Shaping sustainability: The role of framing, costs and techno-optimism in driving pro-environmental choices

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Abstract

To combat climate change, more products are entering the market that consist of new sustainable technologies. However, recent figures show that people are less and less willing to pay extra for sustainable technologies compared to the often less sustainable variants. The aim of this study is to investigate to what extent the framing of the outcomes of thosee technologies (electric vehicles and smart thermostats) can influence people's intention to adopt them in their lives, and how this effect is moderated by the perceived financial costs of the behavior and the level of techno-optimism of the customer. It is assumed that positively framed messages emphasizing the environmental benefits of these technologies will lead to higher adoption intentions, particularly for behavior that has a lower financial cost and among participants who are more techno-optimistic. To answer those questions, an online between-subjects experiment was conducted among participants from all over the world ($N =$ 277). The results show that, although high-impact framing leads to higher behavioral intentions than low-impact framing, a neutral approach is most effective. No significant results are found for the moderating effects of perceived financial costs and techno-optimism. Based on these findings, it seems that while framing the environmental benefits of certain behavior can influence behavioral intentions, the impact of perceived financial costs and techno-optimism may be less pronounced than anticipated, indicating a need for further research into how the barrier of financial costs of pro-environmental behavior can be broken, so that more people are willing to do their part.

Keywords: framing, pro-environmental behavior, sustainable technologies, perceived financial costs

1. Introduction

In recent years, there seems to be a negative trend around environmentally conscious consumer behavior. Where in 2020 57% of customers were willing to pay more for a product they considered sustainable, this percentage has decreased to only 41% in 2023 (Mace, 2023). This is a worrying development, especially when we see that, for example, two of the five highest-impact actions for households to fight climate change alone concern expensive technological innovations (Frischmann & Chissell, 2021). In this top five, we do find solar panels, which in the short-term can cost consumers on average €4,099 to €5,199 more than concluding a normal energy contract, while replacing regular lighting with LED lighting often involves a financial increase of €10 per lamp, which can end up in hundreds of euros for an entire household (LiteLab, 2021; Zonneplan, 2024). These financial obstacles, such as upfront costs, seem to make many consumers forget that in the long run this financial investment will pay off and that investing in sustainable technologies now can save them a lot of money in the future (Scheller et al., 2024). It seems there is a growing need for knowledge on how to convince consumers to invest in sustainable technologies, despite the high initial costs, by clearly communicating the long-term benefits and the impact those products have on climate change.

To convince consumers that the use of sustainable technologies, despite the high initial costs compared to their non-environmentally friendly counterparts, is of great importance, well-thought-out communication strategies are a key element (Allen, 2015). An approach often used in science to achieve behavior change goals through communication is framing. Frames highlight particular facets of a problem and make them more salient in our thoughts (Entman, 1993). Several studies have shown that framing in pro-environmental behavior contexts is most effective when the outcome of the simulated action is highlighted within the context of the chosen framing, thereby persuading people to perform the intended behavior (Raimi et al., 2019; Hameed & Khan, 2020; Bonhi et al., 2024). The visibility of the results of certain behaviors builds a sense of efficacy among customers, where they become more motivated to exhibit certain behaviors when they believe their actions have a measurable and meaningful impact (Gordon et al., 2013). Seeing the outcomes strengthens their belief in their ability to realize change, which encourages further engagement. To this date, it has been shown that

customers are more likely to install solar panels, choose eco-friendly ways of transportation and purchase energy-efficient household products when they are informed in advance about the positive consequences (both personal and environmental) that those technologies can have (Schulte et al., 2021; Mohanty et al., 2023; Scheller et al., 2024). Based on those findings, it is critical to conduct additional research into how those outcome-based framing strategies can be used even more effectively to overcome obstacles that may limit the adoption of sustainable technologies.

The literature reveals multiple gaps in understanding the effectiveness of outcome-based frames on the stimulation of pro-environmental behavior. First, many studies fail to gain insights into whether framing the outcomes of sustainable behavior can reduce resistance to this behavior as a result of the high financial costs. It is therefore still relatively unclear whether communicating the positive consequences of using pro-environmental technologies can ensure that people are persuaded to make this financial sacrifice, when they know they are making a positive contribution to the environment. Recent studies have found that the perceived costs of eco-friendly behaviors, like higher prices for green products, can reduce the willingness of consumers to buy those products, even if they are environmentally conscious (Shen & Wang, 2022; Liu & Madni, 2024). Framing can provide a good solution for this by emphasizing the interests and desired outcomes in such a way that the negative effect of costs is suppressed, and people remain willing to engage in the behavior despite the financial commitment. Whether this also proves to be the case in practice has not yet been investigated.

Studies have also not fully explored yet what kind of role customer trust in technology plays in the adoption of these pro-environmental technologies in everyday life. Techno-optimism, as this concept has been called by previous studies, seems to have in general a positive influence, where optimistic individuals are more likely to support and adopt green technologies, seeing them as a key element to solving the biggest climate change problems (Gardezi & Arbuckle. 2018; Cologna et al., 2024). On the other hand, there are also techno-sceptics, who have little confidence in these new environmentally friendly techniques and therefore prefer to ignore them (Trieste & Turchetti, 2024). Whether it is possible to convince these people of the effectiveness of these techniques and if so, how, is still little known. This study also addresses this research gap by investigating the influence of

framing strategies on both techno-optimists and techno-skeptics in promoting their use of sustainable technologies.

To contribute to the understanding of how framing strategies can effectively respond to the use of sustainable technologies, this research focuses on the influence of outcome-oriented framing techniques, in which the outcome of the use of sustainable technologies is communicated to the consumer, on the intention of these same consumers to implement the technologies in their daily lives. In addition, the role of financial obstacles to the application of these techniques is further examined and an attempt is made to provide more clarity on how the level of techno-optimism can be influenced by the use of framing techniques. The ultimate goal of this study is to provide insights into how framing strategies can reduce financial obstacles and stimulate sustainable behavior. Based on this, the following research question was formulated:

RQ: *In what way do framing techniques that emphasize the impact of sustainable technologies influence their usage intention, and how do financial obstacles of the behavior and the level of techno-optimism of the customer moderate this relationship?*

This research question is based on several theories that are important for the different relationships between the variables concerned. Most important and central to this study is the framing theory, which states that the way an issue is presented (the "frame") influences how people interpret and process information, shaping their decisions and behavior (Entman, 1993). The limitation of this theory, however, is that it focuses on how the sender can shape his message and apply framing to it while ignoring the cognitive processes that take place on the receiver's side and can explain why framing is effective. For this reason, this study will also focus on other theories that provide more insight into the reasoning behind the behavior that is stimulated by framing, such as the theory of reasoned action. This theory states that a person's choice to engage in a specific behavior is determined by the results they anticipate from carrying out the behavior (Al-Suqri & Al-Kharusi, 2015). This theory is important for this study, because it gives more detailed insights into how framing can influence a customer's perception of the outcome of the desired sustainable behavior, increasing the likelihood that they will engage in the encouraged behavior.

As mentioned earlier, this study has much to add to the current scientific knowledge. First, this research can add new insights to the existing literature on how external factors can influence the framing process in the context of environmentally friendly behavior. This study expands the understanding of the mechanisms that drive consumer decision-making, in such a way that those customers consider using sustainable products, by linking framing theory to financial obstacles and the influence of techno-optimism. For society, this could mean that companies that want to market their environmentally friendly products gain better insight into how to persuade consumers, despite their high product costs or technologically skeptical target group. On the other hand, it is also very relevant to investigate what happens when the environmental impact of a green technology is mitigated by framing, where the consumer is told that the use of it may have some impact on the climate crisis, but not too much. In this way, highlighting the smaller, achievable impact of sustainable products can help companies make their products more accessible to consumers. This lowers the barrier to behavior change and makes it easier for a wider audience to make sustainable choices, even in the face of higher costs or technological skepticism.

The structure of this paper is as follows: In the next section, a theoretical explanation is made in which the most relevant theories and scientific findings are discussed that are relevant to answering the research question and based on which testable hypotheses will be formulated. To test these hypotheses, an experiment will be conducted in which the effectiveness of various outcome-based framing techniques on the pro-environmental behavioral intentions of consumers will be tested. The associated design, operationalization and results will be discussed. Finally, the findings of this experiment will be linked back to the existing theories and limitations are discussed that could explain a possible difference in results, after which a final judgment will be made about the research question and recommendations for further research will be discussed.

2. Literature Review

2.1 Framing Effects on Pro-Environmental Behavior

Research investigating the efficacy of messages centered on environmental themes has primarily focused on the persuasive impact of different framing methods on customers' intentions to

participate in pro-environmental actions. Framing is most often defined as a process in which the sender emphasizes certain elements within a way of communication, most often to promote a certain action (Entman, 1993). Typically, message intervention strategies focus on the channels, content, and structure of messages that may increase consumer willingness to buy sustainable goods (Goldstein et al., 2008). Most often message framing is divided into positive and negative message framing (Li et al., 2021). This could be for example gain/loss framing or success/fail framing. In pro-environmental communication, this distinction between the positive and negative outcomes of sustainable behavior is also often made, to show people the gain or loss of performing or not performing the sustainable behavior (Chang & Wu, 2015). Prior research has investigated how message framing affects consumer attitudes and behavior, but the findings regarding the impact of various message frames are not entirely consistent.

According to some studies, by evoking favorable associations and beliefs about the outcome of certain behavior, positive message framing had a greater impact on the target audience's sustainable behavior intentions than negative messages. For instance, Yang et al. (2018) found evidence that framing a situation in a positive manner led to higher intentions among customers to purchase green electricity than when the situation was framed in a negative manner. When participants were told that the entire population already uses green energy, they were more likely to follow this behavior than when they were told that only a small part of the population exhibited this behavior. Peters et al. (2017) showed that the acceptance among customers for smart sustainable technologies doubled when the information about the technologies was provided with the use of positive frames, like highlighting the environmental benefits. Regarding the product type, whether it is hedonic (like a stylish electric car) or utilitarian (such as energy-efficient household appliances), for both product categories positive framed messages seem to be more effective than negative ones when it comes to stimulating purchase intention (Lee et al., 2018). Raimi et al. (2019) underline this positive effect of positive framing but also relativize the effect by stating that a more moderate framing approach, in which the technology is seen more as a partial solution to the overall climate problems, will lead to more support for the technologies in question. According to the authors, the danger of an overly positive approach is that a

moral hazard effect occurs, in which customers start to believe that the technology in question will solve all problems, thereby reducing other important pro-environmental behavioral expressions.

The main reason these studies find a positive relationship between positive framing and sustainable behavioral intentions can be explained by how framing has been manipulated across all studies. In all studies, the participant was only shown a text that presented the advantages and disadvantages of the promotion technology. Because no long-winded information video or multi-page text was used, but only a very short, clear overview of the pros and cons, the participants were distracted as little as possible and the manipulation had the desired effect. In addition, all of the study samples consist primarily of young adults, with the majority of all four samples consisting of people under the age of 30. It has been scientifically proven that younger generations increasingly behave more environmentally conscious than older generations, which could explain why these studies find significant results (Bulut et al., 2017). However, this is also a major shortcoming of these studies, because it limits the generalizability to older generations, and therefore weakens the external validity of the results. It may be possible that older people are less receptive to positive framing or have other motivations to exhibit sustainable behavior.

One of the most widely used theories that can explain why positive framing is more effective than negative framing in encouraging pro-environmental behavior, is the theory of reasoned action (Kumar et al., 2022). According to this theory, a customer's choice to engage in a specific behavior depends on the results they anticipate from carrying out the behavior (Al-Suqri & Al-Kharusi, 2015). When it appears that the consequences of the behavior yield or are worth more to the person himself or herself and to his or her environment than the cost of exhibiting the behavior, the person is more likely to exhibit the desired behavior (Steg, 2014). By applying a positive framing approach, the positive perception of the outcomes of using sustainable technologies is strengthened, which according to this theory makes people more likely to exhibit the behavior. A second theory, that is often used to explain the positive effect of framing on behavioral intentions, and that is strongly linked to the theory of reasoned action, is the theory of planned behavior. According to this theory, three elements affect a person's behavioral intention: attitude toward the behavior, subjective norms, and the applicable behavioral control, which in turn dictates the actual behavior (Ajzen, 1985). When someone has a

positive attitude towards the encouraged behavior due to the positive consequences it can have, the social pressure to perform the behavior, and the customer's own belief that he or she is capable of performing the behavior, the customer is most likely to apply the behavioral (Yuriev et al., 2020). Research has shown that positive framing can increase social pressure by telling customers that large numbers of other customers have already adopted sustainable technology before them, while, as mentioned earlier, positive framing works particularly well to highlight the positive outcomes of sustainable behavior (Peters et al., 2017; Yang et al., 2018).

To add to the previous findings, Tong et al. (2021) argues that there is an important intermediate step between the process of being exposed to the positive frame and behavioral change. In their study, they find evidence that positively framing information about green products evokes emotions such as hope among customers. Hope increases the perception of the feasibility of the goals that are communicated, which leads to greater support for sustainable technological innovations, because people believe that positive change is possible and they can play an active role in this. (Deci & Ryan, 2000; Maartensson & Loi, 2021). In addition, Florence et al. (2022) question even the extent to which single framing is the most effective way of stimulating sustainable behavior. Although they argue that positive framing is more effective than negative framing in motivating people to behave in a certain way, the researchers argue that it is even more effective to use two-message frames, which combine different framing strategies. Think of a combination of positive and concrete framing, to communicate both the positive outcomes and a concrete plan of behavior. According to the researchers, this is more effective because the use of multiple framing strategies brings up a broader range of emotional and cognitive responses, resulting in deeper message processing and a higher likelihood of behavioral change. Emphasizing both the positive and concrete elements of the message increases not only motivation, but also the sense of feasibility, resulting in stronger support for the use of sustainable technologies.

However, some studies do show some different results regarding the effectiveness of positive framing. Several studies find evidence that it is not positive framing, but negative framing that leads to more sustainable behavior among customers (Amatulli et al., 2017; Wang et al., 2022; Essl et al., 2024). The overarching argument given in almost all of these studies is that negative framing

reinforces risk perception among customers. By using negative frames, a fear is created among customers, whereby the consequences of climate change are experienced as so serious for the customer himself or herself and their environment, that the customer is motivated to take action himself or herself to prevent the approaching dangers from becoming reality (Essl et al., 2024). Looking at the operationalization of the concept of 'framing', it quickly becomes clear why these studies find a different result than the previously mentioned studies that find an opposite effect. The studies that find a significant effect for negative framing define this concept as 'the negative consequences that occur when a behavior is not performed' (Wang et al., 2022). This is closely related to the gain/loss frame, which highlights either the gains of performing or the losses of not performing a behavior (Hause & Bregulla, 2024). In the studies where a significant effect for positive framing is found, negative frames are seen as the weaker or lesser consequences of performing the behavior (Yang et al., 2018). In these studies, it is always assumed in the framing that the consumer does perform the behavior, where the consequences of this behavior are made greater in positive framing or weakened in negative framing. This difference in operationalization may explain the variation in results, as studies focusing on the risks of inaction in negative framing are more likely to elicit strong emotional responses, such as fear, which drive behavioral change (Chang & Wu, 2015). On the other hand, studies emphasizing the weaker benefits of action in negative framing may fail to create the same level of urgency or motivation. Based on this information, the following hypothesis was formulated

H1: *Positive impact framing will lead to higher behavioral intentions to adopt sustainable technologies compared to negative impact framing.*

2.2 Cost Boundaries

Although many people want to live a more sustainable life, in reality it often seems that this is not possible for everyone. Low-income families, in particular, cannot afford to purchase environmentally friendly products because they are in general more expensive than their "non-sustainable" counterparts (Carette et al., 2012). Current research into the obstacle that financial costs form to implement sustainable technologies in customers' daily lives shows a relatively one-sided

picture. Shakeel et al. (2023) found that among many factors that decide whether someone is willing to adopt solar panels, such as demographic, environmental and regulatory factors, cost-related factors the most important factor are for customers in the adoption of solar panels. One note that the researchers do make is that the impact of financial costs depends on the motivation of customers to purchase energy-saving technologies. When this becomes an investment decision, factors such as the payback period will play a major role, making customers more likely to break through the financial barrier, but only if there is a profitable equation at the bottom line. Lu et al. (2018) underscores the importance of the payback factor with their findings that state that technologies with a long payback period typically carry a higher risk of financial recovery. When the customer lacks knowledge about this payback period, the negative effect of these financial obstacles on the willingness to adopt those technologies is even stronger. Alrashoud & Tokimatsu (2019) build on these insights by finding significant evidence that for people who are unwilling to install solar panels, the high installation cost is the main driver for this decision. To avoid these financial barriers and persuade customers to consider these sustainable technologies, leasing appears to be a good solution for many people (Rai & Sigrin, 2013).

One of the main explanations why those studies do find a significant relationship between financial costs and pro-environmental behavioral intentions may be related to the fact that the studies only look at the implementation of solar panels. Because people experience financial benefits immediately after purchase, such as lower energy costs, people seem to be more willing to pay the high price (Rai & McAndrews, 2012). However, research shows that for a technology like electric cars, the long-term financial benefits are often overshadowed by additional uncertainties, such as the availability of charging stations, charging times and battery life, making people less likely to take the financial risk (Liao et al., 2017; Bobeth & Kastner, 2020; Nazari et al., 2023). The immediate financial benefit experienced with the purchase of solar panels and the associated uncertainties that may outweigh cost considerations for other sustainable technologies, like electric vehicles, shows the importance of further research into financial obstacles to adopting sustainable technologies.

From an economic standpoint, it also seems obvious that people become less motivated to purchase a good or service as its price rises. The law of demand, as it is known in economics, states

that quantity demand will decrease when the price rises (Nicholson, 1972). Price elasticity of demand, which describes how responsive the quantity of a product demanded is to a change in its price, is closely associated with this idea (Tellis, 1988). Research has shown that products with high price elasticity experience a significant drop in demand when prices rise, whereas goods with low price elasticity are less sensitive to price changes. Research shows that the price elasticity of demand for pro-environmental technologies is relatively high, suggesting that consumers are more likely to reduce their purchase willingness of these products if the price increases (Diederich & Goeschl, 2017). Because many sustainable technologies are seen by people as discretionary purchases, i.e., a purchase that is not seen as necessary, a price increase will make many people more likely to postpone the purchase of this type of product because it is not perceived as absolutely necessary (Nazarenko & Saleh, 2024).

Although almost all studies seem to agree on the negative effect of increased costs that sustainable technologies can have on behavioral intentions, an opposite explanation can be found. In their study, Griskevicius et al. (2010) find evidence that when the information about a green product is framed as a contribution to environmental impact, higher costs can lead to higher intentions. The main reason behind this result is that for many people costs are directly related to how impactful the product is. This means that for some customers higher prices will create the idea that those products have a greater impact on the environment than cheaper products. However, their results can be explained by the combination of a sample existing of only students and the fact that only purchase intention (and not purchase behavior) was measured. Research has shown that, although young consumers may express a strong intention to purchase eco-friendly products, situational factors often prevent these intentions from leading to actual purchase behavior (Kim & Lee, 2023). Although they indicate that they want to choose the more expensive products, their actual behavior will likely be different, which explains why this study finds a different result than the other studies.

In order to overcome those financial obstacles and convince customers, applying framing techniques in customer communication seems in theory to be an effective approach (Homar & Cvelbar, 2021). By convincing customers of the positive consequences of using sustainable technologies, these consequences may outweigh the financial costs for some of them, making them

willing to undergo this behavioral change. However, almost no research has been conducted to find empirical evidence for this. Saxena et al. (2021) argue that to encourage people to recycle their waste, it is effective to frame information in such a way that the financial penalty for waste disposal is higher than the fully loaded costs of recycling it. At first glance, comparing the costs of implementing sustainable behavior with the higher costs of not implementing it seems like an effective approach. However, since the study mainly presents itself as a literature review, but does not test whether this approach is actually effective through an experiment, these statements may be questioned. Fesenfeld et al. (2021) reach a broader conclusion, arguing that issue framing alone is insufficient to increase support for ambitious environmental policies with clearly visible financial costs in citizens' daily lives. This is because issue framing focuses on changing attitudes and perceptions of benefits, without reducing or offsetting actual costs, leaving consumers still confronted with the visible financial barriers of sustainable technologies. The researchers believe that issue framing may have a larger impact on attitudes in areas where costs are less visible. However, it is up for discussion to what degree the financial consequences of pro-environmental behavior can and should be hidden from citizens. For that reason, more research must be done to investigate the role of financial costs and the effect that framing can have, to understand to what extent it is possible to influence the perception of these costs without hiding the real financial implications. In conclusion, based on the information provided above, the following hypothesis is formulated.

H2: *The influence of framing on pro-environmental behavioral intentions is moderated by perceived financial costs, such that higher perceived costs reduce the positive effect of framing on intentions to adopt sustainable behaviors.*

2.3 Techno-Optimism

An important factor that determines whether people are willing to use innovative green products, such as an electric car or sustainable household appliances, is their personal belief in the ability of these technologies to actually contribute to realizing a greener planet. In science, this trust in technology is known as techno-optimism. The scientific definition is "a belief in the ability of technology to solve important societal challenges, particularly in the context of climate change and

environmental problems" (Cologna et al., 2024). However, this type of optimism does not have to be limited to physical objects. Immaterial concepts like ideas or institutions, such as educational programs about environmentally conscious behavior, can also be considered technology and for that reason fall into the category of techno-optimism (Danaher, 2022). Besides that, techno-optimism is related to techno-determinism, which views technological innovations as a self-sufficient force, capable of solving problems without human intervention (Dafoe, 2015; Danaher, 2022). In other words, techno-optimism is the belief that technology, whether in the form of products or ideas, has the potential to improve the world, often without the direct involvement of humans. What makes this concept so interesting, however, is that the current literature is very divided about which group (techno-optimists or techno-skeptics) benefits most from the application of framing.

On the one hand, studies argue that using positive framing is mainly effective for people who are already techno-optimistic, so it can stimulate their pro-environmental behavior and strengthen their belief in technology as a solution to climate challenges (MacKinnon et al., 2022; Kaida & Kaida, 2017, 2019). The reason for this finding lies in the confirmation bias theory, which states that people only tend to process and accept information that confirms their own perceptions (Nickerson, 1998). This means that techno-optimists are more likely to accept positively framed information about sustainable technologies because it aligns with their existing belief in the effectiveness of technology in solving environmental issues (Nickerson, 1998; Palmucci & Ferraris, 2023; Korteling et al., 2023). Because positive communication strengthens their opportunism towards these technologies, these types of customers appear to be more likely to behave environmentally friendly in combination with those technologies. For techno-skeptics, this can mean that when they encounter positively framed information about sustainable technologies, they are more likely to reject it. Instead, they will likely start focusing on the potential drawbacks and limitations, which reinforces their skepticism and reduces their likelihood of adopting these technologies (Korteling et al., 2023).

On the other hand, there is also proof that shows an opposite result, arguing that positive framing of the effects of sustainable technologies is most effective for techno-skeptical groups. For example, Kahan et al. (2015) find evidence in their experiment that when customers gain more knowledge about climate change solutions, like in this study geoengineering, their concern about

climate change increases. This relates to the study by White & Simpson (2013), who finds evidence that when people who are initially negative about the potential of technology to solve climate problems are exposed to persuasive interventions about the positive effects of the technologies, they are more likely to be persuaded to use these technologies themselves. As these skeptics come into contact with information that contradicts their existing beliefs, cognitive dissonance occurs (McGrath, 2017). According to this theory, people who experience a sense of discomfort as a result of being exposed to information that conflicts with their beliefs, are more likely to adjust their behaviors to reduce this discomfort. When techno-skeptics are repeatedly exposed to these positive messages and therefore want to regain their cognitive consistency, they seem to be more likely to adjust their behavior than techno-optimists who do not experience this cognitive dissonance.

This contradiction now raises the question of whether the effect of framing is likely to be more effective for techno-optimists or techno-skeptics. Previous research shows that, especially in the field of pro-environmental behavior, behavioral change as a result of cognitive dissonance is difficult to achieve (Bosone et al., 2022). This is because deep-rooted habits prove difficult to reverse, even through cognitive dissonance. Even when people experience cognitive dissonance, deeply ingrained habitual behaviors, like for example riding a gasoline car, are less likely to be influenced by conflicting interventions. Resistance to new technologies can be so ingrained in extreme techno-skeptics' daily lives, that even an intervention that is supposed to induce cognitive dissonance is ineffective. However, other studies show that, in the case of pro-environmental behavior, reading information that is consistent with someone's own perspective has a strengthening effect on their behavior intentions (Meng et al., 2023; Vrselja et al., 2024). These studies show that confirmation of a techno-optimists own idea about the positive impact technologies can have frequently reinforces self-perception as environmentally responsible, which can boost intrinsic motivation to maintain or increase pro-environmental behaviors.

Until now, it has been assumed that when someone becomes more optimistic about the role of technology, regardless of whether this happens through confirmation bias or cognitive dissonance, someone will behave more sustainably. Within science, there is also some evidence that a more optimistic view toward green technologies can negatively affect behavioral intentions. For example,

Gardezi and Arbuckle (2018) find that when farmers exhibit more techno-optimistic characteristics, their support for climate change adaptation will lower and make them more likely to postpone actions related to adaptation. Soland (2013) follows up on this by finding that techno-optimism weakens customers' feelings to act pro-environmental. The main argument the researchers use for this result has to do with moral obligation. Because people have so much confidence in technology and its ability to solve climate problems, their sense of moral obligation to engage in pro-environmental behavior diminishes as they are convinced that technology is already doing enough (Soland, 2013). The explanation for this result lies hidden in the operationalization of these two studies. Where the studies that do find a positive relationship use an experimental design, these two studies use a survey study. First, this may imply that moral obligation is the predictor of techno-optimism. People who are less involved in pro-environmental behavior and experience less of a sense of moral obligation may be more inclined to embrace technology as a solution to environmental problems. In addition, these survey studies cannot rule out that other factors, such as personal values or external influences, also play a role in the formation of the negative relationship. The experiments that find a positive relationship can rule this out with more certainty. Based on the information provided above, the following hypothesis is formulated.

H3: *The influence of framing on pro-environmental behavioral intentions is moderated by techno-optimism, such that higher levels of techno-optimism strengthen the positive effect, while lower levels of techno-optimism weaken this effect.*

Figure 1

Conceptual Framework of framing, financial costs and techno-optimism
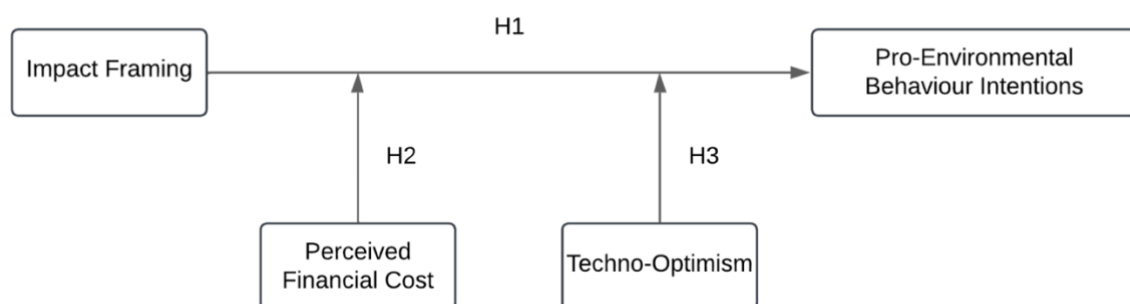
3. Method

3.1 Design

This study's primary objective is to learn more about how pro-environmental behavior intentions are influenced by various framings of technological impacts, perceived financial costs and level of techno-optimism. With an emphasis on encouraging sustainable choices and addressing potential obstacles to adopting green alternatives, this study attempts to comprehend how these factors influence consumer decisions. A 2 (high vs. low impact frame) x 2 (high vs. low perceived financial cost) between-subjects design was chosen in order to find answers to these questions. This kind of experimental design is selected, because there is a small change of confounding effects when examining the effects of perceived costs and impact framing on behavioral intentions (Bhattacherjee, 2012). Although a 2x2x2 between-subjects design could be used to manipulate techno-optimism too, it is decided to measure this variable using a scale. Adding a third independent variable would increase the number of conditions to eight, complicating interaction effect interpretation and requiring a much larger sample size. Given time and resource limitations, this approach risked underpowered results, so a 2x2 design is chosen.

The design of the study is of great importance to ensure the internal validity of the results (Tosch et al., 2019). Internal validity refers to the degree to which researchers can be certain that a relationship established in a study cannot be explained by other variables than the independent variables that are included in the design. To ensure this validity in this experiment, several steps are taken. First of all, randomization is used to randomly assign participants to one of four conditions (High Impact/High Cost, High Impact/Low Cost, Low Impact/High Cost, Low Impact/Low Cost), which ensures the internal validity by minimizing systematic differences between groups (Kaya, 2015). This is further strengthened by the addition of a fifth condition, the control group, which ensures that any observed effects can be attributed solely to the experimental manipulations of impact and cost, rather than to external factors. In addition, the experiment includes a manipulation check, which provides insight into the extent to which the manipulation is perceived as desired by the participants, so that the observed effects can be attributed to the manipulations and not to alternative explanations. Apart from the manipulation, all participants also experience exactly the same

questioning and instruction procedure, to make sure that any variation in the results cannot be attributed to differences in the experimental procedure. Finally, a between-subjects design is chosen instead of a within-subjects design, to ensure internal validity. A within-subjects design was not selected because it increases the risk of carryover effects, such as anchoring or fatigue, which could distort participants' responses and undermine the internal validity of the results.

3.2 Sample

To obtain a sufficient number of participants for the study, a convenience sampling method is performed. To decide what the sample size should be to have sufficient power, a g-power analysis is performed with ANCOVA: fixed effects, main effects and interactions as statistical test and an effect size of 0.25, an error probability of 0.05 and a group number of 5. Based on this analysis it has been determined that the goal is to obtain a minimum of 400 participants for the experiment. By sharing a recruitment text with an accompanying link in various Facebook and Reddit recruitment groups, an attempt is made to gather as many participants as possible. In addition, the experiment is placed on several recruitment sites, where other researchers could fill out the questionnaire in exchange for credits that they could use to recruit participants themselves. Participants can participate in the experiment online from their desired environment by clicking on the link. The only requirement to participate in the experiment is that the participant needs to be 18 years or older. By allowing as many people as possible to participate in the study, an attempt is made to ensure the external validity of the study. External validity means that the results of this study can be generalized to other populations or contexts beyond the specific sample and conditions of this experiment. By imposing minimum requirements for participation, the aim is to include a diverse and broadly representative sample, thereby enhancing the potential for generalizing the findings. However, because many other students are active within those recruitment groups, the sample will likely end up with mainly young people.

After repeating this recruitment method for several weeks and sharing the link within these groups, a total sample of 417 participants is collected. However, participants who failed the attention check ("To test whether you are still paying attention, enter 'Neither agree nor disagree' here") or participated while under 18 are subsequently removed from the data list. This results in the removal of

41 participants, of whom three are under 18 and 38 failed the attention check, leaving a final sample of 376 participants. The average age of the participants is, as expected, relatively low with an average of approximately a bit higher than 25 years old (M = 25.46, SD = 7.55). As for the gender of the sample, it turns out to be slightly evenly distributed, with somewhat more than half, being female, namely 58.5% (n = 220) and 39.4% male (n = 148). The remaining 1.3% identifies themselves as non-binary (n = 5) and only three persons do not prefer to say what gender they are. In terms of their educational level, the largest proportion is found to have a Bachelor's degree at 37.8% (n = 142), followed by 21.8% with some university but no degree (n = 82) and 19.9% with a professional degree (MA, MBA, PhD, etc) (n = 75). The income of the participants is also measured, because this is a potentially interesting covariate for perceived financial cost at a later point in time. This shows that more than half of the participants, however, have or no income with 29.0% (n = 109) and 24.2% having a yearly income of less than €10,000 (n = 91), which is in line with the assumption that mainly many students participate in the experiment. Finally, the level of climate change concern among participants is also measured as a possible covariate. This shows that the people in the sample are mainly moderately concerned about climate problems with a percentage of 34.0% (n = 128), closely followed by 33.0% of the people who are very concerned (n = 124).

3.3 Pre-test

Before the necessary data for the experiment is collected, a pre-test is carried out to test to what extent the developed manipulation material has the desired effect and is evaluated by the participants in the way it is intended. For this purpose, 59 participants are collected via online survey exchange platforms and randomly assigned into one of the four conditions. The stimulus that these participants are presented with is in the form of a text, in which they are given information about the effectiveness of either an electric car or a smart thermostat in the form of a percentage reduction in a typical household's ecological footprint that the use of this technology will result in. In addition, the text also contains a description of the average costs that would be associated with this action. This results in four conditions, namely High Impact/High Cost, High Impact/Low Cost, Low Impact/High Cost and Low Impact/Low Cost conditions. After being exposed to one of the four conditions, the

participant has to answer two questions. The first one has the goal to measure how the participant evaluated the financial investment of the technology in the text and was formulated as "How big do you think the financial investment of this technology is?". This question can be answered on a 5-point Likert scale (1 = very small, 5 = very big). The second question concerns the impact the technology would have on the climate, according to the participant: "How much impact do you think this technology will have on reducing a household's carbon footprint?". This question can also be answered using a 5-point Likert scale (1 = very little impact, 5 = very much impact).

In order to investigate how participants evaluate the developed stimulus material, two dichotomous variables are created in SPSS for cost and impact (0 = Low Cost and Low Impact, 1 = High Cost and High Impact), with which an independent sample t-test is performed. First, the results of this test show that the high cost conditions are perceived as significantly more expensive ($M = 4.08$, $SD = 1.10$) than the low cost conditions ($M = 2.69$, $SD = 1.06$), $t(54) = -4.80$, $p < .001$. Furthermore, for impact, sufficient evidence is also found that the high impact conditions perceive the stimulus as more impactful ($M = 3.38$, $SD = 1.02$) than the low impact conditions ($M = 2.59$, $SD = 1.22$), $t(54) = -2.63$, $p = .011$. Based on these findings, it can be concluded that the manipulation is successful and for that reason, it can be used in the experiment.

3.4 Procedure

As already described, participants are recruited by sharing a recruitment test with an accompanying link to the experiment within different recruitment groups and by posting the experiment on recruitment sites. In the recruitment text, the potential participants are briefly introduced to the topic of the experiment, told how long the study will approximately take and ask for their participation. By clicking on the link, they are guided to the online experiment itself. The experiment starts with the ethical considerations. Participants are again told that the study is about sustainable technologies and how likely the participant considers him- or herself to implement these technologies in their daily life. It is communicated that the participant always has the right to stop participating in the experiment at an earlier stage and that all answers given will be anonymous and can not be traced back to the person concerned. The participant then has to agree and acknowledge

that he or she is 18 years of age or older, read and understand all the given information, agrees that the obtained data will be used in the study and reserve the right to stop the study at any time. Once informed consent is accepted, the experiment itself begins.

First, the participants are asked about their various demographics. These includes age, gender, education level, nationality and current income. Finally, their current level of climate change concern is measured by the question 'To what extent are you concerned about climate change and its effects on the environment?'. After that, the manipulation takes place. Randomization is implemented using the Qualtrics survey tool to assign participants randomly to one of the four experimental conditions or the control condition. The accompanying texts that are used as manipulation can be found in Figure 2 and Figure 3.

Figure 2

Texts used as manipulation for the different experimental conditions

	High Cost	**Low Cost**
High Impact	Imagine you are considering a new technology designed to reduce household carbon emissions. By purchasing an electric car, this technology is expected to decrease a typical household's ecological footprint by approximately 25%, potentially contributing meaningfully to climate solutions. The technology requires an initial investment of €51,000. While this financial commitment is significant, it offers substantial environmental benefits.	Imagine you are considering a new technology designed to reduce household carbon emissions. By purchasing a smart thermostat, this technology is expected to decrease a typical household's ecological footprint by approximately 25%, potentially contributing meaningfully to climate solutions. The technology requires an initial investment of €25. Despite the low cost, it offers substantial environmental benefits.
Low Impact	Imagine you are considering a new technology that has a moderate effect on household carbon emissions. By	Imagine you are considering a new technology that has a moderate effect on household carbon emissions. By using a

purchasing an electric car, this technology is expected to decrease a typical household's ecological footprint by approximately 5%, contributing to individual environmental goals.	smart thermostat, this technology is expected to decrease a typical household's ecological footprint by approximately 5%, contributing to individual environmental goals.
The technology requires an initial investment of €51,000. This financial commitment is substantial, with a modest environmental impact.	The technology requires an initial investment of €25. Although the cost is modest, it provides a modest environmental impact.

Figure 3

Text used for the control condition in the experiment

<div align="center">

Control

Imagine you are considering purchasing a new technology designed to reduce the ecological footprint of households. This technology has the potential to lower the ecological footprint of a typical household.

The cost of the technology varies depending on factors such as the type of technology and how it is applied. The environmental impact of the technology can also vary depending on factors like the level of usage, maintenance, and the specific conditions under which it is implemented.

</div>

Participants are briefly told that they will see a text that provided them with information about a technology that can contribute to solving climate problems. After that, they see the corresponding manipulation text that belonged to the condition they are assigned to and that is already tested in the pre-test. Only after 10 seconds, a click-through button will appear, to ensure that people will not skip the text immediately. Next, four questions appear that have the goal of measuring the concept of 'behavioral change'. The high cost condition is asked about the likelihood of using electric cars, low cost conditions are asked exactly the same questions, but for a smart thermostat and the people in the control condition are also asked the same questions, but the term 'environmentally friendly technologies' is used instead of the product. After this, the manipulation check is carried out using the

same questions from the pre-test. This is followed by the 5 items for the measurement of 'techno-optimism', answered on a 5-point Likert scale (1 = strongly disagree, 5 = strongly agree). An attention check is also performed, in which the participant is asked to click on one of the answer options to check that the participant does not provide answers without reading the question. In the end, the participant is debriefed on the purpose of the study and thanked for participating.

While developing the procedure of the experiment, the ecological validity of the study is taken into account as much as possible. This validity concerns the extent to which the results are transferable to situations as they would occur in reality. This is attempted by having participants fill in the experiment online in their own environment, instead of in a controlled laboratory setting. This approach creates a more natural context, aligning with how people encounter and process information in their daily lives. Besides that, it is tried to make the stimulus material as similar as possible to realistic information that someone might encounter on a daily basis in advertisements or articles. By keeping the information short and concise and using examples that are often advertised, this experiment tries to reflect real-world experiences as closely as possible. However, it is important to note a limitation in this regard. People are frequently exposed to various forms of information about sustainable technologies in a short amount of time, each presented in a unique way. As a result, one type of information may interfere with the processing of another. This dynamic interaction of opposing frames is not captured in the current study because each participant received only one type of information. While this approach ensures internal validity by avoiding confounding effects, it has limited ecological validity because it does not fully replicate the complex decision-making environment that people face in reality.

Finally, by developing the procedure of the experiment, also the reliability of the study was taken into account. A study can be considered reliable when the results are consistent and when the study is carried out again in the same way, it produces the same results (Rudeck et al., 2020). To maximize this reliability, several steps were taken. First of all, the variables that have been measured were operationalized based on existing literature and established scales to ensure that they were reliable and valid. Using scales that have already been validated in previous research helps to ensure consistency and accuracy in the measurement of the variables. Besides that, the experimental

procedure was standardized, meaning that all participants were presented with the same questions in the same order, and the stimuli were as identical as possible across the four conditions. This prevented variations that could influence the outcomes.

3.5 Operationalization

Impact Framing. The way in which the impact that a particular technology can have on tackling climate problems is communicated to the participant has been manipulated in this study. A distinction is made between two types of framing. On the one hand, there is the high-impact frame, in which participants are told that the promoted technology could have a large share in realizing climate goals. In these groups, it was said that performing the action, related to the perceived financial costs, could reduce the ecological footprint of a typical household by up to 25%. On the other hand, there is the low-impact frame, in which it is emphasized that the technology will only have a modest impact on the environment and could only reduce 5% of the footprint of a typical household. This manipulation is included in the experiment in the form of a short text of approximately 50-70 words. Participants are told to imagine themselves in a situation where they were considering a new technology that has a moderate effect on household carbon emissions and are then given some details about the impact of the technology in question. The pre-test already shows that this form of manipulation is evaluated as intended by the participants. In the definitive sample, it is again found, but this time with a less clear difference, that the high-impact conditions consider their text as more impactful ($M = 3.48$ $SD = 1.09$) than the low-impact conditions ($M = 3.07$, $SD = 1.13$), which is consistent with the results previously found from the pre-test, $t(296) = -3.21$, $p = .001$.

Pro-environmental behavior intentions. This variable is evaluated using 4 scale items adapted from Chuang et al. (2018). All items are evaluated using a five-point Likert scale ranging from 1 as "strongly disagree" to 5 as "strongly agree". An example of the statements that participants are presented with is "I intend to use [an electric car/ a smart thermostat/environmentally friendly technologies] in the future". As can be seen, there are 3 different versions of the items. This is because the items have to match the technology that the participant has seen promoted in the text for these items. For example, participants in the high-cost conditions have to be asked questions that included

electric cars. For the control condition, a neutral approach is chosen and therefore asked to what extent they are willing to purchase environmentally friendly technologies. Besides those behavioral changes, all items are exactly the same for all conditions. To ensure that a reliable and valid scale was formed, a factor and reliability analysis is performed.

This Factor Analysis with Principal Axis Factoring and Oblimin rotation shows that a factor can be formed with an Eigenvalue higher than 1. This factor has an Eigenvalue of 3.16 and an explained variance of 79.00%. After this, a reliability analysis is carried out to test whether, even with slightly changed questions, the variables will remain the same if the survey is conducted at different times (Göral & Hannum, 2024). This results in a Cronbach's alpha of 0.91, which implies that these four items together form a very reliable scale. The Cronbach's alpha cannot be improved by removing an item, resulting in all 4 items being included in the final scale ($M = 3.65$, $SD = 0.98$). This average shows that participants generally score moderately high on pro-environmental behavior intentions, indicating a positive trend toward adopting sustainable behaviors.

Perceived Financial Cost. Together with impact framing, the activity and the associated costs that are framed in the text are also manipulated. A distinction is made between high and low costs. The high-cost conditions describe what impact purchasing an electric car can have on the environment. For many people, this is a major investment and by indicating in the texts that participants see that this action entails an average purchase price of €51,000, this is considered one of the most expensive environmentally friendly high-cost actions. For the low-cost conditions, the choice is made to replace a regular thermostat by purchasing a smart thermostat that is able to optimize energy use and reduce heating costs effectively. Although the text for these low-cost conditions exactly matches that of the high-cost conditions, in this text electric cars are replaced by a smart thermostat and a corresponding price of €25 is mentioned. Depending on someone's financial situation, this condition can also be perceived as expensive, although it still requires a considerably smaller financial investment than an electric car. For this manipulation, the pre-test shows, just as for the impact frame, that the stimulus is experienced as intended by the participants. This result is confirmed again within the final sample, in which the participants from the high cost conditions

experience the costs in the text as more expensive ($M = 3.97$, $SD = 0.98$) than the participants in the low cost conditions did ($M = 2.36$, $SD = 1.04$), $t(296) = -13.67$, $p < .001$.

Techno-optimism. Techno-optimism is measured using the general attitudes towards technology scale (Cologna et al., 2024). The original scale consists of 15 items that assess people's trust in technological innovations. However, Cologna and colleagues find 3 different factors in their factor analysis and therefore divides the 15 items into 3 different scales; techno-fix, techno-optimism and techno-pessimism. For this study, only the 5 items that together form the techno-optimism scale are used. In the study by Cologna et al. (2024), the items are measured using a six-point Likert scale. In order to remain consistent with the previous measurements in the current study, it is decided to adjust this for this study to a five-point Likert scale, ranging from 1 as "strongly disagree" to 5 as "strongly agree". An example of one of the five statements is "Technology makes our lives easier and more comfortable". Although the previous study shows that the scale is reliable, a factor and reliability analysis is performed again to be sure of the validity and reliability.

This Factor Analysis with Principal Axis Factoring and Oblimin rotation shows that a factor can be formed with an Eigenvalue higher than 1. This factor has an Eigenvalue of 3.01 and an explained variance of 60.16%. The subsequent reliability analysis shows that the techno-optimism scale is very reliable with a Cronbach's alpha of 0.83. Again, the scale cannot be improved by removing an item, so that the final techno-optimism scale consists of all 5 items ($M = 4.08$, $SD = 0.71$). This average shows that the participants in the sample are very techno-optimistic, which makes them score very high on the 5-point scale on average.

4. Results

4.1 Main effect of impact framing

Before the analyses can be performed, the dataset is checked for possible missing values or outliers. This shows that only 2 values for age have to be made missing, because the numbers 2 and 30+ are filled in. For all other variables, no strange values that have to be made missing or outliers are found. In order to gain more insight in advance into how the different variables are related to each other, a correlation matrix with Pearson correlation is performed. These correlation values can be

found in Table 1. What is surprising, is that techno-optimism is positively correlated with pro-environmental behavioral intentions. This could mean that when someone becomes more optimistic about green technology, this person is more likely to behave environmentally consciously. However, based on this value it cannot be determined whether techno-optimism is actually the predictor of behavioral intentions, or whether it is the other way around. In addition, it appears that pro-environmental behavioral intentions are strongly positively correlated with climate change concerns, which is logical to say the least. Age is also negatively correlated with techno-optimism, suggesting that young people in particular are more optimistic than older people. Finally, it is noticeable that impact does not form a significant correlation with any other variable, which suggests that the impact of this manipulation on the other scale variables is likely to be limited.

Table 1

Descriptive statistics and correlations of research variables

	Variable	*M*	*SD*	1	2	3	4	5	6	7	8	9
1.	Age	25.46	7.55	-								
2.	Climate Change Concern	3.33	1.04	.12*	-							
3.	Pro Environmental Behavior	3.65	0.98	.02	.43**	-						
4.	Techno-Optimism	4.08	0.71	-.15**	-.05	.16**	-					
5.	Impact	-	-	.01	.01	.06	.07	-				
6.	Cost	-	-	.06	-.07	-.15**	.10	.02	-			
7.	Gender	-	-	-.07	.17**	.08	-.03	-.01	.07	-		
8.	Education	-	-	.34**	.07	.13*	.03	.11	.09	-.03	-	
9.	Income	-	-	.34**	.06	.03	.04	.03	.01	.01	.27**	-

**. Correlation is significant at the 0.01 level (2-tailed)

*. Correlation is significant at the 0.05 level (2-tailed)

To test H1, a categorical variable is created for impact first. Three groups are formed within this variable, each containing one of the experimental conditions (1 = High Impact, 2 = Low Impact, 3 = Control group). With this categorical variable for the impact frame and pro-environmental behavior intentions as the dependent variable, a one-way ANOVA is performed to examine the relationship between those three variables. The model includes age, gender, and climate change concern as covariates, to ensure that the observed relationship between the impact frame and behavior intentions will not be biased by these variables. This Univariate analysis shows that the use of impact framing is a significant predictor of pro-environmental behavior intentions, $F(2, 369) = 5.75$, $p = .003$, $\eta^2 = 0.20$. All results can be found in Table 2. This means that the type of impact framing has a small but statistically significant effect on pro-environmental behavioral intentions. About 20% of the variance in pro-environmental behavioral intentions can be explained by the use of impact framing. This suggests that the way the impact of actions is framed can influence participants' intentions to engage in pro-environmental behavior. However, looking at the average of the different groups, something very special stands out. Not one of the experimental conditions, but the control group shows on average significantly the highest pro-environmental behavior intention ($M = 3.93$, $SD = 0.78$), $F(2) = 4.54$, $p = .011$. However, for the two experimental conditions, the high impact conditions are on average more willing to apply the promoted technology in their daily lives ($M = 3.63$, $SD = 1.00$) than the low impact conditions ($M = 3.52$, $SD = 1.02$), although it should also be noted that the difference in averages is so small that the difference in the effect of impact framing appears to be very minimal.

Table 2

Effect of framing on pro-environmental behavior (with covariates)

Measure	Sum of Square	df	Mean Square	F-value	p-value
Age	.245	1	.245	.319	.572
Gender	.015	1	.015	.019	.890
Climate Change Concern	63.740	1	63.740	82.925	.000
Impact	8.835	2	4.417	5.747	.003
Error	279.790	364	.769		
Corrected Total	354.783	369			

Finally, to determine to what extent the three different groups differ from one another, a contrast test is performed. To first check whether the high and low impact conditions differ significantly from each other, this contrast test is performed, in which high impact is given the value 1 in the model, low impact -1 and the control group 0. This test shows that the mean of both conditions is not significantly different from each other, $t(370) = -0.99$, $p = .321$. This means that the high impact and low impact conditions do not significantly influence the dependent variable differently, suggesting that the framing of impact level does not have a distinct effect on participants' behavioral intentions. However, when the two experimental conditions are compared with the control group, a significant result is found, $t(370) = 2.84$, $p = .005$. It can be concluded that participants who are shown a neutral text that does not mention a specific behavior or financial cost, are significantly more likely to behave pro-environmentally than anyone who is in one of the experimental conditions. Despite this, the difference between high- and low-impact frames is not significant, resulting in a rejection of H1.

4.2 Moderation of perceived cost

To test H2, the variable perceived financial cost is included in the model. To make this possible, a dummy variable for cost is developed (0 = Low Cost, 1 = High Cost). This is used to perform a factorial ANOVA, in which the control group is excluded and an interaction term is created for the variables impact and cost within this analysis. However, this factorial ANOVA analysis does

not find significant evidence that the perceived financial costs of the promoted behavior moderate the effect of framing on behavioral intentions, $F(1, 294) = 2.98$, $p = .085$, $\eta^2 = 0.18$. The remaining results can be found in Table 3.

Table 3

Moderation by financial costs on framing-behavior (with covariates)

Measure	Sum of Square	df	Mean Square	F-value	p-value
Age	.005	1	.005	.006	.936
Gender	.432	1	.432	.510	.476
Climate Change Concern	42.866	1	42.866	50.618	.000
Income	.000	1	.000	.000	.983
Impact	.712	1	.712	.841	.360
Cost	5.749	1	5.749	6.789	.010
Impact*Cost	2.525	1	2.525	2.982	.085
Error	243.045	287	.847		
Corrected Total	302.103	294			

This result means that the relationship between impact framing and behavioral intentions does not differ significantly when the communicated cost of the behavior in the text is high or low. Looking at the averages of the four conditions it appears that the high impact/low cost condition shows significantly the highest pro-environmental behavior intentions on average ($M = 3.87$, $SD = 0.92$), $F(3) = 3.54$, $p = .015$. The other high impact condition, where people were presented with the high-cost behavior, scored lower than the low-cost condition ($M = 3.38$, $SD = 1.03$). For the low impact conditions, the difference between high cost ($M = 3.45$, $SD = 1.12$) and low cost ($M = 3.58$, $SD = 0.93$) is found to be relatively small. The results can be found as a graph in Figure 4. Based on the non-significant ANOVA test, it can be concluded that H2 can be rejected.

Figure 4

Average behavioral intentions across experimental conditions
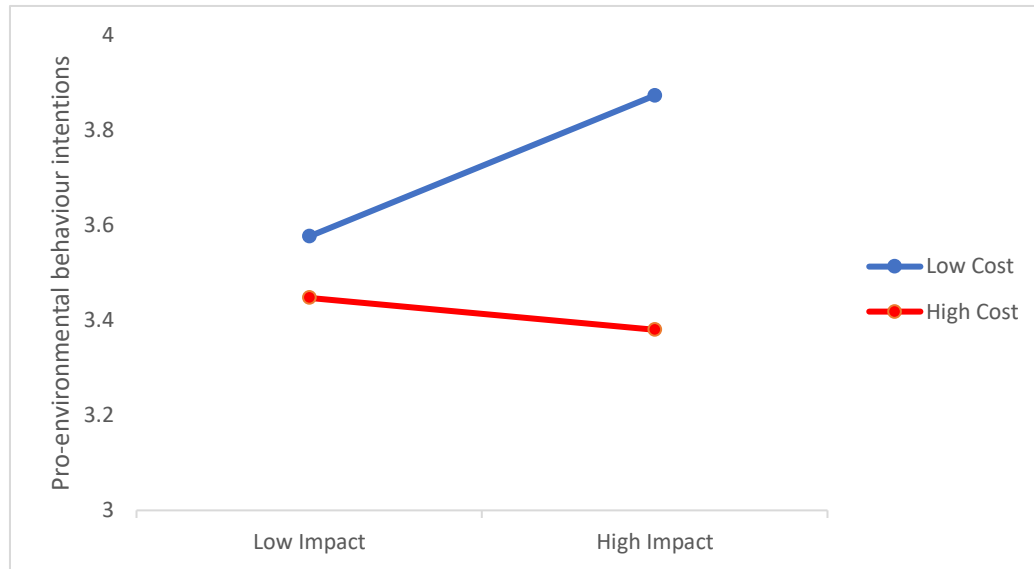
4.3 Moderation of techno-optimism

Finally, a PROCESS bootstrapping procedure by Hayes is performed to test H3. Within this model, techno-optimism is included as a continuous moderator, allowing a Johnson-Neyman test to be performed to test whether the effect of impact framing on behavioral intentions is stronger for people who exhibit more techno-optimistic characteristics than for techno-skeptics. In this model, the covariates age, gender, education and climate change concern are also included. The PROCESS analysis is performed and no significant evidence is found for the proposition that techno-optimism moderates the relationship between framing and behavior, $F(1,287) = 0.01$, $p = .922$, $\eta^2 = 0.00$. All the results of the test can be found in Table 4.

Table 4

Moderation of techno-optimism on framing-behavior (with covariates)

Measure	Coeff	*SE*	95% CI		*p*
			LL	*UL*	
Age	-.007	.008	-.022	.001	.380
Gender	.063	.098	-.129	.254	.522
Climate Change Concern	.386	.052	.283	.488	.000
Education	.117	.039	.040	.194	.003
Impact	-.011	.609	-1.209	1.188	.986
Techno-optimism	.194	.097	.003	.385	.047
Impact*Techno-optimism	.015	.148	-.277	.306	.922

This result shows that the impact of the framing on behavior intentions is similar for both techno-optimistic and techno-skeptical people, suggesting that techno-optimism does not play a significant role in altering the effect of the framing on behavior intentions in the context of this study. When looking at the means of these two variables combined in more detail, a non-significant result is also found in which, regardless of whether someone is techno-optimistic (*M* = 3.78, *SD* = 1.01), or skeptical (*M* = 3.59, *SD* = 0.99), high impact leads to higher pro-environmental behavior intentions than for the low impact conditions in which both techno-optimists (*M* = 3.47, *SD* = 1.09) and techno-skeptics (*M* = 3.40, *SD* = 0.95) are both less willing to adjust their behavior, F(3) = 0.39, *p* = .763. This distribution can be seen in Figure 5. Based on those non-significant findings, also H3 needs to be rejected.

Figure 5

Average behavior intentions by framing condition and level of techno-optimism
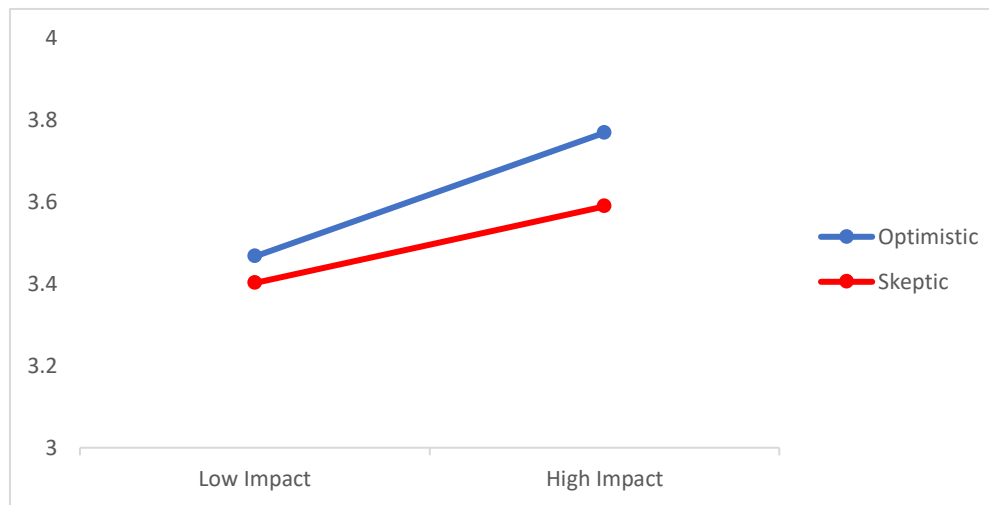
5. Discussion

5.1 Impact of neutral messaging

This study aims to find an answer to the following research question: In what way do framing techniques that emphasize the impact of sustainable technologies influence their usage intention, and what role do economic barriers and techno-optimism play in this process? The first hypothesis states that using positively framed messages about the impact of sustainable technologies will lead to more pro-environmental behavioral intentions than more negatively framed messages. Based on the collected data and performed tests, there is not enough evidence found to state that there is a significant difference between the two experimental impact conditions. The data shows that the high impact conditions, who were shown a text in which they were told that their actions could have a large positive impact on the environment, scores on average higher on the behavior intention scale than the people in the low impact conditions. However, because there is no significant contrast between those two experimental conditions, it cannot be concluded with certainty that high impact will also lead to more positive behavioral intentions in the entire population. What can be concluded, although not predicted in advance, is that people in the control condition, and therefore not shown a specific impact frame, show significantly more behavioral intentions than both experimental conditions.

Although this study does not find significant differences between the high- and low impact conditions, previous literature suggests that positively framed messages often lead to more pro-environmental behavior than negatively framed messages (Peters et al., 2017; Raimi et al., 2019; Yang et al., 2018). As the theory of reasoned action states, people are more likely to engage in pro-environmental behavior when they are convinced that the outcomes of that behavior will be positive for the environment (Al-Suqri & Al-Kharusi, 2015). Similarly, the theory of planned behavior emphasizes that positive framing promotes favorable attitudes toward sustainable behaviors. It also increases the perceived pressure from others to perform the behavior and strengthens the belief in someone's own ability to do so, making people more likely to engage in pro-environmental behavior. (Ajzen, 1985; Yuriev et al., 2020). These previously confirmed theories suggest that highlighting the positive outcomes of certain behavior could enhance pro-environmental behavior intentions, as it may create a sense of hope and awareness among customers (Tong et al., 2021). However, the non-significant result indicates that further research is needed to gain more insights into the distinct effects of both high and low impact frames.

As mentioned, the study does find a significant result that indicates that the control condition shows even stronger behavioral intentions than both experimental conditions, suggesting that the use of framing, in general, may have a weakening effect compared to a neutral message. This is a very striking result since no studies in the context of sustainable behavior have found a similar result to date. However, looking critically at the operationalization of the control group, this striking relationship can be explained by the theory of reactance. This theory states that when people feel that their freedom to make choices is threatened, they tend to resist the stimulated behaviors (Brehm, 1966). Kavvouris et al. (2020) find evidence that this threat to freedom may interfere the relationship between communication about pro-environmental behavior and actual behavioral intentions. Eagly & Chaiken (1993) add to this by stating that the greater the pressure to perform specified behavior, and the associated increased fear that people experience of losing their freedom of choice, the greater the resistance to the encouraged behavior. In the case of this study, the percentage of footprint reduction mentioned can have served as a pressure for people to perform the behavior. The greater the effect the behavior can have on solving climate problems, the greater societal pressure someone can feel to

perform this behavior (Kotyza et al., 2024). However, according to the theory of reactance, this pressure may have had a contradictory effect on the participants. Because no specific behavior is stimulated in the control condition, but environmentally conscious behavior in general, which the participant can fill in by themselves, and no pressure is put on them by communicating any effectiveness percentage, the participant may have felt more freedom of choice within this control condition. This may explain why these people show higher behavioral intentions than the two experimental conditions.

An operational explanation that might explain why this study is unable to find a significant difference between positive and negative framing, unlike other studies, may lie in the manipulation of impact. Although a pre-test is performed which shows that the manipulation used was significantly effective, and although this is also the case in the final sample, the effect is not very strong. Looking at the averages for pro-environmental behavior between the high impact and low impact groups, this appears to be only 0.4 points on a 5-point scale. In comparison, in the pre-test this difference is 0.8 points. This can mean that the way impact was framed is not strong enough to influence behavioral intentions, especially among the high impact groups, leading participants in the experimental conditions to respond not higher than the neutral control condition. To avoid this problem in future research, it seems effective to use a more direct framing approach, which, through clearer word choice and more detailed explanations of the specific environmental benefits, thickens the impact effect and makes it clearer to the participants what the text wants to tell them.

In summary, this finding doesn't confirm that positive framing of sustainable technologies leads to more favorable behavioral intentions than negative framing. However, new insights are generated by stating that a neutral approach seems to surpass the effects of framing approaches. The theory of reactance explains this result, where perceived pressure to perform a behavior could reduce the likelihood of it being performed (Brehm, 1966). This introduces a new vision of how framing influences behavior, suggesting that future research should take into account not only framing but also customers' perceived autonomy. However, this is only an assumption based on existing literature. To test whether this is the case, a possible way to measure this is for example by including perceived autonomy as a mediator. Overall, further exploration is needed to fully understand if the level of

autonomy is indeed an explanation of why the neutral condition is more effective in shaping customers' pro-environmental behavioral intentions, than the positive and negative framed ones, or that this result can be attributed to chance or other operationalization limitations.

5.2 Moderating role of perceived costs

The second hypothesis states that the direct effect of framing on behavioral intentions is moderated by perceived financial costs. It was expected that when the perceived financial costs of the behavior are low, the positive effects of framing on behavioral intentions would be stronger, while at higher perceived costs this effect might be weakened because financial obstacles play a bigger role in decision-making. Although previous studies have found significant evidence for similar moderating effects, this experiment is not able to find significant evidence, resulting in the rejection of H2. The ANOVA test comparing the means of the four conditions shows that the low-cost conditions, regardless of the impact frame used, has more pro-environmental behavioral intentions than the high cost conditions. In more detail, for low-cost behavior a high impact approach is slightly more effective than the low impact approach, while for high cost it makes little difference and the behavioral intentions remain relatively constant between the two groups. However, these results are also not significant, which means that the observed patterns cannot be confidently interpreted as meaningful effects, highlighting the need for caution in drawing conclusions about the moderating role of perceived financial costs in this context.

Despite the non-significant results, comparing these findings to current scientific literature is still relevant since it can highlight potential patterns that might influence future studies and lead to a better understanding of the issue. The finding that people are more willing to behave pro-environmentally when exposed to low-cost activities is confirmed by several studies (Diekmann & Preisendörfer; 2003; Kaiser et al., 2010; Lu et al., 2018). The main argument for this finding is related to the associated payback time. When customers are certain that they will earn back their financial investment in the short term, perceived financial risk decreases. As a result, low-cost behaviors seem more immediately rewarding and less uncertain than high-cost behaviors. Regarding the combination of framing and perceived cost, it is not very surprising that no significant results are found. Fesenfeld

et al. (2021) conclude in their literature review that issue framing alone is insufficient to promote expensive sustainable behavior, because this form of communication only influences the perceptions of the outcomes, but it doesn't reduce the actual cost. In other words, people may be motivated to engage in sustainable behavior, but if they do not have the resources to do so, they are still limited in their options.

Looking at the operationalization of studies that do find significant results, it is noticeable that they do not focus on a single type of behavior. Instead, unlike this study which focuses on either electric cars or a smart thermostat, these studies consider a wide range of behaviors with varying costs, from owning an energy-efficient household appliance to using a bicycle or public transport instead of a car (Kaiser et al., 2010). Focusing on just one or two pro-environmental behaviors may overlook specific factors related to financial costs, such as tax benefits for electric cars or subsidies for energy-efficient appliances, that could increase willingness to buy those products despite their high purchase price, but may not have the same effect on other behaviors. By examining a broader range of behaviors with varying financial costs, these factors are less likely to go unnoticed, increasing the likelihood of detecting significant results. It could be possible that people in the sample are aware that there are positive financial incentives for electric driving, which could ultimately reduce the high purchase price and explain why the high cost conditions in this sample still show high behavioral intentions. To avoid the influence of these behavioral factors, future studies should examine a larger range of behaviors with varied costs and financial incentives, as well as how these costs connect to framing effects.

Although the findings are not significant and H2 is rejected, there are still some theoretical implications to be noticed. Although the possibility is outlined in advance that framing might be able to overshadow perceived costs by convincing people of the good outcomes that even expensive sustainable technologies can have, these non-significant results show that the relationship between framing and costs is more complex than is often assumed. Further research should be able to map out the various underlying processes that customers experience when evaluating these costs and how they can be convinced in this regard, possibly with impact framing or with another framing approach, such as gain and loss framing. Besides this, these results highlight the need for further exploration into the

contextual factors that could play an important role in the evaluation of sustainable behavior among customers. Contextual factors related to perceived costs, such as tax benefits and subsidies, should be taken into account more closely in further research, as they can strongly influence the perception of certain costs.

5.3 The influence of techno-optimism

The last hypothesis states that the effect of framing on pro-environmental behavioral intentions is moderated by techno-optimism. It was expected that the effect would be stronger for people who were techno-optimistic than for people who were techno-skeptical. However, no significant evidence is found for this statement either, which means that H3 also has to be rejected. Looking at the different averages, it can be noticed that techno-optimistic people are more motivated to show pro-environmental behavior than skeptics. High impact framing has a reinforcing effect in this respect compared to low impact framing, but since this ANOVA test was also not significant, no definitive conclusions can be drawn about the role of techno-optimism in moderating the framing effect on pro-environmental behavioral intentions.

The significance level for this interaction effect shows that there is a 92.2% chance that the outcome of this test is due to chance. However, the finding that techno-optimists are generally more likely to behave pro-environmentally, regardless of which frame they are presented with, seems to be in line with what previous research has found (Gardezi & Arbuckle. 2018; Cologna et al., 2024). People who are more optimistic about new sustainable technologies believe that those advancements can effectively solve environmental problems, boosting their confidence in the effectiveness of technologies, which in the end motivates pro-environmental behavior. As for the role that impact framing can play in the perception of these optimists, research suggests that this can be explained by the process of confirmation bias (MacKinnon et al., 2022; Palmucci & Ferraris, 2023; Cologna et al., 2024). Techno-optimistic customers are more likely to accept information that promotes the effective outcomes of sustainable technologies, because this information confirms their existing belief that technology is an effective solution to climate problems (Korteling et al., 2023). This explains why for the optimistic people in the sample, high impact framing seems to be more effective than low impact

framing. For techno-skeptics, however, this theory suggests that they are more likely to reject information that promotes technology because it does not align with their negative beliefs. As a result, they respond less strongly to high impact framing, while low impact framing appears to be more effective, as it better aligns with their existing beliefs about the limited effectiveness of technological solutions (Rau et al., 2022). Nonetheless, the strong non-significance of the results in this study limits the confidence with which these findings can be interpreted in the context of existing theories, as it is unclear whether the findings reflect true effects or simply random variation.

What can then be the reason that in the sample of this study for techno-skeptics, high impact framing still leads to higher behavioral intentions than low impact framing? The main reason may also seem to be the direct reason why this study, unlike previous research, finds no significant evidence for the moderating effect of techno-optimism. When looking critically at the sample, it appears that the sample contains almost no techno-skeptic participants. Looking at the median for techno-optimism in the sample, it turns out to be 4.20. This, combined with an average techno-optimism of 4.08 shows that the people in the sample are already extremely techno-optimistic by nature. The problem with this is that there are very few participants who are actually techno-skeptical, which may explain why there is no significant result found, as the sample lacks sufficient representation of the skeptical group to adequately test this moderating effect. To avoid this problem in future research, it is important to collect a more mixed sample, including people who are much less optimistic about pro-environmental technologies than was found in this sample. Research shows that people of higher age, lower education levels and from regional locations are often less positive about new technologies, so focusing on these target groups seems important to get a more complete view of how framing influenced both optimistic and skeptical customers (Rojas-Mendez, 2017). This statement is also partly confirmed in the current sample, as a significant negative correlation was found between age and techno-optimism.

Since no significant effect is found for the moderating effect of techno-optimism either, there can only be drawn some limited conclusions about the implications of this result. While earlier research suggested that techno-optimists might be more driven to act sustainable by seeing a high impact frame (due to their belief in the power of technology to solve environmental issues), this study

indicates that the influence of techno-optimism might not be as strong as expected. A positive takeaway from this non-significant result is that it suggests that a big part of the population is already somewhat techno-optimistic, which can ensure that new technological innovations regarding sustainability will be accepted more quickly by society. However, this study has not been able to provide an answer to which communication approach is the most effective in persuading techno-skeptical customers to reconsider the use of sustainable technologies. In order to gain more insight into this, it is therefore important to conduct further research that specifically targets techno-skeptical customers, exploring different communication strategies that could challenge their existing beliefs and potentially shift their attitudes toward greater acceptance of sustainable technologies.

Although this study was not able to confirm most of the hypotheses, the results that are found certainly provide more insights into what effect framing can have on customers' pro-environmental behavior. Contrary to previous research, which often states that positive framing leads to more behavioral intentions than negative framing, this study proves that a neutral message, in which the consumer is not guided by persuasive information, can be even more effective than a framed message. This study goes further than many other studies that rely solely on framing theory, where people take on the message without thinking for themselves and adjust their behavior accordingly. This study adds more knowledge to current science by stating that for customers their level of autonomy in making a behavioral choice is most important and that an unbiased communication approach can be most effective, rather than relying on overtly persuasive framing techniques. Regarding the two moderation effects, this study proves that the effect of both perceived costs and techno-optimism is a complex phenomenon. The result suggests that individual differences, such as personal values or previous experiences with certain technologies, as well as social influence, can overshadow the effect of these two moderators. To gain a more detailed insight into which differences have which effect, further research is required.

Although the primary intention of this study was to provide companies with more insight into how they can convince customers in practice to purchase their sustainable products, even when a high financial price is charged for this, this study does offer other practical relevance. Companies can, with their communication strategy, try to focus more on protecting customer autonomy. By being more

transparent about the pros and cons of their products or services in terms of sustainability and avoiding 'positive' or 'negative' framing, companies allow customers to maintain their sense of autonomy. When the product aligns with their personal values, customers are more likely to choose it themselves. In addition, this approach can increase customer trust in the company. When customers feel less manipulated, this can lead to greater brand loyalty towards the sustainable company, which can lead to both greater customer retention and financial success in the long run.

5.4 Other limitations and future research

In the course of this discussion, several limitations of this study have already been addressed. However, there are still some unmentioned shortcomings that can be pointed out that may have affected the generalizability of the results. With an average age of less than 26 years, it is noticeable that the sample consists of relatively many younger people. However, previous research has shown that young people in particular are more concerned about the climate than older people, who are much less concerned (Bulut et al., 2017). This is in line with the average climate change concern in the sample, where 78% of participants are moderately concerned or more about climate change. This is a problem, because it could explain why all conditions, regardless of the stimulus they were presented with, scored so high on the pro-environmental behavior intention scale. Because these young people are already very environmentally aware, it is possible that the impact frames had only a limited effect on them or only reinforced their pre-existing perceptions. This form of sampling bias ensures that the external validity of the study is limited, because the results can only be traced back to younger groups. By collecting a more diverse sample in terms of age in follow-up research, this external validity can be better protected.

In addition, this study only measures the behavioral intention of the participants. However, previous research has shown that the intentions that people show in advance do not in reality correspond to their actual consumer behavior (Kim & Lee, 2023). This means that, although the high impact frame leads to more pro-environmental behavioral intentions among participants, it does not necessarily ensure that these intentions will be realized in actual consumer behavior. In order to gain insights to what extent this will actually lead to sustainable behavior, it is recommended that a field

study will be conducted as further research, in which actual consumer behavior is measured, possibly in real-world settings such as purchases or product usage, to observe if the behavioral intentions translate into concrete actions.

Besides the many suggestions for future research that have already been given, some advice is also mentioned for further research that can provide new relevant insights. For example, now that this study provides more insight into which forms of communication and framing lead to the most behavioral intention, more insights can be generated into how this can be applied in practice. For example, by investigating for which communication channel outcome framing is most effective or which visual elements best reinforce the textual elements examined in this study, companies can gain a clearer understanding of how they can best approach and influence their target group. In addition, this study hypothesizes that people in the high impact conditions may feel potential social pressure to perform the incentivized behavior, which compromises their freedom of choice and may explain why the neutral condition was more effective in this study. By including social factors such as peer influence and societal norms in future research, it can be determined to what extent external pressures impact the effectiveness of different framing techniques and whether they influence the perceived autonomy of individuals when making pro-environmental choices.

In conclusion, this study wants to provide valuable insights into how companies can frame and communicate the effectiveness of their sustainable products in solving climate change to their customer. Although all hypotheses cannot be confirmed due to non-significant results, making it difficult to determine which approach may be the most persuasive, are those findings able to underline the importance of nuanced communication strategies that respect customers' sense of autonomy, instead of forcing them to perform a certain behavior. However, to gain a better understanding of how to counter the annual decline in people's willingness to pay more for a product that is considered sustainable, more research is needed. Because when people are no longer willing to adopt sustainable behavior in their daily lives that requires a higher financial investment in the short term, but that will pay off both financially and environmentally in the longer term, an effective solution to the ever-growing climate concerns seems very far away.

Reference List

Ajzen, I. (1985). From intentions to actions: A theory of planned behavior. In *Springer eBooks* (pp. 11–39). https://doi.org/10.1007/978-3-642-69746-3_2

Allen, M. (2015). Understanding pro-environmental behavior: Models and messages. In *CSR, sustainability, ethics & governance* (pp. 105–137). https://doi.org/10.1007/978-3-319-18005-2_4

Alrashoud, K., & Tokimatsu, K. (2019). Factors influencing social perception of residential solar photovoltaic systems in Saudi Arabia. *Sustainability*, *11*(19), 52-59. https://doi.org/10.3390/su11195259

Al-Suqri, M. N., & Al-Kharusi, R. M. (2015). Ajzen and Fishbein's theory of reasoned action (TRA) (1980). In *Advances in knowledge acquisition, transfer, and management book series/Advances in knowledge acquisition, transfer and management book series* (pp. 188–204). https://doi.org/10.4018/978-1-4666-8156-9.ch012

Bhattacherjee, A. (2012). Experimental design. In *Social science research: Principles, methods, and practices* (2nd edition, pp. 83–93). CreateSpace. https://repository.out.ac.tz/504/1/Social_Science_Research-_Principles_Methods_and_Practices.pdf

Bobeth, S., & Kastner, I. (2020). Buying an electric car: A rational choice or a norm-directed behavior? *Transportation research part F: Traffic psychology and behaviour*, *73*, 236–258. https://doi.org/10.1016/j.trf.2020.06.009

Bonhi, T. C., Karim, R. A., Sharmin, S., Jahan, N., & Chowdhury, F. (2024). Fostering pro-environmental behavior of university students through goal framing theory: the mediating role of environmental knowledge. *Global knowledge memory and communication*. https://doi.org/10.1108/gkmc-12-2023-0516

Bosone, L., Chevrier, M., & Zenasni, F. (2022). Consistent or inconsistent? The effects of inducing cognitive dissonance vs. cognitive consonance on the intention to engage in pro-environmental behaviors. *Frontiers in psychology*, *13*, 1-9. https://doi.org/10.3389/fpsyg.2022.902703

Brehm, J. W. (1966). A theory of psychological reactance. *The american journal of psychology*, *81*(1), 133. https://doi.org/10.2307/1420824

Bulut, Z. A., Çımrin, F. K., & Doğan, O. (2017). Gender, generation and sustainable consumption: Exploring the behaviour of consumers from Izmir, Turkey. *International journal of consumer studies*, *41*(6), 597–604. https://doi.org/10.1111/ijcs.12371

Chang, M., & Wu, C. (2015). The effect of message framing on pro-environmental behavior intentions. *British food journal*, *117*(1), 339–357. https://doi.org/10.1108/bfj-09-2013-0247

Chuang, L., Chen, P., & Chen, Y. (2018). The determinant factors of travelers' choices for pro-environment behavioral intention-integration theory of planned behavior, Unified Theory of Acceptance, and Use of Technology 2 and Sustainability Values. *Sustainability*, *10*(6), 1-26. https://doi.org/10.3390/su10061869

Cologna, V., Berthold, A., Kreissel, A. L., & Siegrist, M. (2024). Attitudes towards technology and their relationship with pro-environmental behaviour: Development and validation of the GATT scale. *Journal of environmental psychology*, *95*, 1-12. https://doi.org/10.1016/j.jenvp.2024.102258

Danaher, J. (2022). Techno-optimism: an analysis, an evaluation and a modest defence. *Philosophy & Technology*, *35*(2), 1-29. https://doi.org/10.1007/s13347-022-00550-2

Deci, E. L., & Ryan, R. M. (2000). The "what" and "why" of goal pursuits: Human needs and the self-determination of behavior. *Psychological inquiry*, *11*(4), 227–268. https://doi.org/10.1207/s15327965pli1104_01

Diederich, J., & Goeschl, T. (2017). To mitigate or not to mitigate: The price elasticity of pro-environmental behavior. *Journal of environmental economics and management*, *84*, 209–222. https://doi.org/10.1016/j.jeem.2017.03.004

Diekmann, A., & Preisendörfer, P. (2003). Green and greenback. *Rationality and society*, *15*(4), 441–472. https://doi.org/10.1177/1043463103154002

Entman, R. M. (1993). Framing: toward clarification of a fractured paradigm. *Journal of communication*, *43*(4), 51–58. https://doi.org/10.1111/j.1460-2466.1993.tb01304.x

Fairbrother, M. (2016). Geoengineering, moral hazard, and trust in climate science: evidence from a survey experiment in Britain. *Climatic change*, *139*(3–4), 477–489. https://doi.org/10.1007/s10584-016-1818-7

Fesenfeld, L. P., Sun, Y., Wicki, M., & Bernauer, T. (2021). The role and limits of strategic framing for promoting sustainable consumption and policy. *Global environmental change*, *68*, 102266. https://doi.org/10.1016/j.gloenvcha.2021.102266

Florence, E. S., Fleischman, D., Mulcahy, R., & Wynder, M. (2022). Message framing effects on sustainable consumer behaviour: a systematic review and future research directions for social marketing. *Journal of social marketing*, *12*(4), 623–652. https://doi.org/10.1108/jsocm-09-2021-0221

Frischmann, C., & Chissell, C. (2021). *The powerful role of household actions in solving climate change*. Project drawdown. https://drawdown.org/insights/the-powerful-role-of-household-actions-in-solving-climate-change

Gardezi, M., & Arbuckle, J. G. (2018). Techno-optimism and farmers' attitudes toward climate change adaptation. *Environment and behavior*, *52*(1), 82–105. https://doi.org/10.1177/0013916518793482

Goldstein, N. J., Cialdini, R. B., & Griskevicius, V. (2008). A room with a viewpoint: Using social norms to motivate environmental conversation in hotels. *Journal of consumer research*, *35*(3), 472–482. https://doi.org/10.1086/586910

Göral, E., & Hannum, C. M. (2024). The effect of moral framing on attitudes towards offshore wind farms in Turkey. *Journal of behavioral and experimental economics*, *110*, 102189. https://doi.org/10.1016/j.socec.2024.102189

Gordon, E., Baldwin-Philippi, J., & Balestra, M. (2013). Why we engage: How theories of human behavior contribute to our understanding of civic engagement in a digital era. *SSRN electronic journal*. https://doi.org/10.2139/ssrn.2343762

Griskevicius, V., Tybur, J. M., & Van Den Bergh, B. (2010). Going green to be seen: Status, reputation, and conspicuous conservation. *Journal of personality and social psychology*, *98*(3), 392–404. https://doi.org/10.1037/a0017346

Hameed, I., & Khan, K. (2020). An extension of the goal-framing theory to predict consumer's sustainable behavior for home appliances. *Energy efficiency*, *13*(7), 1441–1455. https://doi.org/10.1007/s12053-020-09890-4

Homar, A. R., & Cvelbar, L. K. (2021). The effects of framing on environmental decisions: A systematic literature review. *Ecological economics*, *183*, 106950. https://doi.org/10.1016/j.ecolecon.2021.106950

Kaida, K., & Kaida, N. (2017). Wake up for the environment: An association between sleepiness and pro-environmental behavior. *Personality and individual differences*, *104*, 12–17. https://doi.org/10.1016/j.paid.2016.07.014

Kaida, N., & Kaida, K. (2019). Positive associations of optimism–pessimism orientation with pro-environmental behavior and subjective well-being: a longitudinal study on quality of life and everyday behavior. *Quality of life research*, *28*(12), 3323–3332. https://doi.org/10.1007/s11136-019-02273-y

Kaiser, F. G., Byrka, K., & Hartig, T. (2010). Reviving campbell's paradigm for attitude research. *Personality and social psychology review*, *14*(4), 351–367. https://doi.org/10.1177/1088868310366452

Kavvouris, C., Chrysochou, P., & Thøgersen, J. (2019). "Be careful what you say": The role of psychological reactance on the impact of pro-environmental normative appeals. *Journal of business research*, *113*, 257–265. https://doi.org/10.1016/j.jbusres.2019.10.018

Kaya, C. (2015). Internal validity: A must in research designs. *Educational research review*, *10*(2), 111–118. https://doi.org/10.5897/err2014.1835

Kim, N., & Lee, K. (2023). Environmental consciousness, purchase intention, and actual purchase behavior of eco-friendly products: The moderating impact of situational context. *International journal of environmental research and public health*, *20*(7), 5312. https://doi.org/10.3390/ijerph20075312

Kotyza, P., Cabelkova, I., Pierański, B., Malec, K., Borusiak, B., Smutka, L., Nagy, S., Gawel, A., Lluch, D. B. L., Kis, K., Gál, J., Gálová, J., Mravcová, A., Knezevic, B., & Hlaváček, M. (2024). The predictive power of environmental concern, perceived behavioral control and social norms in shaping pro-environmental intentions: a multicountry study. *Frontiers in ecology and evolution*, *12*, 1-14. https://doi.org/10.3389/fevo.2024.1289139

Korteling, J. E., Paradies, G. L., & Meer, J. P. S. (2023). Cognitive bias and how to improve

sustainable decision making. *Frontiers in psychology*, *14*, 1-14.

https://doi.org/10.3389/fpsyg.2023.1129835

Kumar, S., Gupta, K., Kumar, A., Singh, A., & Singh, R. K. (2022). Applying the theory of reasoned

action to examine consumers' attitude and willingness to purchase organic foods.

International journal of consumer studies, *47*(1), 118–135. https://doi.org/10.1111/ijcs.12812

Lee, H., Liu, S., & Cheng, Y. (2018). Positive or negative? The influence of message framing,

regulatory focus, and product type. *International journal of communication*, *12*, 788-805.

https://ijoc.org/index.php/ijoc/article/view/7601/2266

Li, Y., Yang, D., & Liu, Y. (2021). The effect of message framing on consumers' intentions to

purchase recycling-aiding products in China. *Sustainability*, *13*(12), 6966.

https://doi.org/10.3390/su13126966

Liao, F., Molin, E., & Van Wee, B. (2017). Consumer preferences for electric vehicles: a literature

review. *Transport reviews*, *37*(3), 252–275. https://doi.org/10.1080/01441647.2016.1230794

LiteLab. (2021). *A cost and benefit breakdown of LED replacement lamps vs halogen lamps*.

https://litelab.com/blog/led-replacement-lamps-vs-halogen-lamps

Liu, F., & Madni, G. R. (2024). Moderating role of policy incentive and perceived cost in relationship

of environmental awareness and green consumption behavior. *Plos one*, *19*(2), e0296632.

https://doi.org/10.1371/journal.pone.0296632

Lu, Y., Chang, R., Shabunko, V., & Yee, A. T. L. (2018). The implementation of building-integrated

photovoltaics in Singapore: drivers versus barriers. *Energy*, *168*, 400–408.

https://doi.org/10.1016/j.energy.2018.11.099

Maartensson, H., & Loi, N. M. (2021). Exploring the relationships between risk perception,

behavioural willingness, and constructive hope in pro-environmental behaviour.

Environmental education research, *28*(4), 600–613. https://doi.org/10.1080/13504622.2021.2

015295

Mace, M. (2023). *Consumers less willing to pay more for sustainable products during cost-of-living

crisis*. Edie. https://www.edie.net/consumers-less-willing-to-pay-more-for-sustainable-produ

cts-during-cost-of-living-crisis/#:~:text=Sustainability%20remains%20an%20important

%20shopping,compared%20to%2057%25%20in%202020.

MacKinnon, M., Davis, A. C., & Arnocky, S. (2022). Optimistic environmental messaging increases state optimism and in vivo pro-environmental behavior. *Frontiers in psychology*, *13*, 1-7. https://doi.org/10.3389/fpsyg.2022.856063

McGrath, A. (2017). Dealing with dissonance: A review of cognitive dissonance reduction. *Social and personality psychology compass*, 11(12), 118-135. https://doi.org/10.1111/spc3.12362

Meng, Y., Chung, D., & Zhang, A. (2023). The effect of social media environmental information exposure on the intention to participate in pro-environmental behavior. *Plos one*, 18(11), 1-21. https://doi.org/10.1371/journal.pone.0294577

Mohanty, V., Filipowicz, A. L. S., Bravo, N. S., Carter, S., & Shamma, D. A. (2023). Save a tree or 6 kg of CO2? Understanding effective carbon footprint interventions for eco-friendly vehicular choices. 1–24. https://doi.org/10.1145/3544548.3580675

Nazarenko, E., & Saleh, M. I. (2024). A new conceptual model for consumer willingness to pay premium prices for sustainable products. *Social responsibility journal*, *20*(8), 1437–1450. https://doi.org/10.1108/srj-10-2023-0566

Nazari, F., Mohammadian, A., & Stephens, T. (2023). Exploring the role of perceived range anxiety in adoption behavior of plug-in electric vehicles. *arXiv (Cornell University)*. https://doi.org/10.48550/arxiv.2308.10313

Nicholson, W. (1972). *Microeconomic theory: basic principles and extensions*. http://lib.ugent.be/en/catalog/rug01:002032846

Nickerson, R. S. (1998). Confirmation bias: a ubiquitous phenomenon in many guises. *Review of general psychology*, *2*(2), 175–220. https://doi.org/10.1037/1089-2680.2.2.175

Palmucci, D. N., & Ferraris, A. (2023). Climate change inaction: Cognitive bias influencing managers' decision making on environmental sustainability choices. The role of empathy and morality with the need of an integrated and comprehensive perspective. *Frontiers in psychology*, *14*, 1-10. https://doi.org/10.3389/fpsyg.2023.1130059

Peters, D., Axsen, J., & Mallett, A. (2017). The role of environmental framing in socio-political

acceptance of smart grid: The case of British Columbia, Canada. *Renewable and sustainable energy reviews*, *82*, 1939–1951. https://doi.org/10.1016/j.rser.2017.06.020

Rai, V., & McAndrews, K. (2012). Decision-making and behavior change in residential adopters of solar PV. *Proceedings of the world renewable energy forum*, 2875–2880. https://ases.confe rence-services.net/resources/252/2859/pres/SOLAR2012_0785_presentation.pdf

Rai, V., & Sigrin, B. (2013). Diffusion of environmentally-friendly energy technologies: buy versus lease differences in residential PV markets. *Environmental research letters*, *8*(1), 014022. https://doi.org/10.1088/1748-9326/8/1/014022

Raimi, K. T., Maki, A., Dana, D., & Vandenbergh, M. P. (2019). Framing of geoengineering affects support for climate change mitigation. *Environmental communication*, *13*(3), 300–319. https://doi.org/10.1080/17524032.2019.1575258

Rau, H., Nicolai, S., & Stoll-Kleemann, S. (2022). A systematic review to assess the evidence-based effectiveness, content, and success factors of behavior change interventions for enhancing pro-environmental behavior in individuals. *Frontiers in psychology*, *13*, 1-24. https://doi.org/10.3389/fpsyg.2022.901927

Rudeck, J., Vogl, S., Banneke, S., Schönfelder, G., & Lewejohann, L. (2020). Repeatability analysis improves the reliability of behavioral data. *Plos one*, *15*(4), 1-16. https://doi.org/10.1371/journal.pone.0230900

Saxena, R., Kishore, S., & Srivastava, V. (2021). Framing and control for sustainability of industries. *Technological sustainability*, *1*(1), 64–81. https://doi.org/10.1108/techs-08-2021-0003

Scheller, F., Morrissey, K., Neuhoff, K., & Keles, D. (2024). Green or greedy: the relationship between perceived benefits and homeowners' intention to adopt residential low-carbon technologies. *Energy research & social science*, *108*, 103388. https://doi.org/10.1016/j.erss.2023.103388

Schulte, E., Scheller, F., Sloot, D., & Bruckner, T. (2021). A meta-analysis of residential PV adoption: the important role of perceived benefits, intentions and antecedents in solar energy acceptance. *Energy research & social science*, *84*, 102339. https://doi.org/10.1016/j.erss.2021.102339

Shakeel, S. R., Yousaf, H., Irfan, M., & Rajala, A. (2023). Solar PV adoption at household level:

Insights based on a systematic literature review. *Energy strategy reviews*, *50*, 101178. https://doi.org/10.1016/j.esr.2023.101178

Shen, M., & Wang, J. (2022). The impact of pro-environmental awareness components on green consumption behavior: The moderation effect of consumer perceived cost, policy incentives, and face culture. *Frontiers in psychology*, *13*, 1-13. https://doi.org/10.3389/fpsyg.2022.580823

Soland, M. (2013). "Relax. . . Greentech will solve the problem!": Socio-psychological models of environmental responsibility denial due to greentech optimism. https://doi.org/10.5167/uzh-84597

Steg, L., Bolderdijk, J. W., Keizer, K., & Perlaviciute, G. (2014). An integrated framework for encouraging pro-environmental behaviour: The role of values, situational factors and goals. *Journal of environmental psychology*, *38*, 104–115. https://doi.org/10.1016/j.jenvp.2014.01.002

Tellis, G. J. (1988). The Price Elasticity of Selective Demand: A Meta-Analysis of Econometric Models of Sales. *Journal of marketing research*, *25*(4), 331–341. https://doi.org/10.1177/002224378802500401

Tong, Z., Liu, D., Ma, F., & Xu, X. (2021). Good news or bad news? How message framing influences consumers' willingness to buy green products. *Frontiers in psychology*, *11*, 1-10. https://doi.org/10.3389/fpsyg.2020.568586

Tosch, E., Bakshy, E., Berger, E. D., Jensen, D. D., & Moss, J. E. B. (2019). PlanAlyzer: assessing threats to the validity of online experiments. *Proceedings of the ACM on programming languages*, *3*, 1–30. https://doi.org/10.1145/3360608

Trieste, L., & Turchetti, G. (2024). The nature, causes, and effects of skepticism on technology diffusion. *Technological forecasting and social change*, *208*, 123663. https://doi.org/10.1016/j.techfore.2024.123663

Vrselja, I., Pandžić, M., Rihtarić, M. L., & Ojala, M. (2024). Media exposure to climate change information and pro-environmental behavior: the role of climate change risk judgment. *BMC psychology*, 12(1). https://doi.org/10.1186/s40359-024-01771-0

White, K., & Simpson, B. (2012). When do (and don't) normative appeals influence sustainable

consumer behaviors? *Journal of marketing*, 77(2), 78–95. https://doi.org/10.1509/jm.11.0278

Yang, Y., Solgaard, H. S., & Ren, J. (2018). Does positive framing matter? An investigation of how framing affects consumers' willingness to buy green electricity in Denmark. *Energy research & social science*, *46*, 40–47. https://doi.org/10.1016/j.erss.2018.06.006

Yuriev, A., Dahmen, M., Paillé, P., Boiral, O., & Guillaumie, L. (2020). Pro-environmental behaviors through the lens of the theory of planned behavior: A scoping review. *Resources conservation and recycling*, *155*, 104660. https://doi.org/10.1016/j.resconrec.2019.104660

Zonneplan. (2024). Zonnepanelen kosten. https://www.zonneplan.nl/zonnepanelen/kosten

Appendix 1: Experiment

{Information 1}

The experiment will start with a few basic questions about yourself.

Q1_1

What is your age in years?

- _____

Q1_2

What is your gender?

- Man

- Woman

- Non-binary

- I prefer not to tell

Q1_3

What is the highest level of education you have completed?

- Some primary school

- Completed primary

- Some secondary school

- Completed secondary school

- Vocational or similar

- Some university but no degree

- University bachelors degree

- Graduate of professional degree (MA, MS, MBA, PhD, JD, MD, DDS, etc.)

- Prefer not to say

Q1_4

What is your nationality?

- _____

Q1_5

What is your current yearly income (in €)?

- No income

- Less than €10.000

- €10.000 - €19.999

- €20.000 - €29.999

- €30.000 - €39.999

- €40.000 or more

- Prefer not to say

{Information 2}

You will now see a text that provides you with information about a technology that can contribute to solving climate problems. Read the text carefully. After 10 seconds, a button will appear that allows you to continue to the next section.

{High Impact – High Cost Condition}

Imagine you are considering a new technology designed to reduce household carbon emissions. By purchasing an electric car, this technology is expected to decrease a typical household's ecological footprint by approximately 25%, potentially contributing meaningfully to climate solutions.

The technology requires an initial investment of €51,000. While this financial commitment is significant, it offers substantial environmental benefits.

{Low Impact – High Cost Condition}

Imagine you are considering a new technology that has a moderate effect on household carbon emissions. By purchasing an electric car, this technology is expected to decrease a typical household's ecological footprint by approximately 5%, contributing to individual environmental goals.

The technology requires an initial investment of €51,000. This financial commitment is substantial, with a modest environmental impact.

Q2_1 {High Cost Conditions}

Read each statement about your own pro-environmental behavior intentions, and indicate to what extent the statement applies to you

	Strongly disagree	Somewhat disagree	Neither agree or disagree	Somewhat agree	Strongly agree
I intend to use an electric car in the future	**0**	**0**	**0**	**0**	**0**
I plan to buy an electric car over a patrol car when I want it in the future	**0**	**0**	**0**	**0**	**0**
I will recommend others to buy an electric car	**0**	**0**	**0**	**0**	**0**
Buying an electric car would be one of my preferences	**0**	**0**	**0**	**0**	**0**

{High Impact – Low Cost}

Imagine you are considering a new technology designed to reduce household carbon emissions. By purchasing a smart thermostat, this technology is expected to decrease a typical household's ecological footprint by approximately 25%, potentially contributing meaningfully to climate solutions.

The technology requires an initial investment of €25. Despite the low cost, it offers substantial environmental benefits.

{Low Impact – Low Cost}

Imagine you are considering a new technology that has a moderate effect on household carbon emissions. By using a smart thermostat, this technology is expected to decrease a typical household's ecological footprint by approximately 5%, contributing to individual environmental goals.

The technology requires an initial investment of €25. Although the cost is modest, it provides a modest environmental impact.

Q2_1 {Low Cost Conditions}

	Strongly disagree	Somewhat disagree	Neither agree or disagree	Somewhat agree	Strongly agree
I intend to use a smart thermostat in the future	**0**	**0**	**0**	**0**	**0**
I plan to buy a smart thermostat over a regular thermostat when I want it in the future	**0**	**0**	**0**	**0**	**0**
I will recommend others to buy a smart thermostat	**0**	**0**	**0**	**0**	**0**
Buying a smart thermostat would be one of my preferences	**0**	**0**	**0**	**0**	**0**

{Control Condition}

Imagine you are considering purchasing a new technology designed to reduce the ecological footprint of households. This technology has the potential to lower the ecological footprint of a typical household.

The cost of the technology varies depending on factors such as the type of technology and how it is applied. The environmental impact of the technology can also vary depending on factors like the level of usage, maintenance, and the specific conditions under which it is implemented.

Q2_1 {Control Condition}

	Strongly disagree	Somewhat disagree	Neither agree or disagree	Somewhat agree	Strongly agree
I intend to use environmentally friendly technologies in the future	**0**	**0**	**0**	**0**	**0**
I plan to buy environmentally friendly technologies over non-environmentally friendly technologies when I want it in the future	**0**	**0**	**0**	**0**	**0**
I will recommend others to buy environmentally friendly technologies	**0**	**0**	**0**	**0**	**0**
Buying environmentally friendly technologies would be one of my preferences	**0**	**0**	**0**	**0**	**0**

Q2_2 {Manipulation Check Cost}

How big do you think the financial investment of the technology that was described in the text is?

- Very small

- Somewhat small

- Neither big or small

- Somewhat big

- Very big

Q2_3 {Manipulation Check Impact}

How much impact do you think the technology that was described in the text will have on reducing a household's carbon footprint?

- Very little impact

- Somewhat little impact

- Neutral

- Somewhat big impact

- Very big impact

Q3_1 {Techno-optimism}

Read each statement about your own pro-environmental behavior intentions, and indicate to what extent the statement applies to you.

	Strongly disagree	Somewhat disagree	Neither agree or disagree	Somewhat agree	Strongly agree
Technology makes our lives easier and more comfortable	0	0	0	0	0
Technology expands our limits	0	0	0	0	0

Without technological innovation the economy will become less stable	**0**	**0**	**0**	**0**	**0**
Technology means progress	**0**	**0**	**0**	**0**	**0**
The development of technologies is important for the economy	**0**	**0**	**0**	**0**	**0**
To test whether you are still paying attention, enter 'Neither agree nor disagree' here	**0**	**0**	**0**	**0**	**0**