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Uses of Behavioural Economics for Environmental Economists

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Abstract

In this literature review, we critically examine methodologies and insights in behavioural economics, focusing on elicitation methods, preference dynamics, and policy implications. We begin by differentiating between stated and revealed preference techniques used to understand environmental preferences. We highlight innovative methods such as virtual reality (VR) and augmented reality (AR) for their ability to create immersive environments for more accurate data collection. We explore the evolution of preferences over time and across generations, noting significant shifts due to aging, socio-economic changes, and major events like economic crises. We debate the stability of preferences, presenting evidence that suggests variability influenced by numerous factors. We discuss behavioural game theory as a crucial tool for understanding strategic decision-making, combining insights from psychology and economics. At the policy level, we address the growing use of artificial intelligence (AI) and the ethical considerations in behavioural economics, contrasting the individual-focused i-frame and system-focused s-frame approaches. We identify the era of misinformation as a major challenge, necessitating strategies to enhance media literacy and information transparency. We conclude by advocating adaptive, ethically sound approaches in behavioural economics to better address the complex issues facing society.

Keywords: Behavioural economics, experimental economics, environmental economics, game theory, AR, VR, misinformation

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1 Introduction

Behavioural methods and theories have been used in experimental microeconomics since the 60s (see the pioneering work of Vernon Smith in the USA and Reinhard Selten in Europe (Smith, 1976, Selten, 1990). The spread of these ideas to other fields in Economics has been uneven, although it can be argued that regarding applications to the real world, behavioural issues are ubiquitous.

In this review we will present the main methods and theories that can be useful in Environmental Economics. We start with the fundamentals, by discussing consumer preferences and ways to elicit those. We then proceed by presenting evidence that these preferences are not always stable and discuss issues arising from this instability. This discussion is useful to interpret behaviour even in simple decision tasks, such as an individual consumer deciding how much water to consume or conserve.

Some situations of interest in behavioural economics go beyond simple decisions and involve interaction between agents. We discuss behavioural game theory as a tool to analyze and interpret behaviour in these games, going beyond classic concepts such as the Nash equilibrium, which are obviously important in normative terms, but have been found to be less potent in the field.

2 Elicitation methods

2.1 Understanding Environmental Preferences: Stated and Revealed Preference Methods

Eliciting accurate preferences for environmental services necessitates effective methodologies. Two primary approaches prevail: Stated Preference (SP) and Revealed Preference (RP) methods. While RP methods, rooted in observed behaviours within proxy markets, are traditionally upheld as the gold standard in economics (Samuelson, 1948), the combination of SP and RP methods proves more suitable for environmental valuation (Adamowicz et al., 1994). This section examines this dichotomy, extolling the virtues of RP while elucidating SP's efficacy in understanding environmental preferences.

RP methods scrutinize consumers' actual choices within proxy market goods or services, whereas SP methods analyze hypothetical consumer choices regarding non-market goods or services (Samuelson, 1948). In eliciting environmental preferences, RP methods typically rely on observed behaviors, such as consumers' decisions regarding the purchase or use of related goods or services (Krupnick et al., 2002).

SP methods offer several advantages in this context. Firstly, they enable the measurement of Willingness to Pay (WTP) for environmental goods that do not currently exist, facilitating the assessment of potential future improvements or novel amenities (Hanemann, 1994). Secondly, SP methods allow for systematic attribute variation within alternative scenarios, enhancing preference parameter estimation (Angrist and Pischke, 2010, Scarpa and Rose, 2008). Finally, SP methods facilitate the estimation of nonuse values, providing a comprehensive understanding of the total economic value associated with environmental resources (Aanesen et al., 2015).

Despite these advantages, SP methods face challenges, notably hypothetical bias, where stated WTP differs from true WTP due to the absence of actual transactions (Carson and Hanemann, 2005). Addressing and mitigating this bias remain paramount in environmental valuation, particularly given the observed disconnect between WTP and willingness to accept compensation (WTA) for environmental goods (Schkade and Payne, 1994).

Strikingly, psychological parameters such as emotional experience and satisfaction correlate with WTP for environmental resources, suggesting avenues for richer valuation models (López-Mosquera and Sánchez, 2011). Thus, integrating SP and RP methods in incentive-compatible designs holds promise for advancing environmental valuation methodologies.

2.2 Settings and Designs

Behavioural economics empirical studies heavily rely on methodologies from experimental eco- nomics (Loewenstein, 1999). The compilation in Table 1 (Koundouri et al., 2023) summarizes key empirical frameworks, spanning from controlled laboratory setups to real-world field scenarios (Harrison and List, 2004). Laboratories, for instance, offer tightly controlled environments where potential confounding factors remain constant across groups under scrutiny. By manipulating only the variable of interest, researchers can attribute behavioural discrepancies among participants to this factor, facilitating causal inferences and bolstering the internal validity of the experimental design (Lonati et al., 2018). Nevertheless, this meticulous control often sacrifices external validity, as the disparities between controlled settings and authentic environments introduce uncertainties (Galizzi and Navarro-Martinez, 2019). Consequently, doubts persist regarding the extent to which laboratory investigations can yield universally applicable quantitative insights (Loewenstein, 1999). Despite this, the ultimate yardstick for empirical findings lies in their real-world relevance, given economics' practical orientation towards guiding decision-making. Hence, field experiments emerge as a remedy, transplanting inquiries from controlled laboratory environments to more ecologically valid settings (see Table 1; Harrison and List, 2004). However, the dichotomy between laboratory and field experiments doesn't inherently entail a trade-off between internal and external validity (Lonati et al., 2018): with meticulous methodological rigor, researchers can strive to uphold both even within field investigations (Harrison and List, 2004).

DCEs are increasingly used to evaluate environmental policy options (Rakotonarivo et al., 2016, Boeri and Longo, 2017, Mao et al., 2020). A DCE elicits participant's preferences over complex goods through presenting them with a sequence of choices that differ on multiple dimensions along attributes of interest (e.g. different policies for renewable energy, described by the respective reduction in greenhouse gas emissions, number of power outages, jobs lost/created, and cost increase (Boeri and Longo, 2017). Given the multifaceted nature of many environmental outcomes, DCE reveal the most important attributes determining people's preferences and their respective trade-offs, even enabling forecasts of demands and behavior. However, a systematic meta-analysis of DCEs found a low consistency between valuations and low reliability of hypothetical valuation when compared to non-hypothetical cases (Rakotonarivo et al., 2016).

2.3 Novel approaches: VR and AR

Many critical global issues, including climate change and conflicts, stem from two psychological barriers: the inability to foresee the long-term consequences of present actions and the challenge of empathizing with the experiences of others (Krpan et al., 2023). Virtual Reality (VR) and Augmented Reality (AR) technologies offer promising solutions to overcome these barriers. For example, VR and AR have been demonstrated to reduce gain-loss asymmetry in land use choice experiments (Bateman et al., 2009), potentially improving decision-making by considering both short-term gains and long-term implications. From a behavioural economics perspective, VR and AR simulations provide environments that closely mimic real-world settings, thereby closing the empathy gap and aligning with theories regarding the stability of preferences previously discussed. The integration of VR and AR technologies presents a promising frontier for environmental economists. By addressing key psychological barriers and enhancing decision-making processes, these innovative tools offer novel avenues to tackle complex environmental challenges and foster sustainable outcomes. Through further exploration and application, VR and AR hold the potential to revolutionize how we understand and address environmental issues in the pursuit of a more resilient and equitable future.

2.4 Key take-away points

- **Revealed Preference (RP) methods analyze actual behavior**: RP methods provide insights into individual preferences by observing real decisions in proxy settings, making them the gold standard for economic valuation.
- **SP methods enable the measurement of non-use values**: By allowing participants to express preferences for goods they may not directly use, SP methods offer a more comprehensive valuation of environmental resources, capturing total economic value.
- **Integrating SP and RP methods improves environmental valuation**: Combining both methods provides a richer, more accurate understanding of environmental preferences, overcoming the limitations of each when used in isolation.
- **Virtual Reality (VR) and Augmented Reality (AR) can help overcome psychological barriers**: VR/AR technologies bridge the empathy gap and long-term consequences perception, enhancing decision-making in environmental contexts by providing immersive experiences that mimic real-world scenarios.

3 Preferences

A substantial part of Economics – especially environmental – relies on understanding people's preferences in order to either aggregate them to arrive at nation-wide policy decisions, or, in case policy-makers want to educate people on the best course of action that differs from people's current actions – to better understand motives behind current behaviours and how to work with those motives to achieve more sustainable behaviours. It is also important to be able to create long-term models that can accommodate possible behaviour shifts in their forecasts. In recent years, the intersection of behavioural economics and environmental economics has garnered significant attention (Shogren and Taylor, 2008, Koundouri et al., 2023). Environmental issues, characterized by their long-term consequences (Kahn et al., 2021), have become a focal point of global concern. Understanding human behaviour and decision-making processes is paramount in addressing these challenges effectively (Pollitt and Shaorshadze, 2013). This section will delve into the pivotal role of behavioural economics in providing insights into people's preferences, the dynamics of decision-making over time, and the implications for environmental economists.

3.1 Preferences Across Generations and Over Time.

Environmental problems, such as climate change, deforestation, and biodiversity loss, pose significant threats to current and future generations. These issues are inherently complex, often involving interconnected systems and exhibiting long-term horizons for both their causes and consequences. Traditional economic models, while useful in many respects, often fail to capture the intricacies of human behaviour and decision-making in the context of environmental problems (Frederiks et al., 2015). Behavioural economics offers a complementary framework that can enhance our understanding of individual and collective responses to environmental challenges (Heinz and Koessler, 2021).

A recent insight from behavioural economics is the recognition that people's preferences are not always stable - or, more precisely, appear to be stable in rank-order rather than level (Schildberg-

Hörisch, 2018). While variation of preferences between individuals is widely known and routinely accommodated when, for example, evaluating policy approaches (Heck- man, 2001), in recent years evidence has come up showing that preferences may change within individuals (Meier and Sprenger, 2015, Schildberg-Hörisch, 2018). Large lifetime shocks, such as living through economic recession can significantly alter individuals' decision-making processes and, potentially, preferences (Malmendier and Nagel, 2011). Even when these events are anticipated, such as retirement, their impact on behaviour can be profound, prompting change in consumption patterns, leisure activities, and pro-social attitudes (Moreau and Stancanelli, 2015, Mutchler et al., 2003, Georganas et al., 2022). Behavioural economics offers valuable insights into how individuals adapt to such life events and the implications for environmental policy and planning.

Environmental decisions often involve significant consequences, spanning both wide geo- graphical areas and extended timeframes. A critical challenge is that humans tend to give disproportionately lower value to outcomes that are temporally distant. This temporal dis-counting occurs not just for financial reasons, such as adjusting for inflation, investment risks, or future opportunities, but also in a behavioural sense—where immediate outcomes are valued more highly than the same outcomes delayed, even by a brief period.

Evidence from various domains suggests that when it comes to environmental outcomes, individuals tend to undervalue improvements in air quality more than they overvalue comparable deteriorations. Similarly, people are more likely to discount small-scale environmental improvements, such as reducing pollution in a lake, more heavily than large-scale improvements like reducing ocean pollution. Another example includes a preference for overfishing in the present rather than prioritizing the long-term sustainability of ecosystems, even when both options are framed in future terms.

This tendency also extends to how individuals perceive environmental issues, such as climate change (Weber, 2010), energy consumption patterns (Werthschulte and Löschel, 2021) and willingness to pay for environmental services (Clot and Stanton, 2014). While the applicability of traditional time-discounting models to environmental decisions remains debated, early findings suggest that people may exhibit similar discounting patterns when comparing environmental and financial outcomes in hypothetical scenarios (Hardisty and Weber, 2009).

3.2 Role of Uncertainty of Environmental Outcomes

Environmental decision making often involves uncertainty, where outcomes are non-deterministic. Such uncertainty can be classified into two categories: risk and ambiguity. In situations of risk, probabilities of outcomes are known, allowing individuals to assess the likelihood of potential consequences. However, ambiguity arises when these probabilities are unknown, making it difficult to assign likelihood to different outcomes (Knight, 1921). This distinction is particularly relevant for environmental issues, where both the outcomes (e.g., floods, droughts, hurricanes) and the costs and benefits of addressing them may be ambiguous (Heal and Millner, 2018).

Evidence from field experiments indicates that individuals, such as farmers dealing with climate change, exhibit heightened risk aversion under conditions of ambiguity (Alpizar et al., 2011). When facing unclear probabilities, decision-makers tend to adopt more conservative strategies, especially when adaptation costs are significant, often prompting coordinated actions to reduce collective costs. This behaviour suggests that ambiguity plays a crucial role in shaping environmental decisions and preferences for collective action.

Human responses to environmental risks are not only influenced by the known or unknown nature of probabilities but also by the domain in which the risk occurs. Research shows that risk preferences may vary depending on the context—whether they pertain to health, financial, or environmental outcomes (Weber et al., 2002). Additionally, how risks are framed or elicited can shape people's responses (Charness et al., 2013). For instance, individuals may react differently to incentives aimed at reducing environmental risks compared to health-related risks, and their preference to eliminate risk entirely may be stronger than their willingness to simply reduce it (Hansson and Lagerkvist, 2012).

When ambiguity enters the equation, decision-making becomes more complex. The lack of clear probabilities can reduce cooperation in collective actions, such as pro-environmental behaviors. Individuals often face a trade-off between personal gains and collective benefits, but ambiguous outcomes and uncertain behaviour among other cooperators can hinder such cooperation (Raihani and Aitken, 2011). To effectively address global environmental challenges, policies must not only manage risk but also account for the ambiguity that can inhibit collective efforts. Understanding both the psychological and behavioural responses to these uncertainties is essential for promoting coordinated, large-scale environmental actions.

3.3 Reactions to major events.

Preferences can shift in response to external events, such as natural disasters (Cassar et al., 2017). These events can either prompt reevaluation of priorities – updating of beliefs (Kamiya and Yanase, 2019) or be visceral, short-term reactions (Loewenstein et al., 2003). Understanding these dynamic responses is crucial for designing effective environmental policies that account for human behaviour and adapt to changing circumstances. This variability is particularly pertinent in the context of environmental decision-making, where individuals must weigh short-term costs against long-term benefits. For instance, is it possible that preferences regarding conservation efforts or sustainable consumption behaviours may shift as individuals age, experience life events, or are exposed to new information?

Recent research highlights how external shocks can shape individual preferences, particularly in the wake of extreme events. Extreme environmental events such as natural disasters, for example, have been shown to trigger shifts in attitudes toward government intervention, resource allocation and environmental policies (Georganas, Koundouri, & Velias, 2025). Such fluctuations in preferences following crises such as wildfires, floods (as well as man-made disasters such as train crashes) resemble Loewensteins' hot-cold visceral states mentioned above. These findings contribute to a broader understanding of how major events shape decision-making, emphasizing the need for policies that account for the transient yet impactful nature of crisis-induced preference shifts. These findings resonate with broader evidence on the role of exogenous shocks in shaping social preferences and collective identity. Reinhardt (2017) highlights the fundamental difference between living through a disaster and merely thinking about one, with real-life exposure eliciting more intense and lasting shifts in perception. Similarly, research on positive shocks, such as national sports victories, suggests that collective experiences can meaningfully reshape national identity and social cohesion (Depetris-Chauvin et al., 2020). Taken together, these studies emphasize the profound impact of external events—whether crises or triumphs—on individual and societal preferences. Understanding these dynamics is essential for designing policies that harness or mitigate the effects of such shocks, ensuring that interventions remain effective in both immediate and long-term contexts.

3.4 Discussion: should we expect preferences to be stable? How do we move forward?

Emotions may affect preferences and decisions (Bechara and Damasio, 2005), occasionally leading to biases of judgement, and systematic errors in predicting emotional outcomes (Nis- bet and Zelenski, 2011). For instance, individuals may fail to maximize the hedonic benefit from simple acts like talking a walk outdoors (Nisbet and Zelenski, 2011). Consequently, active exposure to environmental stimuli may improve experiential learning, thus circumventing such errors in affective forecasting.

Also, aggregating preferences of groups of individuals becomes challenging. Humans differ in terms of many factors, including their pro-environmental attitudes. Considering socio- demographic and psychometric factors, participants that actively take pro-environmental initiative seem to have higher education and income, while being more oriented towards out- door activities (Bodur and Sarigöllü, 2005). However, concerned and unconcerned individuals do not statistically differ in terms of age, gender, and occupation. Cross-cultural studies are in line with this finding, demonstrating limited evidence of heterogeneity in environmental regard driven by factors such as gender (Chan et al., 2019), or personality traits (Milfont et al., 2006). The role of age is less clear, with some studies suggesting no effect (Gray et al., 2019), while more recent accounts show higher pro-environmental behaviour in old compared to young individuals (Wang et al., 2021, Xu et al., 2021). In contrast, socio-economic aspects like rural-urban residence, or political orientation seem to affect environmental concerns (see Gifford and Nilsson, 2014, for a comprehensive review of relevant factors).

3.5 Key take-away points

- **Understanding the complex nature of preferences**: By recognizing the dynamic nature of preferences, the influence of major life events, and the responsiveness to external stimuli, environmental economists can develop more nuanced approaches to policy design and implementation.
- **Challenges in eliciting preferences**: A major challenge lies in eliciting accurate preferences from individuals, especially when traditional methods may fail to capture the complexities of decision-making in environmental contexts. Behavioural approaches offer innovative techniques for eliciting preferences, such as choice experiments, field studies, and experimental economics, which can provide richer insights into decision-making processes.
- **Robust methodologies can enrich models**: Behavioural economics offers valuable tools for forecasting future behaviour and assessing the potential impact of environmental policies, helping develop more realistic models that account for the complexities of human behaviour and decision-making under uncertainty.

4 Behavioural game theory

Many situations in environmental issues can be described as games, starting from the classic tragedy of the commons (Hardin, 1968). Classic game theory is traditionally used to analyze games, including refinements for increasingly complex games. However, it seems that these concepts are often elusive for regular people, especially those not very familiar with the games they are playing. Recent advances in behavioural game theory help predict behaviour better than standard concepts, like the Nash equilibrium.

Two concepts in particular have been shown to explain behaviour in static, one shot games, level-k (Nagel, 1995) and Quantal Response Equilibrium (QRE).

The level-k model assumes that players have heterogeneous beliefs but best respond to those. Player types are classified by their beliefs: type 1 is usually assumed to best respond to random play (of a type 0 player, who may or may not exist). Type k above 1, best responds to k-1. Level-k has been shown to describe behaviour very well, especially when players are not very familiar with the game, e.g. when they are playing for the first time. The introduction of new environmental regulation can resemble such situations - in the initial stages the citizens are not very familiar with the new rules and have not had time to develop sophisticated strategies.

The Quantal Response Equilibrium (McKelvey and Palfrey, 1995) relies on a different observation that the best response is sometimes too strong an assumption. The traditional bibliography in decision and game theory assumes that between two choices, people will always choose the one with the highest expected payoff. This has been questioned when real people are involved in decision making, in the lab or in the field.

The seminal work of Goeree and Holt (Goeree and Holt, 2001) shows that in lab experiments, small payoff changes can make a very large difference in play in games, even when game theory predicts no change. Consider for example a matching pennies game, in the following figure.

In the standard version, with symmetric payoffs, play follows the Nash equilibrium, with 48% choosing left and 52% choosing right. Changing the payoff for player one in UL from 80 to 320, changes behaviour drastically for both players. 96% chose top and 84% chose right. Interestingly, the mixed strategy Nash equilibrium prediction changes for player 2 but not for player 1 (who plays to keep 2 indifferent). A game-theoretically unimportant change in payoffs has brought actual behaviour from very close to Nash to something not even resembling Nash.

Table 1. Three One-Shot Matching Pennies Games
(with choice percentages)

		Left (48%)	*Right* (52%)
Symmetric Matching Pennies	*Top* **(48%)**	80, 40	40, 80
	Bottom **(52%)**	40, 80	80, 40
		Left (16%)	*Right* (84%)
Asymmetric Matching Pennies	*Top* **(96%)**	320, 40	40, 80
	Bottom **(4%)**	40, 80	80, 40
		Left (80%)	*Right* (20%)
Reversed Asymmetry	*Top* **(8%)**	44, 40	40, 80
	Bottom **(92%)**	40, 80	80, 40

Figure 1: Three different matching pennies games.

Based on these facts, recent literature proposes concepts that evaluate the payoffs of all choices and predict play probabilities that are related to these payoffs. A particularly successful specification is logit. In games, logit can be used as part of the Quantal Response Equilibrium concept, where players better respond (instead of best respond) given their beliefs, using choice probabilities according to logit. This is an equilibrium concept, since players perfectly anticipate each other's choice probabilities.

4.1 Static replication, dynamic games and learning

QRE fits behaviour in games well, even if the game is repeated in what Vernon Smith calls static replication, and players have time to adapt their strategies. While standard QRE applications do not assume heterogeneous players, play is typically not restricted to point strategies, since QRE predicts a whole distribution (given by the logit formula). An important feature of the logit specification is that strategies far away from a player's best response might be played with a high probability. What is important is the expected payoff of each action, not its distance from the best response as with the usual normal errors' specification. For an illustration in relatively complicated games (see Georganas, 2011) where QRE predicts bids much higher than values in English auctions with resale, although standard theory would predict value-bidding. Indeed, QRE fits behaviour much better, since many (but not all) subjects do overbid substantially.

QRE and level-k were not initially created to analyze dynamic games. A main issue in dynamic games is that once you observe an irrational move by one player, your belief that they are rational should be updated. To avoid such complications, the analysis often focuses on the first stage of the game and assumptions can be made about behaviour in the next stages, to reduce the game to essentially a static version (see Georganas, 2011).

A relatively large literature that focuses directly on learning in games exists, starting with the early papers on reinforcement learning. Although no concept dominates in the literature, Experience Weighted Attraction by (Camerer and Hua Ho, 1999) is a broad model.

with several parameters, which includes many other models as special cases (reinforcement learning and fictitious play). In this concept strategies have attractions that start at some initial point, are then updated based on players' experience of payoffs and then determine choice probabilities according to some rule (logit can be used, similarly to QRE). Importantly, strategies that were not chosen can also be used in this updating, and the concept includes a parameter for the extent that this happens. The model also includes discount rates for previous attractions (this represents how fast people forget what they have experienced). EWA fits data better than simpler models, even accounting for the (large) number of extra parameters. The main critique is that to apply the concept several choices have to be made that can influence the results, starting with the initial attraction of different strategies. In general, for applications, fitting a proper learning model such as EWA is recommended if there is good evidence that strategies change substantially over time.

4.2 Summary

To summarize, a game theoretic solution concept is necessary when thinking about situations of strategic interaction, as is often the case in environmental issues (from resource allocation situations to negotiations between different parties how to distribute the upcoming gains and losses resulting from climate change). Recent literature suggests that QRE and level-k are more useful concepts than Nash equilibrium and refinements thereof, to describe the behaviour of real people in the field, especially in static games, if incentives are relatively low and people's experience in these situations are relatively limited. On the other hand, the behaviour of more experienced players, such as managers, CEOs and state regulators can be modelled closer to perfect rationality. QRE and level-k can still accommodate this heterogeneity, assigning higher rationality to these types. That would mean a higher λ in the case of QRE, or a higher level of play in terms of the level-k model.

Finally, if the game is played over many stages and/or periods, applying a model of learning might be advisable, to analyze how player rationality evolves over time.

5 Policy level

Behavioural economics can help environmental policies become more effective by understanding and leveraging human psychology. By aligning policy design with how people behave—rather than assuming that they will always act rationally—governments can increase the success of environmental programs and drive more sustainable practices. Behavioural economics has influenced the design and implementation of both the UN Agenda 2030 for Sustainable Development and the European Green Deal, though the influence may not always be immediately visible or explicitly stated.

Both initiatives share a common goal of fostering sustainable development and addressing global challenges, and behavioural economics provides insights into how people make decisions, which can be leveraged to design policies that encourage sustainable behaviour more effectively. For example, several of the SDGs involve concepts that align with the principles of behavioural economics. As already indicated in this paper, nudging is a core concept in behavioural economics, and it has influenced efforts to encourage SDG 12: Responsible Consumption and Production, which encourages sustainable consumption patterns, and nudging can be applied to influence consumer behaviour towards greener products. For instance, nudging consumers towards buying products with a lower carbon footprint through default settings or labeling systems can help promote more sustainable consumption. SDG 13: Climate Action entails campaigns that frame climate action as "the norm" (such as using renewable energy or adopting sustainable transportation options), which have proven to be more effective than simply providing financial incentives.

Moreover, Behavioural economics principles such as loss are being used to design policies that drive sustainable behavior. In the context of SDG 13 (Climate Action), the UN has encouraged the use of carbon taxes or emissions trading systems. The introduction of carbon pricing appeals to loss aversion by making carbon emissions "costly," incentivizing businesses and individuals to reduce their carbon footprint. Programs that offer rebates or rewards for adopting environmentally friendly behaviors (e.g., electric vehicle subsidies or incentives for energy-efficient homes) rely on the idea of offering immediate, tangible rewards, which align with the present bias that often influences decision-making.

The way environmental policies or goals are framed can significantly impact public support and behavior. For example, the UN often emphasizes the positive framing of sustainable development—focusing on the opportunities for economic growth, job creation, and health benefits associated with sustainability rather than just the costs or risks of inaction. SDG 3 (Good Health and Well-Being) and SDG 11 (Sustainable Cities and Communities) emphasize the benefits of sustainable practices, such as cleaner air and healthier cities. Framing these benefits in a positive light makes it easier to gain public support for policy changes. Encouraging governments, businesses, and individuals to publicly commit to sustainability goals is a key strategy in behavioural economics. Agenda 2030 leverages commitment devices to ensure countries follow through on their sustainability promises. Countries that commit to the SDGs, such as reducing emissions or investing in green technologies, may do so with public declarations or international agreements that hold them accountable, leveraging both social pressure and the commitment bias (the desire to stay true to commitments).

As far as the European Green Deal (EGD) -aiming at European climate-neutrality by 2050, reduction of pollution, and ecosystems resilience, clean tech leadership of European companies and social cohesion (leave nonone behind)- while it doesn't directly state that it is based on behavioural economics principles, several key aspects of the Green Deal are informed by insights from the field of behavioural economics. The EGD includes policies that utilize nudging to promote sustainable behaviors without coercion. These nudges aim to change people's behaviors toward environmental goals through subtle design changes. Making green energy the default option for consumers, unless they opt out, is a classic behavioural economics technique. The Green Deal has promoted policies like green energy contracts, where renewable energy is often the default, nudging individuals toward more sustainable energy consumption. Moreover, by mandating energy efficiency labels for household appliances, buildings, and vehicles, the EU helps consumers make more informed choices. Clear, easily understandable labels influence consumer decisions by making sustainable options more salient.

The EGD incorporates loss aversion by creating financial incentives for reducing emissions and increasing sustainable behaviour. Carbon Pricing and ETS (Emissions Trading System): The EU's Carbon Trading System (EU ETS) is a direct application of behavioural economics. It creates a financial incentive to reduce emissions by making it costly for businesses to emit carbon dioxide, playing on loss aversion. By charging companies for exceeding their emissions quotas, the EU creates a strong incentive to reduce their carbon footprint. Moreover, the EGD offers subsidies for electric vehicles, energy-efficient buildings, and renewable energy, tapping into the principle that people are more motivated by rewards (or the avoidance of costs) than by abstract future benefits.

The EGD frequently frames sustainability as an essential and collective goal, aligning with social norms to encourage widespread adoption of sustainable practices. By highlighting how "most people" or "most countries" are moving toward greener solutions, the EU encourages others to follow. Governments are often leaders in adopting green practices, and the Green Deal encourages the EU to adopt green procurement standards, ensuring that public spending aligns with sustainability goals. This use of peer pressure within public institutions drives wider societal changes.

In addition, the EGD emphasizes commitments to long-term environmental goals, such as reaching net-zero emissions by 2050. These public commitments use the principles of behavioural economics to increase the likelihood that the targets will be met. EU member states are encouraged to make public commitments to achieving net-zero emissions, which act as a commitment device to ensure that countries remain accountable to their environmental goals. EGD policies also involve citizens through initiatives such as the European Climate Pact, where individuals and organizations are encouraged to make public commitments to sustainable behaviors, leveraging both social pressure and the desire to be consistent with public declarations.

While behavioural economics may not be explicitly mentioned as a core component of the UN Agenda 2030 or the European Green Deal, its principles have undoubtedly influenced the design and implementation of these frameworks. Both initiatives leverage key concepts from behavioural economics, such as nudging, loss aversion, social norms, and commitment devices, to promote sustainable behaviour on an individual, organizational, and governmental level. By applying insights from how people actually make decisions—often irrationally or influenced by cognitive biases—these global and regional initiatives are more likely to succeed in fostering long-term, sustainable change.

5.1 Heterogeneity and growing use of AI

Effective evaluation and reporting of heterogeneity in treatment effects are essential for understanding the conditions under which environmental interventions yield observable effects in environmental economics. For example, consider initially highly successful Opower's behavioural intervention based on social norms that led to substantial reductions in energy consumption in the assigned households. However, when rolled out on a larger scale, the effect was much smaller in size, whilst remaining statistically significant. (Allcott, 2015) demonstrates that while the initial evaluations were robust and indicated significant efficacy, the weaker estimated average effect in later evaluations can be attributed to the demo- graphic differences among communities as the program scaled up. Communities included in the initial evaluations tended to be more progressive and prosperous, with larger homes and greater opportunities for energy efficiency improvements. However, as the program expanded to include a broader range of communities, particularly lower-income or less environmentally inclined ones, the average treatment effect became less impressive. This highlights the heterogeneous effects of the Opower treatment, suggesting that its effectiveness varies across different contexts and populations rather than being inherently unreliable. Moving forward, it is important to obtain rich microdata to carefully measure and report the likely sources of heterogeneity in treatment effects. Additionally, heterogeneity can be leveraged to build better theories, which engage with moderating socio-economic factors when building models and hypothesizing causal mechanisms Article (Bryan et al., 2021).

Bryan et al. (2021) emphasizes the potential exacerbation of group-based inequality due to a homogeneous approach in artificial intelligence (AI) and behavioural intervention research. This approach, characterized by a focus on main effects and disproportionate representation of majority groups, can lead to biased outcomes favoring these groups. In AI, algorithms trained on predominantly white data may produce biased outputs, while behavioural interventions primarily benefiting the majority group can deepen existing inequalities. For environmental economics, this underscores the relevance of considering diverse perspectives and ensuring equitable outcomes, particularly in policy-making processes concerning environmental management and sustainability, where marginalized communities often face disproportionate burdens and lack access to decision-making mechanisms.

5.2 Ethical aspects of behavioural economics: i-frame vs s-frame

A rising concern among behavioural economists concerns the focus of interventions. Chater and Loewenstein (2022) criticize that current interventions predominantly address changes in individual behaviour (referred to as “i-frame”), rather than changes of the system in which they operate, such as regulation or taxation (an “s-frame”). Critically, providing small i- frame interventions may crowd out people's support for more effective, system-level policies (Werfel, 2017, Hagmann et al., 2019). Serving the interests of corporations, this may convey.

the false hope of small steps being enough, deflecting from wider, costlier, and much more effective, policies.

Going forward, scientists need to heed this discrepancy of falsely valuing individual over government action and consider the potential for system-level change in their investigations.

5.3 Environmental economics in the era of misinformation

In the current digital age, the spread of misinformation poses significant challenges for various fields, including environmental economics. Misinformation, defined as false or misleading information spread regardless of intent, can have profound impacts on public perception, policy-making, and economic behaviour. This section explores how misinformation affects environmental economics and the role of behavioural economics in mitigating its adverse effects.

Distorted Public Perception and Behaviour. Misinformation can lead to misconceptions about environmental issues, such as climate change, pollution, and sustainability. For instance, misleading narratives downplaying the severity of climate change can result in public apathy, reducing support for necessary environmental policies and sustainable practices (Lewandowsky et al., 2017). Behavioural economics studies suggest that people are influenced by heuristics and biases, making them susceptible to misinformation that aligns with their preexisting beliefs.

Policy and Regulatory Challenges. Policymakers rely on accurate information to design effective regulations and policies. Misinformation can lead to the adoption of suboptimal policies, either by underestimating the urgency of environmental issues or by promoting ineffective solutions (Farrow et al., 2017). The spread of false information can also polarize public opinion, making it difficult to achieve consensus on critical environmental policies.

Economic Decisions and Market Outcomes. Investors, businesses, and consumers make decisions based on the information available to them. Misinformation can skew market outcomes by influencing these decisions. For example, misinformation about the environmental impact of certain products can affect consumer preferences and demand, potentially hindering the adoption of green technologies and sustainable practices (Delmas and Lessem, 2014).

Behavioural economics provides valuable insights into how people process information and make decisions, offering strategies to counteract the effects of misinformation.

Nudging Towards Accurate Information. Nudges are subtle interventions that guide people towards better decisions without restricting their choices. In the context of misinformation, nudges can include prompts that encourage individuals to be more careful in taking the online information at face value. For example, there is some recent evidence suggesting that social media platforms can implement nudges that alert users to potential misinformation (Clayton et al., 2020). Whilst the effects in such studies are currently modest in size, further calibration of intervention approaches is hoped to decrease the likelihood of users relying on or sharing false information.

Enhancing Information Literacy. Behavioural economics suggests that improving information literacy can help individuals critically evaluate the information they encounter. Educational programs and public awareness campaigns can teach people how to discern credible information from falsehoods (Wineburg and McGrew, 2019). This can involve training on recognizing common tactics used in misinformation, understanding scientific consensus, and using fact-checking tools.

Debiasing Techniques. Misinformation often exploits cognitive biases such as confirmation bias (favoring information that confirms preexisting beliefs) and the availability heuristic (relying on readily available information). Debiasing techniques can help mitigate these biases. For instance, preemptive debunking, or "prebunking," involves exposing individuals to weakened versions of misinformation along with refutations, thereby inoculating them against the misinformation's effects (Cook et al., 2017).

Community-focused programs. Programs that engage local communities in environmental monitoring and information dissemination have proven effective in promoting accurate information and sustainable behaviors. By involving community members in data collection and analysis, these programs enhance trust and reduce susceptibility to misinformation (Bollinger and Gillingham, 2012).

5.4 Key take-away points

- **Accounting for treatment effect heterogeneity improves intervention scalability**: Recognizing and measuring heterogeneity in treatment effects is crucial for scaling environmental interventions, as varying demographic contexts can significantly influence their outcomes.
- **Bias in AI and behavioural interventions can perpetuate inequality**: Failing to account for group-based heterogeneity in AI models and behavioural interventions risk deepening existing socio-economic inequalities, underscoring the need for equitable data and policy design.
- **Ethical Considerations in Behavioural Economics**: Critiques highlight the focus on individual behaviour change (i-frame) over systemic changes (s-frame). Small interventions may inadvertently undermine support for more effective, system-level policies. Acknowledging this discrepancy and considering the potential for broader change is also essential for ethical environmental economics.
- **Mitigating misinformation strengthens environmental policy and market outcomes**:

Addressing misinformation is critical for ensuring an informed public sup- port and decision-making in environmental policy, as unchecked falsehoods can skew economic behaviors and hinder the adoption of sustainable practices.

6 Discussion and main conclusions

Theories from behavioural economics but also concrete methodology can be very useful in environmental economics. We have presented the main literature on preferences, how to elicit them and major issues that lead behaviour away from rational benchmarks. These concepts should be important for simple decision making, but interactive games are also affected when people are less than rational. We have presented the main concepts in behavioural game theory that fit behaviour well in static one-shot games and have also addressed learning in non-static games.

There are many open questions for the future, especially for combinations of theory and experimental results to address major issues. For example, how should governments go about preventing environmental disasters if citizens currently do not treat it as a major priority? Two main deviations from full rationality can exist here: (a) citizens underestimate the probability of environmental calamities, and (b) that they underestimate their own preferences, the intensity of the disutility when disaster strikes. In section 3 we have shown evidence on both points, but it remains unclear what policy makers can then use as citizens “true" preferences.

Specifically, there is a growing literature on how individual preferences react to major macroeconomic events, such as economic depressions (Malmendier and Nagel, 2011) or pandemics (Baker et al., 2020). Such change in preferences suggests that *after* an environmental disaster people will change their preference and care more about the environment, but it could be too late. Our WP exposes such instability of preferences over government spending on prevention of disaster, raising questions about the appropriate course of action for democratic governments. The potential for instability to fuel populism further complicates the landscape, as strategic populists capitalize on the shifting priorities of the public, promoting short-term gains at the expense of long-term economic and societal growth.

One potential solution is to leverage behavioural insights to design more proactive policy interventions. This aligns with global sustainability efforts such as the UN Agenda 2030 and the European Green Deal, which incorporate behavioural economics principles—often implicitly—to improve policy effectiveness.

A key lesson from these initiatives is that policies should not only reflect people's current stated preferences but also anticipate how those preferences might evolve. Governments could, for instance, measure preferences in regions recently affected by environmental disasters and use these insights to inform policymaking in areas where preventative action is still feasible. However, to ensure objectivity, risk probabilities should be based on expert assessments rather than subjective estimates shaped by personal experience. Additionally, debiasing strategies could help align public perceptions with objective risks. While previous research suggests that primes can influence behaviour, their effects are weaker than real-life experiences. However, immersive technologies such as virtual or augmented reality (VR/AR) could potentially elicit stronger visceral responses, making future risks feel more tangible and encouraging preventative action.

Ultimately, the integration of behavioural economics into environmental policy design offers promising pathways for more effective and sustainable interventions. By acknowledging the limitations of rational decision-making models and leveraging behavioural insights, policymakers can craft strategies that align with how individuals actually perceive and respond to environmental risks.

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References

Table 1: Overview of behavioral experimental designs.

Description	Example[a]	IV	EV	Comment	Key studies with environmental focus
Incentive compatible					
Laboratory experiment (LAB)					
laboratory setting, typically with student samples and abstract framing of task	Students decide how much money to donate to an anonymous peer, and how much to keep themselves.	↑	↓	Pro: highest exp. control Con: GOF from lab to field / student to other unclear	Harbaugh et al. (2007)*
Artefactual field experiment (AFE)					
LAB with specific target population	Coffee farmers in Costa Rica decide how much money to donate to an anonymous peer, and how much to keep themselves.	↑	→	Pro: improved GOF to target group Con: hard to recruit representative sample	Menges et al. (2005)
Framed field experiment (FFE)					
AFE extended by field setting (, realistic commodities, outcomes, information, and stakes)	Coffee farmers in Costa Rica make investment decisions for adapting their farms to extreme weather events, with decisions determining monetary payoff.	→	↑	Pro: improved GOF to target group + setting Con: hard to recruit representative sample	Alpizar et al. (2011) Anderson et al. (2017) Galizzi and Navarro-Martinez (2019) Werthschulte and Löschel (2021)
Natural field experiment (NFE)					
FFE within natural task environment; participants kept unaware of experiment	Crop insurance provider analyses numbers and worth of insurance contracts of coffee farmers in Costa Rica, before and after extreme weather events.	↓	↑	Pro: most naturalistic setting reduced Hawthorn effect[b] Con: little control of confounds	Clot and Stanton (2014)
Not incentive compatible					
LAB / AFE / FFE / NFE with hypothetical stakes					
Respective designs with hypothetical outcomes	Coffee farmers in Costa Rica make hypothetical investment decisions for scenarios such as adapting their farms to extreme weather events.	→	↓	Pro: easy and cheap Con: low consistency / reliability of hypothetical valuation	Hardisty and Weber (2009) Deryugina (2013)
Discreet choice experiment (DCE)					
Participants choose hypothetical alternatives differing on multiple dimensions along attributes of interest.	Coffee farmers in Costa Rica choose potential plans for extreme weather adaptation, described by respective cost increase, reduced risk of crop failure, and expected change in crop yield.	→	↓	Pro: capture multidimensionality of environmental outcomes Con: low consistency / reliability of hypothetical valuation	Boeri and Longo (2017) Mao et al. (2020)
Contingent valuation study (CVS)					
Participants answer surveys assessing valuation of non-market commodities like environmental resources	Survey respondents state their maximum WTP for a change in the provision of the goods or service, or their minimum compensation (WTA) if the change is not carried out.	→	→	Pro: grants value estimates for non-monetary resources Con: response bias / protest answers	Khaw et al. (2015)* López-Mosquera and Sánchez (2011)

[a]Examples constructed around the FFE by Alpizar et al. (2011)
[b]Hawthorn effect: participants changing their behavior due to the fact of being observed
Symbols: ↑ = high; → = medium; ↓ = low; * = studies using behavioral design, combined with neuroscience method
Abbreviations: IV = internal validity; EV = external validity; GOF = generalizability of findings; WTP = willingness to pay; WTA = willingness to accept