laws of nature	0,69	0,54
	The Earth is like a spaceship with very limited room and resources	0,69	0,44
	The balance of nature is very delicate and easily upset	0,78	0,39
	If things continue on the present course, we will soon experience a major ecological catastrophe	0,76	0,36
Perceived benefits of nanotechnology *"Nanotechnology can …"*	… have positive effects on economic growth	0,84	0,32
	… improve daily life of the people	0,83	0,26
	… create job opportunities	0,71	0,43
	… benefit public health	0,81	0,25
	… foster innovation in our country	0,83	0,32
	… benefit the environment	0,76	0,29
Perceived risks of nanotechnology	Risk of breathing nanoparticles	0,90	0,23
	Risk of ingesting nanoparticles	0,81	0,34
	Risk of developing diseases (such as tumors, cardiovascular pathologies, allergies etc.)	0,82	0,30
	Risk of air pollution	0,84	0,22
	Risk of water pollution	0,88	0,20
	Risk of producing hazardous waste	0,84	0,29
Green trust in companies *"Business enterprises …"*	… are committed to protect the environment	0,77	0,29
	… make reliable statements regarding environmental protection	0,70	0,35
	… give priority to environmental protection rather than their economic interests.	0,80	0,29
Green trust in government *"Government bodies at various levels (local, regional, national, European) …"*	… are committed to protect the environment.	0,86	0,16
	… make reliable statements regarding environmental protection	0,83	0,26
	… give priority to environmental protection rather than their economic interests.	0,87	0,22
Green trust in universities *"Universities and research centres …"*	… are committed to protect the environment.	0,55	0,34
	… make reliable statements regarding environmental protection	0,82	0,24
	… give priority to environmental protection rather than their economic interests.	0,65	0,33

information (Scheufele and Lewenstein, 2005). Despite this assumption, individuals' extant level of information or previous knowledge are often accounted as control variables in studies on public acceptance of nanotechnology to control for its impact on perceptions of benefits and risks. However, similar studies have often underlined that impact of information on perceptions of risks and benefits is often minimal when individuals strongly rely on cognitive heuristics or emotional bias to formulate judgements on new technologies (Lee et al., 2005; Siegrist et al., 2007; Brown et al., 2015). Level of information is a self-reported 5-point categorical variable, ranging from "not informed at all" to "very informed".

4. Results

4.1. Assessment of the measurement model

To assess validity of the measurement model, an exploratory factor analysis (EFA) to varimax rotation was performed including all the items of the latent variables described in the conceptual model. As displayed in Table 3, the EFA supported preliminary assumptions on the measurement model: all the items load on six distinct factors with loadings greater than 0.5 and uniqueness values lower than 0.5.

Consequently, a confirmatory factor analysis (CFA) was performed to verify the unidimensionality of the constructs (Anderson and Gerbing, 1988). Validity and robustness checks confirm the good fit of the model: the comparative fit index (CFI) is 0.94 and the Tucker-Lewis index (TLI) is 0.92 (above the threshold of 0.90); the root-mean-square error of approximation (RMSEA) is 0.06; the standardized root mean-squared residual (SRMR) is 0.06 (Iacobucci, 2010).

Convergent validity was assessed by checking the significance of the standardized regression coefficient between each observed variable and the associated construct: all items are significantly related ($p < 0.001$) to their latent construct, and all regression coefficients are higher than 0.05 (Cunningham et al., 2001). Then, we computed the average variance extracted (AVE) to measure the amount of total variance explained by each construct: all constructs have AVE values equal to or higher than 0.5. Lastly, Composite Reliability (CR) is higher than 0.6 for all constructs. To assess discriminant validity, we computed pairwise correlation between all observed variables: items that belonging to different constructs are only weakly correlated, as the correlation coefficients are lower than 0.5. Discriminant and convergent validity are therefore satisfactory (Table 4) (Hair et al., 1998).

4.2. Testing hypothesis

To test the hypothesis, we structured two hierarchical regression equations. Hierarchical regression indeed allows testing one or more moderations on the relation between a predictor and an outcome variable, by including interaction or product terms in the last step of the regression equation (Frazier et al., 2004). Accordingly, based on Frazier et al. (2004), three product terms were generated by multiplying the predictor (i.e. environmental awareness) with the moderators (i.e. green trust in companies, government and universities).

The first hierarchical regression equation included perceived benefits of nanotechnology as dependent variable, while the second included perceived risks of nanotechnology as the dependent variable. Both equations were structured following the same procedure. In the first step (Model 1), only the control variables (i.e. age, gender, level of information) were entered in the equation. In the second step (Model 2), the predictor (i.e. environmental awareness) and moderators (i.e. green trust in companies, government and universities) were included. In the third and last step (Model 3), the three product terms were included.

4.2.1. Testing hypothesis H1.a, H2.a, H3.a and H4.a

Table 5 displays results of the hierarchical regression on perceived benefits of nanotechnology. The F-test is statistically significant ($p < 0.001$) for all models and both predictor and interaction terms increasingly contribute to the amount of variance explained in all models.

In Model 2, the R-squared increases from 0.056 to 0.152 and the difference is statistically significant ($p < 0.001$) and environmental awareness is positively and significantly related with perceived benefits of nanotechnology ($\beta = 0.198$, SE $= 0.062$, $p < 0.01$). In Model 3, R-squared increases to 0.199 ($p < 0.001$), and the relation between environmental awareness and the dependent variable is positive and significant ($\beta = 0.205$, SE $= 0.061$, $p < 0.01$). Accordingly, Hypothesis 1.a

Table 5
Regression results for Perceived benefits of nanotechnology. Standard errors are in parenthesis. ***p < 0.001, **p < 0.01, *p < 0.05.

DV: Perceived benefits of nanotechnology	*Model 1*	*Model 2*	*Model 3*
Environmental awareness		0.198 (0.062)**	0.205 (0.061)**
Green trust in companies		0.076 (0.071)	0.066 (0.070)
Green trust in government		0.037 (0.072)	0.027 (0.071)
Green trust in universities		0.183 (0.066)**	0.219 (0.065)**
Environmental awareness * Green trust in companies			0.126 (0.069)**
Environmental awareness * Green trust in government			0.013 (0.067)
Environmental awareness * Green trust in universities			−0.225 (0.063)***
Age	−0.012 (0.004)**	−0.011 (0.004)**	−0.011 (0.004)**
Gender	−0.059 (0.120)	−0.103 (0.118)	−0.079 (.117)
Level of information	−0.125 (0.054)	−0.048 (0.055)	−0.059 (0.054)
Constant	0.946	0.833	0.714
Observations	264	264	264
F-test	***	***	***
R-squared	0.056	0.152	0.199

Table 4
Squared correlations among latent variables, average variance extracted and composite reliability.

	Environmental awareness	*Perceived benefits*	*Perceived risks*	*Green trust in companies*	*Green trust in government*	*Green trust in universities*	AVE	CR
Environmental awareness	1						0.5	0.7
Perceived benefits	0.035	1					0.6	0.7
Perceived risks	0.036	0.106	1				0.7	0.8
Green trust in companies	0.045	0.060	0.005	1			0.6	0.8
Green trust in government	0.014	0.057	0.000	0.286	1		0.6	0.8
Green trust in universities	0.006	0.118	0.016	0.197	0.221	1	0.6	0.7

is not supported.

With regard to the moderation of green trust, according to results in Model 3, green trust in companies positively moderates the relation between environmental awareness and perceived benefits of nanotechnology (β = 0.126, SE = 0.069, $p < 0.01$), thus Hypothesis 2.a is supported. Green trust in government is not a significant moderator of the relation between environmental awareness and benefits of nanotechnology, thus Hypothesis 3.a is not supported. Green trust in universities negatively moderates the relation between environmental awareness and perceived benefits of nanotechnology (β = −0.225, SE = 0.063, $p < 0.001$), thus Hypothesis 4.a is not supported.

As for the control variables, the relation with age is statistically significant ($p < 0.01$) and negative across all the Models, while relations with gender and level of information are not significant.

4.2.2. Testing hypothesis H1.b, H2.b, H3.b and H4.b

Table 6 displays results of the hierarchical regression on perceived risks of nanotechnology. The F-test is statistically significant for all models and the amount of variance explained increases from Model 1 to Model 3.

In Model 2, the R-squared increases from 0.056 to 0.152 and the difference is statistically significant ($p < 0.05$). The relation between environmental awareness and perceived risk of nanotechnology is positive and significant (β = 0.177, SE = 0.068, $p < 0.01$). Similarly, in Model 3, the R-squared increases to 0.102, and the relation between NEP and perceived risk of nanotechnology is still positive and significant (β = 0.169, SE = 0.067, $p < 0.01$). Thus, Hypothesis 1.b is supported.

As far as concerns the moderation of green trust, in Model 3, only green trust in universities positively moderates the relation between environmental awareness and perceived risks of nanotechnology (β = 0.139, SE = 0.069, $p < 0.01$), while green trust in companies and in government do not significantly moderate this relation. Accordingly, Hypothesis 2.b, 3.b and 4.b are not supported.

As for the control variables, the relation between perceived risks of nanotechnology and level of information is statistically significant and negative across all the models, while relations with age and gender are not significant.

Table 6
Regression results for Perceived risks of nanotechnology. Standard errors are in parenthesis. ***$p < 0.001$, **$p < 0.01$, *$p < 0.05$.

DV: Perceived risks of nanotechnology	*Model 1*	*Model 2*	*Model 3*
Environmental awareness		0.177 (0.068)**	0.169 (0.067)**
Green trust in companies		−0.029 (0.078)	−0.032 (0.077)
Green trust in government		0.079 (0.078)	0.094 (0.078)
Green trust in universities		−0.085 (0.072)	−0.107 (0.072)
Environmental awareness * Green trust in companies			−0.125 (0, 076)
Environmental awareness * Green trust in government			0.119 (0.074)
Environmental awareness * Green trust in universities			0.139 (0.069)**
Age	0.002 (0.004)	0.002 (0.005)	0.000 (0.004)
Gender	−0.045 (0.124)	−0.123 (0.130)	−0.110 (0.130)
Level of information	−0.164 (0.057)***	−0.139 (0.060)**	−0.119 (0.060)**
Constant	0.557	0.620	0.567
Observations	264	264	264
F-test	*	*	***
R-squared	0.032	0.069	0.102

4.3. Assessing the robustness of the model, common method variance and endogeneity

Self-report methods are generally used to measure environmental attitudes (Milfont and Duckitt, 2010). Accordingly, in this study, data are collected by means of a self-administered questionnaire. However, this approach may be susceptible to risk of common method variance (Campbell and Fiske, 1959). Despite several procedural remedies were adopted while designing the questionnaire to minimize common method variance, further tests are required. According to Fuller et al. (2016), the Harman's single factor test constitute a reliable method to control for potential biases. Fuller et al. (2016) indeed argue that the Harman's test might fail to detect common method bias only when variables' Cronbach's alpha coefficients are greater than 0.95. The Harman's test showed that the largest factor accounts for the 32% of the variance, and five factors with eigenvalues greater than 1 emerged. Thus, common method variance does not emerge to affect the dataset.

Additional statistical tests were executed to assess the regression models' robustness. Specifically, the normal distribution of residuals was checked by means of the Shapiro-Wilk test (Fan and Gencay, 1995), while Breusch-Pagan test was performed to verify that heteroscedasticity does not concern the models. Then, variance inflation factors (VIF) were calculated to assess variables' multicollinearity: mean VIF is 1.29 (considerably lower than the threshold of 5) and VIF is lower than 2.0 for all variables. Tolerance levels are significantly higher than the threshold of 0.1. Therefore, multicollinearity does not affect the models' variables (Kennedy, 2003)

Lastly, endogeneity was tested by assessing the presence of omitted variables in both hierarchical regression models by means of the Ramsey's regression specification-error test. Omitted variables bias indeed constitute a major source of endogeneity that may hamper the reliability of regression coefficients: in fact, when relevant variables are omitted, variations in the dependent variable may be incorrectly attributed to the explanatory variable (Ramsey, 1969). Ramsey's test implies regressing the dependent variable on both the explanatory variable and non-linear combinations of the explanatory variable (i.e. its powers, second through fourth): a significant coefficient between the latter and the dependent variable indicates a model misspecification, i.e. the presence of potential omitted variables. For both regression models, the test yielded p-values above the 5% significance level, thus indicating that the null hypothesis of correct model specification is accepted and that the model is not affected by omitted variables.

5. Discussion and conclusion

5.1. Contribution to the literature

By examining the specific case of nanotechnology. the present study examines the role of environmental attitudes – specifically, environmental awareness and green trust – as influential heuristics in public acceptance of key enabling technologies (Kahan et al., 2009). Drawing on the cognitive miser model of information processing (Fiske and Taylor, 1991), the study assessed the influence of environmental awareness on perceptions of benefits and risks of nanotechnology. In addition, the study tested the moderation of green trust in companies, government and universities in the relations between environmental awareness and perceptions of benefits and risks of nanotechnology (Chen and Chang, 2013). The study provides multiple contributions to the literature on public acceptance of novel enabling technology (Ganesh Pillai and Bezbaruah, 2017; Taufik and Dagevos, 2021), as well as practical implications for conceiving information strategies aimed at supporting acceptance of technological innovations (Joubert et al., 2020).

The study's results are consistent with previous literature on the role of cognitive predispositions and affect heuristics in public perceptions about novel technology. The results of the study indeed support a "cognitive miser" perspective on individuals' opinion formation processes with regard to science and technology: in fact, the study's results evince that, while environmental awareness appears to be a significant predictor of both benefits and risks perceptions of nanotechnology, the level of information is only significant when perceived risks are considered. On the one hand, this result suggests that people who are more familiar with nanotechnology likely have a less negative view on nanotechnology (Cobb and Macoubrie, 2004). On the other hand, this result indicates that the scientific literacy perspective – whose exclusive focus regards the level of information and knowledge – does not suffice to explain individuals' perceptions about novel enabling technologies (Siegrist et al., 2007; Matin et al., 2012).

In this view, the study addresses previous scholars' calls to further research on cognitive determinants of public acceptance of novel technologies (Ho et al., 2019). Specifically, the study contributes advancing the understanding of environmental attitudes, beliefs and ecological worldviews as influential cognitive determinants of perceptions about new enabling technologies (Lee et al., 2022). In particular, while previous studies investigated influence of environmental attitudes on support for enabling technologies in terms of benefit-risk ratio (Vandermoere et al., 2011; Matin et al., 2012), the present study provides a more nuanced assessment of the influence of environmental awareness on perception of benefits and risks of technology, by differentiating constructs for perceived benefits and perceived risks.

This approach adds to the novelty of the study's contribution. In fact, while previous studies, such as Vandermoere et al. (2011) and Matin et al. (2012), found ecological worldviews to be related with opposition to nanotechnology, the present study finds environmental awareness to positively influence both perceptions of benefits and risks of nanotechnology. These results suggest that people endorsing an ecological worldview recognize both benefits and risks of novel technology, partially contradicting previous insights stating that environmental concerns lead to opposition to technological innovations (Lee et al., 2022). Accordingly, the study corroborates previous scholars claiming complementarity between ecological beliefs and belief in technological development and economic growth, as a result of an increasingly sophisticated understanding of the complexity of environmental issues (Lalonde and Jackson, 2002). In this perspective, assuming that environmental concerns lead to opposition to novel enabling technologies appears as a too simplistic assumption. In light of these results, deploying communication initiatives to clarify environmental health risks associated with the diffusion of enabling technologies appears as a major priority to foster acceptance of KETs in society and among environmentally-sensitive consumers (Fleischer and Grunwald, 2008). Similarly, providing more information on the environmental benefits associated with specific applications of KETs appears important (Suárez-Perales et al., 2021).

The study also contributes to the literature on public trust and acceptance of novel technologies (Macoubrie, 2004; Siegrist et al., 2007; Vandermoere et al., 2011). Specifically, by drawing on the concept of green trust (Chen, 2010), the study sheds light on the laymen's perceptions about the credibility, responsibility and commitment of diverse societal actors with regard to the specific domain of environmental protection. In this view, the study conceives trust as a multi-faceted constructs, which may vary across diverse domains, such as science, technology or economics. The study's results suggest that effects of trust on the relation between environmental awareness and perceptions about nanotechnology varies according to societal actors. Accordingly, these results entail several implications for practice, which are discussed in the following paragraph.

As far as concerns the control variables utilised in the study, the results are mostly consistent with previous research. Consistently with Vandermoere et al. (2011), age emerges to be negatively related with perceived benefits of nanotechnology, suggesting that older people tend to be less enthusiastic about nanotechnology. Lastly, gender is not significant in both models, partially contradicting previous studies (e.g. Lee et al., 2005) which suggested that females have higher risk perceptions about novel technologies compared to males.

5.2. Implications for practice

The main implications for fostering public acceptance of KETs concerns the role of public trust in shaping perceptions about novel KETs. Building on previous contributions (Cobb and Macoubrie, 2004; Lee et al., 2005; Kamarulzaman et al., 2020), the study focuses on public trust in societal actors responsible for advancing technological development – i.e. business companies, governmental agencies and universities – and tests the moderation of three trust constructs on the relations between environmental awareness and perceived benefits and perceived risks of nanotechnology. While previous studies rely on generic trust measures, the green trust constructs utilised in the study specifically address perceptions of the commitment, responsibility and credibility of relevant actors in the domain of environmental protection (Ho et al., 2019). Furthermore, by focusing on public trust in a narrow set of societal actors, previous studies do not allow comparing the effects of diverse trust measures on perceptions about nanotechnology and their interaction with environmental attitudes.

The results of the moderation models indeed show different effects of green trust depending on the societal actor in which trust is put. According to study's results, green trust in business companies positively moderates the relation between environmental awareness and perceived benefits of nanotechnology. This result advances the understanding of the influence of trust in business leaders on perceptions of enabling technologies (Cobb and Macoubrie, 2004; Siegrist et al., 2007), indicating that environmental attitudes increase perceptions of benefits of novel technologies especially when supported by trust in the environmental commitment of business companies. Accordingly, undertaking initiatives for increasing public trust in the environmental responsibility of technological companies emerges as a meaningful path to foster acceptance of enabling technologies from environmentally-sensitive consumers. To this aim, supporting adoption of environmental management certifications (e.g. ISO 14001 or EMAS) or product labels (e.g. EU Ecolabel) may contribute enhancing trustworthiness and transparency of business enterprises (Saeed and Riaz, 2021). Furthermore, providing education and information to the public with regard to similar labels is necessary in order to ensure their correct interpretation and avoid risks of reputational backlashes.

Interestingly, green trust in research universities appears to exert the opposite effect. Specifically, green trust in universities negatively moderates the relation between environmental awareness and perceived benefits, and it positively moderates the relation between environmental awareness and perceived risks of nanotechnology. These results suggest that higher trust in the environmental commitment of research institutions increases scepticism towards nanotechnology, by enhancing perceptions of the risks and decreasing perceptions of benefits in environmentally-sensitive individuals. High green trust in universities may be associated to greater exposure to scientific information concerning the risks and benefits of novel technologies, and therefore contribute to a more cautious stance towards nanotechnology in environmentally-sensitive individuals. In this perspective, universities and research centres appear to play a crucial role in spreading awareness about environmental and health risks associated with the application of KETs (Larsson et al., 2019; Liu et al., 2021). Accordingly, public communication on the part of the academic and scientific community appears to be important in contributing to acceptance of enabling technologies.

Lastly, the interaction between green trust in governmental agencies and environmental awareness is not significant, in relation to both perceived benefits and perceived risks. These results are in contrast with the study by Vandermoere et al. (2011), which found public trust in governmental agencies to be a significant antecedent of perceptions about nanotechnology. However, such dissimilar results may be attributed to the diverse trust measures utilised: while Vandermoere et al. (2011) measured generic trust in governmental agencies, the present study measured trust in relation to the environmental commitment, credibility and responsibility of governmental agencies. Therefore, taking into account previous contributions, our results may suggest that the influence of trust in governmental agencies on perceptions about enabling technologies is not contingent upon the role of government in environmental protection. Governmental activity that affect KETs development pertains to very diverse domains, such as funding research, patenting and regulating the commercialization of products and services. Accordingly, further research is needed to clarify how the influence of public trust in government on perceptions about KETs varies based on the diverse domains of governmental activity examined.

5.3. Limitations and future research

The present study, like any scientific contributions, has some limitations, which in turn provide implications for future research. First, the study relies on a survey on Italian consumers. Affect heuristics, such as environmental attitudes and trust, may be determined by factors like national culture or local traditions (Rathore and Mahesh, 2021). Accordingly, the results here presented could be limitedly generalizable in other countries. Therefore, future studies are needed to assess the generalizability of the results in other geographical contexts with the aim to shed light on the role of cultural differences through a cross-country research approach. Second, the study considers a limited set of demographics as control variables in the model (i.e. age and gender): thus, future research may consider additional individual-level controls – such as level of income and work experience – that could affect individuals' perceptions about novel technologies. Third, the study examines perceptions about nanotechnology as a proxy KETs, without addressing perceptions about KETs' applications in specific sectors or products (such as consumer goods). Perceptions about KETs may indeed vary depending on specific applications (van Dijk et al., 2017). Accordingly, future studies are needed to investigate the influence of heuristics, such as environmental awareness and green trust, in perceptions of benefits and risks of specific KETs applications. Lastly, the present study does not account for variations in perceptions about KETs as a result of changing environmental attitudes over time (Macnaghten et al., 2019). However, environmental attitudes and worldviews are likely to evolve in response to societal progress and to the increasing urgency of environmental issues (Lalonde and Jackson, 2002). Accordingly, future studies could rely on longitudinal data to assess how public perceptions about enabling technologies evolve over time in response to changing environmental attitudes and ecological worldviews.

CRediT authorship contribution statement

Niccolò Maria Todaro: Data curation, Methodology, Formal analysis, Conceptualization, Software, Writing - original draft, Writing - review & editing. **Natalia Marzia Gusmerotti:** Methodology, Investigation, Resources, Project administration, Supervision, Validation. **Tiberio Daddi:** Funding acquisition, Project administration, Supervision, Validation. **Marco Frey:** Funding acquisition, Supervision, Validation.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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