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**Understanding Public Opinion and the Role of Information:
New Insights into Social Acceptance of the Swiss Energy
Transition**

Inaugural dissertation submitted by Sophie Ruprecht
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“How many things, too, are looked upon as quite impossible, until they have been actually effected?” – Gaius Plinius Secundus

Nothing applies more to the completion of my dissertation than the above quote. And I do not think I could have done it, or at least not as comfortably, without the support of an army of people. To all of you, from the bottom of my heart: Thank you.

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Preface

This thesis addresses the environmentally pressing and socio-politically salient question of what public opinion towards different aspects of the energy transition currently looks like, including whether this varies between different population groups and how the provision of information influences such levels of social acceptance. By identifying several factors that contribute to advancing the energy transition as well as showing that information indeed alters acceptance levels thereof, I can contribute to literature in multiple ways: Whereas most research so far has been conducted in the U.S., I focus on Switzerland, which is a special case in many aspects. So, for one, I add to the study of public opinion in a direct-democratic context, which is essentially dependent upon public policy support. Two, by analysing high-quality data and by conducting a series of information experiments, I give insights into how social acceptance of different energy policies and technologies can be improved. And three, by investigating specific population subgroups, I can conclude that social acceptance of energy policies and technologies is not homogeneously distributed, thus making it necessary to target certain groups specifically.

Each of this thesis' four articles examines a specific research question that contributes to its overarching puzzle. Article 1 and 2 seek to understand which project characteristics render a citizen-financed photovoltaics (PV) project socially acceptable. In the first case, I study how different frames or underlying personal factors affect this social acceptance. In the second case, I look into how different forms of knowledge are related to different preferences of such project characteristics. Article 3 investigates how a vote advice application influences vote intention of a real-life ballot proposal (Swiss Energy Act 2017). Lastly, Article 4 examines how an information treatment changes people's willingness to pay higher environmental taxes. In sum, the findings obtained contribute to our understanding of current public opinion regarding the Swiss energy transition as well as how information provision affects social acceptance of various energy policies and technologies.

Articles 3 and 4 have already been peer-reviewed and published in academic journals. Article 3 was published in *Acta Politica* (Impact Factor (IF): 1.2) and Article 4 in *Environmental Research Communications* (IF: 2.9). Article 1 is currently in advanced stages of review in *Energy Research & Social Science* (IF: 6.7). Article 2 is under review in *Utilities Policy* (IF: 4), of which earlier versions have also been presented and discussed at various workshops and conferences.¹

¹ Specifically, I presented the manuscript in the political science research seminar 2023 and the political science PhD-colloquium 2023 (University of Bern, Switzerland), at the EPSA conference 2023 (Glasgow, Scotland) as well as the SPSA conference 2024 (St Gallen, Switzerland).

1 Introduction

If the world continues with its current climate policies and actions, global temperatures are projected to rise by 3.2°C by the end of the century (IPCC, 2023a, p. 68). This substantially exceeds the agreed-upon effort to limit global warming to 1.5°C, a mark declared in the 2015 Paris Agreement (see United Nations, 2015), thus highlighting a significant shortfall in global climate mitigation. Global warming of this scale would lead to irreversible changes, i.e. tipping points: Ice sheet melt will not only cause sea levels to rise but is also likely to lead to the collapse of the Gulf stream system. Biodiversity will be lost, for example in vital ecosystems such as the Amazon rainforest or coral reefs. Regionally, extreme weather events like droughts, heavy rainfall or storms are predicted to increase as well (IPCC, 2023a). With the world heading towards this ominous future, it is imperative to take immediate and sustained action. In order to minimise these adverse effects, a multitude of changes will have to be made, with the overarching goal of limiting greenhouse gas emissions to avoid further global warming. This mainly implies a need to transition all energy systems towards sustainable, renewable and carbon-neutral energy sources (IPCC, 2023b, p. 28ff.). While the 2015 Paris Agreement laid the groundwork for becoming carbon-neutral by 2050 and some efforts have been made, the world is currently not on track to reach the imposed goals, especially in terms of reducing greenhouse gas emissions, and more ambitious policies need to be implemented (see Climate Action Tracker, 2023a; United Nations, 2023).

Apart from the necessity to achieve carbon-neutrality, after the Russian attack on Ukraine, another, yet related, problem appeared: The dependence on foreign and mostly fossil energy sources. Before the start of this war, the European Union (EU), a hitherto major buyer of Russian fuels, saw significant increases in fossil fuel imports (Eurostat, 2024). Due to Western sanctions such as the embargo on fossil fuels, various countries now fear gaps in their energy supply, which reiterates the urgency to rapidly become more energy-independent. At the same time, less than 20% of the energy consumed in the EU originated from renewable sources (Eurostat, 2024; Ritchie et al., 2024), which illustrates both where sustainable improvements in the energy system can be made as well as how the potential energy supply gap can be reduced. The EU is not an anomaly in this regard, as other world regions also exhibit low shares of renewable and decentralised energy consumption (e.g. 11% in the U.S. (U.S. Energy Information Administration, 2023; Ritchie et al., 2024) or 14% worldwide (Ritchie et al., 2024)), thus emphasising the need to make more efforts globally.¹ The summation of all these factors renders it inevitable to introduce more

¹ For comparison, the share of renewable energy production for the mentioned regions amounted to 39% in the EU, 22% in the U.S. and 29% worldwide (on average) (Ritchie et al., 2024).

stringent policies to advance the energy transition and to combat climate change. Accordingly, this dissertation aims to shed light on socially accepted policies and technologies that could contribute to decentralised and climate-friendly energy production.

While achieving the energy transition has been deemed technically feasible (Hug et al., 2023), its implementation remains challenging, as social factors also play a significant role in fulfilling this promise. This is especially true in (direct-)democratic contexts, where public support for policy measures is required (e.g. Dermont et al., 2017; Druckman and Bolsen, 2011; Wüstenhagen et al., 2007). Climate change however remains a highly divisive issue, often with large segments of the population ignoring or discounting the threats of potential consequences (Roser-Renouf et al., 2015). In this sense, climate change is not just an environmental, but also a socio-political problem, as has already been recognised by Anthony Downs (1972), as “social [...] and environmental processes [...] are mutually implicated” (Cox and Depoe, 2015, p. 15). While environmental problems are caused by humans interacting with nature, they are also socially constructed, as these problems need to be recognised, which is more likely when they are acknowledged to bear significant implications (Blumer, 1971; Cox and Depoe, 2015). In other words, problem awareness is only made apparent through the communication of relevant information (Hansen, 2015). To gain sufficient levels of social acceptance to transform the energy system, as one of the core elements of climate change mitigation, getting those still reluctant on board is essential. By communicating information, optimally, awareness and knowledge about the issue at hand are fostered (Gass and Seiter, 2022; Khatibi et al., 2021). Stated differently, “the public needs to have a reasonable understanding of climate change and their role in causing and responding to it” (Whitmarsh, 2015, p. 341). However, there exists a variety of factors affecting the process and outcome of information provision, which accounts for the difficulties in changing attitudes and behaviours (Whitmarsh, 2015). Furthermore, as the following chapters will illustrate in more detail, the effects of being exposed to information are highly heterogeneous. For example, not all population groups are expected to react similarly to the provision of new information (e.g. Bayes et al., 2023; Green et al., 2023). If social acceptance of a matter is desired to be further increased, such subgroup effects are inherently followed by the need to tailor communication or political measures more specifically to certain audiences. Therefore, the second priority of this dissertation is to go beyond identifying technically feasible solutions that advance the energy transition but to find solutions which are also socially accepted.

To bring it all together, the framework displayed in Figure 1.1 summarises this dissertation’s overarching research question: *How socially accepted are various energy technologies and policies by different population groups, and how does information alter these levels of societal support?*

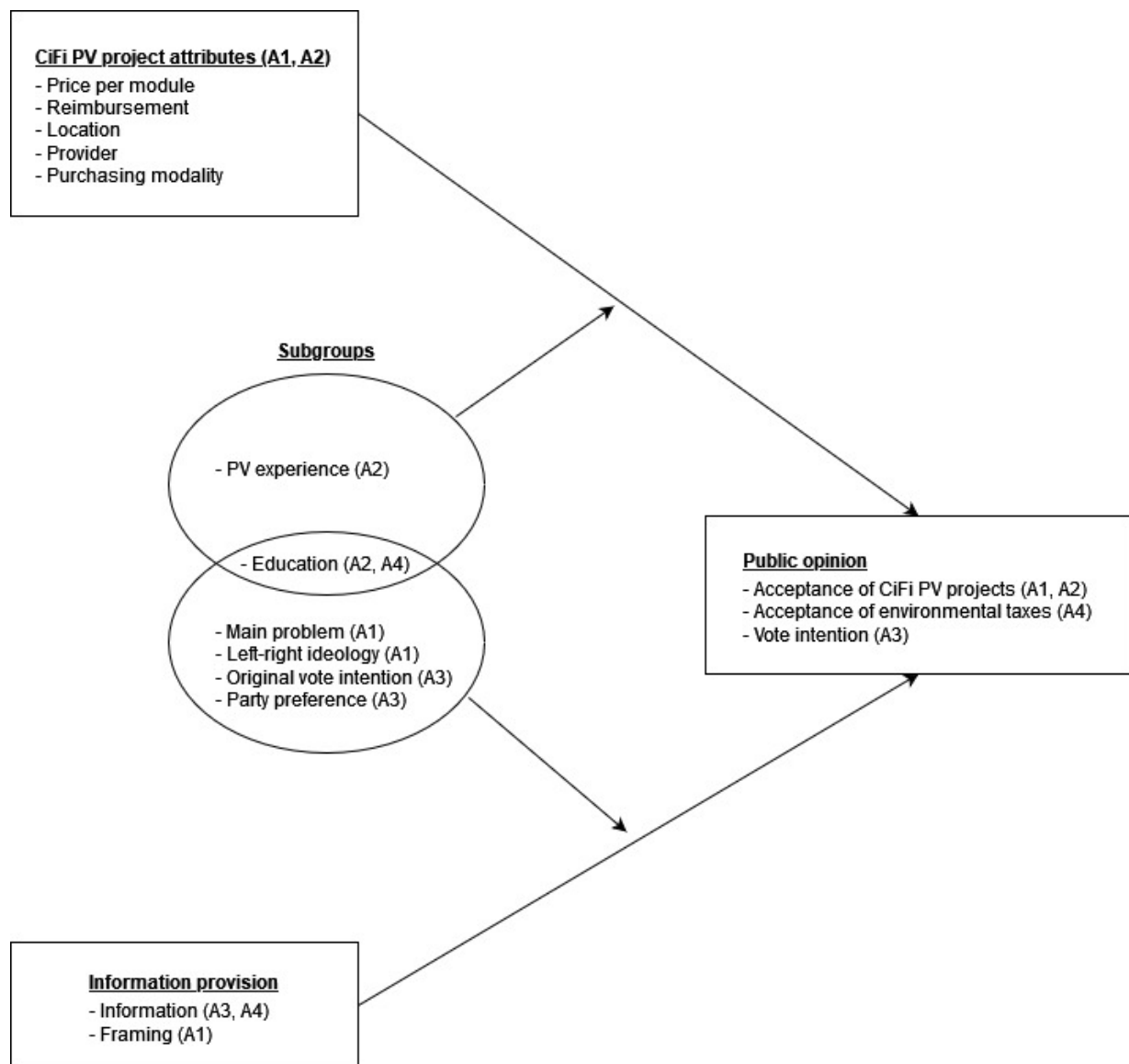


Figure 1.1: Dissertation framework: Article summary and contributions

Note: A1 = Article 1, A2 = Article 2, A3 = Article 3, A4 = Article 4.

Source: Own depiction.

Apart from overall redounding to making energy policies more palatable to citizens, this thesis also has other contributions to offer. Figure 1.1 demonstrates what each of the four articles themselves adds to this dissertation. Further, Chapter 1.1 - 1.4 will go into more detail on certain contributions. To start with, a first contribution lies in capturing multiple aspects of public opinion in the field of energy politics. The study of public opinion is especially warranted in a democratic context, where policies are optimally developed in line with the public will, thus leaving citizens with the task of forming and expressing their opinion (Druckman, 2001;

Rudolph, 2022). Given the multifaceted and complex nature of climate change, it is also crucial to adopt a comprehensive approach that draws upon a range of technologies and policies as well as different dimensions of social acceptance.² Regarding the former, technological feasibility alone will not suffice, as potential solutions also have to be socially accepted in order to effectively accelerate the energy transition. This might, for example, encompass voluntary projects, policies or information tools. I will study one of each: Citizen-financed photovoltaic (CiFi PV) projects, environmental taxes and vote advice applications (VAA). First of all, citizen-financed PV projects are large-scale PV installations that are located in a public area and which are co-founded by many private actors. Hence, they especially provide a good and inclusive opportunity for those citizens to participate and invest in who do not own the roof of their dwelling, thus being unable to install their own PV panels (e.g. Peters et al., 2018; Schumacher et al., 2019). The conditions that foster people’s willingness to invest in such projects are therefore thoroughly investigated (Article 1 and 2), specifically by identifying preferred project characteristics. As citizen-financed PV projects are much less known in society and remain a niche part of energy systems (Nolden et al., 2020), they still bear great potential. These analyses also capture multiple dimensions of social acceptance, i.e. socio-political and market acceptance, which allows for broader conclusions regarding public opinion on optimal CiFi PV project conditions than most previous studies.³ Secondly, I investigate how information can increase people’s willingness to pay higher environmental taxes, a policy instrument that is deemed highly effective but is socially unpopular (Article 4) (see e.g. Drews et al., 2024). And third, I look into whether a vote advice application, i.e. a tool that informs users about their optimal position on a ballot vote, aids users’ opinion formation and whether it shapes their vote intention (Article 3). Giving all citizens equal and maximum opportunities to get access to information about the respective matter is essential, especially from a “democratically enlightened” point of view (e.g. Dahl, 1989), as only given these preconditions are citizens capable of approaching personally optimal, i.e. “true”, opinions based on their best interests. Following this enlightened understanding, better informing citizens is crucial whenever this leads to opinion changes. In conclusion, not only do the four articles look at different aspects of energy politics, I also investigate different dependent variables in the sense of differentiating between opinions, preferences and behavioural intentions, which has also been proven to be of relevance, and therefore capture public opinion in a broad way.

² The concept of social acceptance, according to Wüstenhagen et al. (2007), comprises three dimensions: socio-political, community and market acceptance. Socio-political acceptance is the broadest and most abstract form and measures public (i.e. societal), stakeholder or policymaker acceptance of a renewable energy technology or policy. Due to this general character of overall support, measured socio-political acceptance is often (misleadingly) high. Community acceptance is more concrete and acceptance levels therefore typically much lower, as it measures acceptance of a specifically planned project by local authorities or residents, i.e. siting decisions. This dimension is also related to the infamous NIMBY (“Not In My Back Yard”)-debate. Lastly, market acceptance either measures actual technology adoption by consumers (demand side), investments or provision (supply side). This dimension is related to the “diffusion of innovation”-theory. This threefold measurement proves relevant, as past research has indicated that the dimension of social acceptance under study matters for the level of acceptance and that unequal findings can be explained by looking at different dimensions thereof.

³ Owed to the survey context, community acceptance could not be captured.

Two, as already insinuated, three out of the four articles analyse the influence of information on social acceptance of an energy policy or technology. While the VAA purely informs citizens about their ideal vote choice based on indicated preferences related to the EnA (Article 3), the environmental tax information treatment intends to neutrally deliver information on scientific consensus on environmental taxes, as well as to explain how they function (Article 4). Inherent in this latter study, it is assumed and confirmed that a lack of knowledge is partly responsible for low acceptance of environmental taxes. To determine social acceptance of citizen-financed PV projects, I use a slightly different approach, as a framing experiment was implemented preceding the conjoint experiment (Article 1). The information included therein generally informed respondents about citizen-financed PV projects. Further, a 2x2 framing experiment was delivered to respondents: When it comes to potential investors' project involvement, frames varied between emphasising a respondent's personal or collective involvement and contribution (the first framing dimension) and between contributing to either climate change mitigation or electricity supply (the second framing dimension). To the best of my knowledge, the combination of framing and conjoint experiments remains rare so far and has not been addressed in the field of energy politics.⁴ Even though information effects have long been experimentally investigated, replications always serve the purpose of enhancing external validity (see e.g. McDermott, 2011). By focusing on a single case (i.e. Switzerland, see Chapter 1.5), I give a more thorough overview on how information and framing experiments affect social acceptance of various energy policies and technologies.

Three, in light of the inconsistencies in previous findings, I adhere to the recommendations put forth by earlier studies, which emphasise the necessity for an examination of population subgroups (see e.g. Arceneaux et al., 2013; Bayes et al., 2023; Vuichard et al., 2021). Subgroup analyses can serve two related purposes: For one, they inform us about the robustness of results. I tested for the moderating effects of people's main problem perception as well as their political orientation with regard to citizen-financed PV project acceptance (Article 1).⁵ Further, I check whether a VAA user's original vote intention and party preference influences the relationship between the VAA-treatment and the post-treatment vote intention (Article 3). As such moderating effects were identified, this leads to the second purpose of subgroup analyses, namely the possibility of identifying subgroups which deviate from the main effect, thus having to be addressed differently. In the case of policy-making, this calls for more targeted action. In a democratic context, where policymakers should respond to public opinion, getting people to express their personally optimal preferences is crucial (see also Chapter 1.1 and Chapter 1.4). Again following the democratically enlightened understanding, individuals' "true" preferences can only be approached when people

⁴ Dasandi et al. (2022) and Fesenfeld and Bernauer (2022) pose two exceptions in this regard, who followed similar designs by evaluating the likelihood to support climate change policies or food waste regulation, respectively.

⁵ The tenants in Article 1 are not counted as a subgroup, as tenants formed the full sample and were not used as a moderating variable.

are provided with all information available. Some studies suggest that insufficient knowledge is responsible for low support of environmental policies (e.g. Bekker et al., 2017; Stoutenborough and Vedlitz, 2014). As information ideally increases awareness and knowledge about a matter (Khatibi et al., 2021), and because people with different amounts of knowledge react differently to new information (Bardes and Oldendick, 2012), my main focus in the subgroup analyses lies on investigating various dimensions of knowledge, i.e. by varying the degree of its abstractness, and testing whether those more knowledgeable are, in fact, more in favour of environmental policies and technologies. In the past, knowledge has also been linked to certain civic virtues, such as higher political participation (e.g. Angrist et al., 2023; Wolak, 2022), thus justifying the need for more studies surrounding this relevant concept. Therefore, I first of all differentiate between more abstract and more specific forms of knowledge, i.e. education and experience (with PV), and look at what CiFi PV project factors are deemed acceptable by these subgroups (Article 2). Results point to the fact that preference differences among subgroups exist, underlining the relevance of (knowledge) subgroup analyses. Further, I investigate the impact of the information treatment on willingness to pay higher environmental taxes in total, but also separately for three groups with varying levels of educational attainment (Article 4). This proves relevant, as information only matters for those least educated.

Four, all analyses are based on recent, high-quality and representative data, thus increasing the chances of locating “true” effects and generalising results. The analyses surrounding CiFi PV project acceptance are based on newly designed and gathered survey data (Stadelmann-Steffen et al., 2022a) that I helped collect in the fall of 2022 in Switzerland (Article 1 and 2). This survey was a key element of the SWEET-EDGE-project, which dedicates itself to finding both technically and socially optimal solutions to advance the energy transition. The effects of using a VAA were also derived from primary data, which was collected in the spring of 2017 before the Energy Act (EnA) ballot vote (Article 3). On the other hand, the analyses to identify the impact of an information treatment on willingness to pay higher environmental taxes was based on secondary data from MOSAiCH 2020 (Article 4). As a part of the International Social Survey Programme (ISSP), it is a thematically diverse and large-scale survey conducted annually in Switzerland, therefore contributing to frequent measurement of public sentiment towards relevant topics (Staehli et al., 2021).

And five, all four articles allow for causal interpretation of results due to their various experimental designs. To test for optimal investment conditions of citizen-financed PV projects, I contributed to designing a novel conjoint experiment. Conjoint analysis mimics real-life decision-making more closely than conventional survey questions and reduces the risk of social desirability bias due to the simultaneous presentation of multiple project characteristics (Article 1 and 2). As project constellations, i.e. scenario comparisons, are repeatedly presented to respondents, counterfactuals are created, thus permitting causal conclusions. Next, to study the impact of the VAA in the context of the EnA 2017, a three-wave panel survey was launched. Vote intentions were measured both before and after receiving the experimental VAA-treatment (Article

3). Making use of the secondary MOSAiCH 2020 data, I located an unused experiment that was unwittingly included in the dataset and therefore analyse the impact of being exposed to a scientific information treatment on willingness to pay higher environmental taxes between the two survey waves (Article 4).

Ultimately, I argue that capturing public opinion in a democratic state is crucial in order for governments to adequately fulfil their duty in serving the people. In some cases such as climate change mitigation, however, the greater good in the sense of collective benefits should outweigh individual costs or policy preferences. As this is seldom the case currently, finding the underlying barriers is of key relevance. Stated differently, to combat such crises, the government needs majority support to implement policies that have personally visible costs but benefits to all, with the overarching problem being as to how such policy-making can be achieved without neglecting democratic statutes. Without social acceptance, new technologies and policies are rarely successful (e.g. Druckman and Bolsen, 2011; Wüstenhagen et al., 2007). This assumption of respecting public preferences underlies the research questions in Article 1 and 2, specifically by measuring social acceptance of citizen-financed PV projects, including the influence of different frames as well as knowledge subgroup effects. I further argue that, sometimes, a lack of information or knowledge is at least partially responsible for low levels of support for environmental policies. Hence, providing people with more information could potentially convince them of scientific findings and lead them to change their opinion towards supporting more stringent measures to advance the energy transition. This is tested in Article 3 and 4. Article 3 looks at how a novel vote advice application helps with users' opinion formation in the scope of the real-world EnA ballot vote. And lastly, Article 4 shows how differently educated citizens change their willingness to pay higher environmental taxes when being provided with more information on the matter. Overall, I therefore contribute to a more thorough understanding of public opinion in the field of energy politics.

1.1 Public opinion

As all four of the articles included in this dissertation are collectively embedded in the framework of public opinion, I first of all need to explain the complexity behind the origin and meaning of this term. The concept of public opinion has been around for centuries and has undergone many transformations of meaning. For example, the notion and relevance of public opinion was already present and recognised in ancient Greece and Rome (Anderson and Turgeon, 2023b; Bardes and Oldendick, 2012; O'Keefe, 2004). However, it is said that Rousseau (1712-1778) was among the first to introduce the modern concept of public opinion (Erikson and Tedin, 2007). Following the age of Enlightenment, the U.S.-Founding Fathers took upon the idea that the "mass public was deemed competent to exercise its sovereignty" (Bardes and Oldendick, 2012, p. 3), which is nowadays fundamental to democratic societies and the cornerstone of democratic theory (e.g.

Atkinson et al., 2021; Rudolph, 2022).⁶ Today, and due to the failure of individuals to strive for collective interests, democratic societies have evolved from the traditional Greek understanding of democracy. Instead of citizens being involved directly in decision-making, this usually happens indirectly through elected officials (Anderson and Turgeon, 2023b).⁷ In other words, the premise is that democratic systems and its policymakers have to respond to public demands and take these preferences as broad guidelines for action (Atkinson et al., 2021; Bardes and Oldendick, 2012; Freeland, 2015; Weissberg, 1976). Accordingly, today’s consensus is that, to some degree, policies are expected to reflect the public will if democratic representatives do not want to risk their legitimacy and longevity (Rudolph, 2022). In turn, this leaves citizens with their task of competently forming opinions in order for democratic officials to respond to these preferences (Dahl, 1971; Druckman, 2001). To cite Abraham Lincoln: “With public sentiment on its side, everything succeeds, with public sentiment against it, nothing succeeds” (Weissberg, 1976, p. 2). Therefore, “public opinion on policy matters” (Achen, 1975, cited in Bardes and Oldendick, 2012, p. 3, but see also Druckman et al., 2012), also in this dissertation.

But what exactly does public opinion mean or entail? As mentioned, the concept knows numerous definitions with different aspects or emphases and its understanding has also changed over time. So far, still no consensus on a general definition has been reached. In the 19th century, public opinion was viewed as an “opinion of a collective entity”, whereas in the 20th century, it was differentiated into an “aggregation of individual and group preferences” (Gunnell, 2011). As one of few, Bardes and Oldendick (2012, p. 5) also stress the aggregate part by defining public opinion as “the aggregate of the views of individual adults on matters of public interest”. They further elaborate that public opinion can address any issue of interest at any level of government and could even be located in the private sector. Some scholars kept their definitions more general. One of the most broad and abstract definitions about public opinion stems from Freeland (2015, p. 562), who defines it as “the expression of beliefs, ideology, and sentiments within a citizenry with regard to the conduct of human affairs”. Howe and Krosnick (2022, p. 105) narrow this general definition down to “opinions on matters of public debate that have significant implications for society”. This stresses the fact that a lot of topics are up for debate in the public, but that its implications also need to be consequential enough to be included in their definition of public opinion. They also somewhat disagree with Freeland (2015) in the sense that public opinion is not just about any opinion or beliefs but is “restricted to [...] issues that are matters of public debate, or where there is uncertainty regarding public consensus on an issue” (Howe and Krosnick,

⁶ This presumption did not go uncontested: Most famously probably, Walter Lippmann argued that the mass public is not competent enough because people do not take the time to thoroughly inform themselves on relevant matters (Lippmann, 1922). As a consequence, humans create simplified mental images of the world, which are based on heuristics. These stereotypes are then used to form opinions (Freeland, 2015). Even worse, according to Lippmann (1922), while opinions are resistant to contradicting information, they are influenced by elite propaganda and subject to passions (Erikson and Tedin, 2007; Freeland, 2015).

⁷ A notable exception in this regard is, of course, Switzerland. In addition to having elected representatives who draft legislation, direct-democratic instruments also allow citizens to directly position themselves on certain ballot proposals.

2022, p. 104). Hennessy (1985, p. 8) specifies public opinion as “the complex of preferences expressed by a significant number of people on an issue of general importance”. This was one of the first definitions stating the relevance of direction and intensity of opinions. Keeping their definition comparably short, Erikson and Tedin (2007, p. 8) simply summarise public opinion “as the preferences of the adult population on matters of relevance to government”. However, Katz (1966, p. 150) for example deviates from this static definition, and instead viewed it as a “public opinion process”, that is, “a description at the collective level and [which] refers to the mobilisation and channeling of individual responses to affect group or national decision-making”.⁸ Despite highlighting similar aspects, all definitions listed above define public opinion in slightly different terms, which again stresses the concept’s complexity.

A few notable points I take away from the definitional efforts on public opinion address the following: Regarding “the public”, in the course of this dissertation, I follow Weissberg (1976), who states that this definition includes those people whose opinion is politically relevant. All four of my articles are based on samples representative of the population (aged 18 and above) and each of the articles also conducts subgroup or moderation analyses. Therefore, what is defined as the public still varies. Next, as is explained in Chapter 1.2, “opinion” can also be defined in different ways, but, put simply, I view it as the “preference for a course of action” (Weissberg, 1976, p. 12). Even though some definitions incorporate the word “aggregate”, I quantitatively study relationships on the individual level. However, as I use regression analysis, this also results in average effects for the aggregate. Lastly, the “issue of relevance” is also a crucial aspect in my understanding of the public opinion definition. This would certainly underline the “significant implications for society”-part of the definition by Howe and Krosnick (2022). This was, in fact, even brought up almost fifty years earlier by Weissberg (1976), who stated that knowing about public opinion is fair enough, however, when following the political approach of this definition, public opinion is only relevant if these opinions also hold political significance. Furthermore, this relevance has to be demonstrated and cannot simply be assumed. Depending on the article, the issue of relevance varies, however, they are all related to energy politics, which is undoubtedly one of the most central and debated topics in current Western politics. Following Roser-Renouf et al. (2015, p. 368), who state that “global climate change is an environmental threat of the gravest magnitude”, I would go as far as to argue that finding socially accepted solutions to accelerate the energy transition and thus mitigate climate change is the main challenge of this millennium.

⁸ He argues that this public opinion process entails four stages: First, salience of a problem emerges. Next, the problem is discussed and its salience once again increased. Third, alternative solutions are formulated and lastly, the final mobilisation of opinions necessary to affect a collective decision occurs (Katz, 1966).

1.2 Theoretical concepts

With “public opinion” serving as an umbrella term of what each of the four articles measures and contributes to, inherent in this term is the word *opinion*, which also needs to be further defined and distinguished from related concepts, such as attitudes, beliefs or behaviour. This differentiation is relevant because each of the constructs can lead to different study results in terms of effect size and direction. Depending on the scientific discipline or the era of research, all of these concepts may be defined in slightly nuanced understandings, but in this dissertation, I will adhere to the following meanings.

Starting with *beliefs*, they can be defined as inclinations to accept something as true or false (Bardes and Oldendick, 2012). These levels of (dis-)agreement are directed toward an object that is more “matter of fact” (i.e. scientific) than opinions (“matter of preference”) (Erikson and Tedin, 2007, p. 7). However, beliefs can be based on selective information and therefore still be biased. Some scholars see beliefs as determinants or building blocks of attitudes (Ajzen and Fishbein, 2000; Eagly and Chaiken, 1993; O’Keefe, 2016b), since “evaluations [i.e. attitudes, see below] are based, in part, on beliefs” (Druckman and Lupia, 2000, p. 4). Accordingly, changes in the set of accessible beliefs can lead to attitude changes (Ajzen and Fishbein, 2000), for example when being exposed to new information (Druckman and Lupia, 2000).

Attitudes are latent constructs, meaning that they are not directly observable (Erikson and Tedin, 2007), as also becomes clear in the definition by Eagly and Chaiken (1993, p. 1), labelling attitudes as a “psychological tendency”, which refers to “a state that is internal to a person”. Most social psychologists agree that attitudes are “relatively enduring orientations toward objects that provide individuals with mental frameworks for making [...] sense of this world” (Bardes and Oldendick (2012, p. 14), but see also Ajzen (1989), Druckman and Lupia (2000) or Erikson and Tedin (2007)). The main characteristic of attitudes is the one of evaluation (Ajzen, 1989; Ajzen and Fishbein, 2000; Eagly and Chaiken, 1993; Gerrig and Zimbardo, 2008; Katz, 1966), i.e. the overall degree of favourability a person expresses towards an object (Ajzen and Fishbein, 2000; Eagly and Chaiken, 1993; Crano and Prislin, 2008). In order to measure the otherwise unobservable attitudes, a three-part typology has proven helpful: The affective component captures feelings towards the object, whereas the cognitive component consists of the expression of beliefs, i.e. perceptions of and information about the object. Lastly, the conative component comprises behavioural intentions (e.g. Ajzen, 1989; Eagly and Chaiken, 1993; Olson and Kendrick, 2008). Katz (1960, p. 163) further described attitudes as the “raw material out of which public opinion develops”.

Accordingly, *opinions* can be defined as expressions of underlying attitudes (Bardes and Oldendick, 2012; Freeland, 2015), either in words or writing (Erikson and Tedin, 2007). They are viewed as “disagreements about matters of preference” (Erikson and Tedin, 2007, p. 7), indicating that opinions do not reflect something that is factually true or false, which consequentially

renders them more a matter of personal taste than beliefs (Freeland, 2015). Opinions do not just vary in terms of direction but also regarding intensity, i.e. the personal importance ascribed to an object (Freeland, 2015). These differences may stem from factors such as self-interest (Erikson and Tedin, 2007; Katz, 1966), disparate cultural traditions or past experiences (Hennessy, 1985). Opinions, as expressions of attitudes, are more prone to fluctuate, depending on current moods, contextual factors or frames (Ajzen and Fishbein, 2000). Thus, opinions can also be described as “manifest responses [that][...] are [...] merely fallible indicators of the latent evaluative disposition”, i.e. attitude (Ajzen and Cote, 2008, p. 289).

Related to attitudes and opinions is the concept of *preferences*. Preferences are always relative in the sense that at least two objects are subjectively compared to each other and transitively ordered (Kaci, 2011). Following Druckman and Lupia (2000, p. 2), preferences are “a comparative evaluation of (i.e. a ranking over) a set of objects”. These rankings are derived from attitudes (Druckman and Lupia, 2000). This implies that preferences encompass an affective (feelings of like or dislike) as well as a cognitive dimension (level of sophistication needed for ordering) (Erikson and Tedin, 2007).

Attitudes, opinions and preferences can all be antecedents to *behaviour* (e.g. Ajzen, 1989; Ajzen and Fishbein, 2000; Kaci, 2011), i.e. the “overt actions of an individual” (Albarracin et al., 2005). Unlike its antecedents, behaviour is directly observable (Gerrig and Zimbardo, 2008). The closest and best precedent to actual behaviour is *behavioural intention*, which is a “statement about actions one would personally take” (Schuman and Johnson, 1976, p. 163). In other words, behavioural intentions are said to be “indications of how hard people are willing to try, of how much of an effort they are planning to exert, in order to perform the behaviour” (Ajzen, 1989, p. 250). It remains to say that the attitude-behaviour-relationship is not simply unidirectional, instead, behaviours can also influence attitudes (e.g. Ajzen and Fishbein, 2000; Eagly and Chaiken, 1993).⁹

Adhering to these conceptual definitions, the central variables in this thesis’ articles either refer to opinions, preferences or behavioural intentions. As argued above, I treat attitudes as unobservable and use opinions or preferences to proxy underlying attitudes.¹⁰ Article 1 and 2 focus on solar PV project design in the scope of a conjoint experiment, where multiple project attribute levels are randomly combined and thus form project configurations, which then have to be evaluated in terms of three dependent variables capturing project acceptance. Given this evaluative characteristic, Article 1 and 2 clearly examine underlying attitudes. While project rating (as a DV) more generally captures respondents’ opinion on both project configurations presented, I

⁹ Further, some studies discussing the attitude-behaviour-gap in the field of energy politics are, i.a., Claudy et al. (2013), Higham et al. (2016), Stadelmann-Steffen and Thalmann (2021) or Zhang et al. (2021).

¹⁰ While some variables may be labelled as attitudes in the article themselves, conceptually, they still are opinions or preferences, thus following Anderson and Turgeon (2023a), who also use the terms attitudes and opinions interchangeably. Chapter 1.3.1 for example looks at multiple concepts, therefore, I use “attitude” to address all of them as an umbrella term.

would refer to the DV of project choice as a preference, based on the comparative feature. The last DV, i.e. the amount of chosen modules, could be declared as a behavioural intention, as it measures stated willingness to invest. Article 3 also operationalises behavioural intentions. Therein, respondents have to indicate their intended vote choice regarding the ballot proposal on the new Swiss Energy Act from 2017. Due to this stated action, I argue that this is more than a measurement of preferences. Furthermore, and as was criticised many times in the literature due to not being considered (see e.g. Bardes and Oldendick, 2012; Blumer, 1948; Erikson and Tedin, 2007; Schuman and Johnson, 1976), preceding their voting intention, survey respondents had to weigh various energy policy opinions. As argued by numerous scholars, not all attitudes, beliefs or opinions matter equally for opinion formation, or behavioural intention, in this case. Article 4, investigating how willing respondents would be to pay higher environmental taxes to protect the environment, seems to be a borderline case of behavioural intention (as opposed to being a simple opinion). However, due to the “willingness to pay”-wording, I would still place it closer to the behavioural side of the above framework.

In essence, this chapter demonstrates that there are a number of distinct yet interrelated concepts and that, depending on the construct under study, results may vary, both in effect size and direction. This is an important aspect that research often overlooks when drawing inferences between various studies. The closer research operates to actual behaviour, the more realistic the captured effects should become. Owing to the survey context of the four articles, behavioural intentions are the closest antecedent to actual behaviour that I can capture, therefore consistently operating on the non-behavioural, i.e. cognitive, level.¹¹

1.3 The role of information

Having established the basic assumption under which this dissertation operates, i.e. that “public opinion matters” (Druckman et al., 2012, p. 430), the next step is the elaboration on how information per se places itself in this framework. Information as a concept does not know an established definition, as its meaning is context-dependent. Broadly speaking, information can be seen as a resource or commodity in the sense of a message from a sender to a recipient (McCreadie and Rice, 1999). In short, the main idea of information provision is the creation of awareness and knowledge (Khatibi et al., 2021), with the ultimate goal of persuading the recipient of one’s

¹¹ This should not at all be seen as a limitation, as attitudes matter a great deal for democracies and public opinion. Studies that were unable to link attitudes to actual behaviour might, in fact, have studied the wrong behaviour, thus failing to establish a correlation (see Druckman, 2022a, p. 75). Generally, attitudes and behaviours are said to be reasonably consistent (O’Keefe, 2016a). Furthermore, O’Keefe (2021) showed that, in most cases, persuasive messaging affects non-behavioural outcomes in the same direction and magnitude as behavioural outcomes. Accordingly, the findings obtained should be reasonably likely to happen in reality as well.

message (e.g. Druckman, 2022a).¹²

Persuasion can be defined as “a successful intentional effort at influencing another’s mental state through communication in a circumstance in which the persuadee has some measure of freedom” (O’Keefe, 2016a, p. 27). Gass and Seiter (2022, p. 34ff.) summarise the key aspects needed for something to count as persuasion: Intentionality, successful effects, free will and conscious awareness, some sort of (symbolic) action and more than one person being involved. Ideally, persuasion achieves compliance (Gass and Seiter, 2022) in the form of behavioural changes following attitudinal shifts (O’Keefe, 2004). However, research on persuasion seems highly divided and effects can seldom be generalised. Druckman (2022a) therefore established the “generalising persuasion framework”, which explains how individual persuasion studies still connect to another and why studies arrive at different conclusions. In short, the framework finds that important sources of variations are found when studying different actors, treatments, outcomes and settings.

In this present case, the goal of persuading an audience is tied to the need to establish more effective policies to accelerate the energy transition, as public engagement in climate change mitigation and adaption is crucial (Khatibi et al., 2021). In democracies, majority support is a prerequisite for successful implementation, which accordingly renders public acceptance of such policies essential (Dermont et al., 2017; Druckman and Bolsen, 2011; Wüstenhagen et al., 2007). As posited in Downs (1958)’ theory of instrumental rationality, people translate information into opinions based on a cost-benefit analysis. Since environmental quality is a public good, personal costs are typically higher than perceived benefits to all (Anderson et al., 2017), which is why policy adoption and implementation in the field of energy policy is this cumbersome. Even though it is a problem that not a lot of information trickles down (Converse, 2006), as further elaborated in the following chapters, information is a promising tool to increase knowledge by fostering an understanding of climate change impacts and to persuade humans to take action (Khatibi et al., 2021). A meta-study on the effect of information on political choices also found “that possessing more information changes preferences, thus suggest[ing] that less informed citizens are not making optimal choices” (Chong and Mullinix, 2022, p. 121) – a finding in accordance with both the information deficit model as well as Dahl’s (1989) enlightened understanding of democracy.

When faced with topics of information provision with the attempt of persuasion, one should also address the question of its legitimacy. Deception, for instance, also counts as a form of persuasion, which includes deliberate distortions of a message, i.e. lies, either by not telling the whole truth or by reporting false contents (Gass and Seiter, 2022, p. 301ff.). Overall, forms of manipulation aim at influencing preferences based on incorrect information, which may ultimately cause recipients to act against their actual interests (Druckman, 2001). In this dissertation’s

¹² This pathway assumes a more systematic reasoning, however, I acknowledge that other, more heuristic, forms of information processing exist and work as well to form opinions (see e.g. Chaiken, 1980; De Angelis et al., 2020; Colombo and Steenbergen, 2021).

respective articles, all information presented to respondents adheres to ethical guidelines of not distributing deceptive or even factually false information. Therefore, I do not deem any of these information or framing treatments as illegitimate manipulation. In this context, the term “persuasion” is only understood to refer to a non-manipulative, fact-based approach to convince another person of one’s message.

As the following chapters will illustrate, research on persuasion is highly diverse and evidence is split into positive, negative and insignificant effects. I therefore argue that it depends on someone’s point of view whether or not the provision of more information can be associated with politically beneficial outcomes. As I follow Robert Dahl’s (1989) enlightened understanding of democracy, receiving more information is viewed positively whenever it manages to change someone’s opinion.¹³ Only with a maximum amount of information can humans think and act optimally, hence providing policymakers with “true” public opinion from which the latter can develop socially accepted policies.

1.3.1 Attitude change

As stated before, the goal of persuasion is to gain compliance (e.g. Gass and Seiter, 2022; Gerrig and Zimbardo, 2008; Green and Gomez, 2022), which can be achieved in a number of ways. However, the respective articles included in this dissertation which look at attitude change only focus on the influence of information. Unlike some studies which look at *how* information affects attitudes (e.g. dual-process models), I do not analyse psychological or process-related mechanisms, which would be beyond the scope of this dissertation.¹⁴ Instead, I rely on established theories and hone in on *whether (and if so, in what direction)* information changes attitudes, thus being input/output-oriented. Before going into more detail in the two subsequent chapters, a few remarks on the theoretical mechanisms of attitude change shall be made.

While attitude change knows a variety of definitions,¹⁵ the basic assumption I follow lies in a simple stimulus-response model, i.e. some form of learning or successful persuasion (e.g. Hovland, 1959), in the best case. Accordingly, information as the stimulus targets and updates beliefs, which then ideally leads to a reaction in an attitude or behavioural intention (Ajzen and Fishbein,

¹³ This is irrespective of whether the reached conclusion is in favour or against collective benefits such as environmental protection. “True” preferences simply represent the result of a person’s cost-benefit-calculation, i.e. their personally desirable outcome.

¹⁴ Similarly, I also do not test for selective exposure to information (see e.g. Cotton and Hieser, 1980).

¹⁵ Druckman and Lupia (2000, p. 6), for example, propose two forms of (in their case) preference change: One, new information can make a person change their preference between two types of objects A and B or, two, they differentiate an object P into P_1 and P_2 (i.e. objects of distinct types). Interestingly enough, Druckman and Lupia (2000) as well as Eagly and Chaiken (1993) argue that preference formation and preference change can be treated as identical because new preferences always stem from existing preferences and are not created out of thin air. In other words, existing preferences are simply refined when being exposed to a new stimulus. In my dissertation, I however refer to opinion formation for cross-sectional analyses (Article 1 and 2), whereas opinion change refers to analyses based on longitudinal data (Article 3 and 4).

2000). Attitude changes are observed when a uniform stimulus produces (more or less) uniform responses, which then allows for the isolation of the causal factor responsible. By selectively manipulating the stimulus, attitudes or behaviours can then be changed predictively (Hennessy, 1985). When new information leads recipients to reevaluate their stance on an issue and change their attitudes, due to the potential implications for democracy elaborated on in Chapter 1.1, it seems requisite to make policy preferences as authentic as possible when studying public opinion (Erikson and Tedin, 2007).

Despite not being able to test the underlying psychological mechanisms that explain such shifts in attitudes, there exists a vast amount of literature explaining why and how these changes might occur. Accordingly, some of the following mechanisms could also be at play for the information effects which I identify in my subsequently presented articles. For instance, and most generally, the theory of cognitive dissonance (Festinger, 1962) posits that, when a new stimulus creates an imbalance with preexisting attitudes, attempts are undertaken to reduce this dissonance and make attitudes or behaviours more congruent with the newly acquired information. This idea was also brought forward by Katz (1960), in the sense that attitude change only happens when some incompleteness or inconsistency is detected in a person's existing attitudinal structures and learning processes set in. Specifically focusing on persuasion research, Watt et al. (2008) propose two more detailed reasons for attitude change: The function matching hypothesis states that attitude changes occur when an attitude no longer serves its function or need. The message processing hypothesis brings the idea forward that "different attitude functions induce different types of message processing" (Katz, 1960, p. 195).¹⁶ In terms of personal motives which explain such attitudinal shifts, one is seen in a desire to conform to others' expectations (normative social influence) and another is the desire to accept information received from others as true (informational social influence) (Katz, 1960). In conclusion, these functional approaches to attitudes claim that attitudes serve psychological functions, which implies that persuasive attempts have to target the underlying function to increase the chances of being successful (O'Keefe, 2016b). On the other hand, according to belief-based models, attitudes can be changed by following three approaches: One, the evaluation of an existing salient belief may be changed. Two, the strength of an existing salient belief can be influenced. Or three, the set of salient beliefs may be changed overall (see e.g. O'Keefe, 2016b, p. 2). Irrespective of the specific approach, the information experiments in this dissertation follow the implicit assumption that the information presented changes an underlying psychological function, need or belief, which subsequently induces a form of cognitive dissonance, thus potentially resulting in a change of corresponding attitudes.

¹⁶ A prominent approach featuring four functions of attitudes was originally developed by Katz (1960, p. 170ff.): instrumental / utilitarian (maximise rewards and minimise penalties to get along socially), knowledge (cognitive focus, frames of reference to understand one's world), value expression (positive expression to central values, conserve one's self-image) and ego-defense (avoid dissonant elements to preserve one's self-image, either by denial, misinterpretation or rationalisation).

As previously argued and as will become evident in the following chapters, research on attitude change in general and regarding information or framing effects in particular is highly diverse and context-dependent. Ajzen and Fishbein (2000) assert that persuasive communication is not as straightforward as simply providing information, since other factors have been found to be important determinants as well. While the generalising persuasion framework (Druckman, 2022a) summarises key factors that can explain such variations in persuasion attempts, there are also other, more psychological or contextual factors outside of persuasion that further add to these diverse effects. One of the most solid findings is that attitude strength greatly matters (Bassili, 2008; Katz, 1966; Zumofen et al., 2023). Not just for behaviours (Schuman and Johnson, 1976) but also for persuasive efforts, where a person’s attitudes have to be accessible to them (Ajzen and Fishbein, 2000; Druckman and Lupia, 2000), salient and activated in order to be influential (O’Keefe, 2004). Katz (1960) argued that the intensity of an attitude is determined by the strength of the affective component (which mostly refers to an attitude’s relevance or ranking) and the cognitive component (which refers to an attitude’s specificity or generality and the degree of differentiation of beliefs). Changes in one component often lead to changes in the other in order to restore congruence. But also the larger context has been shown to matter, and that a person may only act upon an attitude when the relevant one is strong enough (Hennessy, 1985). Article 1 and 2 consider such findings. For one, people’s underlying motivations (political left-right orientation, main problem perception) are interacted with different frames. And two, the conjoint scenario generally offers a broader context than simple survey questions, due to the simultaneous presentation of various project factors. Included in the generalising persuasion framework (Druckman, 2022a) is also another factor I would like to point out specifically due to its relevance for Chapter 1.3.2: The credibility of the information emitter (e.g. Eagly and Chaiken, 1993; Gass and Seiter, 2022; O’Keefe, 2016b). It seems proven that highly accepted communicators are more influential than actors perceived less credible and trustworthy (Katz, 1966). As Chapter 1.3.2 expatiates upon, science may serve as such an accepted communicator (e.g. Druckman, 2022b), or even mediator between the political and public sphere.

The following two chapters now address two possibilities to induce changes in opinions or preferences: Information (Chapter 1.3.2) and framing (Chapter 1.3.3) effects. Whereas framing effects are, of course, also information effects, in the scope of this thesis, I do want to make the distinctions I adhere to more clear. By information effects, I mean the unidirectional provision of information, whereas I see framing as a special case of information experiments in the sense that multiple information treatments are distributed. Put differently, I understand information effects as the influence of *how much* information is provided, i.e. receiving no information vs. receiving information. Framing effects, in my understanding, capture the influence of *how* information is presented, i.e. always receiving some information, which is however phrased differently.

1.3.2 Information effects

Information effects as described above are studied in Article 3 and 4. As explained, information itself does not know a universal definition, but in its broadest sense, information describes a message that is produced by a source and afterwards decoded by a receiver (Ash, 2012; McCreadie and Rice, 1999). In the scope of this dissertation, I adhere to the following definition: “Information is an absolute quantity which has the same numerical value for any observer. The human value of the information, on the other hand, would necessarily be a relative quantity, and would have different values for different observers, according to the possibility of their understanding it [sic] and using it later” (Brillouin, 2013, p. 10). This definition already indicates the complexity surrounding information effects, i.e. that the influence of information provision on attitude change is not straightforward. Specifically, there exist numerous issues or theories, such as motivated reasoning (Kunda, 1990), which lead people to process (e.g. scientific) information based on existing beliefs in a way to arrive at personally desirable conclusions. For instance, this may happen by disregarding conflicting information (Howe and Krosnick, 2022). Else, Arce-neaux et al. (2013) show that listening to the other side does not increase one’s acceptance of counterattitudinal information. On the contrary, it may even increase resistance, especially when recipients do not have the option to tune out from information provision. I take these findings as an indication that personal control over a situation seems to majorly matter when exposed to information treatments and that nudging recipients too much towards one direction may cause more harm than good.

This would coincide with findings from Priest (2015), who highlights the current trend in science communication to engage the public and foster exchanges to keep socially relevant issues at bay, as audiences are not just passive. Article 3 therefore looks at the influence of a vote advice application (VAA) on forming one’s vote intention in the context of an energy ballot proposal. Using an iterative approach, this VAA only mirrors the user’s preferences and does not attempt to systematically induce a predetermined opinion (e.g. from an environmentally optimal or scientific standpoint) onto the recipient. This approach allows users to retain their sense of personal control and also does not confront them with contradictory information that could potentially lead to reactance.

Picking up on the term “science communication”, this is an important and newer subject in the field of information effects. As previously argued, the main objective of information provision is the creation of awareness and knowledge (e.g. Khatibi et al., 2021). Science greatly contributes to this democratically relevant goal (see Chapter 1.1), as it “exists to provide systematic knowledge to improve decision-making” (Druckman, 2022b, p. 14), thus making science an “unrivaled information source on which to base decisions” (Druckman, 2022b, p. 8). According to the scientific consensus messaging approach, informing the public about the overwhelming evidence of scientific consensus on climate change should increase support for mitigation policies (Bayes

et al., 2023).¹⁷ Similarly, the scientific literacy model of opinion formation posits that the creation of knowledge (i.e. making people scientifically literate) is essential for humans to accurately assess risks and benefits related to technologies and policies (Druckman and Bolsen, 2011). Whereas society often does not unilaterally share an opinion, science may have already reached a broad consensus, e.g. on hotly debated issues such as vaccination hazards or climate change (Howe and Krosnick, 2022). Such disunity, often owed to certain social groups exhibiting higher levels of distrust towards science, becomes problematic when a public good like environmental quality is endangered and, in the case of climate change, time is ticking in order to avoid reaching irreversible tipping points. Nowadays, politics and science are very intertwined, which can lead to skewed perceptions¹⁸ of scientific or expert information (Green et al., 2023). Whereas science creates knowledge, politics often misuses the name of science, which is also well-documented for climate change issues (Druckman, 2022b). Therefore, scientific communication also becomes a political challenge (Green et al., 2023). For example, misinformation, i.e. “when people endorse false beliefs about objectively verifiable information” (Druckman, 2022b, p. 14), can lead to repercussions such as undermining the scientific community or being worse off due to actions based on false beliefs, both individually and collectively (e.g. as a society).¹⁹ Problems are especially grave whenever public opinion diverges from scientific consensus (Druckman, 2022b). Evidence of the influence of scientific cues is, accordingly, also very heterogeneous (Bayes et al., 2023; Green et al., 2023). The Gateway-Belief-Model, a form of scientific consensus messaging, argues that the successful communication of scientific consensus information manages to combat misinformation. However, findings mostly apply to climate change perception, whereas less evidence is present for support for climate change policies (Bayes et al., 2023; van der Linden et al., 2019). Furthermore, the presentation of factual information has also been shown to matter very little (Druckman and Bolsen, 2011). In Article 4, I take this absence of evidence as a baseline for further research and argue, based on the information deficit model,²⁰ that a lack of information or knowledge is at least partly responsible for lower willingness to pay higher environmental taxes, and that scientific information manages to overcome this problem – at least for the lowest education population group (which is, coincidentally, also more prone to distrust science (see e.g. Obreja et al., 2023)). This is empirical evidence in line with Druckman (2022b) specifying inequality, in the sense that some social groups lack access to or knowledge about

¹⁷ Empirically, there is a lot of evidence supporting the positive impact of scientific consensus messaging, e.g. for policy support for governmental funding (Chinn et al., 2018), COVID19-actions (Kerr and van der Linden, 2022) or climate change mitigation (Lewandowsky et al., 2013; van der Linden et al., 2015).

¹⁸ Such as through partisan lenses, see e.g. Bugden (2022).

¹⁹ Misinformation has increasingly become a problem in the last decade. Not only do such misconceptions have adverse consequences, they also render political compromise difficult (see Druckman, 2022b).

²⁰ The information or knowledge deficit model assumes that a paucity of scientific knowledge causes scepticism towards science. Further, it is presumed that these low levels of acceptance can be increased by experts providing better and more comprehensible information (see e.g. Nisbet and Scheufele, 2009; Rowan et al., 2021). It should also be noted that it is not the intention of this model to take an elitist stance in any way, as it simply reiterates the necessity for more information whenever opinion changes occur subsequently. This protects affected individuals from forming and expressing personally suboptimal preferences.

science, as one major threat to science.

1.3.3 Framing effects

While I generally assume that information helps people to approach their “true” preferences, there is also evidence suggesting that providing the same information can have heterogeneous effects, depending on its wording. Accordingly, another, more established form of persuasion is framing, “a way to describe the power of a communicating text” (Entman, 1993, p. 51) by selecting “some aspects of a perceived reality and mak[ing] them more salient in a communicating text, in such a way as to promote a particular problem definition, causal interpretation, moral evaluation, and/or treatment recommendation for the item described” (Entman, 1993, p. 52). Frames therefore “set the context for perception” (Nisbet and Newman, 2015, p. 329). Once again delineating framing from unethical forms of persuasion, framing does not include the spreading of false information. However, it can pare down information, give more weight to certain aspects or simplify contents (Nisbet and Newman, 2015). While I generally agree with Nisbet and Newman (2015, p. 325) that “there is no such thing as unframed information”, Article 1 in this dissertation specifically compares the influence of different frames to each other, whereas Article 3 and 4 do not involve such framing experiments and the information given to respondents there is viewed as neutral (Article 3) or at least balanced (Article 4).

As already mentioned, framing and information effects are often hard to distinguish, as they both affect people’s beliefs. While information introduces new considerations that might induce attitude change, framing only increases accessibility and importance of existing beliefs, i.e. framing changes the nature of the problem by providing new information (Chong and Mullinix, 2022).²¹ Information effects show that the public is responsive to facts, whereas framing “supposedly undermines the validity of public opinion” (Chong and Mullinix, 2022, p. 128). So, in short, “frames influence public perceptions of environmental problems by connecting the mental dots for the public” (Nisbet and Newman, 2015, p. 329). In my case, as explained in Chapter 1.3.2, I look at a special case of information, i.e. scientific information. Therefore, a key difference between framing and scientific information herein is, according to Druckman and Bolsen (2011), that frames are mostly fact-free, meaning that they do not cite studies or statistics. A framing effect occurs when frames in communication shape frames in thought (Druckman, 2001).

Not surprisingly, public opinion is said to be very vulnerable to framing (Entman, 1993), especially whenever citizens process information automatically, e.g. by using heuristics such as elite

²¹ However, there are instances where framing has been shown to form new beliefs rather than emphasise existing ones (see the literature review in Chong and Mullinix, 2022, p. 129).

discourse. Both emphasis and equivalence framing²² is frequently and strategically used by political elites (Druckman, 2001) to affect public opinion (Druckman et al., 2012). Justifiably, this raises the question whether and how “true” public opinion can even be determined, and whether and how democratic representatives should react to something as malleable (Entman, 1993, p. 57).

Another problem lies in the fact that framing effects are highly heterogeneous and context-dependent. While the general consensus is that opinions should move in the framed direction whenever people are exposed to a frame (Chong and Druckman, 2007; Druckman et al., 2012), there exist a variety of factors contributing to the diversity of outcomes, such as cultural components (O’Keefe, 2016b), source credibility (Druckman, 2004; Eagly and Chaiken, 1993; Gass and Seiter, 2022; Hovland and Weiss, 1951; O’Keefe, 2016b), accessibility of beliefs (Druckman, 2001), the recipient’s personality, mood (O’Keefe, 2016b), motivations and abilities (Druckman and Bolsen, 2011). Further, there is an ongoing debate about the dominance of primacy or recency effects (e.g. Druckman et al., 2012; Gass and Seiter, 2022).²³ Naturally, dependent variables are also contingent upon the contents of the message, as is for example observed in moral framing (Feinberg and Willer, 2013; Green et al., 2023) or gain vs. loss framing (Gass and Seiter, 2022; O’Keefe, 2016b). The framing experiment in Article 1 considers a motivation- (electricity supply vs. climate change mitigation) and a level-dimension (individual vs. collective, i.e. “you can” vs. “we can”). This latter dimension can be viewed as a special case of framing, so-called wise interventions, which are very brief and precise interventions that target relevant underlying psychological mechanisms, often by using active instead of passive language (Walton, 2014). A well-known example is studying whether using the words “voter” or “to vote” makes a difference for changing voter turnout rates (e.g. Gerber et al., 2018; Walton, 2014), therefore being similar to our individual vs. collective framing. Overall, framing something as personally relevant seems more effective (e.g. Hulleman and Harackiewicz, 2009).

As will become more evident in Chapter 1.4, there are also limits to framing (Druckman, 2001), as frames do not resonate with all groups (e.g. Druckman, 2004; Roser-Renouf et al., 2015) and there is evidence of moderating effects, e.g. with political knowledge, education or expertise (Chong and Mullinix, 2022; Druckman, 2004). Research shows that such factors can both enhance or suppress framing effects, depending on the circumstances, similar to heuristics or theories like motivated reasoning (Chong and Mullinix, 2022, p. 128-129). Interestingly, studies that combine frames with factual information cannot show to further increase support for

²² Emphasis framing refers to focusing on a subset of relevant considerations, which leads recipients to focus thereon. Such frames are not logically identical, as they focus on different considerations. Equivalence framing “examines how the use of different, but logically equivalent, words or phrases [...] causes individuals to alter their preferences” (Druckman, 2001, p. 228-230).

²³ Primacy effects describe the observation that frames that are presented first dominate opinions. On the other hand, recency effects appear when information or frames that are seen most recently bear the biggest weight for opinions (Chong and Druckman, 2007; Druckman et al., 2012).

carbon-nanotube technology or genetically-modified foods (than when presented without facts) (Druckman and Bolsen, 2011). Keeping this context-dependency in mind, the following chapter will now investigate the possibility of knowledge subgroup effects.

1.4 The study of knowledge subgroups

As has become increasingly clear, not only in persuasion research but also in general, there exists the potentiality of heterogeneous (treatment) effects (see e.g. Arceneaux et al. (2013, p. 227), Bayes et al. (2023) or Vuichard et al. (2021)). Apart from moderation analyses²⁴ (Article 1 and 3, see Figure 1.1), I account for this possibility by primarily focusing on knowledge subgroup analyses (Article 2 and 4), as knowledge has been proven to greatly vary across societal groups.²⁵ In order to secure conscientious or enlightened decision-making, people need to have a maximum amount of information or knowledge to best evaluate a matter. This is in line with the “civic virtue”-argument of democratic theory and enlightened formation of public opinion (Wolak, 2022). According to Katz (1960), knowledge is one of the four main functions of attitudes, as it helps people to search for meaning and understanding, which is needed to structure their world as well as to create consistency within oneself. In turn, this also indicates that attitude change happens when new information creates ambiguity and dissonance (Katz, 1966). Treating opinions of respondents with differing levels of knowledge identically is problematic, as possessing less knowledge coincides with individuals being more susceptible to new information (Bardes and Oldendick, 2012). From this, it follows that policy preferences may not just differ depending on the amount of information or the frame provided but also depending on someone’s level of prior knowledge (Erikson and Tedin, 2007; Wolak, 2022). Generally, the relevance of knowledge has long been recognised, e.g. in the scope of the cognitive mobilisation hypothesis (Inglehart, 1990), which states that people with greater cognitive resources, such as higher education or more knowledge, are more likely to participate in politics, due to being better informed. Research also suggests that more human capital helps individuals to be better equipped to understand climate change science (Angrist et al., 2023). This makes sense, as the more information a person has, the better their ability to link various concepts to one another (see Erikson and Tedin, 2007, p. 8). Especially in a direct-democratic context, where citizens can frequently express their opinion, being exposed to new information and building up a foundation of knowledge therefore potentially bears crucial implications.

While, first of all, a more general form of knowledge is analysed, i.e. the role of education (Article 2 and 4), a more concrete form of knowledge, i.e. experience, is also studied (Article 2).

²⁴ The moderating variables are: main problem perception, left-right ideology, original vote intention and party preference.

²⁵ Even though all adults are included in the definition of public opinion, this does not exclude the study of subgroup effects (see Erikson and Tedin, 2007, p. 8).

Starting with education, the question of inequality inherently arises, in the sense that some groups lack access to or knowledge about science (Druckman, 2022b). Systematically targeting lower education groups might, for that reason, counteract such inequalities. But arguing along the lines of “critical science literacy”, it has been suggested that possessing scientific knowledge alone, i.e. knowing facts, does not suffice. Instead, a broader set of skills is crucial in order for individuals to understand the relationship between various political, social and natural domains (Priest, 2015). This reinforces the relevance of studying education and its effects. It has long been proposed that more educated individuals have a more structured belief system, which in turn also increases their level of political sophistication (Converse, 2006; Eldersveld, 1956; Wolak, 2022). Including the role of information when looking at implications of education, it has been shown that the level of education at least partly influences the amount of information that people absorb (Converse, 2006), but also that more educated individuals are generally better informed about a variety of topics (Erikson and Tedin, 2007) as well as more politically knowledgeable (Barabas et al., 2014). Current research further highlights the need to moderate scientific consensus messaging with education to find out whether support for climate policies varies (Bayes et al., 2023, p. 25), since the level of political competence has been shown to affect the relationship between being provided with political information and opinion formation (Sciarini and Tresch, 2011). Evidence is however not consistent so far: Coppock et al. (2020) argue that persuasive message effects tend to be small, which might be explained by such heterogeneities, but this is not the case in their study on candidate favourability and vote choice. I take these findings as the baseline as to why I consider the study of knowledge subgroups important. To start with, I check whether differently educated respondents express different preferences for citizen-financed PV project designs (Article 2). Second, I go one step further and test whether information about environmental taxes affects different education groups heterogeneously (Article 4). This is also in accordance with Dahl’s (1989) deliberation: While all opinions count, “true” opinions are best approached when people are exposed to all information available. If this is followed by attitude changes, of course, this is democratically relevant. Eldersveld (1956) refers to this possibility of primarily influencing less educated individuals as a “compensation effect”.

As mentioned, I also look at a more specific dimension of knowledge: Experience, which is basically another word for learning (Article 2) (Gerrig and Zimbardo, 2008, p. 193). Blumer (1948) has long criticised the lack of checking for this factor. According to him, not all opinions should count equally, as it makes a difference whether a respondent thinks about an issue for the first time during a survey or whether a person has already been intensely involved prior. Since direct experience renders attitudes more accessible (Gerrig and Zimbardo, 2008, p. 645) and more stable (Bardes and Oldendick, 2012) due to an increased amount of information a person has about a subject, their attitudes should also be more predictive of behaviour, i.e. raise consistency between the two concepts. The quality of an experience however influences the direction of this

relationship (see e.g. Ajzen (1989, p. 258-259) or O’Keefe (2016b, p. 37)).²⁶ This happens because people update their belief systems when faced with new experiences (Druckman and Lupia, 2000). Ajzen and Cote (2008, p. 304) perfectly summarised the relevance of looking at subgroups with varying degrees of experience in the following statement: “By comparing subgroups of participants who are currently performing and not performing the behaviour, or those who intend to perform it in the future with those who don’t, we can gain insight into the considerations that guide people’s actions.” In practice, research has shown that due to greater uncertainties, persons less familiar or experienced with a subject are more prone to be influenced by messages (e.g. Bardes and Oldendick, 2012; de Vreese and Schuck, 2014). This would imply that those most informed or involved would be less susceptible to (mis-)information and thus, public opinion would also be more stable. In turn, policy-making could be designed for the long term, being less subject to fluctuations and achieving more efficient outcomes.

To sum up, this chapter highlighted the importance of scrutinising the effects of knowledge more closely, as knowledge is related to a broad range of democratically relevant aspects. In case significant effects are detected, policymakers should take appropriate measures.

1.5 The case of Switzerland

In order to give a more encompassing overview of public opinion on energy politics as well as to keep the analyses’ context constant, the research question underlying this dissertation will be studied in a single country: Switzerland. So far, a lot of research both on energy politics but even more so on information effects was conducted in the U.S., limiting the degree to which evidence on the matter can be generalised for example to Switzerland. As climate change however is a global problem, not just environmentally but also politically, it is inevitable to replicate studies in other contexts as well. Despite the often voiced complacency that such a small country can only negligibly contribute to climate change mitigation, I purposely focus on the country that was once famously called “a microcosm of Europe” (Rokkan, 1974, p. xi).

This implied geographical, cultural, social and political diversity is one reason making Switzerland a perfect research case, increasing chances of finding similar effects in other countries as well. The pronounced degree of direct democracy (Vatter, 2020) reinforces the relevance to study Swiss public opinion in general. Direct democracies allow its citizens to frequently voice their opinions, which, on the one hand, makes them more “naturally informed” and, on the other hand, allows researchers (and even policymakers) to capture a more realistic picture of public opinion than in other contexts. As research suggests that less educated, experienced or informed individuals tend to be more influenced by new information (see Chapter 1.3-1.4), Switzerland would posit

²⁶ According to Zajonc (1968), mere exposure to a subject alone increases familiarity with it and thus automatically forms positive attitudes towards it.

a least-likely case in this sense. The downside of these direct-democratic benefits is that public support for policy measures is imperative (e.g. Dermont et al., 2017; Druckman and Bolsen, 2011; Wüstenhagen et al., 2007), which often complicates and slows down policy-making.

As mentioned above, so far, a lot of research is U.S.-centric, a high-emission country with comparatively low beliefs that climate change is human-made, and where information is therefore expected to be more influential than in contexts with already more environmentally-conscious citizens (Tschötschel et al., 2021).²⁷ Replicating information experiments outside of the U.S. context, especially in least-likely cases, could accordingly greatly contribute to a more general understanding of how information provision affects recipients.

Alongside other Western countries, Switzerland still has a long way to go, despite having committed to becoming carbon-neutral by 2050. Currently, Switzerland’s ecological footprint is disproportionately high (i.e. two and a half planets Earth would be needed if every country used resources like Switzerland currently does) (Federal Statistical Office, 2024) and the country lags behind its stated goal to fulfil the Paris Agreement goals (Climate Action Tracker, 2023b). Unsurprisingly, the repeatedly emphasised need to accelerate the energy transition has also led to increased salience of the topic in Switzerland. This not only becomes evident due to natural occurrences such as adverse impacts of climate change (e.g. extreme floods, heatwaves or the rapid retreat of glaciers) but also socially in the “Fridays for Future”- or “Last Generation”-movements. Further, it is mirrored in the unprecedented vote gain of green parties in 2019 as well as the recent amount of popular votes on the matter: Starting in 1908, 7 out of the 27 votes on an energy-related issue took place since 2015, out of which three were supported at the ballot (see Swissvotes, 2024).²⁸

In light of this increased environmental awareness, the new energy law, the Energy Act 2017, laid the groundwork for becoming carbon-neutral by 2050 by naming the cornerstones of the Swiss energy transition as boosting energy efficiency, saving energy, increasing the share of renewable energies as well as phasing-out nuclear energy (The Federal Council, 2016). Despite these attempts to tackle the energy transition more seriously, the situation became even more serious after the start of the Russian war on Ukraine, which reiterated the need to become more energy-independent for many countries. Switzerland is no exception in this aspect, as in 2022, 70% of its energy demand had to be imported, with most of it being fossil fuels (Swiss Federal Office of Energy, 2023). Pressure to become more energy-independent and carbon-neutral has been mounting, and the insufficient actions against climate change undertaken by Switzerland have recently also been denounced by the European Court of Human Rights (ECtHR). The court has

²⁷ In Germany, for example, effects of scientific consensus information provision (see Chapter 1.3.2 for further explanations) were insignificant for policy support (Tschötschel et al., 2021). However, since Switzerland differs from Germany in the sense that science is not as politically prominent, this still calls for replication.

²⁸ The three supported proposals were the Energy Act (2017), the Climate and Innovation Act (2023) and the Act on a Secure Electricity Supply from Renewable Energy Sources (2024) (Swissvotes, 2024).

ruled in favour of a complaint by the association “Schweizer KlimaSeniorinnen” (“Swiss climate seniors”), who feared endangerment of human lives owed to progressing climate change. Even though the sensational verdict caused a massive public outcry in Switzerland due to perceived international interference, it is likely to set a precedent for other states as well to hereafter having to improve their climate policies (see e.g. KlimaSeniorinnen, 2024; Humanrights, 2024; SRF, 2024). This combination of high public awareness and conducive external circumstances seems to offer a good window of opportunity for further environmental policy-making.

In short, Switzerland faces substantial obstacles such as a lack of social acceptance to implement further and more stringent measures to mitigate climate change. Therefore, identifying the factors which, on the one hand, shape public opinion towards social acceptance of various energy technologies and policies and, on the other hand, studying whether and how information manages to change societal support thereof could not just benefit Swiss policymakers but also give insights to those elsewhere.

1.6 Overview of the thesis

With this thesis, I work towards gaining a deepened understanding of what opinions, preferences and behavioural intentions currently exist and how they are changed by information provision in the broader context of the Swiss energy transition. I do this by building upon and connecting various strands of existing literature and by both collecting original and making use of secondary data. While the first two articles primarily look into how public opinion towards renewable energy projects is formed, the latter two articles identify how information leads to changes therein. This approach hence addresses the frequently voiced criticism that research often only focuses on either one of these two aspects, but rarely combines them in a more holistic way. I attempt to adhere to such criticism by analysing data from a single context, Switzerland, where the investigation of (political) attitude formation and change is especially warranted due to the country’s pronounced direct democracy. By capturing various public opinions in the field of energy politics, I want to point out how the energy transition could be further advanced, given the technological possibilities and the (socio-)political will to do so. In short, I contribute to research by giving a clearer picture about publicly-supported energy policies and technologies and how different forms of framing and information provision affect social acceptance thereof (see also Figure 1.1 for an overview of this dissertation’s framework). The following chapters summarise the four articles, providing an initial overview of this cumulative dissertation.

1.6.1 Involving tenants in citizen-financed PV projects – An analysis of conjoint and framing experiments in Switzerland

The first article was recently resubmitted to *Energy Research & Social Science* (Brückmann et al., 2024) and is co-authored by G. Brückmann and I. Stadelmann-Steffen.

Motivated by the need to find both technologically feasible and socially accepted ways to combat climate change, we investigate social acceptance of citizen-financed photovoltaic (PV) projects. These are co-founded clusters of solar panels that are provided by a supplier and offered for investments. As conventional solar PV installations are typically restricted to homeowners, we look into this alternative form of solar energy production that also allows tenants to contribute to the transition of the Swiss energy system. The inclusion of tenants is critical, as their population share in Switzerland amounts to about 60% (Eurostat, 2023), previously excluding a large majority from contributing to climate change mitigation. We therefore experimentally investigate which project factors are positively evaluated by tenants, and how different frames (climate change vs. electricity supply, individualistic vs. collectivist) of citizen-financed PV projects influence their project evaluation. The conjoint experiment encompasses five project factors, which were identified following consultation with experts and a review of the relevant literature. These factors are: Price per module, form of reimbursement, project provider, project location and purchasing modality. In each of the five project comparisons, two hypothetical projects were generated, wherein each of the project attributes' levels were randomly combined. Then, these two projects were opposed to each other and shown to respondents, who first of all had to choose one of the two projects, then decide how many modules they would want to buy and lastly, independent of their purchasing intention, evaluate each of the two projects separately. This created three dependent variables, with project rating operationalising socio-political, and project choice and the number of modules representing market acceptance.

Using novel data from the SWEET-EDGE survey (Stadelmann-Steffen et al., 2022a) from fall 2022, we find that tenants prefer projects that have a material form of reimbursement, a local or public project provider and locally installed projects. This is primarily important for project choice and rating, however, project design barely matters for market acceptance, i.e. investment intention. We further show that respondents' ideological predispositions matter for socio-political acceptance: Respondents who are concerned with energy supply rate projects more favourably when presented with a framing treatment that highlights the citizen-financed PV projects' contribution to secure electricity supply. Moreover, framing these projects as a collective opportunity increases the number of chosen modules, i.e. market acceptance, for politically right-leaning persons. Overall, our findings indicate that providing respondents with targeted communication increases one form of social acceptance, respectively, but also that efforts are needed to make citizen-financed PV projects attractive for different population segments if the promising potential of such projects is to be fully exploited.

1.6.2 Going solar? Unveiling the role of knowledge in shaping social acceptance of citizen-financed PV projects in Switzerland

The second article is single-authored and currently under review in *Utilities Policy* (Ruprecht, 2024). Earlier manuscript versions were presented and discussed at two workshops and two conferences.

Similarly to Article 1, and by using the same dataset and conjoint set-up, this study investigates the role of citizen-financed PV project design on socio-political and market acceptance. However, the research question now focuses on the general Swiss population as well as on the role played by (prior) knowledge. Regarding the latter, I examine both education as a more abstract and past experience with solar PV as a more concrete dimension of knowledge. The relevance of studying knowledge primarily lies in its many benefits for democracy (e.g. conscientious voting behaviour (Singh and Roy, 2014)), society (e.g. political tolerance (Hall, 2018)) and the environment (e.g. pro-environmental behaviour (Kronrod et al., 2023)). As effects are seldom universal, subgroup analyses have also been suggested by Leeper et al. (2020) or Vuichard et al. (2021), for example. Accordingly, the analyses of various knowledge subgroups intend to find the potentially different social acceptance of citizen-financed PV project design. Policymakers and project providers therefore have to target certain population groups specifically, depending on their degree of (prior) knowledge.

For the full sample, the attributes of reimbursement, location and provider matter most for social acceptance. But results heavily vary depending on the concreteness of knowledge and the dimension of social acceptance: Irrespective of project attribute levels, for socio-political acceptance (project rating), higher education always leads to more favourable ratings, which is only partly true for more experience. For market acceptance (number of chosen modules), both higher education and more experience with solar PV generally lead to higher willingness to invest. For the second variable measuring market acceptance (project choice), results are less straightforward. More education or experience sometimes leads to positive, insignificant or negative project acceptance, depending on the project attribute level. From these findings, I conclude that, depending on the stage of the investment process (i.e. binary decision of investment vs. project evaluation and investment share), other factors seem to be relevant, depending on the knowledge-subgroup under question. This also goes to show that, when analysing knowledge, its operationalisation matters. From a practical point of view, for those less educated or experienced, information campaigns might be essential to get them involved in the first place. Highly educated respondents might benefit from a reduction of bureaucratic hurdles due to their pre-existing openness to such projects. One could also learn from those with project experience, as they might provide a “best practice” model for providers to see what truly matters to investors.

1.6.3 The role of vote advice application in direct-democratic opinion formation: an experiment from Switzerland

The third article was published in *Acta Politica* (Stadelmann-Steffen et al., 2022b) and is jointly written with I. Stadelmann-Steffen and H. Rajska.

This article focuses on the use of a vote advice application (VAA) and whether and how it manages to change users' opinion on Switzerland's new Energy Act (EnA). VAAs are a decision aid that provide voters with personalised information about their position, compared to parties or, in this case, a policy issue (Neijens and de Vreese, 2009). For ballot proposals that result in a yes/no-vote, a lot of pros and cons have to be weighted first, which renders decision-making a complex process. VAAs might facilitate this process and help increase participation in the ballot vote. Theoretically, both the use and the message of a VAA can be consequential: Using a VAA has been shown to affect people's opinion (Ladner, 2012; Luskin et al., 2002), as it supports opinion formation, thereby reducing the share of undecided voters. The message of a VAA can also have persuasive effects. This is the case when the provision of new information, in this case the voting recommendation, affects the voting intention, either for previously undecided or differently-minded voters. Furthermore, intensifying effects take place when the VAA affirms the user's original vote intention.

Whereas most VAA-research looks at the electoral context, only few examine the role of VAAs in users' direct-democratic opinion formation. Panel data was collected in Switzerland during the EnA referendum campaign in 2017, where, in the last wave, a VAA-experiment was implemented, where a treatment group received VAA-input and the control group did not see the VAA-part of the survey. Treated users first had to answer questions on their agreement with the objectives of the new law, which resulted in a personal score from 0 to 100. Next, users had to indicate whether the VAA-result was in line with their original voting intention. Our analyses show that, after the VAA-use, the share of undecided voters was smaller in the treatment than in the control group (use-effect). Additionally, we find evidence for message-effects, since consulting a VAA had both a persuasive and an intensifying effect, as it managed to change as well as strengthen voters' pre-existing voting intentions. The persuasive effect primarily appeared for previously undecided users. In summary, we conclude that VAAs manage to ease citizens' opinion formation by decreasing uncertainty, thus increasing their likelihood of participating in the final vote.

1.6.4 Bridging the gap: The influence of information and education on acceptance of environmental taxes in Switzerland

The fourth article is single-authored and was published in *Environmental Research Communications* (Ruprecht, 2023).

This article questions whether information about environmental taxes can change recipients' willingness to pay them. Practical implications of this study are potentially momentous, as environmental taxes are deemed very effective in changing polluters' behaviour (Goulder, 1995; Fremstad et al., 2022; Rafique et al., 2022), thus being a relevant policy tool in the scope of the energy transition. However, due to their visible costs, they are very unpopular (e.g. Leiserowitz et al., 2021; Umit and Schaffer, 2020), and changing their public perception remains challenging. Previous research on information effects has produced very heterogeneous results, warranting an investigation into the matter in the field of environmental taxes. One consistent finding is that a lack of knowledge about how such taxes work contributes to low support (Sturgis and Allum, 2004; Leiserowitz et al., 2021). Arguing along the lines of the information deficit model (see e.g. Nisbet and Scheufele, 2009; Rowan et al., 2021; Sturgis and Allum, 2004), I theorise that the distribution of environmental tax information increases individuals' knowledge about and accordingly their support for these taxes. I also set forth that previous research inconsistencies might be explained by analysing different population subgroups, which is a hitherto underutilised opportunity to scrutinise the data in more detail. Since not everyone might profit similarly from additional information, I investigate subgroups with varying levels of abstract knowledge, i.e. differently educated individuals. Apart from the environmental benefits if more such taxes were implemented, positive effects would also bear socially important implications: Following Robert Dahl's (1989) enlightened understanding of democracy, a lack of information or knowledge about a matter becomes problematic whenever people change their opinion if presented with more information.

By analysing MOSAiCH 2020 panel data (Staehli et al., 2021), I am able to identify a causal information effect on willingness to pay environmental taxes. However, this effect does not appear in the full sample. Instead, my analyses indicate that only treating less educated individuals with information about environmental taxes results in significant increases in their support for such taxes. Therefore, targeting certain groups with specific information renders information campaigns much more effective (see also Bareinz and Uebelmesser, 2020). In this case, providing less educated citizens with more information about how environmental taxes function might prove crucial to gain their political support, as this might well be the population group that could tip future votes in favour of the environment.

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2 Article 1: Involving tenants in citizen-financed PV projects – An analysis of conjoint and framing experiments in Switzerland

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Abstract

Solar photovoltaics (PV) on rooftops and existing infrastructure are a cost-effective and widely accepted technology that plays a crucial role in the energy transition. However, individual installations of PV systems are limited to property owners, excluding most tenants. This study focuses on a more inclusive type of PV, i.e. citizen-financed PV projects (CiFi PV), and experimentally examines their social acceptance, distinguishing between socio-political and market acceptance. We study design and framing of CiFi PV to make them appealing to tenants, while also considering the moderating role of individual predispositions. Our survey experiment of 1674 tenants shows that projects with material reimbursement, a public or community provider, and proximity to local infrastructure are more likely to be accepted and preferred. However, it also reveals that project design cannot explain concrete investment intentions. Furthermore, while ideological predisposition has a strong influence on socio-political acceptance, targeted communication can enhance the willingness to invest in CiFi PV among those with lower propensities to invest. Most importantly, a promising way to promote individual tenants' investment in renewable energy is to communicate about CiFi PV while emphasising the collective dimension of the energy transition. This approach has the potential to increase the investment intentions among right-leaning individuals, while it does not appear to significantly deter left-leaning and centrist individuals.

Keywords: Solar PV, Energy Security, Climate Change, Social Acceptance, Citizen-Financed PV Projects, Willingness to Invest

2.1 Introduction

With climate change impacts becoming more and more visible, accelerating the energy transition and moving away from fossil energy becomes ever more pressing. One important lever to accelerate the energy transition is to better exploit the potential of renewables in general and solar power through photovoltaics (PV) in particular (International Energy Agency, 2024; Heinisch et al., 2023). PV is deemed to play a crucial role in that process (International Energy Agency, 2023) with still great potential for expansion globally (Korfiati et al., 2016) and in the country of study, Switzerland (Trutnevyte et al., 2024; Swiss Federal Office of Energy, 2019). Moreover, PV deployment at the household level makes individuals not only electricity consumers but also producers, which has positive spillovers, such as increased engagement with and acceptance of other renewable energy projects (Peters et al., 2018).

Against this background, extensive research has investigated the drivers and barriers to residential PV adoption, particularly focusing on homeowners' investment decisions (e.g. Uz and Mamkhezri, 2024; Makešová et al., 2023; Neumann et al., 2023; Alipour et al., 2021; Bach et al., 2020; De Groote et al., 2016; Mundaca and Samahita, 2020; Schulte et al., 2022). However, this focus on residential PV and related research on homeowners excludes a considerable part of the population, namely all those who do not own their home. This, in turn, has several implications. First, from a research perspective, the previous focus on homeowners (see e.g. Schulte et al., 2022, for a meta-analysis) implies much less is known about other individuals' PV preferences and the factors that drive their investment behaviour. Second, from a societal perspective, especially in country contexts where home ownership rates are relatively low, the potential of PV adoption at the household level is naturally limited. This not only has technical consequences but also means that a substantial part of the population is not addressed in efforts to increase renewable energy production. This may lead to feelings of being left out in the process and, consequently, to a lower propensity to accept and support measures related to the energy transition. For societies aiming to increase the supporting coalition behind the energy transition, the question arises as to how to get this important group “on board” (Brückmann et al., 2023).

In this context, *citizen-financed photovoltaic projects (CiFi PV)* present a less familiar yet promising avenue for inclusive participation and investment (Sierro and Blumer, 2024). Such CiFi PV are co-funded or crowdfunded by citizens, often consist of a larger array of solar panels arranged by a supplier, are typically located in public or commercially-used areas, and can also include open-space installations, e.g. in agricultural or alpine areas (Sierro and Blumer, 2024). Due to their size, they are advantageous from a techno-economic point of view (Nuñez-Jimenez et al., 2023). As these projects are collectively funded by multiple private stakeholders, they are accessible to a wide spectrum of individuals as starting prices are low,¹ and particularly serve

¹ There are available offers in Switzerland starting at CHF 10 (approx. USD 11.33 as of March 15, 2024), see solarvignette.ch. In the experiment presented in this study, shared solar investments start at CHF 200.

residents who lack the opportunity to install solar PV on their personal property, such as tenants. Consequently, the CiFi PV studied here are characterised by offering an alternative avenue for individuals to contribute to transforming the energy landscape and fighting against climate change through their investment in decentralised domestic renewable energy generation. Despite research indicating similar acceptance rates for CiFi PV as for conventional PV (Stauch and Vuichard, 2019), currently, little is known about the conditions under which tenants find such large CiFi PV attractive to invest in.²

In the present study, we address and combine these important yet neglected dimensions of PV deployment and investigate the social acceptance of CiFi PV among tenants,³ thus focusing on those segments of the population who do not own their own homes, and who therefore represent an understudied social group in terms of their willingness to accept and invest in PV projects. It should be noted that this focus does not imply that CiFi PV projects are exclusively for tenants. Indeed, this type of PV project may also be appealing to some homeowners. In fact, these projects represent a relatively low-effort method of personally engaging in the energy transition, with a relatively lower level of financial investment.⁴ To illustrate, a homeowner may lack the financial resources to invest in a comprehensive PV installation on their roof but may be interested to contributing a smaller amount of money to a co-financed project. This example shows that, for both homeowners and tenants, involvement in such PV projects will not necessarily be a purely economic decision but may also be influenced by non-financial factors (Schall, 2020; Sloot et al., 2019; Strazzeria and Statzu, 2017). The study operates under the overarching assumption that, similar to conventional residential PV installations, the acceptance of and investment in CiFi PV may be driven by motivations beyond purely economic considerations (Braitto et al., 2017; Ebers Broughel and Hampl, 2018). One such motivation is ideological, i.e. the motivation to contribute to renewable energy production and mitigate climate change. A second motivation concerns risk reduction when such CiFi PV are regarded as a means to increase energy independence and security of energy supply (see e.g. Tobler et al., 2012, p. 206).⁵ The design and set-up of CiFi PV may thereby speak differently to such diverging motivations and attract different people. Using different frames, we will reinforce individual ideological predispositions to examine how to

² To the best of our knowledge, only one other study explicitly focuses on (urban) tenants in the context of PV projects (Koch and Christ, 2018). We depart from them by using large-N data as well as including rural tenants.

³ While the group under investigation in this paper also includes individuals living in cooperatives, the crucial characteristics for inclusion is that they do not own the house or the apartment in which they live. We will, henceforth, refer to them as *tenants*.

⁴ Investment in CiFi PV can be conceptualised as low-frequency, high-cost behaviour (Karlin et al., 2014). However, relative to investing in a comprehensive PV installation on one's own roof, the amount of money spent on the co-funding will be typically much lower. Moreover, given that the engagement in CiFi PV is largely limited to just paying, we consider the overall effort as rather low.

⁵ We acknowledge that besides financial aspects (e.g. Fleiß et al., 2017), other non-economic motivations such as environmental protection (e.g. Braitto et al., 2017) or positive attitudes towards renewables (e.g. Ebers Broughel and Hampl, 2018) might also be influential. However, due to our experimental design, we deliberately focus on climate change and energy supply motivations, which are currently, and especially since the Russian attack on Ukraine, dominating issues in public discourse.

communicate these projects to the diverse population of tenants. These considerations lead to two interconnected research questions:

1. *How should CiFi PV be designed for high social acceptance, especially socio-political and market acceptance, among tenants?*
2. *What role do ideological predispositions and different project frames play for tenants' social acceptance of CiFi PVs?*

This study adds valuable contributions to the existing body of research in the following respects. Firstly, it sheds light on two hitherto overlooked aspects of PV acceptance: the realm of CiFi PV and the (financial) involvement of tenants in their realisation. Secondly, while previous research has demonstrated that financial incentives are one of the primary drivers of CiFi PV investments with ideological factors assuming another important role (Fleiß et al., 2017), this study contributes to a deeper understanding of the latter. In line with Bhushan et al. (2018), we focus on *why* specific frames work, e.g. how they reinforce individual ideological beliefs. Lastly and finally, the study generates new insights into which designs and types of CiFi PV are acceptable and attractive to a large and diverse group of people. This knowledge is essential for policymakers and CiFi PV providers to design projects and associated communication strategies that effectively engage energy end-users in the energy transition.

Empirically, we focus on the case of Switzerland, a country with a substantial share of tenants, and use original survey data collected in fall 2022. In the survey, we conducted a choice experiment to evaluate which types of CiFi PV appeal to tenants. By distinguishing between general project acceptance and individual investment intention, we follow recent recommendations (Peñaloza et al., 2022, p. 2) and evaluate different forms of social acceptance (Wüstenhagen et al., 2007; Dermont et al., 2017). Moreover, we integrated a split-ballot design to assess the role of varying project frames (e.g. Chong and Druckman, 2007), intended to activate certain individual predispositions.

2.2 Theoretical background

2.2.1 Conceptualising social acceptance of shared PV projects

Social acceptance of renewable energy sources and technologies has been extensively examined in prior research (e.g. Cousse, 2021; Mayer et al., 2021; Plum et al., 2019; Stadelmann-Steffen et al., 2019; Tabi and Wüstenhagen, 2017; Vuichard et al., 2019, 2021, 2022; Baur et al., 2022). The comprehensive concept of social acceptance (Wüstenhagen et al., 2007) encompasses three dimensions: socio-political, community and market acceptance. Previous research has predominantly centred on socio-political acceptance, with relatively limited attention given to studying market

acceptance of renewable energy infrastructure, and thus to consumers and investors (Wüstenhagen et al., 2007).

Existing evidence indicates that socio-political acceptance tends to be higher than other dimensions of acceptance, as the former primarily involves respondents’ general approval without the need for concrete implementation (e.g. Baur et al., 2022) or investment in the renewable energy technology. This trend has been substantiated in the context of large-scale PV as well (Schumacher et al., 2019; Trandafir et al., 2023; Pascaris et al., 2021).

Drawing from these considerations, we conclude that different aspects of social acceptance mean different things and can be shaped by varying factors and mechanisms. Therefore, analysing different types of social acceptance is crucial in gaining a deeper understanding of “true” social acceptance of CiFi PV and its triggers. Here, we examine the antecedents of market acceptance, i.e. *stated willingness to invest* in CiFi PV and *project preferences*, as well as broader socio-political acceptance, conceptualised in terms of general *project acceptance*. The upper part of Figure 2.1 illustrates our conceptualisation.

We argue that socio-political acceptance and investment intentions are individual decisions and considerations in the first place. However, they are also strongly driven by the specificity of a given project. Therefore, in Section 2.2.2, we discuss how varying *project designs* affect tenants’ interest in CiFi PV. Moreover, social acceptance of and willingness to invest in these projects may not only depend on how they are designed but also on how they are advertised to tenants. In Section 2.2.3, we thus delve deeper into how *project framing* may reinforce tenants’ underlying ideological predispositions, namely, how their motivations and political ideologies moderate framing effects (see lower part of Figure 2.1 for an overview).

2.2.2 The role of project design

The way CiFi PV are designed may resonate differently with various people, attracting different individuals based on their underlying preferences and the concrete project design. Here, we focus on tenants and their preferences for CiFi PV project design.

We opt for an explorative approach. Thus, our research design is based on previous research and expert interviews.⁶ This enables us to derive broad expectations about different design dimensions, while we refrain from formulating explicit hypotheses about specific PV project design characteristics.

One relevant project characteristic is the way in which investors are **reimbursed**. We lean on the crowdfunding-literature, which distinguishes between two forms of reimbursement, non-financial

⁶ see Appendix 2.7.6

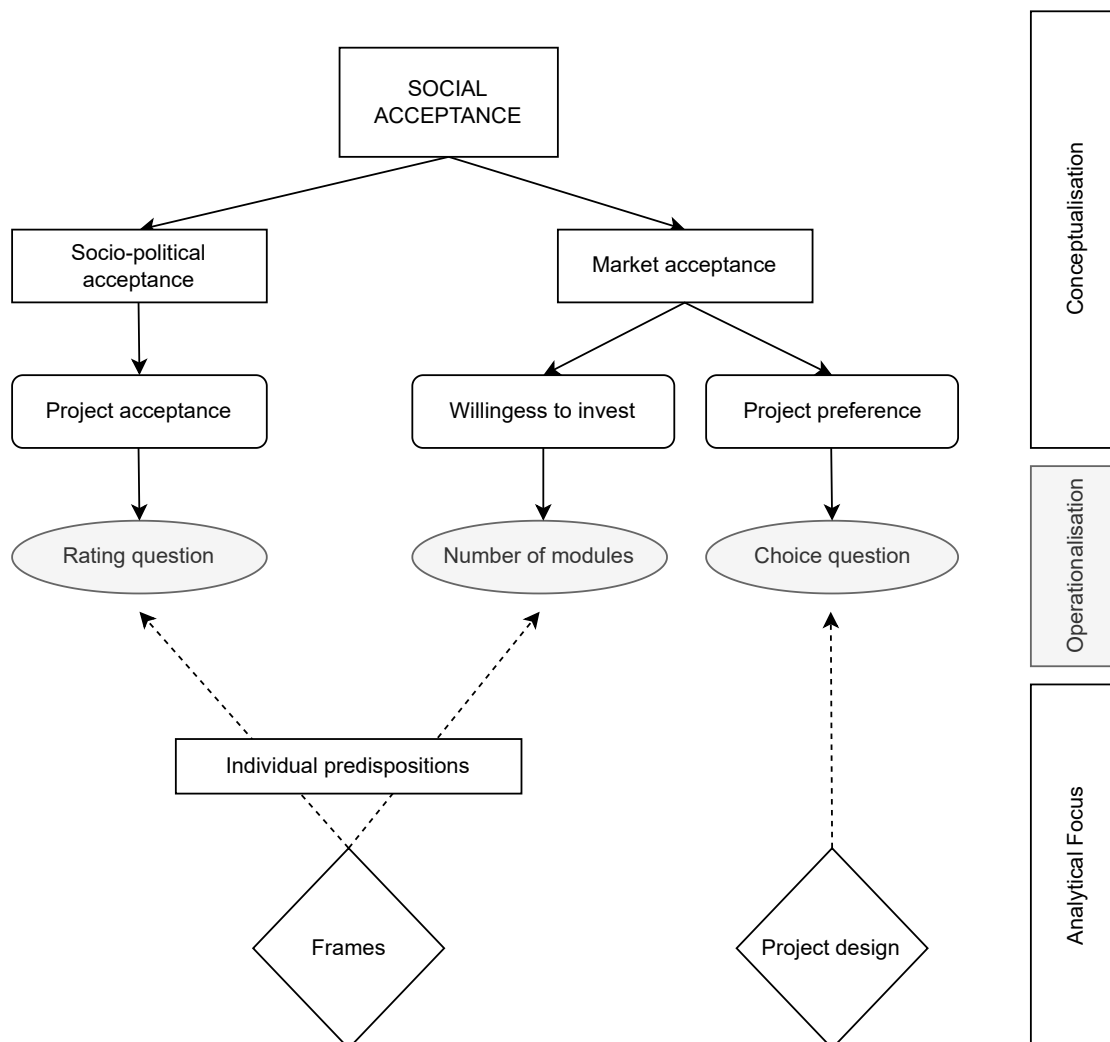


Figure 2.1: Conceptualisation of social acceptance of CiFi PV projects

We study two dimensions of social acceptance, namely socio-political acceptance and market acceptance. Oval shapes indicate operationalisations (see Section 2.3). Diamond shapes indicate experimental features (randomised elements) and how they are used to study social acceptance of CiFi PV in this analysis. For more information about the integration of this conceptualization into the survey, see Figure 2.2.

and financial. While the first encompasses donations (no compensation) or non-monetary rewards, the latter includes lending (paybacks, interest payments) and equity (shareholder profits) (Bonzanini et al., 2016). Despite the fact that CiFi PV often do not pay off financially (or only in the long run (Reinsberger and Posch, 2016)), it can be assumed that visible, i.e. typically material and financial, “benefits” (Stadelmann-Steffen and Dermont, 2018) that compensate the investment costs may positively affect tenants’ acceptance of CiFi PV. However, project investors might also receive immaterial and symbolic (i.e. non-financial) reimbursement, e.g. a solar vignette. Schall (2020) for example finds positive effects of “psychic returns”, e.g. positive feelings from an investment, on willingness to invest in a renewable energy project. While such reimbursement might be a valid “compensation” for those with strong climate change attitudes or for those who generally support climate change mitigation (Bell et al., 2005; Gustafson et al., 2020), on average, immaterial reimbursement might be less likely to increase individual investments. For CiFi PV specifically, Trandafir et al. (2023) also conclude that private financial reimbursements are preferred over collective benefits. Moreover, Du et al. (2024) show that even costs matter less than revenue for most respondents. Based on this discussion, we argue that material reimbursement such as a payback via the electricity bill is the most visible and obvious benefit that moreover is relevant for most tenants.

The **location** of renewable energy infrastructure has repeatedly been shown to strongly influence their social acceptance (Betakova et al., 2015; van der Horst, 2007; Tabi and Wüstenhagen, 2017; Walter, 2014; Sherren et al., 2021), leading to uneven spatial distributions with potential associated costs (see e.g. Thormeyer et al., 2020; Wen et al., 2023). Generally, PV projects in highly valued locations such as untouched nature and landscapes generate more opposition. While the NIMBY phenomenon has been found to be too simplistic of an explanation for lacking acceptance (Wolsink, 2000; Devine-Wright, 2011), and two studies even emphasise investors’ expressed importance of regional or local power production (Koch and Christ, 2018; Peters et al., 2018), infrastructure that is close by someone’s place of living is more likely to be rejected (see Kaenzig et al., 2013; Mayer et al., 2021; Plum et al., 2019; Swofford and Slattery, 2010). In the same line, agricultural zones, roads or former military sites are preferred over residential zones (Stadelmann-Steffen and Dermont, 2021). Thus, the location of CiFi PV likely affects tenants’ acceptance and investment intentions.

One aspect thus far not empirically studied are **provider** characteristics. We agree with Chan et al. (2017) that project characteristics such as ownership, management and enrolment options may, however, play an important role in individual investment decisions. The CiFi PV could be supplied by private companies of different sizes, by local energy providers, clubs or a municipality. Following Hammerle et al. (2021), Firestone et al. (2009), Stadelmann-Steffen and Dermont (2021) as well as Warren and McFadyen (2010), we expect public suppliers to be most preferred, e.g. over banks or other private providers. One reason is that the Swiss energy system is still not fully liberalised. Hence, public providers of electricity services are basically the type of provider citizens are used to. Moreover, given that the management of shared PV production

has a community dimension, it can be expected that public providers are perceived as more trustworthy in their management (see also Blank (2000) for a similar argumentation with respect to the provision of social services). Similarly, local energy providers, local civil society initiatives (e.g. cooperatives, clubs or associations) as well as local firms are likely preferred due to their proximity (Sagebiel et al., 2014).

2.2.3 The role of project framing

Framing, i.e. to “select some aspects of a perceived reality and make them more salient in a communicating text, in such a way as to promote a particular problem definition, causal interpretation, moral evaluation and/or treatment recommendation” (Entman, 1993, p.52), has long been used as a communication strategy, i.e. in politics or marketing. In the context of renewable energy expansion, evidence suggests that support for renewable energy is highest when framed in an “energy security”-way, followed by climate change and, lastly, economic opportunity frames (Lockwood, 2011). Spence et al. (2014) present similar results: Framing energy reductions in terms of CO₂ savings motivated participants to save energy and to donate to climate change related charities.

Investments in local renewable energy projects can also be framed in different ways (Djerf-Pierre et al., 2016), which likely affects the social acceptance of CiFi PV. Since investing CiFi PV is rather novel or at least less known to the broad public, framing effects might be particularly strong, as they have been found to matter most for new pro-environmental behaviours (Kronrod et al., 2023). Hence, the central assumption is that how a project is framed influences its social acceptance among tenants. Thereby, whether and how individuals react to specific frames is contingent upon their predispositions, namely their underlying motivations and political ideologies (e.g. Bourcet and Bovari, 2020). In line with Wolske et al. (2018, p.1) and his argument of “tailoring messages to targeted consumer segments”, we expect frames that match a person’s motivation or political ideology to activate their willingness to act, i.e. to invest in CiFi PV.

We distinguish between four frames, which combine two different dimensions: climate and environment vs. energy transition and energy supply, as well as individualism vs. collectivism. The first dimension distinguishes between framing PV projects as a way to contribute to renewable energy production in order to mitigate climate change, on the one hand, and conceiving such projects as an investment to increase energy independence and security of energy supply, on the other (see, e.g. Tobler et al., 2012). As stated in Section 2.2.3, this frame is derived from existing research. We refrained from introducing another frame for economic benefits, as this has either been shown to be irrelevant for climate policy support (Bernauer and McGrath, 2016), pro-environmental intrinsic motivation (Steinhorst and Klöckner, 2018) or willingness to invest in a renewable energy (RE) crowdfunding (Bourcet and Bovari, 2020). Others even find it capable of dampening a pre-existing pro-environmental motivation (Ling and Xu, 2021). Taking up

the idea that frames can reinforce underlying personal motivations, we discuss these two frames with respect to two individual motivations, i.e. whether individuals prioritise climate change as a societal problem or whether they perceive the energy issue as the main problem. This idea is in accordance with Romero-Castro et al. (2021), who determined that RE project investment decisions are complex.

As a second frame dimension, the distinction between individualism and collectivism is considered. These perspectives assign different responsibilities for problem solving, and accordingly, co-investment in PV projects is either framed as an individualistic or a collective act (Bouman et al., 2021; Walker et al., 2014) (see Section 2.2.3). As understandings about collectivism and individualism are strongly related to political ideology (Ballew et al., 2020; Choma et al., 2020), we discuss these frames with respect to individual left-right self-placement.

The next subsections present a more detailed discussion about how the different frame dimensions and frames are expected to affect the taste for CiFi PV contingent on individual motivations and political ideologies.

Climate vs. energy

As established by extensive research, individuals who hold strong concerns about climate change have consistently demonstrated the highest levels of support for RE initiatives (Bornstein and Lanz, 2008; Bourcet and Bovari, 2020; Carlisle et al., 2015; Conradie et al., 2021; Karlstrøm and Ryghaug, 2014; Thalmann, 2004; Unsworth and Fielding, 2014). These individuals are most likely to prioritise climate change mitigation as a political problem (Stadelmann-Steffen and Thalmann, 2021) and, therefore, solutions that directly target this problem may mobilise these individuals most. Accordingly, framing CiFi PV as a contribution to climate change mitigation is expected to further reinforce these individuals' likelihood to co-invest in PV projects. Conversely, individuals who do not perceive climate change as a pressing issue are not likely to be mobilised by such a frame.

Hypothesis 2.1 *Individuals with a strong climate change motivation are most reactive to the climate change frame, i.e. this frame generates the strongest positive effect on these individuals' socio-political acceptance and willingness to invest, compared to other frames and other groups of individuals.*

In contrast to climate change and environmental protection, energy issues and mainly questions related to the electricity supply are important issues also for individuals who do not prioritise climate change mitigation but are motivated by concerns about energy security. Framing CiFi PV as energy supply projects rather than a climate benefit may be a better argument to motivate these individuals for co-investments in PV projects (see Olson-Hazboun et al., 2016; Reinsberger and Posch, 2016).

Hypothesis 2.2 *Given the electricity supply framing, individuals who prioritise concerns about energy security are more likely to accept and to co-invest in CiFi PV.*

As individuals with a climate motivation are likely to have a generally higher propensity to co-invest in renewable energy projects (Cohen et al., 2021), and since we expect other individuals to react more strongly to the electricity frames, Hypothesis 2.2 implies that group differences in the acceptance level will be lower with these frames compared to the climate change frames.

Individualism vs. collectivism

Climate change policy is often cited as a prime example of where collective action is required, but also where individual cost-benefit considerations generate barriers to successful implementation (Ostrom et al., 2010; Smith and Mayer, 2018). Previous research provides varying references to how the individualistic or collective dimension affects individual climate change attitudes and behaviour. One side suggests that communicating community benefits yields the highest scores of societal RE technology acceptance (Walker et al., 2014), thus arguing in favour of the collectivist frame. Similar results are found in Clayton (2018), where collective policy framing enhances acceptance of environmental policies or in Stevenson et al. (2018), who show that community frames lead to more environmentally-friendly individual behaviour. Further pointing to the potential relevance of collective action, recent studies show that social framing (instead of environmental framing) (Klein et al., 2022) enhances pro-environmental behaviour. Such effects also seem to matter a great deal when collective losses are addressed, i.e. framed (Selena Krishen et al., 2014). From the individual perspective, it is assumed that individuals with collective norms and attitudes are more likely to support and take climate action (Smith and Mayer, 2018). Moreover, Bolsen et al. (2014) expect that frames emphasising individual responsibility for the collective outcome make individual action more likely – especially if they are met with according individual values.

Based on these arguments, we expect that frames emphasising either the individualistic or the collective dimension of co-investment in CiFi PV projects will affect individuals in different ways, contingent on their underlying motivations. In contrast to the climate vs. energy framing, the individualistic vs. collectivist framing may interact with respondents' general political attitudes. More specifically, while a left-wing political position typically assigns more responsibility to the state (as the prototypical collective actor) and welcomes state intervention to solve societal problems, right-wing liberal political positions more strongly emphasise individual liberties and responsibilities (Ballew et al., 2020; Stadelmann-Steffen, 2011).

The placement of centre positions in this respect is less clear-cut (Hess and Renner, 2019). On the one hand, the catholic tradition, which has strongly influenced the political positions of the conservative parties at the political centre, takes an anti-state stance and highlights the concept

of subsidiarity of state intervention (Castles, 1994). On the other hand, the latter puts strong emphasis on collective action at the level of civil society, i.e. the family or associations. We argue that the latter may be particularly relevant with regards to co-investment in CiFi PV, which closely fits the type of collective action that centrist or conservative values speak to. Following Bolsen et al. (2014), who, in their argument, refer to the American culture, in which the value of individualism is deeply entrenched, we argue that the same logic can be applied to ideological differences within Switzerland. Namely, we expect that frames that match the values entrenched in different ideological positions will most strongly motivate individuals who exhibit the according ideological position.

Hypothesis 2.3 *Left-leaning individuals as well as individuals at the political centre are more likely to accept and co-invest in PV projects if these projects emphasise the collective dimension, while individuals at the political right are more likely to accept and co-invest in these projects when the individualistic dimension is emphasised.*

Combining the two frame dimensions

The way the two previous subsections have been formulated implies that the two frame dimensions are conceptually independent.

However, this view can be criticised, as, empirically, strong climate motivation and leftist political ideology are strongly correlated. Based on this empirical perspective, it can therefore be expected that there is an overlap between the climate change and the collective frame. As the climate change issue is inherently global, i.e. collective, the combination of the climate change with the collective frame seems to be the most coherent and, therefore, should have particularly strong impact on social acceptance. Similarly, we argue that electricity supply may lead to personal energy shortage, which makes it more directly tangible for individuals, and thus more likely to also trigger the individualistic dimension.

We therefore formulate a last hypothesis:

Hypothesis 2.4 *The combination of the climate and the collective frame, or the combination of the electricity with the individual frame, is most successful in increasing socio-political acceptance of and willingness to invest in CiFi PV.*

2.3 Research design

2.3.1 Data

We analyse original data collected in the scope of the SWEET-EDGE project between August and October of 2022. After institutional ethical approval and pre-testing,⁷ a large-N population survey was fielded in Switzerland. This survey intended to capture a broad range of attitudes towards renewable energy, climate change and environmental policies (see the survey flow below in Section 2.3.2). In accordance with our pre-analysis plan,⁸ the Federal Statistical Office randomly drew addresses from their population register in order to create a representative sample. In the end, sample size amounted to roughly 4'500 respondents (approx. 40% response rate). For the present study, we focus, after minimal data-cleaning (see Appendix 2.7.6), on the sample of 1674 non-homeowners who completed the survey-embedded choice experiment. Descriptive statistics can be found in Appendix 2.7.1.

Switzerland is an ideal case for this study for several reasons: First, Switzerland is a typical case, as like most developed countries, it is currently in the process of transitioning its energy system by including more RE sources to meet international agreements. However, further improvements to decarbonise the energy system are still essential and the expansion of solar energy is presently said to have the most potential (Trutnevyte et al., 2024; Swiss Federal Office of Energy, 2019; Stadelmann-Steffen et al., 2018), but needs to be accelerated. Second, the country exhibits a very high share of tenants (roughly 58% of citizens do not own their house or apartment (Eurostat, 2023)), which is advantageous for analysing this subgroup based on survey data. While Switzerland has the highest share of tenants in Europe (Eurostat, 2023), other countries exhibit similarly high shares of tenants and, therefore, people who cannot install solar PV on own property. Moreover, due to Switzerland's strong participatory political culture, including several ballot votes on the energy transition over the last years, citizens in Switzerland are used to forming opinions on energy-related questions, which is likely conducive to providing valid responses in conjoint experiments (Dermont and Stadelmann-Steffen, 2020). Due to its cultural, linguistic, political and value-based diversity, findings from Switzerland can potentially also be extrapolated to other countries (see Rokkan, 1974).

2.3.2 Survey flow

Figure 2.2 depicts the parts of the survey flow and variables relevant for our study.

⁷ The pre-testing included qualitative testing with consortium members and a quantitative pre-test in a Swiss municipality.

⁸ Available at <https://doi.org/10.17605/OSF.IO/FT2RY>

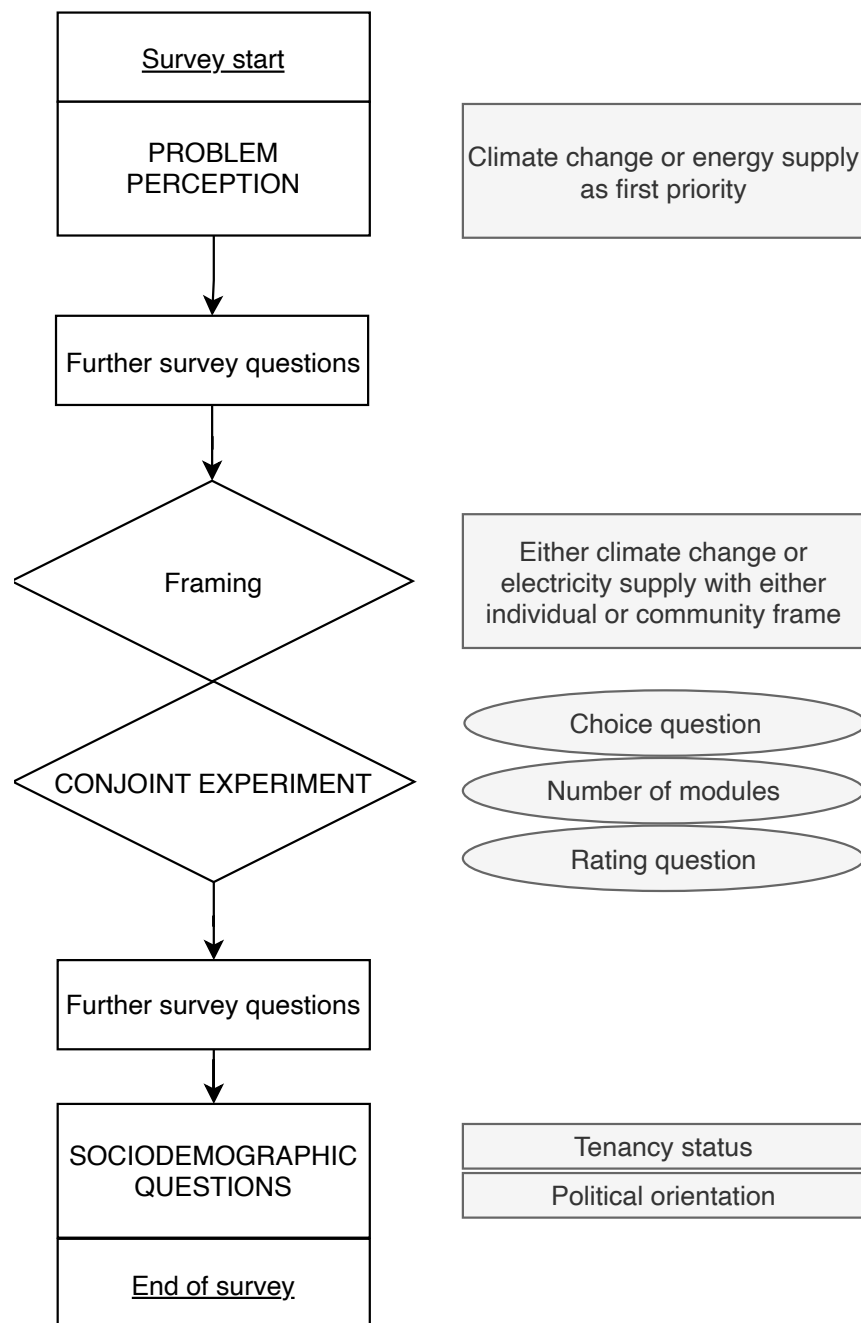


Figure 2.2: Survey flow

Depicted is the survey flow (on the left) as well as the relevant variables (on the right) that we use for the main analyses. The grey fields on the right link to the information on the relevant descriptive statistics provided below in Section 2.7.1.

The question used for capturing varying motivations was implemented to introduce respondents to the survey, which means that they cannot be influenced by the conjoint and framing experiment. The framing experiment was part of the introductory text to the conjoint analysis. Finally, following common practice, the relevant socio-demographic variables, e.g. tenancy status as well as political orientation, were placed at the end of the survey. While these variables could, thus, theoretically be affected by the framing and conjoint experiment, we consider this to be irrelevant with respect to tenancy status and very unlikely for political orientation, which captures a rather stable individual trait. In the following, we proceed with presenting the conjoint experiment in more detail, i.e. the central element of the study, followed by the framing experiment and the individual-level variables.

2.3.3 Conjoint module

A central element in the survey is a conjoint experiment, which enables us to analyse under which conditions, i.e. project designs, individuals are willing to invest in citizen-financed PV projects, combined with a split-ballot framing experiment, based on which we are able to test the influence of different framing conditions on acceptance of CiFi PV.

A conjoint experiment allows for the combined testing of various project attributes, which mirrors a more realistic setting than classic surveys, as respondents can make their decision based on multiple criteria (Auspurg and Hinz, 2014; Hainmueller et al., 2014). Moreover, respondents are randomly assigned to a series of different project configurations, which allows us to create “counterfactual” observations, i.e. we mimic a situation where the *same* individual is exposed to *different* project configurations.

The core idea of conjoint analysis is that respondents are confronted with several hypothetical CiFi PV, which they need to evaluate. We exposed each respondent to five such evaluation tasks, resulting in 16’740 observations in total (1674 tenants x 2 proposals x 5 tasks). The types of responses used most often are a choice (between two projects) and/or a rating (e.g. how favourable/unfavourable projects are rated). The projects are described by several attributes, whereby the concrete values of these attributes, called *attribute levels*, vary randomly between projects and respondents (Hainmueller et al., 2014). Our chosen attribute levels can be seen in Table 2.3.1. In line with current research on conjoint analyses, we randomly offered half the respondents the choice of abstention in the choice between the presented projects, since forced choice for either project can substantively distort estimates (e.g. Miller and Ziegler, 2022).

In terms of implementation, we use a fully randomised design with no restrictions. This not only allows for a nonparametric estimation of the causal quantities of interest (Hainmueller et al., 2014), but also implies that we do not need to exclude any options that might sound unrealistic today but could be feasible in the future (see also Yildiz, 2014). Besides the type of reimbursement, location and the provider of the projects, regarding which we have formulated theoretical

expectations, the project description additionally includes two further attributes (purchasing modality and price),⁹ and thus a total of five attributes (see Table 2.3.1). These as well as their corresponding attribute levels were carefully selected by collecting evidence from past literature as well as by consulting numerous experts involved in existing solar PV projects. Thus, they include relevant dimensions regarding the design of CiFi PV.

As elaborated theoretically, we aim at an encompassing perspective on social acceptance (Wüstenhagen et al., 2007), as displayed in Figure 2.1, and, therefore, include multiple dependent variables capturing the different aspects of social acceptance of CiFi PV. First, we asked respondents to choose one of the two presented citizen-financed solar PV projects for the investment (*choice question*). This first variable, therefore, captures a form of project preference (Dermont et al., 2017) and allows to analyse tenants' trade-offs between different project designs, as described in Section 2.2.2 and empirically used in Section 2.4.1. Second, we asked respondents how many modules they would be willing to buy from their chosen project (*number of chosen modules*), which indicates a stated willingness to invest. Third, we asked respondents to independently rate each of the two projects presented (*rating question*), i.e. regardless of whether they stated an intention to participate in it and thus capturing project acceptance (see Figure 2.3 for exact wording). The final two variables record *levels* of market and socio-political acceptance. Therefore, they serve as dependent variables for the framing experiment, as theoretically motivated in Section 2.2.3, described in Section 2.3.4, and empirically used in Section 2.4.2.¹⁰ Descriptive information for all dependent variables can be found in Appendix 2.7.1.

Conjoint analysis has been successfully implemented both in political science in general as well as in renewable energy contexts in particular (e.g. Brückmann and Bernauer, 2020; Kluge et al., 2021; Hainmueller et al., 2015; Leijten et al., 2014; Zaunbrecher et al., 2017; Wicki et al., 2022). The five-fold repetition of project presentation leads to the creation of counterfactual observations, therefore causally estimating preferences for project attribute levels (Leeper et al., 2020). In line with current literature, we calculate marginal means to describe effect size and direction. These “represent the mean outcome across all appearances of a particular conjoint feature level, averaging across all other features. In forced choice conjoint designs with two profiles per choice task, marginal means by definition average 0.5 with values above 0.5 indicating features that increase profile favourability and values below 0.5 indicating features that decrease favourability.

⁹ We include purchasing modality and price in the project comparisons to make projects as realistic as possible. One of the most robust findings in the research on social acceptance of RE infrastructure or measures is that individuals dislike costs, i.e. higher prices are associated with lower acceptance (e.g. Kotchen et al., 2017; Kubli et al., 2018; Stadelmann-Steffen and Dermont, 2021). Purchasing modality relates to the question as to how individuals learn about this investment opportunity and how simple it is to invest. Following participation and civic engagement literature, we expect that individuals need to be asked and motivated to get engaged (Brady et al., 1995; Stadelmann et al., 2010).

¹⁰ Project preferences, i.e. the choice between project A and B in a choice task, does not capture a level that might vary between frames. We could only observe framing effects on project preference if we assumed that the frames selectively changed the relevance of specific project characteristics. However, we see no theoretical reason why this should be the case.

Table 2.3.1: Design of the conjoint experiment on CiFi PV

Attributes	Attribute levels
Type of reimbursement to respondent	• Credit voucher on the electricity bill (10 years guaranteed) • Mobility voucher, e.g. voucher for charging electric cars or using public transportation (10 years guaranteed) • One time tax deduction • Solar vignette (a proof of investment as a plaque, sticker or the like. 10 years guaranteed.) • The federal government pays the same amount into the old-age and survivors' insurance compensation fund. • The federal government pays the same amount to an energy project in a developing country.
Location of the solar power plant	• On a building in the residential municipality • On a farm • On traffic infrastructure in the residential municipality (e.g. noise barriers of highways and train lines, roofs of bus stops or train stations) • In a skiing area (e.g. avalanche barriers, ski lifts) • On a roof of a large consumer in the residential community (e.g. industry, school, indoor swimming pool)
Provider	• A local club or association • The electricity provider at your place of residence • The municipality of the PV plant • A start-up • A local farm • A large company
Purchasing modality	• Via a form sent by the project managers • During a meeting with project managers • Registration forms are available at retailer checkouts • Via web shop • Within the scope of an information event • Additional option when buying an electric appliance or electric car
Price per module	• 200 CHF • 250 CHF • 300 CHF • 350 CHF

Note: Bold attribute names are abbreviations.

Comparison 1 out of 5: Given these two projects, in which one would you invest?

	Project A	Project B
Provider	A large company	A local farm
Location of the solar power plant	On a roof of a large consumer in the residential municipality (e.g. industry, school, indoor swimming pool)	On a building in the residential municipality
Type of reimbursement to you	The federal government pays the same amount into the OASI compensation fund	The federal government pays the same amount to an energy project in a developing country
Purchasing modality	Within the scope of an information event	Via web shop
Price per module	200 CHF	300 CHF

Which project do you choose?

Project A ☐	Project B ☐
------------------------------------	------------------------------------

In how many solar modules with an area of 1 m² each of your chosen project do you want to invest? (please enter as number/s)

 module(s)

Regardless of whether you invest in these projects or not, would you support their implementation?

	Certainly reject	Rather reject	Neither	Rather approve	Certainly approve
Project A	☐	☐	☐	☐	☐
Project B	☐	☐	☐	☐	☐

Figure 2.3: Conjoint Screenshot

Example of the conjoint experiment as presented to respondents.

For continuous outcomes, marginal means can take any value in the full range of the outcome” (Leeper, 2020).

2.3.4 Framing experiment

To test our expectations that social acceptance of CiFi PV is contingent on project framing, we include a framing experiment around the conjoint experiment.

Before being presented with the five conjoint tasks, participants see an introduction page (see Figure 2.4), informing them about what their evaluation task and what a CiFi PV is. Moreover, depending on respondents’ random assignment to varying framing conditions, they received slightly different information about the benefits of investing in CiFi PV. The framing experiment had a 2x2 set-up, hence creating four frames by combining the scope of involvement (individual vs. collective) with two reasons for solar PV expansion (climate and environment vs. energy transition and supply), as displayed in Figure 2.4. This corresponds to a between-respondent design, where frames vary between respondents but not within respondent (i.e. each respondent evaluates all projects under the same frame).

We forced half of the respondents to stay on the introduction page for at least 15 seconds to test whether this would lead to stronger treatment effects. As the findings presented in the following do not differ between these two groups, we do not further consider this differentiation.¹¹

2.3.5 Individual variables

As we expect variation in social acceptance and varying framing effects among subgroups, we also include two further variables on ideological predispositions for our moderation analyses: political ideology, as operationalised by self-placement on the political left-right scale, as well as a person’s motivation. The left-right scale ranges from 0-10, and we code 0-4 as left, 5 as centre and 6-10 as right. A person’s motivation is operationalised based on their main perceived problem. Respondents were able to choose and rank their top priority from a list of 21 topics, as displayed in Appendix 2.7.2. We focus on those who prioritise “climate change” or “energy supply” and refer to these variable as “motivations” in our paper. As these two motivations are not necessarily mutually exclusive, we focus on the single issue a tenant views as the main societal problem at the moment. We operationalise them as two dummy variables capturing if the single issue viewed as the main societal problem is either energy supply (or any other) or climate change (or any other). This is also displayed in the middle column of Table 2.3.2. We do not have any item non-response in the motivation variable, as it was the first question in the

¹¹ Moreover, forcing respondents to stay on the page for a fixed amount of time did not systematically lead to survey termination. We can therefore recommend the implementation of a page timer to maximise chances of respondents reading instructions, as well as other potentially relevant information.

survey. However, we exclude 43 respondents who did not state their political ideology from the moderation analysis (see Appendix 2.7.1).

Today, all persons, i.e. for example house and apartment owners but also tenants, have the opportunity to invest in solar power, even without owning their own roof. This is the case, for example, with **participation investments**, in which various people together finance a solar power project.

<i>Randomly one framing sentence displayed</i>	Individual	Collective
Climate and environment	Investing in such solar PV projects thus offers you an opportunity to become active yourself in counteracting climate change and protecting the environment.	Investing in such solar PV projects thus offers us an opportunity to take action together to counteract climate change and protect the environment.
Electricity supply	Investing in such solar PV projects thus offers you an opportunity to become active yourself in order to help meet the increased demand for electricity at any time of year, for example from heat pumps, electric vehicles and other new technologies.	Investing in such solar PV projects thus offers us a way to work together to help meet increased electricity demand at any time of year, for example from heat pumps, electric vehicles and other new technologies.

In the following, we present different variants of such solar power projects to you. Please imagine that these are **offers for a co-investment**. You can **co-finance** these projects yourself with a **one-time investment**. By financing one or more solar modules, you can **participate with small financial contributions, but also invest larger amounts**. The energy produced by a solar module with an area of 1 m² corresponds to the annual energy consumption of 2 standard refrigerators or an electric car can drive 1000 km with the electricity produced.

You will see **5 times** in a row **2 participation options** to choose from. The projects differ in terms of different characteristics. Please consider in each case **which project you prefer and how many of those solar panels you want to invest in under these conditions**.

Figure 2.4: Screenshot of the introduction to choice experiment

Respondents only saw the content of one framing sentence at the indicated position in the text, instead of the full table with frame labels.

2.3.6 Method

To investigate the role of project design for social acceptance of CiFi PV, we analyse our data in terms of Average Marginal Component Effects (AMCE) (Hainmueller et al., 2014; Bansak et al., 2022) and in terms of Marginal Means (MM) (Leeper et al., 2020) using the *cregg* (Leeper, 2020) package in R (R Core Team, 2018).

For the framing experiment, we rely on OLS regressions with standard errors clustered on the individual level. In particular, we estimate the following regressions:

$$Y = \beta_0 + \beta_1 D_1 + \beta_2 D_2 + \beta_3 D_1 \times D_2$$

, where, for each model, Y is once socio-political acceptance (measured on a 1-5 point Likert scale) and once the number of modules, while the indicator variables D_1 and D_2 vary between models, as represented in Table 2.3.2.

Table 2.3.2: Indicator variables in regressions

Model represented in			binary indicator D_1	binary indicator D_2
Table 2.4.1	(moderation model)		1 if main motivation is climate change, and 0 otherwise	1 if frame is electricity, and 0 otherwise, i.e. indicating frame is climate change
Table 2.4.2	(moderation model)		1 if main motivation is energy, and 0 otherwise	1 if frame is electricity, and 0 otherwise, i.e. indicating frame is climate change
Table 2.4.3	(moderation model)		1 if the person is politically right, and 0 otherwise	1 if frame is individual, and 0 otherwise, i.e. indicates frame is collective
Table 2.4.4			1 if frame is individual, and 0 indicates frame is collective	1 if frame is electricity, and 0 otherwise, i.e. indicating frame is climate change

2.4 Results

2.4.1 Project design

Figure 2.5 presents the main results for tenants' project preferences contingent on project design characteristics. We observe that the patterns regarding project preference (i.e. choice, Figure 2.5) and project acceptance (rating task, Figure A.2.7.3a, see Appendix 2.7.3) are rather similar. We also display results for willingness to invest (i.e. number of modules in the Appendix 2.7.3 in Figure A.2.7.3b), for which project design seems to matter much less. Therefore, in the remainder of this section, we mainly report findings regarding project preferences.

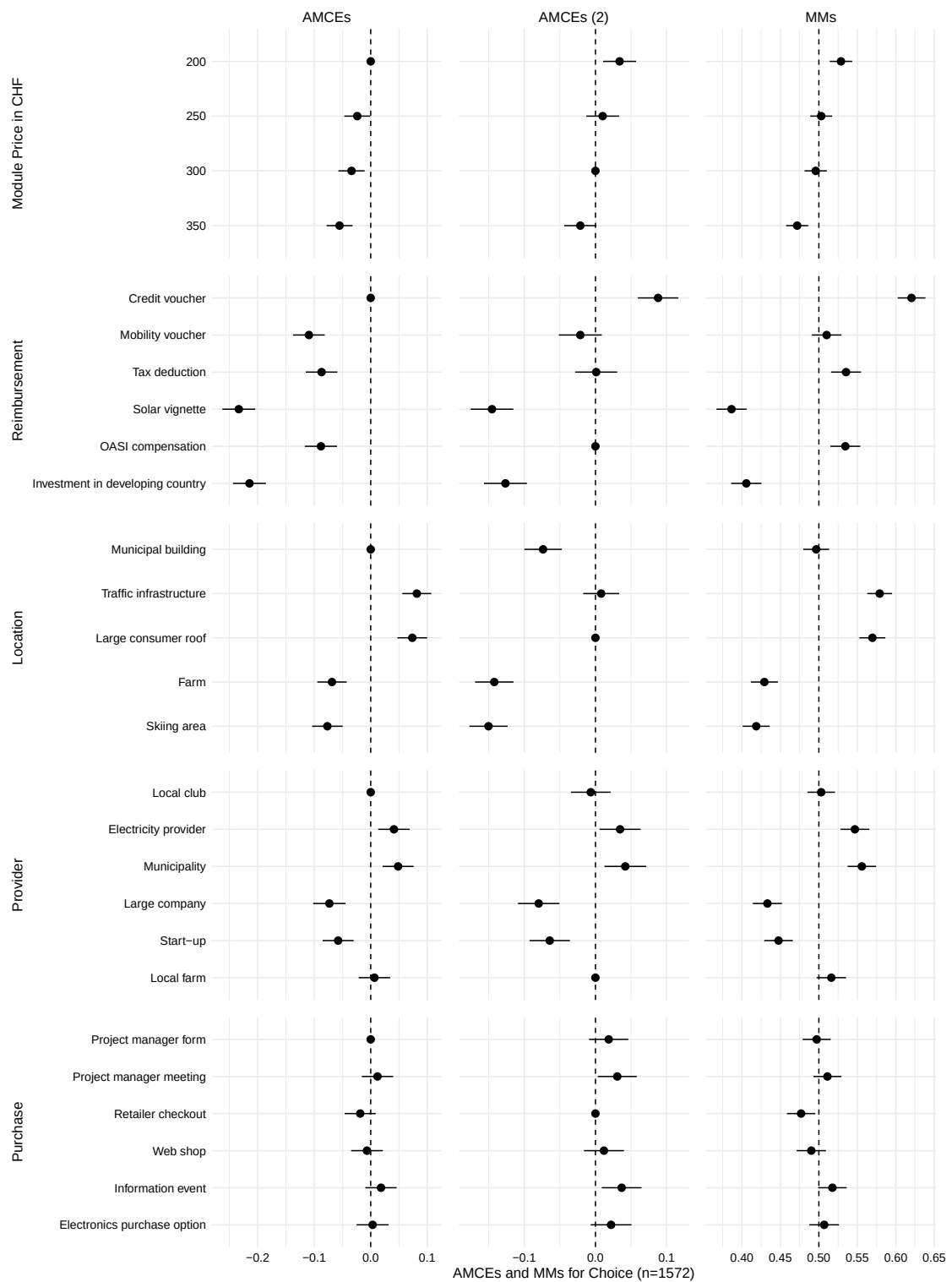


Figure 2.5: AMCE and MM for project choice

Average marginal component effects (AMCEs) and marginal means (MMs) for CiFi PV choice (i.e. project preference) among tenants. Horizontal bars around point estimates indicate 95 % confidence intervals. Points at zero with no confidence intervals indicate baseline levels of the respective attribute. The interpretation of each AMCE for each attribute level is always relative to the baseline category for the respective attribute. As AMCEs and their differences are sensitive with respect to baselines, we varied them, as displayed in AMCEs (2).

Tenants desire material reimbursements to compensate their investment in PV projects. Most notably, they clearly prefer energy credit vouchers, the most obvious material payback. Conversely, projects with immaterial reimbursements like the solar vignette or investments in developing countries exhibit the lowest likelihood to be selected by tenants.

Concerning the PV projects' location, a prominent factor in previous studies, CiFi PV on traffic infrastructure and large consumer roofs are the most preferred locations. Apparently, having CiFi PV in one's own municipality is, on average, preferred to locations in skiing areas and on farms.

It also matters to tenants who provides the CiFi PV: They are evaluated most positively if they are provided by the municipality where the CiFi PV will be installed or by the tenants' electricity provider (which are typically publicly owned). Conversely, individuals tend to appreciate CiFi PV to a lesser extent if the provider is a large company or a start-up. Therefore, in line with our theoretical expectations, public providers are preferred.

Moreover, tenants overall prefer lower prices per module. The slight preference indicated for project manager meetings and information events might indicate a desire for more knowledge about CiFi PV among tenants.

2.4.2 Framing effects

We proceed with testing, in accordance with our hypotheses, whether varying frames reinforce tenants' previously held ideological predispositions, with respect to project acceptance and willingness to invest. Randomly, one of the four frames was displayed to each respondent (see Appendix 2.7.1 for the distributions). We first distinguish between the electricity frames (individualistic or collective) and the climate frames (individualistic or collective). After presenting the results of the moderation hypotheses, we turn to the main effect of the interacted frame dimensions.

With regards to Hypothesis 2.1, from the insignificant interaction terms in Table 2.4.1,¹² we observe that climate-motivated individuals do not significantly differ in their socio-political acceptance of CiFi PV or in their module purchase intentions if the climate frame is used, compared to the electricity frame. These findings suggest that a climate framing for climate-motivated individuals has no additional gain. From the first row of Table 2.4.1, we observe that climate motivation always increases socio-political acceptance, i.e. the project rating, compared to all other motivations but not (significantly) the number of modules. We further illustrate that the preference patterns, i.e. the role of varying project design characteristics, are very similar for the

¹² See also Figure A.2.7.4a and Figure A.2.7.4b in Appendix 2.7.4.

climate and the electricity frame among respondents with different motivations, if we consider acceptance in Figure A.2.7.5a or number of modules, as in Figure A.2.7.5b (Appendix 2.7.5).

Table 2.4.1: Climate motivation and frames

	<i>Dependent variable:</i>	
	Project rating [1-5] (1)	Numb. modules (2)
Climate motivation	0.389*** (0.066) $p = 0.000$	2.686 (1.723) $p = 0.120$
Electricity frame	0.025 (0.045) $p = 0.586$	-0.575 (0.867) $p = 0.508$
Climate motivation x electricity frame	-0.016 (0.095) $p = 0.870$	-2.355 (1.979) $p = 0.235$
Constant (Climate frame, other main motivation)	3.514*** (0.032) $p = 0.000$	8.231*** (0.636) $p = 0.000$
N	1674	1572
<i>Note:</i> OLS with clustered standard errors.		* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

We now turn to individuals with an energy motivation. As Table 2.4.2 shows (see also Figure A.2.7.4c and Figure A.2.7.4d in Appendix 2.7.4), for this group, emphasising the electricity rather than the climate change framing increases the rating of CiFi PV, which supports Hypothesis 2.2.¹³ Whereas under the climate frame, individuals with an energy motivation have a slightly lower marginal mean to accept CiFi PV than other respondents, they exhibit an above-average project acceptance if the electricity frame is used. Conversely, this positive frame effect cannot be observed with respect to the number of purchased modules (see Table 2.4.2, right column). Therefore, the electricity framing can increase socio-political acceptance but not willingness to invest, i.e. market acceptance. Again, the preference patterns do not change by frame in terms of acceptance and are negligible in terms of modules (see Figure A.2.7.5c and Figure A.2.7.5d, as reported in Appendix 2.7.5).

We proceed to test how the individualistic and collective frames motivate people with varying political ideology. In our tenant sample, 611 are politically left-leaning, 481 place themselves in the centre of the 11-point political scale, and 539 on the political right.

¹³ This becomes apparent when calculating the marginal effect of being energy-motivated, which amounts to $-0.095 + 0.278 = 0.183$.

Table 2.4.2: Energy motivation and frames

	<i>Dependent variable:</i>	
	Project rating [1-5]	Numb. modules
	(1)	(2)
Energy motivation	-0.095 (0.094) $p = 0.316$	-0.061 (1.518) $p = 0.968$
Electricity frame	-0.021 (0.043) $p = 0.619$	-0.914 (0.857) $p = 0.287$
Energy motivation x Electricity frame	0.278** (0.133) $p = 0.037$	-1.282 (2.105) $p = 0.543$
Constant (Climate frame, other main motivation)	3.602*** (0.030) $p = 0.000$	8.800*** (0.664) $p = 0.000$
N	1674	1572

Note: OLS with clustered standard errors.

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

Table 2.4.3 depicts that, in accordance with Hypothesis 2.3, whether CiFi PV are framed as an individual or a collective endeavour matters for the number of modules purchased by politically right persons. However, Figure 2.7 illustrates that rightist individuals are more likely – not less likely as theoretically anticipated – to invest in higher numbers of PV modules if a collective frame is used. Conversely, for left-leaning and centrist individuals, the individual frame is slightly more effective when it comes to module numbers (see also Figure A.2.7.5f in Appendix 2.7.5) but differences are insignificant, and even smaller for acceptance (see Figure A.2.7.5e in Appendix 2.7.5).

Interestingly, these findings regarding stated willingness to invest (number of modules) do not hold for socio-political acceptance. While those who place themselves on the political right can be motivated to purchase more modules through a collective frame, their project acceptance is generally considerably lower compared to politically leftist tenants.

Lastly, turning back to the full sample of tenants, Hypothesis 2.4 suggests that some combinations of frames are more effective in increasing social acceptance for CiFi PV, namely the combination of the climate with the collective frame as well as the combination of the individual with the electricity frame. However, Table 2.4.4 does not support this claim. Both Figure 2.8 and Figure 2.9 illustrate that these two frame combinations are not related to significantly higher project ratings and numbers of purchased modules.

Table 2.4.3: Ideological position and frames

	<i>Dependent variable:</i>	
	Project rating [1-5]	Numb. modules
	(1)	(2)
Politically right	−0.189*** (0.060) $p = 0.002$	1.687 (1.320) $p = 0.202$
Individual frame	0.001 (0.051) $p = 0.990$	1.052 (0.976) $p = 0.282$
Politically right x Individual frame	−0.074 (0.085) $p = 0.390$	−3.437** (1.675) $p = 0.041$
Constant (Collective frame, other political position)	3.679*** (0.035) $p = 0.000$	7.755*** (0.633) $p = 0.000$
N	1631	1537

Note: OLS with clustered standard errors.

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

Only respondents who stated their political position.

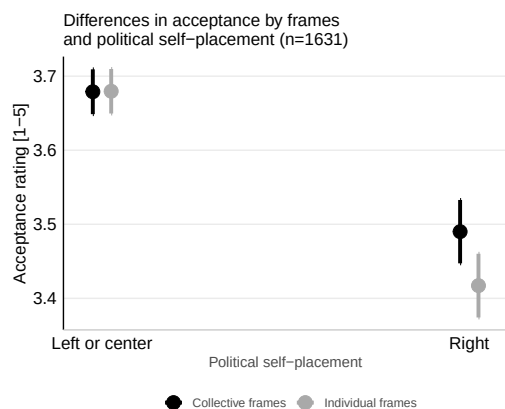


Figure 2.6: Predicted PV project acceptance using individual vs. community framing and interacting it with political self-placement. Vertical bars around point estimates indicate 95 % confidence intervals.

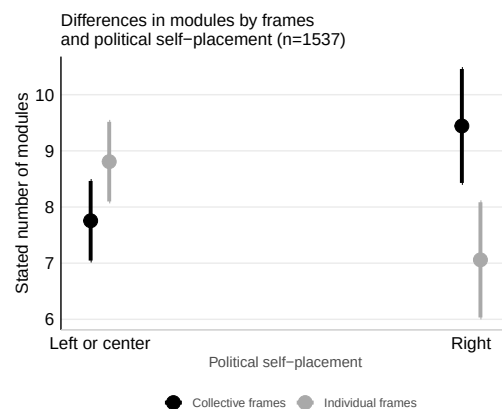
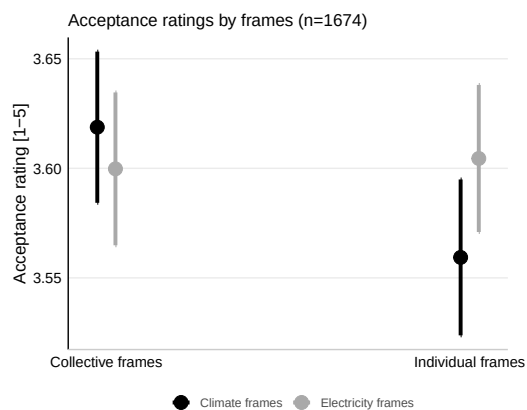
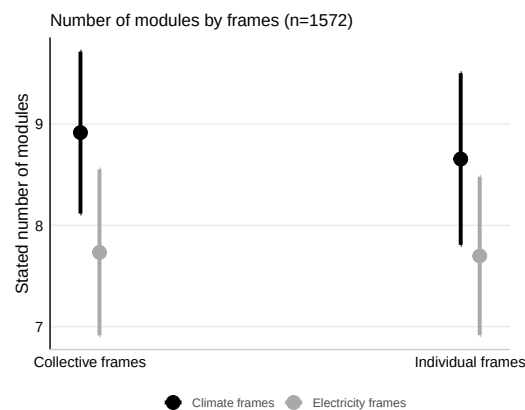


Figure 2.7: Predicted number of chosen modules using individual vs. community framing and interacting it with political self-placement. Vertical bars around point estimates indicate 95 % confidence intervals.

Table 2.4.4: Combination of frames – all tenants

	<i>Dependent variable:</i>	
	Project rating [1-5]	Num. modules
	(1)	(2)
Individual frame	−0.059 (0.057) $p = 0.299$	−0.261 (1.218) $p = 0.831$
Electricity frame	−0.019 (0.056) $p = 0.737$	−1.183 (1.130) $p = 0.296$
Individual frame x Electricity frame	0.064 (0.082) $p = 0.432$	0.226 (1.587) $p = 0.887$
Constant (Collective frame, climate frame)	3.619*** (0.040) $p = 0.000$	8.916*** (0.805) $p = 0.000$
N	1674	1572

Note: OLS with clustered standard errors. * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

**Figure 2.8:** Predicted CiFi PV acceptance by frame combination. Vertical bars around point estimates indicate 95 % confidence intervals.**Figure 2.9:** Predicted number of modules purchased by frame combination. Vertical bars around point estimates indicate 95 % confidence intervals.

2.5 Discussion

Overall, the findings on the design of CiFi PV projects confirm our initial assumption that their social acceptance is influenced by different factors that include but clearly go beyond economic considerations. On the one hand, our results indicate that projects that provide “material benefits” in the form of a voucher on the electricity bill are most popular, while immaterial reimbursements are associated with lower preferences. This is in line with our expectation and the strand of literature suggesting that financial forms of reimbursement are more influential (e.g. Stadelmann-Steffen and Dermont, 2018; Trandafir et al., 2023) than, as suggested by newer research, symbolic ones (e.g. Schall, 2020). On the other hand, our results show that a number of other aspects are relevant in addition to the purely economic arguments. In terms of location, CiFi PV situated on traffic infrastructure and buildings are preferred, while tenants are more sceptical about PV projects located on farms or in skiing areas. These preferences also tie to previous findings, showing that other RE plants placed in valued landscapes are unpopular and people prefer existing infrastructure instead (e.g. Stadelmann-Steffen and Dermont, 2021). It seems that CiFi PV are not exempt from this pattern, despite solar energy generally being very popular. Additionally, project preference is more pronounced when providers exhibit a “public inclination”, such as an electricity provider that is typically publicly owned or a solar plant community. Due to Switzerland’s incomplete energy market liberalisation and Swiss residents being used to public energy providers, as well as past research indicating a preference for local suppliers (Sagebiel et al., 2014), this finding corresponds to our theoretical assumptions. In contrast, the intended quantity of purchased modules is not heavily influenced by project design (see Appendix 2.7.3, Figure A.2.7.3b). These results imply that CiFi PV design has a greater impact on broader aspects of social acceptance but plays a subordinate role in specific investment decisions, pointing to a correct specification of our conceptualisation in Figure 2.1.

Following research by e.g. Bourcet and Bovari (2020); Djerf-Pierre et al. (2016) or Kronrod et al. (2023), we further expected that varying non-financial framings of CiFi PV as well as different pre-existing motivations or ideologies heterogeneously impact social acceptance of CiFi PV. Accordingly, we find that individuals who view climate change as the main societal challenge are not significantly affected by frames, but generally express strong support for CiFi PV on multiple levels (i.e. overall project acceptance and intended investment). On the other hand, framing CiFi PV as a contribution to energy security and independence can significantly increase socio-political acceptance among those who prioritise energy security, but not necessarily their intention to invest. The reversed pattern can be observed when presenting these projects as a collective effort rather than an individual one: This has the potential to increase the intention to purchase more modules among those on the political right, while those on the political centre and left do not show a strong reaction to this framing variation. The latter contrasts with Hypothesis 2.3 that left-leaning individuals and individuals in the political centre, rather than right-wing individuals, would respond more strongly to the collective frame. We believe that

this unexpected pattern is related to the inherently collective nature of CiFi PV, given the co-financing. Combined with a framing that emphasises collective action as a way to solve current energy or climate challenges, this may indeed lead to the perception that these projects are a way to self-organise as a society, without the state – a type of collective action that is well in line with right-wing values in Switzerland. Conversely, the individual framing suggests that it is an individual choice to invest or not to invest. In this situation, right-wing individuals, who are typically less concerned about RE, tend to choose not to invest in these types of projects. Leftist individuals, on the other hand, are more willing to individually contribute to this overarching goal to mitigate climate change and to invest in CiFi PV when being presented with the individualistic frame.

This study is of course not without limitations. While we have carefully selected the project attributes, not least based on interdisciplinary exchange and expertise, we cannot exclude that further aspects are relevant for individual opinion formation on CiFi PV. This might be especially relevant for the intention to invest in PV modules, where our results involve quite some uncertainty (as depicted by wide confidence intervals), suggesting that unobserved factors are influential for respondents' investment intentions. Regarding the latter, the minimum investment in our study was 200 CHF, which is significantly higher than the minimal investment for existing co-funded PV projects. Although we chose this amount to measure genuine engagement, it may have affected response behaviour, particularly among low-income individuals. Another limitation of this study concerns the conjoint design, as it only measures stated instead of revealed preferences and social desirability bias might bias findings upwards. Also, all scenarios presented in conjoint tasks are hypothetical. Whether the indicated project preferences would hold up in real life remains doubtful, as is often the case with survey experiments excluding real investments with respondents' own money. Similarly, as our data stems from one country only, we should be careful in generalising our conclusions beyond the case of Switzerland. However, given the country's many social, geographical and political heterogeneities, we are confident that similar mechanisms might be found in other European contexts.

2.6 Conclusion

To accelerate the transition from fossil fuels to renewable energy sources, it is crucial to better exploit the potential of renewables. Solar photovoltaics are considered to play a significant role in this process and to be highly socially accepted. However, PV deployment is mostly limited to companies and individual homeowners who can install PV on their own property. Therefore, this study investigates a type of PV that offers the opportunity for individuals to engage in co-funding the energy transition, even if they do not have their own roof, namely *citizen-financed PV projects (CiFi PV)*. The study focuses on tenants and analyses, based on novel survey data, how project design and framing influence tenants' social acceptance of CiFi PV. Our main argument

is that social acceptance is particularly high when project design and framing support underlying individual motivations and political ideology.

Our findings, in response to our research questions, first, imply that CiFi PV projects exhibit strongest social acceptance if they are provided by public or community providers, are located on existing infrastructure nearby and provide a material benefit. However, while these design features might maximise socio-political acceptance of CiFi PV and even project preferences as an aspect of market acceptance, the more concrete willingness to invest barely depends on project design. Second, and similarly, individual predispositions such as a climate motivation as well as a leftist political ideology are strong predictors of general project acceptance but are not systematically related to willingness to invest. Third, our findings reveal that framing CiFi PV as collective endeavours might be most promising to increase market acceptance, particularly among individuals at the political right.

This study's limitations suggest several recommendations for future research. More insights are needed on CiFi PV acceptance across different geographical regions but also with regards to income and other structural group differences. Moreover, future studies should reflect about research designs that allow investigating revealed instead of stated preferences. Potentially, field-experiments or transdisciplinary research could draw on the most effective frames, collective climate action, and most accepted project designs and study them "in the field." Such an approach may particularly be informative about the observed discrepancies between general project acceptance and investment behaviour.

This paper is the first experimental study to shed light on the preferences for citizen-financed solar PV projects among those who do not own their housing. The study's main implication is that CiFi PV projects can be a promising way to exploit renewable energy potentials and include tenants in the energy transition. However, it also highlights a major challenge that needs to be addressed for CiFi PV to become a successful and inclusive contributor to the energy transition. Designing CiFi PV projects to be attractive to tenants in terms of project preference and acceptance may not be sufficient to encourage tenant investment. The most promising practical recommendation based on this study's findings is to communicate about CiFi PV while emphasising the collective dimension of current energy and climate challenges. As our findings reveal, this combination seems to be promising in fostering the intention to invest by individuals who are not strongly concerned about the energy transition to mitigate climate change, namely right-wing individuals, while it does not substantially deter left-wing and centrist individuals.

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2.7 Appendix

2.7.1 Descriptives

Variable	Category	Frequency	Percentage
Age category	18-30 years	350	21.08
	31-40 years	325	19.58
	41-50 years	299	18.01
	51-60 years	360	21.69
	61-70 years	243	14.64
	71-80 years	82	4.94
	> 80 years	1	0.06
Gender	female	773	46.99
	male	865	52.58
	non-binary (and other)	7	0.43
Education degree	Secondary I	93	5.81
	Secondary II	717	44.76
	Tertiary	792	49.44
Income category	under CHF 5,000	353	21.66
	CHF 5,001 to CHF 7,000	403	24.72
	CHF 7,001 to CHF 9,000	320	19.63
	CHF 9,001 to CHF 13,000	334	20.49
	over CHF 13,001	220	13.50
Political orientation	Left	611	36.50
	Center	481	28.73
	Right	539	32.20
	None	43	2.57
Tenancy status	Own flat	360	21.51
	Tenant	1163	69.47
	Cooperative	38	2.27
	Other	113	6.75
Climate change as first priority	Yes	306	18.28
	No, other	1368	81.72
Energy supply as first priority	Yes	204	12.19
	No, other	1470	87.81

Variable	Category	Frequency	Percentage
Frame	Climate change & collective	421	25.15
	Climate change & individual	396	23.66
	Electricity supply & collective	412	24.61
	Electricity supply & individual	445	26.58
Choice	Project A	3757	51.93
	Project B	3478	48.07
Rating	Certainly reject (1)	1064	6.36
	Rather reject (2)	1875	11.02
	Neither nor (3)	3654	21.83
	Rather approve (4)	6310	37.69
	Certainly approve (5)	3837	22.92
Modules	NA	2270	23.88
	0 or positive value	7235	76.12
		<i>mean</i>	8.24
		<i>sd</i>	17.59

Data source: Stadelmann-Steffen et al. (2022), own calculations.

2.7.2 Problem Perception

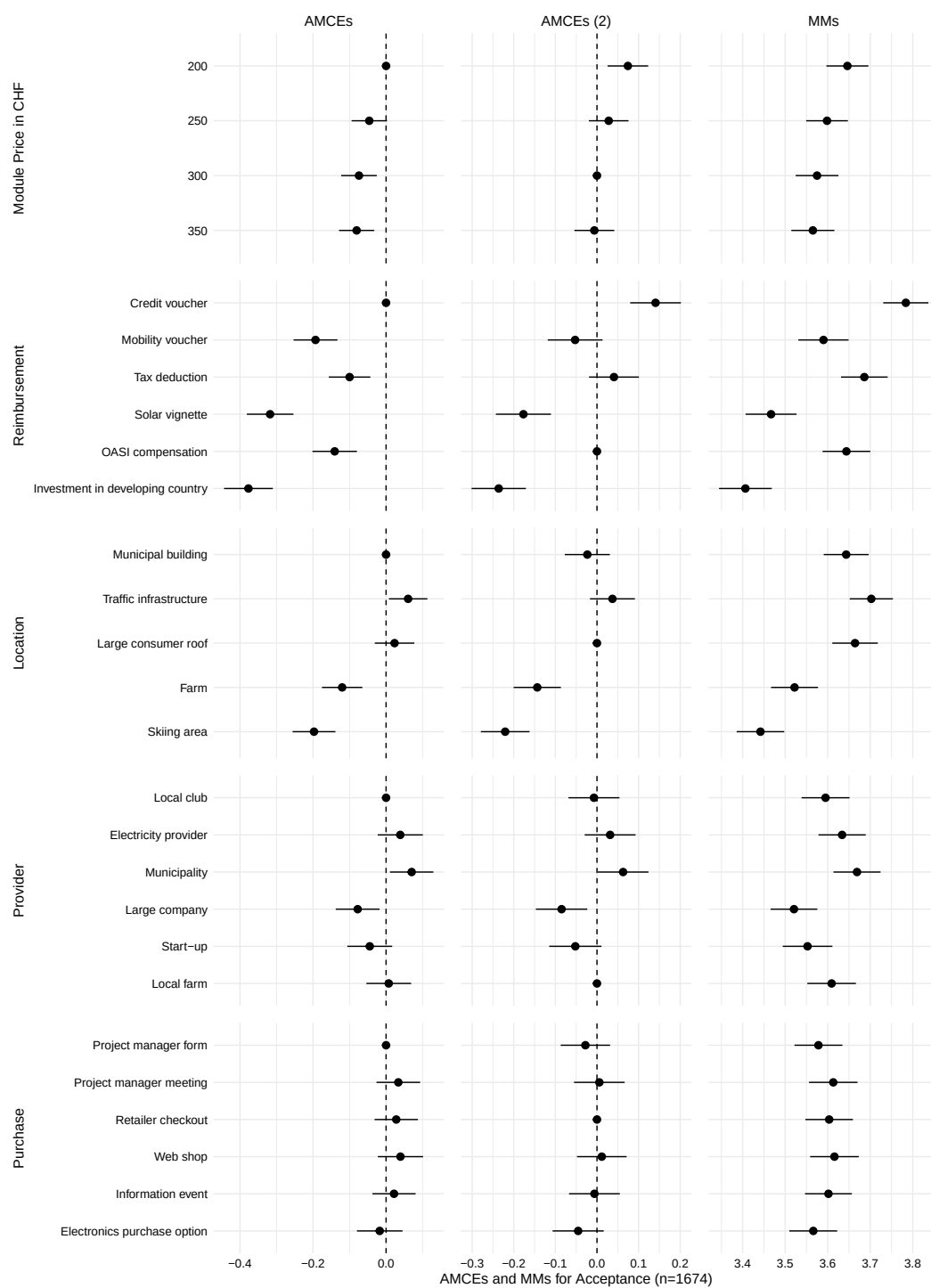
The full question text was: “First, please read the entire list carefully. Then, select the three most important issues.”

The full list of problem areas consists of the following, displayed to respondents in random order:

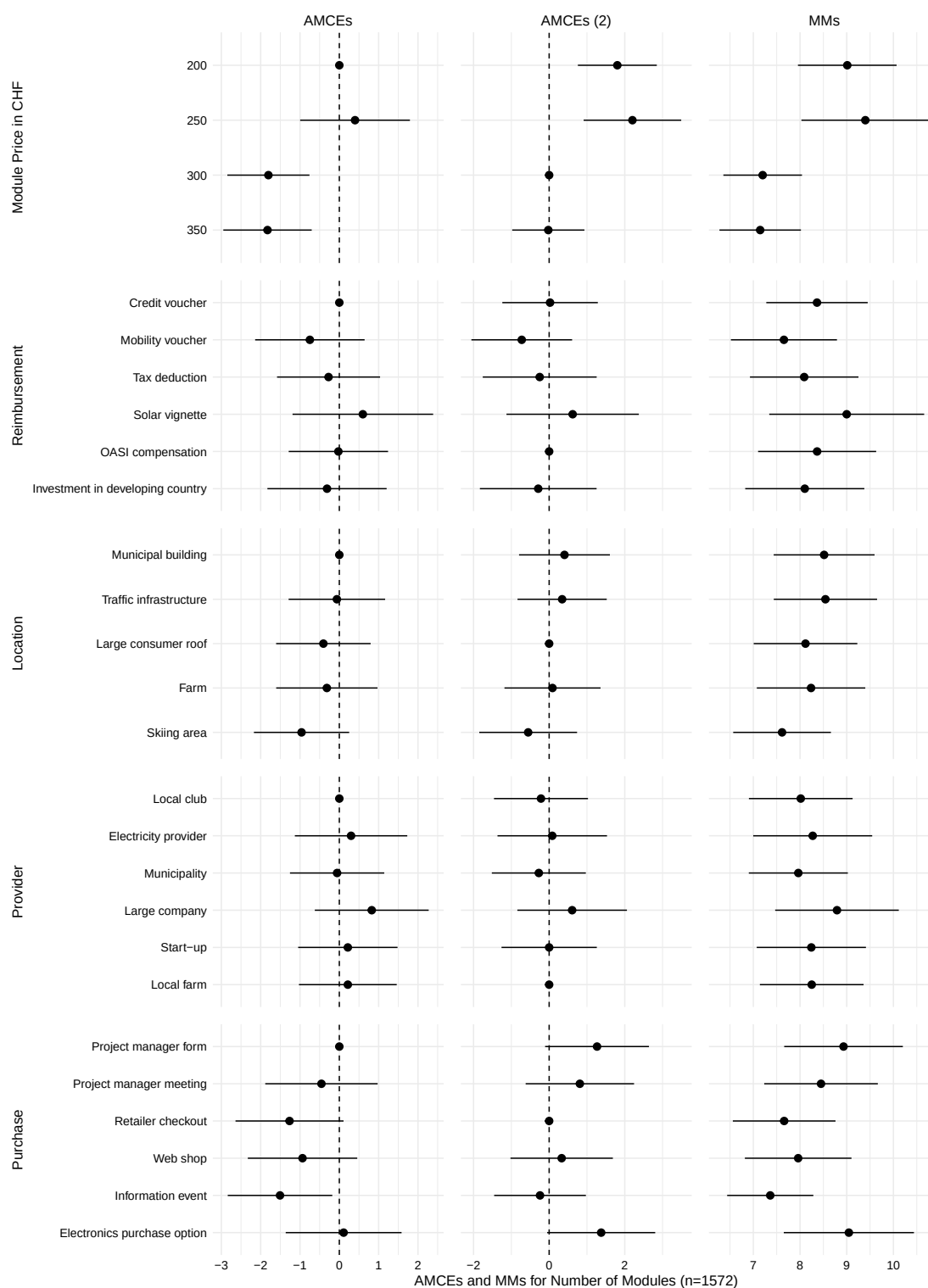
- Retirement provision / OASI
- Unemployment
- Refugees
- Switzerland’s relationship with the European Union
- Health care / health insurance
- Education and education policy
- Transport
- Economic globalisation / free trade
- Environmental pollution
- Biodiversity loss
- Overexploitation of our natural resources
- Crime
- Inequality of income and wealth
- Living together with people of different cultures and religions
- Foreign workers in Switzerland
- Discrimination / equality
- Increase in the Swiss resident population
- Peace / foreign and security policy
- Poverty / wages rising less than prices
- Climate change
- Energy supply

Respondents were asked to select their three main problem areas by ordering these areas into first, second, and third priority. Hence, this survey item combined a multi-selection with a rating task. For the operationalisation of the motivation variable we consider ranking either “Climate change” or “Energy supply” as the **most** important issue, i.e. ranking either of these problems first as the most important problem.

2.7.3 CiFi PV project acceptance among tenants

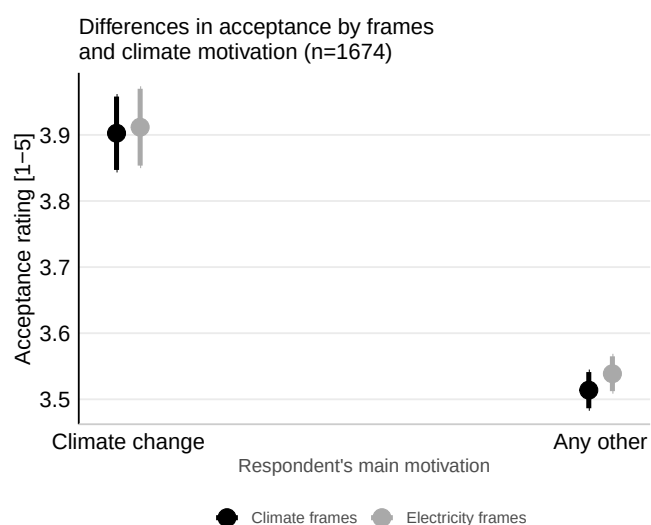


A.2.7.3a: Average marginal component effects (AMCEs) and marginal means (MMs) for shared PV project CiFi PV acceptance among tenants. Horizontal bars around point estimates indicate 95 % confidence intervals. The baseline categories for the AMCEs are at zero with no confidence intervals. As AMCEs and their differences are sensitive with respect to baselines, we varied them, as displayed in AMCEs (2).

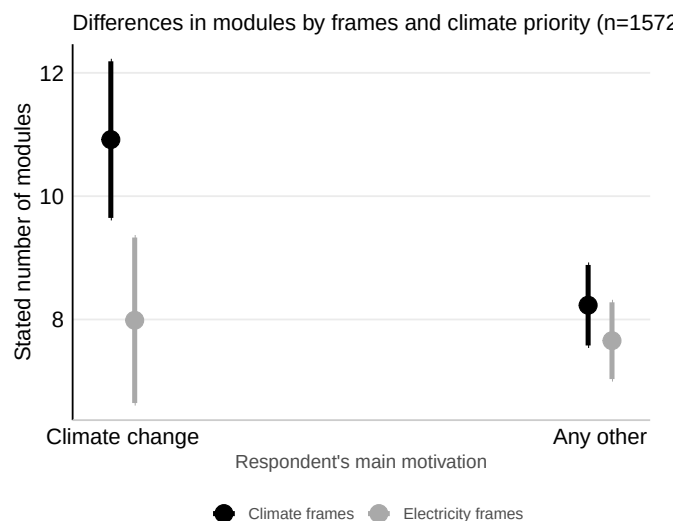


A.2.7.3b: Average marginal component effects (AMCEs) and marginal means (MMs) for tenants' intention to invest in (CiFi PV) (in number of modules). Horizontal bars around point estimates indicate 95 % confidence intervals. The baseline categories for the AMCEs are at zero with no confidence intervals. As AMCEs and their differences are sensitive with respect to baselines, we varied them, as displayed in AMCEs (2).

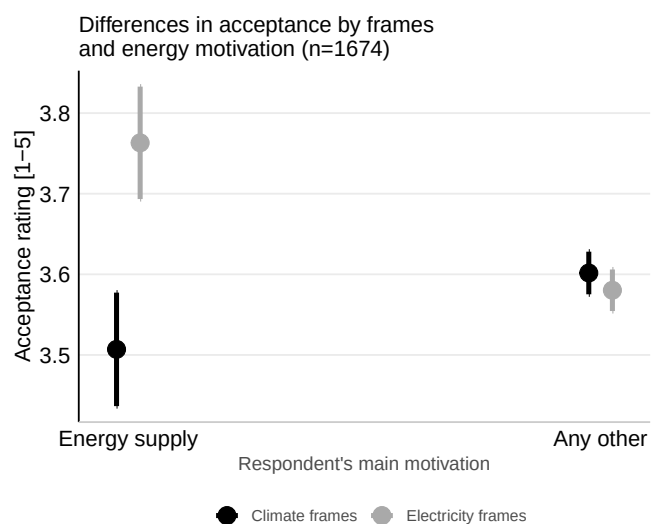
2.7.4 Energy and Climate Framing Effects



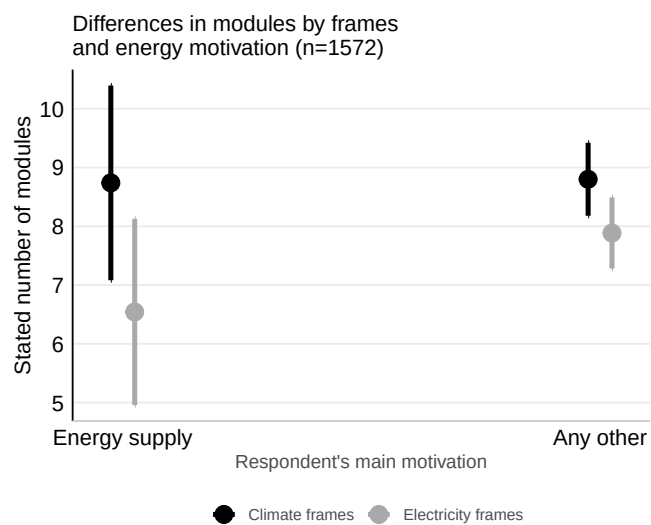
A.2.7.4a: Predicted acceptance of (CiFi PV) using electricity vs. climate framing interacted with climate motivation, operationalised as main problem is climate (or not). Vertical bars around point estimates indicate 95 % confidence intervals.



A.2.7.4b: Predicted number of chosen modules invested in shared PV projects (CiFi PV) using electricity vs. climate framing and interacted with climate motivation, operationalised as main problem is climate (or not). Vertical bars around point estimates indicate 95 % confidence intervals.

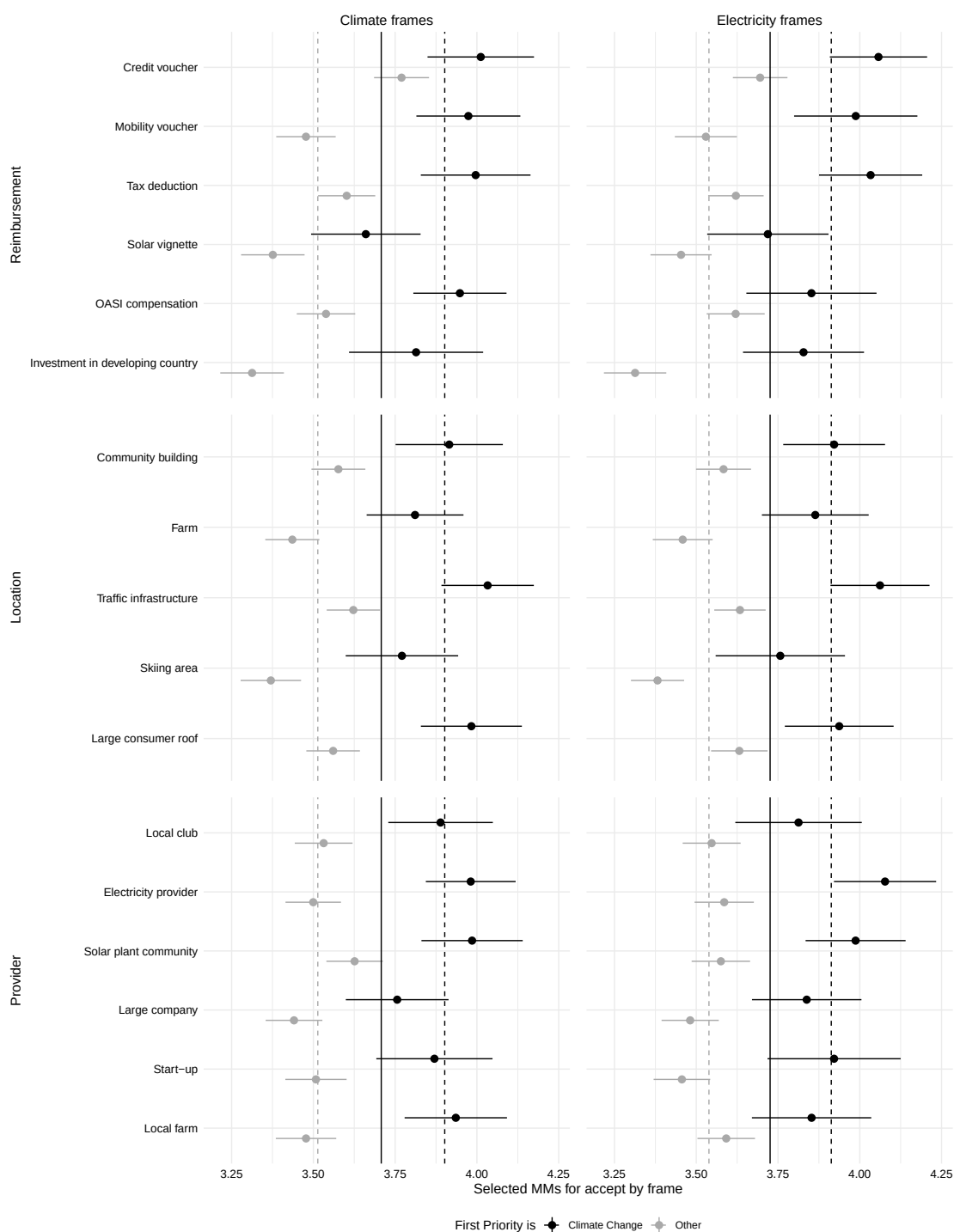


A.2.7.4c: Predicted acceptance of (CiFi PV) using electricity vs. climate framing interacted with interacted with energy motivation, operationalised as main problem is energy (or not). Vertical bars around point estimates indicate 95 % confidence intervals.

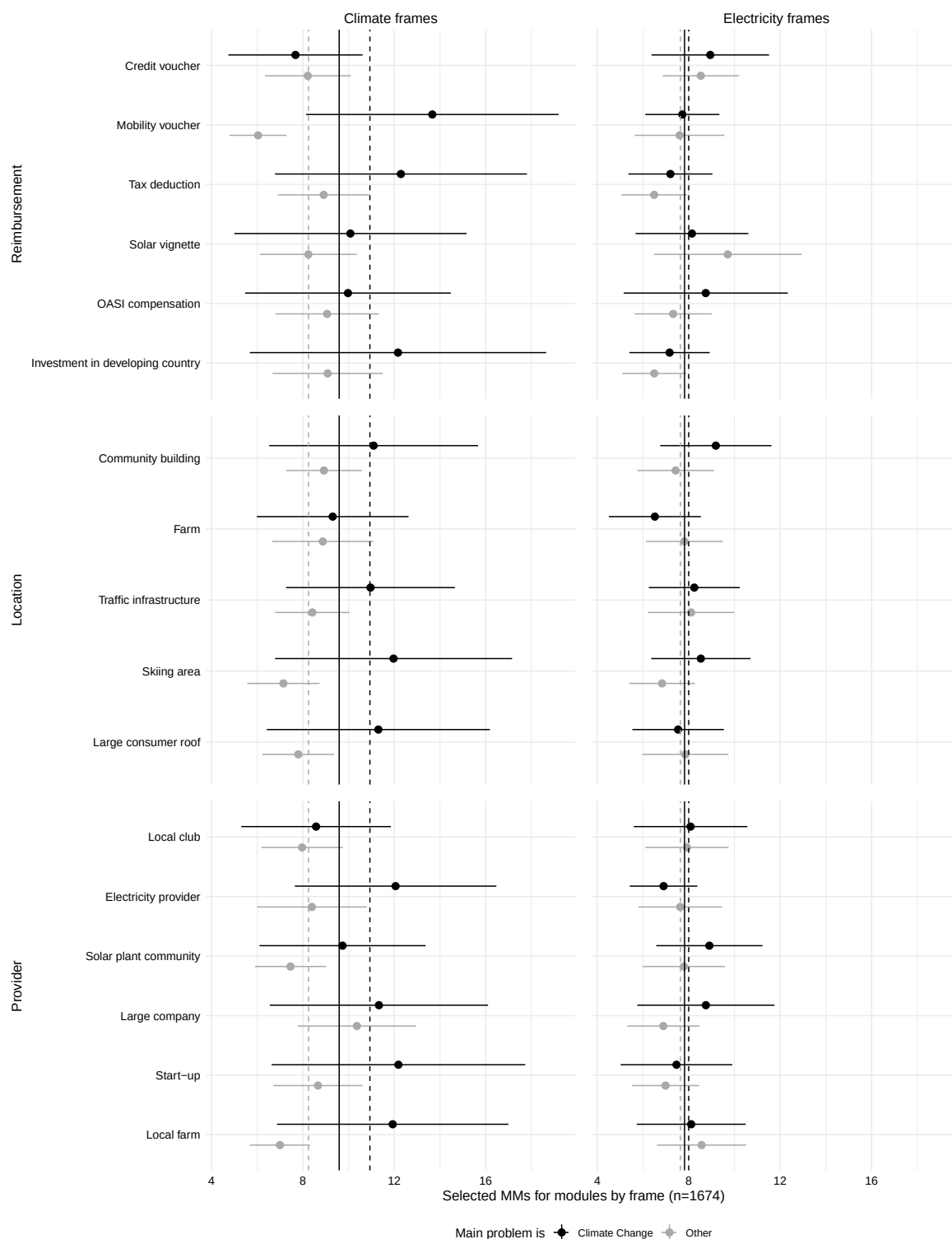


A.2.7.4d: Predicted number of chosen modules invested in shared PV projects (CiFi PV) using electricity vs. climate framing interacted with interacted with energy motivation, operationalised as main problem is energy (or not). Vertical bars around point estimates indicate 95 % confidence intervals.

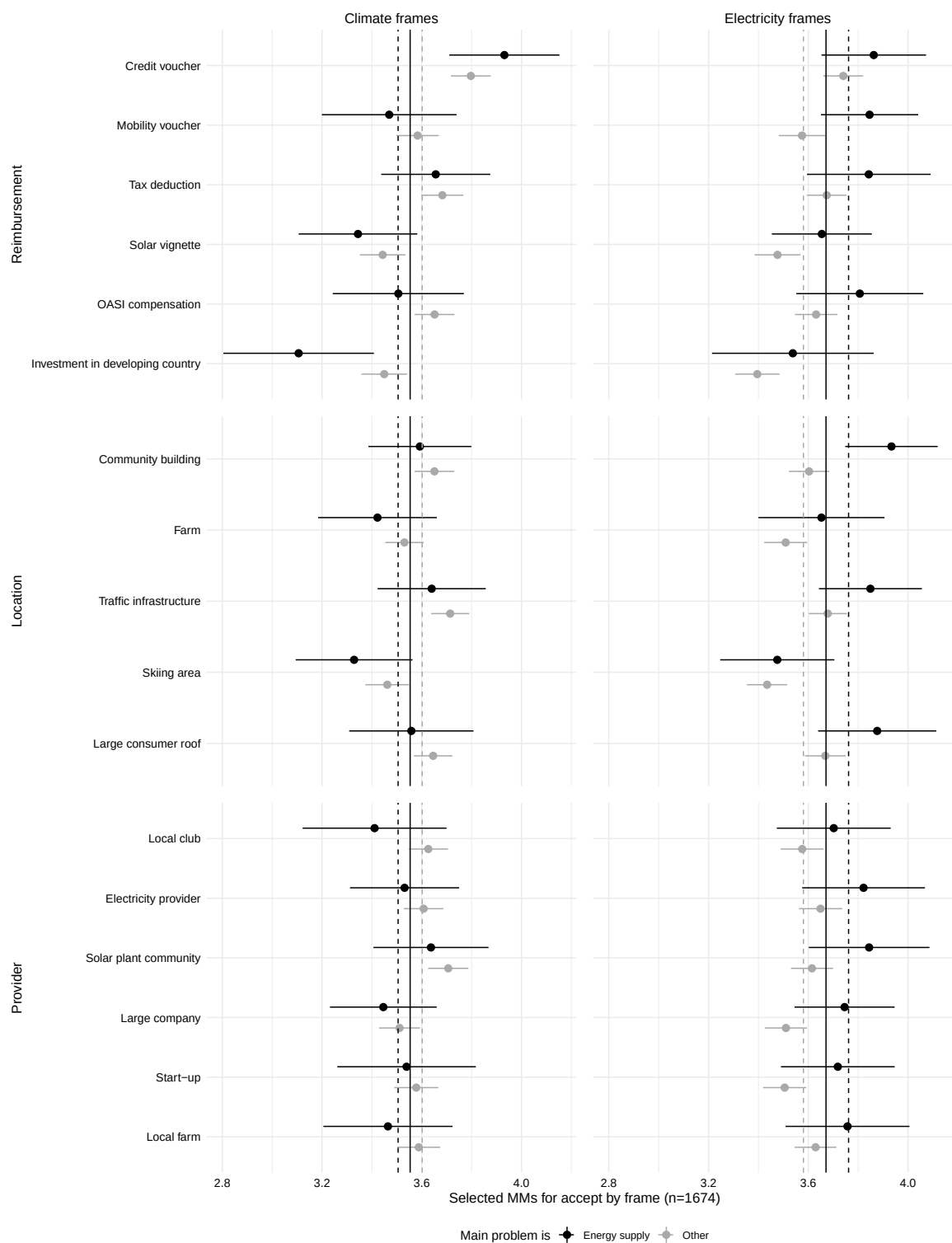
2.7.5 Framing effects on CiFi PV project design evaluations



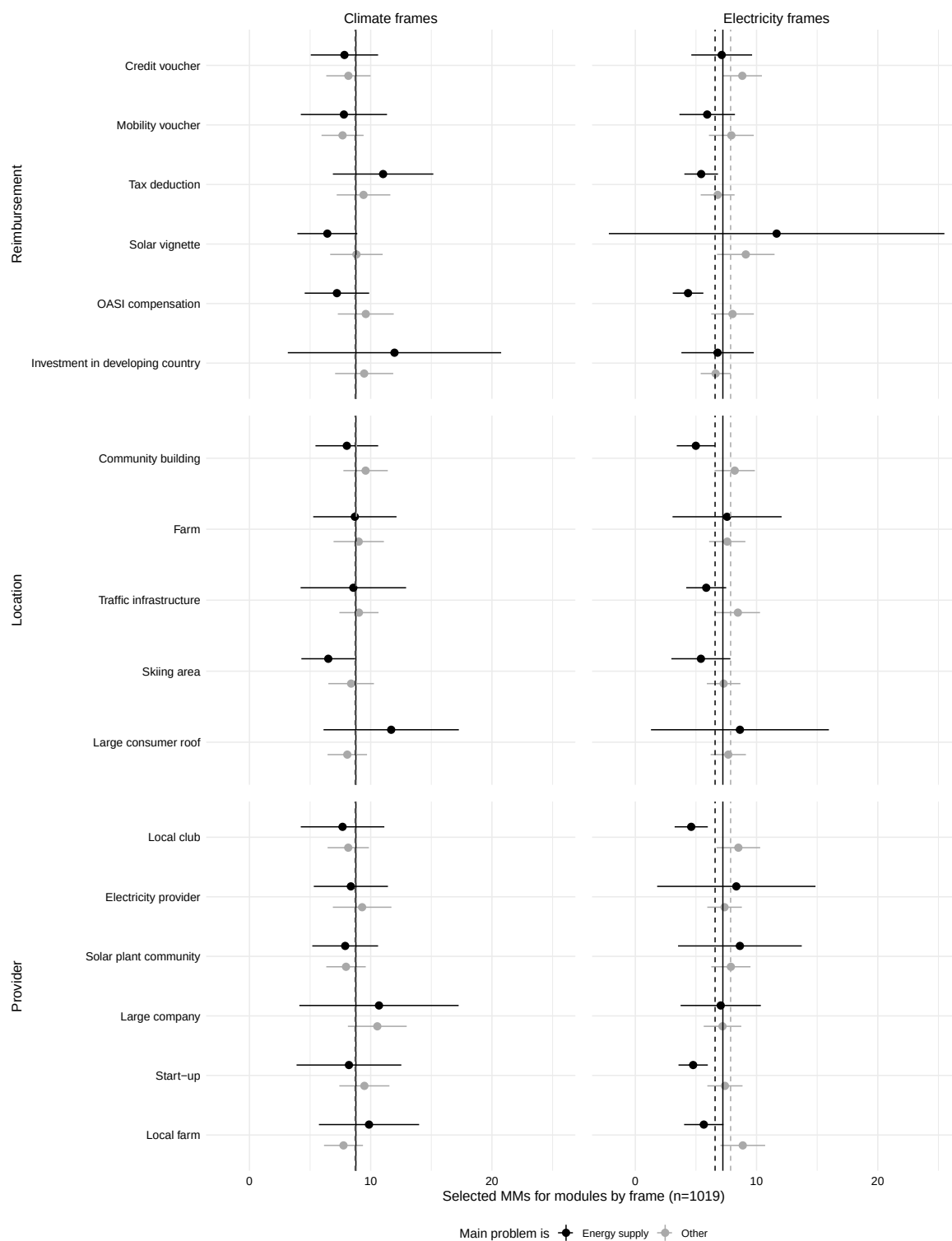
A.2.7.5a: Selected differences in acceptance between individuals with climate motivation and all others, contingent on the frames displayed. Horizontal bars around point estimates indicate 95 % confidence intervals. Solid black lines indicate means by presented frames, dashed lines refer to the means by main motivation and frame.



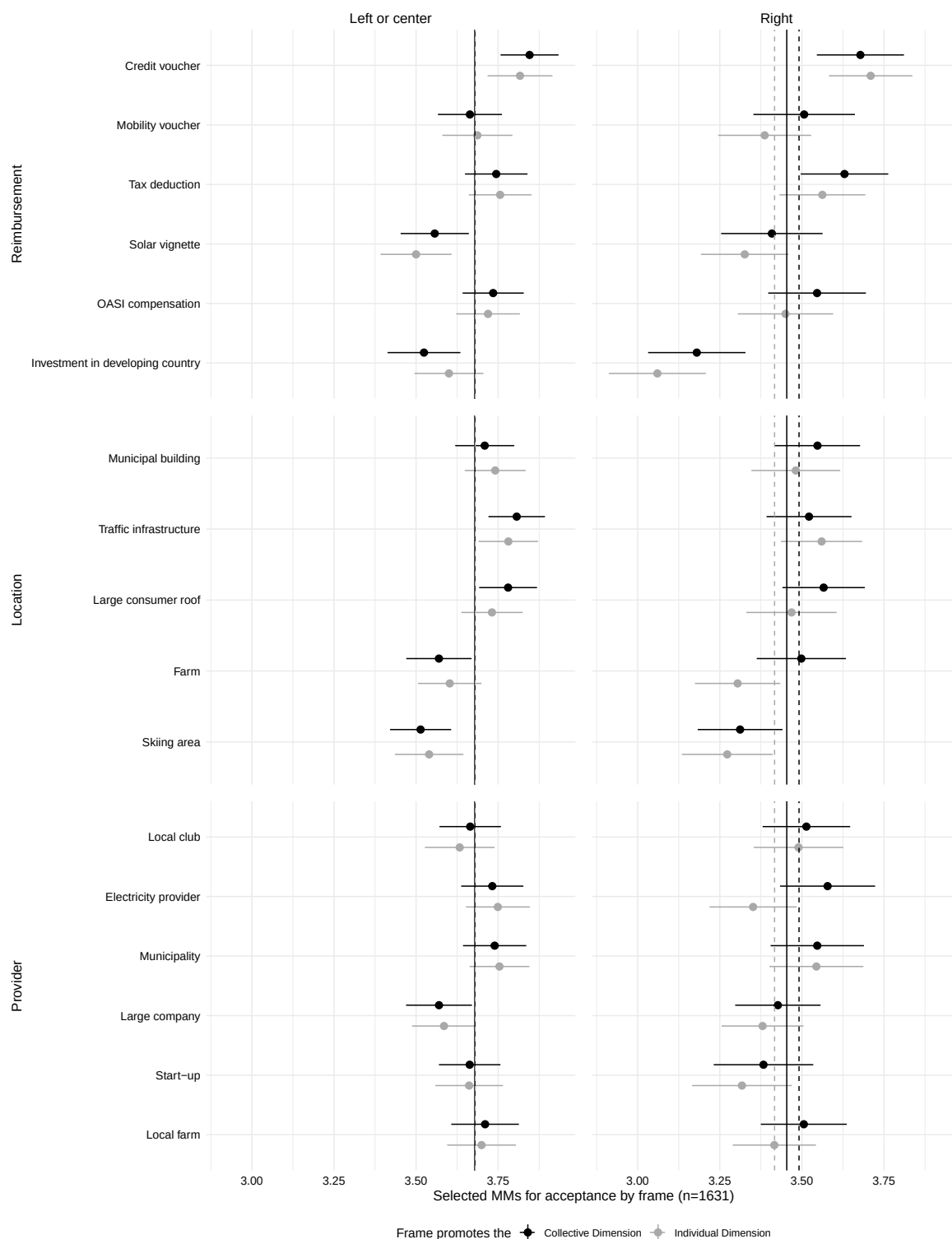
A.2.7.5b: Selected differences in the stated number of modules purchased between individuals with climate motivation and all others, contingent on the frames displayed. Horizontal bars around point estimates indicate 95 % confidence intervals. Solid black lines indicate means by presented frames, dashed lines refer to the means by main motivation and frame.



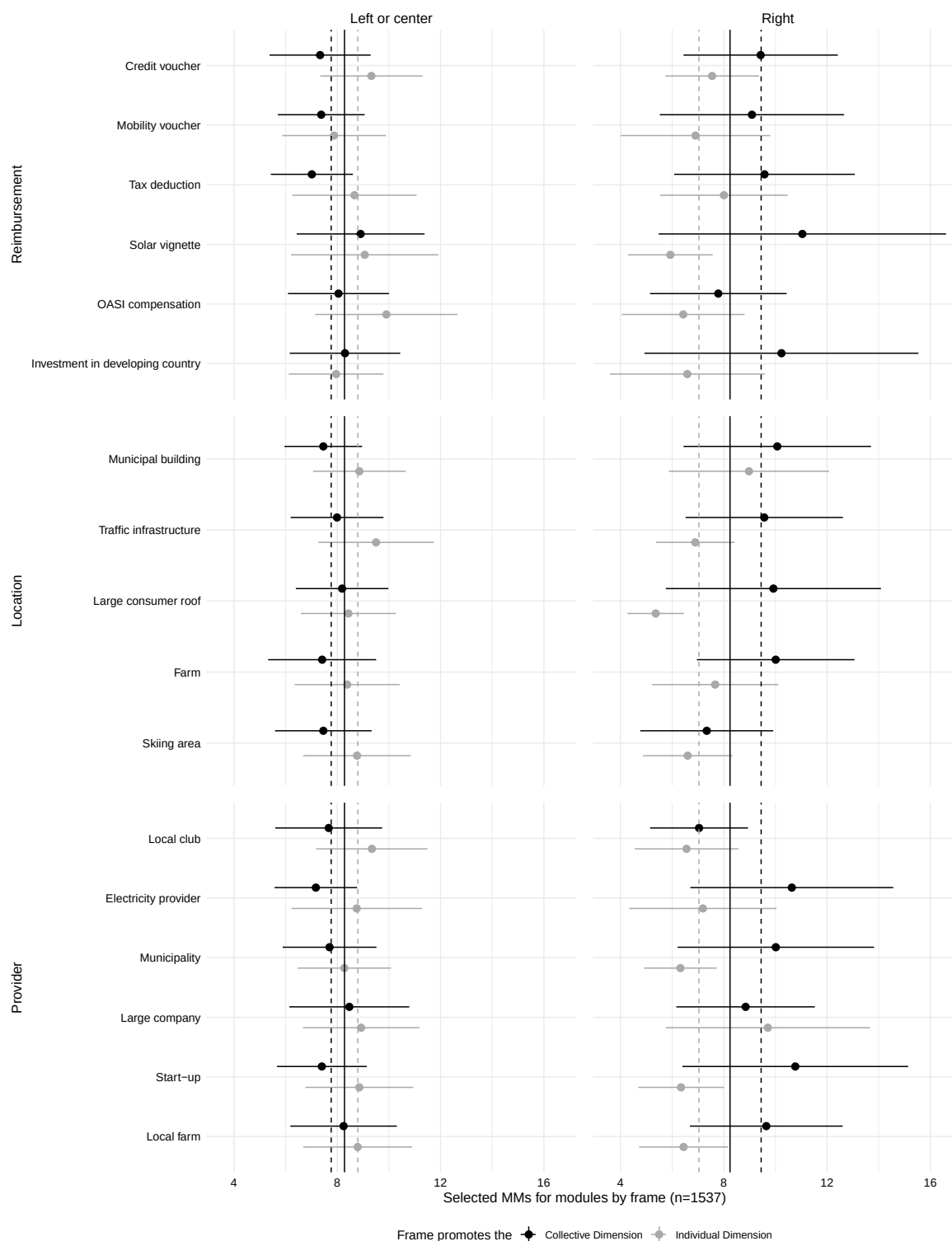
A.2.7.5c: Selected differences in acceptance between individuals with energy motivation and all others, contingent on the frames displayed. Horizontal bars around point estimates indicate 95% confidence intervals. Solid black lines indicate means by presented frames, dashed lines refer to the means by main motivation and frame.



A.2.7.5d: Selected differences in the stated number of modules purchased between individuals with energy motivation and all others, contingent on the frames displayed. Horizontal bars around point estimates indicate 95 % confidence intervals. Solid black lines indicate means by presented frames, dashed lines refer to the means by main motivation and frame.



A.2.7.5e: Differences in acceptance between political left and center vs. right self-placement by collective vs. individual frames. Horizontal bars around point estimates indicate 95 % confidence intervals. Solid black lines indicate means by political ideology, dashed lines refer to the means by political ideology and frames.



A.2.7.5f: Differences in the stated number of modules purchased between political left and center vs. right self-placement by collective vs. individual frames. Horizontal bars around point estimates indicate 95 % confidence intervals. Solid black lines indicate means by political ideology, dashed lines refer to the means by political ideology and frames.

2.7.6 Additional Information

Development of the Survey Experiment and Expert Elicitation

We used expert elicitation to confirm that the information we gathered from previous studies, is relevant for the Swiss case and mirrors current and expected future developments “on the ground”.

For example, we included a reimbursement attribute, drawing upon previous work, e.g. from Schall (2020) who operationalised “psychic returns” (i.e. immaterial benefits) with the item “feeling good about an investment in RE projects”. To include it in the conjoint experiment for the Swiss context, after expert counselling we called it “solar vignette”. Similar, we were informed by previous work, including Chan et al. (2017), which helped us to justify the inclusion of attributes such as provider and purchase modality, as for example this theoretical review article gave recommendations for shared PV project attributes that should be included in future designs, such as project ownership (our provider attribute) and enrolment (our purchase modality attribute). Still, to the best of our knowledge, provider attributes have not been empirically tested apart from our study at hand, therefore, we talked to local experts.

For further reference, the 6 experts were (in alphabetical order) Christof Bucher (professor for PV systems), Maria Anna Hecher (expert on the energy transition from a socio-technical perspective), Annelen Kahl (scientist and co-founder of a PV project), David Stickelberger (manager of a PV project), Peter Toggweiler (pioneer and expert in the PV field) and Evelina Trutnevyte (associate professor for renewable energy systems).

Data Cleaning

We only excluded cases who completed the survey in less than approximately 15 minutes (i.e. lowest 10 % of survey time), or who took over 1 hour, and those who indicated they intended to purchase more than 300 modules. This decision was made to ensure that the study results accurately reflect the target population and to avoid any potential biases. It is important to note that the cost of purchasing more than 300 modules would be at least CHF 60,000, which is nearly one fifth of the Swiss median income in 2021 (Federal Statistical Office, 2023).

The process of data cleaning yielded 2917 respondents who provided information on their house ownership or tenancy status. 1243 respondents claimed that they live in their own house, and were, henceforth, excluded from further analyses. The share of tenants is, thus, somewhat lower in our sample than official data on the Swiss population suggests (roughly 58 % of citizens do not own their house or apartment (Eurostat, 2023)). This is likely due to the fact that respondents from lower socio-economic strata, which are less likely to own a house, are somewhat underrepresented in the survey (as is the case in almost all survey projects).

3 Article 2: Going solar? Unveiling the role of knowledge in shaping social acceptance of citizen-financed PV projects in Switzerland

This chapter is identical with a manuscript under review in Utilities Policy.

The final manuscript has been published as:

Ruprecht, Sophie and Stadelmann-Steffen, Isabelle. 2025. Going solar? Unveiling the role of knowledge in shaping social acceptance of citizen-financed PV projects in Switzerland. *Utilities Policy* 97: 102040. DOI: 10.1016/j.jup.2025.102040.

Abstract

To advance the energy transition, citizen-financed photovoltaic projects offer a more inclusive participation opportunity. Knowing investors' preferences about project attributes is therefore crucial. Apart from the general role played by project attributes for investors' project acceptance, this paper also sheds light on the role of knowledge in the relationship between project attribute configurations and different dimensions of social acceptance. Using original data from Switzerland 2022, conjoint analyses show higher project acceptance for more knowledgeable respondents. Results also vary across knowledge subgroups and the stages of the investment process. Hence, policymakers and project providers should address potential investors differently.

Keywords: Renewable Energy, Social Acceptance, Conjoint Experiment

3.1 Introduction

Like most European countries, Switzerland signed the 2015 Paris Agreement and hence consented to do its part in reaching the net-zero emissions goal in order to keep the rise in mean global temperature below 2°C. As if the rapidly progressing climate change were not motivation enough to advance the slow-moving Swiss energy transition, the energy system is currently also faced with the urgent problem of having to become independent of Russia's fossil energy in light of the war on Ukraine and its concomitant geopolitical tensions. Since hydropower, for example, is almost maximally exploited in Switzerland (Swiss Federal Office of Energy, 2019b) and wind energy faces substantial implementation problems (Schmid, 2023), one of the most promising options to achieve these goals is to introduce more solar power. It is said to be a reliable energy source and currently has the biggest potential for expansion (Moro et al., 2021; Rohrer, 2020; Swiss Federal Office of Energy, 2019a). Further, it has become reasonably priced in recent years (Dujardin et al., 2021) and is highly socially accepted (Salm et al., 2016; Stadelmann-Steffen et al., 2018; Stadelmann-Steffen and Dermont, 2021), especially when implemented at a small scale (Cousse, 2021). In contrast to classic rooftop solar photovoltaics (PV), citizen-financed PV projects (CPP) pose a less-known opportunity for all citizens to participate and invest in. CPPs can be described as solar PV installations that are not built upon one's personal roof. Instead, a larger cluster of solar panels is provided by a supplier, who typically builds them in more public or commercially-used spaces. They are co-founded by many private actors, which technically makes them accessible to everyone. Therefore, CPPs provide a promising alternative opportunity for individuals to contribute to the fight against climate change and the transition of the energy system, notably for residents without the means to install solar PV on their own roof, such as tenants or low-income households. Apart from the mentioned ecological benefits, CPPs can be seen as a financial investment, as the investor gets reimbursed in some form. After the resurgence of more right-wing and the simultaneous weakening of green parties in the Swiss federal elections 2023, the energy transition is now likely to be prioritised even less than before, hence the crucial role of CPPs. Since community initiatives for other renewable energy sources like wind power have proven to work well in attracting investors (see Maruyama et al., 2007), similar effects can be expected for CPPs. Amongst all renewable energy projects, PV projects seem to be favoured by citizens (Ebers Broughel and Hampl, 2018). Therefore, investigating population groups beyond those who traditionally install solar PV (e.g. homeowners, affluent individuals or early adopters of new technologies) greatly contributes to both research and climate change mitigation, as CPPs allow for much smaller investments by a broader pool of potential contributors. As little is still known about how certain CPP attributes are evaluated and whether and under what circumstances people are willing to invest in CPPs, an exploration into what project configurations are considered acceptable seems justified. LaPatin et al. (2023) and Goodarzi et al. (2021) specifically highlight the relevance of identifying wind and CPP attributes that are attractive to investors in order to secure long-term success, as distributing information alone, for example, does not suffice to secure willingness to invest, and knowing about people's preferences

and goals is long-known to be decisive for humans to take action (see Maslow, 1943).

In line with suggestions from previous studies (e.g. Leeper et al., 2020; Siegrist and Cvetkovich, 2000; Vuichard et al., 2021), I will dive deeper than simply investigating social acceptance of CPPs in general, and will do so for multiple population subgroups with various levels of knowledge. Research has long pointed to the relevance of fostering any kind of knowledge: Benjamin Barber (1984), for example, stressed the importance of civic education, and Robert Dahl (1989) famously argued that “true” opinions can only be formed when citizens are provided with a maximum amount of information and are open to integrating it into their current state of knowledge, potentially leading to the formation of new opinions. Empirically, the possession of knowledge has been linked to a variety of democratically or environmentally relevant concepts such as conscientious voting behaviour (Singh and Roy, 2014), coherent preference formation (Ripberger et al., 2012), political tolerance (Hall, 2018) or acceptance of wind energy (Langer et al., 2017). In short, “environmental knowledge is considered an important pre-cursor to pro-environmental behaviour” (Player et al., 2023, p. 1, but see also Tamar et al. (2021)). Knowledge itself is a rather diffuse concept and can be viewed multidimensionally. Hence, I operationalise it by looking at two different forms: Educational attainment and solar PV experience. While the first variable captures an abstract form of knowledge, the latter is much more concrete. This dual examination of sometimes interchangeably used concepts (e.g. Kronrod et al., 2023, p. 13) is made in order to first find potential differences regarding acceptance of CPPs between different subgroups and to secondly compare findings between the two forms of knowledge. The two variables were also chosen due to non-existent evidence on this specific topic at hand. While social acceptance of solar PV does not seem to vary systematically amongst differently educated people and enjoys high approval overall (e.g. Cousse, 2021; Sposato and Hampl, 2018), one can still expect heterogeneous project attribute preferences or investment behaviour in the context of CPPs. For example, more education is associated with green behaviours (Motz, 2021) or higher income (Tamborini et al., 2015), which would suggest higher social acceptance of citizen-financed PV projects as well. Further, education is empirically linked to more solar PV experience (Kaplan, 1999, but see also Appendix 3.6.1) and since previous research has pointed to positive relationships between various experiences and their corresponding acceptance (e.g. Trandafir et al., 2023), looking at the project preferences uttered by those most informed, i.e. those with concrete solar PV experience, could lead to the identification of what Robert Dahl (1989) labelled as “true” opinions.

Therefore, this paper’s research question can be summarised as: *What is the role of general and concrete knowledge pertaining to the relationship between citizen-financed PV project attributes and social acceptance of such projects?*

This research question will be studied in Switzerland. Like other countries, due to both climate change and Russia’s war on Ukraine, Switzerland has to rapidly transition its energy system towards more renewable and independent energy sources. Switzerland is particularly well-suited for the research question stated above, as it has the highest percentage of tenants (Eurostat,

2023a) as well as the second highest median income¹ in Europe (Eurostat, 2023b). In practice, this means that whilst a lot of people would have the financial means to afford some kind of renewable energy, only 40% of the Swiss own their place of residence, leaving 60% of residents without the option to install solar PV on their own roof. CPPs therefore potentially have a large market to fill and could substantially contribute to successfully transitioning Switzerland's energy system.

This paper expands existing research as follows: Empirically, studies on CPP acceptance are so far sparse. In the past, research has shown that, especially for large-scale solar PV, social acceptance is considerably lower the more tangible a project becomes (e.g. Baur et al., 2022). Conceptually, by looking at multiple aspects of social acceptance (Wüstenhagen et al., 2007), I therefore offer a more encompassing perspective on the topic at hand, unlike the majority of research on social acceptance of renewable energy that usually just considers a single dimension. Further, by conducting a conjoint experiment, respondents are asked to make decisions based on multiple project criteria. Such designs most closely resemble real-world situations, and hence counteract criticism regarding oversimplification of choice behaviour and social desirability bias in conventional surveys (Auspurg and Hinz, 2014; Hainmueller et al., 2014, 2015). In addition to presenting the findings of the full population conjoint analysis, I also focus on two knowledge-variables (education and solar PV experience), thus checking for the universality of results and offering additional insight into the relationship between different project configurations and CPP acceptance. An investigation of subgroups with respect to social acceptance of solar PV was also suggested by Vuichard et al. (2021). Conducting subgroup analyses thus also contributes to literature by showing that not all population groups react similarly to the same project attributes, hence posing practical implications for both policymakers and CPP providers.

3.2 Theoretical background

3.2.1 The drivers of citizen-financed PV project acceptance

Social acceptance of renewable energy sources and technologies has been studied extensively in recent years (e.g. Cousse, 2021; Mayer et al., 2021; Plum et al., 2019; Schumacher et al., 2019; Stadelmann-Steffen, 2019; Sütterlin and Siegrist, 2017; Tabi and Wüstenhagen, 2017; Vuichard et al., 2022). The hereby established concept of social acceptance, according to Wüstenhagen et al. (2007), comprises three dimensions: socio-political, community and market acceptance. Socio-political acceptance captures a broad and general form of acceptance by the public or policymakers. There is evidence suggesting that socio-political acceptance tends to be highest, as it only asks about individuals' approval instead of concrete implementation (e.g. Baur

¹ Adjusted for purchasing power.

et al., 2022; Schwenkenbecher, 2017). This is also the case for large-scale solar PV (Schumacher et al., 2019). Community acceptance describes acceptance of residents regarding planned local projects. Market acceptance refers to the process of market adoption from a demand or supply side (Wüstenhagen et al., 2007), hence, it can be seen as the last and most meaningful step to implement renewable energy. Studies focusing on market acceptance of renewable energies are rare, the same holds for research comparing multiple dimensions. I address this shortcoming by including both socio-political and market acceptance.²

Despite existing insights into the general preferences regarding many energy sources such as hydropower (e.g. Tabi and Wüstenhagen, 2017), solar (e.g. Cousse, 2021) or nuclear energy (e.g. Sonnberger et al., 2021; Visschers and Siegrist, 2013), primarily market acceptance remains understudied, as it is more difficult to measure than socio-political acceptance. However, knowing about the factors that boost or hinder actual implementation of renewable energy is more relevant in practice than capturing general preferences, especially since more concrete forms of social acceptance are typically lower due to higher (perceived) personal costs or sacrifices (Baur et al., 2022; Schumacher et al., 2019). In light of the energy transition and the need to increase independence from energy imports, the expansion of renewable energy such as potential-rich solar power plays a crucial role. In general and also in Switzerland, solar energy is highly socially accepted (Azarova et al., 2019; Schumacher et al., 2019; Stadelmann-Steffen et al., 2018; Sütterlin and Siegrist, 2017), less controversial than wind energy (Curtin et al., 2019; Schmid, 2023) and has more potential for further exploitation than hydropower, for example (Swiss Federal Office of Energy, 2019a,b). Instead of installing personal rooftop solar PV, which is not available to a large percentage of the Swiss population due to renting or other mitigating factors, the possibility of participating in CPPs exists, in principle, for everyone. Also called solar community initiatives, CPPs can be seen as a policy tool that fosters decarbonisation (Seyfang et al., 2014) and which consist of medium-scale,³ remotely or off-site built solar panels that are typically co-funded (Peters et al., 2018) and therefore non-governmental (Oteman et al., 2014). Although past studies indicate a high degree of societal support (e.g. Rogers et al., 2008), it seems to be lower than for small-scale solar PV (e.g. Schumacher et al., 2019). Changing citizens' involvement from just consumption to production, i.e. switching to (co-)ownership, seems to be a pivotal factor in order to gain societal consent (Peters et al., 2018; Schumacher et al., 2019). The call for identifying energy project attribute preferences has recently gained impetus (e.g. Goodarzi et al., 2021; LaPatin et al., 2023), as investing and participating in these CPPs supports the energy transition from the bottom-up. Globally, there exists a large number of such solar community providers already, yet, they remain a niche part of overall energy systems (Nolden et al., 2020). Therefore, they still hold great potential.

² I cannot study community acceptance because this dimension is difficult to measure in a broad population survey.

³ Size-wise, CPPs are usually “intermediate between large-field and individual residential or commercial systems” (Peters et al., 2018).

While there exists no universal definition of what energy community projects conceptually encompass (see Seyfang et al., 2014), Walker and Devine-Wright (2008) were the first to propose an abstract framework for specifying community renewables, which includes a process and an outcome dimension. The process dimension is concerned with who develops and provides an energy project, the latter addresses the project’s beneficiaries. In the context of their framework, they define an ideal energy community project as open and participatory (process dimension) as well as local and collective (outcome dimension). Taking these two dimensions into account when dealing with the choice of more concrete project characteristics, the following project attributes seem to matter for social acceptance of renewable energy projects: Location, reimbursement to the investor, purchasing modality, price per module and the provider. While careful attribute selection by experts matters, as is long-known in the theory of innovation diffusion, “perceptions count”, i.e. it is of particular relevance for product adoption how investors perceive a certain attribute and react to it (Rogers, 1995). Drawing on current research, the remainder of this chapter will focus on addressing some potentially influential CPP attributes, which will be taken into account in the subsequent conjoint experiment.

Starting with the *location* of CPPs, some studies have highlighted the value of local and decentralized energy, as long as it does not negatively impact the environment or deter tourists from the area (Rogers et al., 2008; Süsser and Kannen, 2017). Some even gave the highest weight to the protection of flora and fauna (Alvarez-Farizo and Hanley, 2002). And despite being criticised for being too simplistic, the NIMBY (“Not In My Back Yard”)-phenomenon does seem to hold some truth, as wind parks (or even renewable energy projects in general) that are visible and placed in nice landscapes or near residents were less socially accepted (Curtin et al., 2019; Langer et al., 2017; Vuichard et al., 2022). Preferred locations of renewable energy projects are agricultural and industrial zones or former military sites (Pascaris et al., 2021; Stadelmann-Steffen and Dermont, 2021; Vuichard et al., 2022). In line with their high degree of social acceptance, solar PV close to residents is not always negatively evaluated (Vecchiato and Tempesta, 2015).

Next, *reimbursement*, or return on investment, has been shown to be of great importance in conjoint experiments investigating social acceptance of renewable energy projects (Curtin et al., 2019; Salm et al., 2016). For some investors, the decisive factor seems to be financial aspects like purchase subsidies, tax exemptions or car charging discounts (Li et al., 2020), payouts or energy savings for lower-income households (Süsser and Kannen, 2017), revenue sharing with all residents or the municipality of the wind park (Vuichard et al., 2022) or the enhanced prosperity of the region (Rogers et al., 2008). Regarding CPPs, compensation via the solar resource tax is positively evaluated in the study by Vuichard et al. (2021) as are higher personal revenues in general (Trandafir et al., 2023), while other premiums like cash rebates or e-bikes fail to increase social acceptance (Hille et al., 2018). Apart from financial motives, community relationships (Pascaris et al., 2021), sustainability interests (Rogers et al., 2008) or environmental reasons can also increase social acceptance of renewable energy projects, as they are seen as an individual contribution to climate change mitigation (Sloot et al., 2019; Süsser and Kannen, 2017). In the

context of a climate policy bundle, various financial benefits have been shown to be conducive to policy support as well (Bergquist et al., 2020).

Since *purchasing modality*, i.e. how someone learns about the possibility to invest in CPPs and hence buys or rents off-site solar panels, might also be relevant for project acceptance, it is studied as another CPP attribute here. Little research on this factor has been conducted so far, and the respective evidence is mixed. While Stadelmann-Steffen and Dermont (2021) for example find that information events about renewable energy projects do not significantly foster social acceptance more than the distribution of information brochures, other studies indicate that, in general, information does seem to matter for project acceptance (van der Schoor and Scholtens, 2015). Others also report positive effects of information meetings regarding project acceptance of wind or alpine PV projects (Vuichard et al., 2021, 2022). An investigation into more detailed information effects concludes that information distributed via the project’s homepage or a newspaper appeals to more people than a newsletter. Further, Kluge et al. (2021) find that being informed by an independent expert or a project leader is positively evaluated, while information provision by a politician is viewed negatively.

Unsurprisingly, the *price* of an investment has repeatedly been found to be the most important attribute in conjoint experiments, specifically for some regarding carbon tax schemes (Hammerle et al., 2021) and energy system preference (Leijten et al., 2014). As is economically intuitive, cheap prices are more popular (Süsser and Kannen, 2017) and higher prices decrease the chance of deviating from the status quo to renewable energy (Azarova et al., 2019), public support for global climate change cooperation (Bechtel and Scheve, 2013) and acceptance of a climate policy bundle (Bergquist et al., 2020). Additionally, higher investment costs lead to lower willingness to adopt solar rooftop PV (Hille et al., 2018).

Lastly, a CPP’s *provider* might also play a central role in an investor’s decision-making behaviour. In fact, some citizens seem to refuse project participation purely due to their scepticism of whose responsibility energy supply should be or fear that the community itself would be unable to lead an energy project (Rogers et al., 2008). Others however suggest that community-led projects are most popular (Curtin et al., 2019), followed by a preference of public over private providers (Stadelmann-Steffen and Dermont, 2021). Further, there is evidence that social acceptance of local ownership is higher than that of foreign providers (Hille et al., 2018; Salm et al., 2016; Vuichard et al., 2021, 2022).

3.2.2 The role of knowledge

Knowledge about an issue might also play an essential role for it to be accepted. In general, the more knowledgeable a person is, the more rationally they are capable of assessing a problem (Siegrist and Cvetkovich, 2000). Possessing more knowledge is associated with higher awareness

about risks, costs and benefits and, hence, higher acceptance (e.g. Huijts et al., 2012). Accordingly, a lack of environmental knowledge has been associated with lower intention to adopt pro-environmental behaviours (Kronrod et al., 2023). But as far as I am aware, there is no existing research on how CPP acceptance is contingent on citizens' knowledge. Nonetheless, there are some theories suggesting differences in social acceptance between higher and lower educated people or those with and without solar PV experience, which, in this study, are assumed to represent two different dimensions of knowledge. This section will lay out some theoretical differences between a more abstract and concrete form of knowledge about or familiarity with CPPs.

Education

Even though classic solar rooftop PV is highly socially accepted and acceptance does not seem to systematically vary between different education groups (e.g. Cousse, 2021; Sposato and Hampl, 2018), nothing is known about the influence of education on the relationship between CPP configurations and their social acceptance. Education is often treated as a catch-all variable because it is linked to a variety of other factors such as information-processing capabilities (Guerra-Carrillo et al., 2018), environmental knowledge (Tobler et al., 2012), green behaviours (Motz, 2021) or higher income (Tamborini et al., 2015). It has also been positively linked to general renewable energy project acceptance (Ebers Broughel and Hampl, 2018). Therefore, it does not seem too far-fetched to hypothesise that for CPPs, different education groups also exhibit dissimilar preferences for CPP attribute levels or even non-identical investment behaviour, i.e. market acceptance. Theoretically, such differences might be attributed to disparate information-processing, with better educated respondents being less likely to fall back on heuristics than lower educated individuals when making a decision (Chen and Chaiken, 1999). Empirically, this proposition is backed by studies indicating positive relationships between awareness about and consumers' intention to use renewable energies (Irfan et al., 2021), pro-environmental attitudes and willingness to accept higher energy costs (Bechtel and Scheve, 2013), knowledge about wind energy, its ascribed relevance as well as willingness for active involvement (Langer et al., 2017) or between climate change concerns and wind energy investments (Alvarez-Farizo and Hanley, 2002). Further, Azarova et al. (2019) finds that less educated citizens are less willing to deviate from the status quo energy system towards renewable energy communities and Goodarzi et al. (2021) show that higher education leads to higher intentions to adopt solar PV.

In sum, while solar PV acceptance is expected from both high and low education groups, for the reasons mentioned above, their CPP attribute preferences could differ. More educated people are, for example, expectedly more capable of independently investing in a project, thus not being as reliant on project managers to learn about such projects. Higher educated respondents might

further place more weight on environmental⁴ and non-financial aspects and express lower price-sensitivities, which could become especially apparent in higher market acceptance. In turn, this might lead to different real-life investment decisions, such as non-adoption due to unfavourable conditions, justifying an investigation into the preferences of education subgroups for the CPP attributes at hand.

Solar PV experience

Next, previous experience with PV could also exert an influence on CPP acceptance. Since knowledge is linked to both education and experience, and education positively relates to solar PV experience (Kaplan, 1999, but see also Appendix 3.6.1), the latter probably measures a much more concrete and accurate form of knowledge about solar PV than education. Inherent in experience are some kind of feedback processes (e.g. Kolb, 1984; Zaller, 1992), in the sense that “ideas [...] are formed and re-formed” (Kolb, 1984, p.26). Through experience and the “information [generated] to assess deviations from desired goals” (Kolb, 1984, p.22), people evaluate their choice options based upon collected evidence (Weber and Johnson, 2011). As, according to the theory of mere exposure, the “mere repeated exposure of the individual to a stimulus object enhances his attitude toward it” (Zajonc, 1968, p.1), “persons who are highly engaged with an issue may thus develop the crystallised attitudes that most opinion researchers take to be the norm” (Zaller, 1992, p.55). Therefore, as experience with something is also said to increase its salience, this can lead to attitude changes (Zaller, 1992), resulting in the “true” opinion regarding a certain matter gained through experience, as compared to initial opinions (e.g. Dahl, 1989). Such assumptions would moreover be in line with the information deficit model, which states that a lack of knowledge is responsible for low acceptance and can be increased by exposure to more information (e.g. Sturgis and Allum, 2004).

Existing research on familiarity or experience points to the following findings: Past experience with a matter seems to foster its acceptance, but the relationship might not be as simple or straightforward. For example, Cousse et al. (2020) show that while familiarity with wind energy decreases local concern, this does not automatically translate into higher social acceptance. In a similar vein, exposure to hydrogen energy has primarily been linked to higher trust in the technology, which in turn indirectly manages to increase social acceptance (Hienuki et al., 2019). It is also suspected that both knowledge and experience influence a variety of factors surrounding social acceptance (such as trust, perceived risks and benefits or intention to adopt), but that experience itself mainly affects how these factors are weighted that contribute to opinion formation

⁴ While it is unclear whether those with more or less education would be more opposed to placing large-scale solar PV installations in landscapes of value (such as on farmland or in skiing areas), as education is unrelated to wind energy acceptance (Langer et al., 2018), I argue that more educated respondents are more open to put solar panels on existing infrastructure and hence avoid a trade-off between landscape protection and energy generation.

or behaviour intention (Huijts et al., 2012). This would be in accordance with findings from Howe (2021), who shows that extreme weather experiences only reinforce climate change concerns for those who are concerned about it to start with, but not for those initially unconcerned. Positive relationships between familiarity with both wind and solar energy and their social acceptance have also been established (Dällenbach and Wüstenhagen, 2022; Donald et al., 2022; Schumacher et al., 2019) and exposure to solar developments has further been linked to increased community acceptance (Trandafir et al., 2023). But specifically, the only other study investigating experience and energy project attributes concludes that, the more experience a person has with wind energy, the more they value their financial investment into the project and, hence, the financial project aspects overall (Langer et al., 2017).

3.2.3 Theoretical expectations

In order to bring chapter 3.2.1 and 3.2.2 together and to combine the different strands of literature, some general theoretical expectations are set out. Due to the novelty of and the sparse evidence on the matter, I follow a more exploratory approach and refrain from formulating explicit hypotheses. For one, I anticipate that the design of a citizen-financed PV project matters and, two, that more knowledge increases social acceptance. Lastly, different preferences depending on the subgroup seem plausible, i.e. depending on the level of knowledge, varying resources and motivations lead to different project design preferences.

3.3 Research Design

3.3.1 Case selection

This study empirically focuses on Switzerland. In light of the Russian war on Ukraine and like most European countries' need to transition their energy systems, Switzerland must also adapt to new circumstances that require more energy independence from fossil fuels. Additionally, since the diffusion of most renewable energy sources faces many political, societal and technological challenges, which endangers a timely transition of the Swiss energy system, solar energy currently has the biggest potential, as it is the most popular renewable energy source in Switzerland (Stadelmann-Steffen et al., 2018). Due to Switzerland's high rate of tenants (Eurostat, 2023a), who cannot install solar PV on their own roofs, CPPs encounter perfect conditions in this country. Therefore, knowing about potential Swiss investors' project preferences is of distinct importance. In addition, due to the country's high degree of federalism, the implementation of energy policies is primarily located at the cantonal and communal level, allowing policymakers to address the specific needs of individual regions, and leaving the state with only a coordinating role, e.g. in setting the nation's energy targets (Vatter, 2020). Unlike personal rooftop solar PV, CPPs tend to be more large-scale and could therefore, depending on their implementation and regional context,

underlie different solar PV regulations, which asks for a federalist context such as offered by Switzerland. Decentralised structures enable a quicker adaptation of spatial planning regulations than centralised states, hence being closer to citizens' preferences (Dardanelli and Mueller, 2019; Schmid et al., 2021). This resulting diversity in political institutions makes Switzerland both a “realistic case” (Freiburghaus and Vatter, 2023) and a “microcosm” (Rokkan, 1974). In this sense, findings could be of interest to other countries, too. Regarding political feasibility, owed to Switzerland's strong direct democracy (Vatter, 2020) and, hence, citizens' veto power, knowing about voters' preferences is generally of essence in order for politicians to work out new policies that facilitate the more widespread adoption of solar energy.

3.3.2 Data

To analyse social acceptance of CPPs, I employ original data from Switzerland that were collected as part of the federally funded SWEET-EDGE project between August and October 2022. The survey extensively asked about respondents' attitudes towards renewable energy (Stadelmann-Steffen et al., 2022). The Swiss Federal Office randomly drew a sample from their population register that is representative for the Swiss population but is also stratified along Switzerland's three main geographical areas (Midlands, Jura, Alps), resulting in a dataset of approximately 2'500 respondents. Due to the complexity of the web survey, respondent age was restricted to a minimum of 18 years. Participants whose response time exceeded one hour were removed. Some descriptive sample statistics can be found in Appendix 3.6.2.

The independent variables consist of the five CPP attributes that were shown to respondents in the conjoint experiments to describe the hypothetical projects: As set out in chapter 3.2.1, the *location* of the CPP might prove relevant to respondents. Additionally, the way in which (potential) investors are *reimbursed* as well as how a CPP participation can be *purchased* could also be essential. I further expect the *price* per solar PV module to be important for investment decisions. And finally, it might be meaningful to investors to know who the *provider* of the CPP is. The attributes and their levels, shown in Table 3.3.1, have been carefully selected by consulting solar PV experts as well as by turning to existing research.

Table 3.3.1: The Conjoint Design: Attributes and Levels

Attributes	Attribute levels
Type of reimbursement to respondent	• Credit voucher on the electricity bill (10 years guaranteed) • Mobility voucher, e.g., voucher for charging electric cars or using public transportation (10 years guaranteed) • One time tax deduction • Solar vignette (a proof of investment as a plaque, sticker or the like. 10 years guaranteed.) • The federal government pays the same amount into the old-age and survivors' insurance (OASI) compensation fund. • The federal government pays the same amount to an energy project in a developing country.
Location of the solar power plant	• On a building in the residential municipality • On a farm • On traffic infrastructure in the residential municipality (e.g., noise barriers of highways and train lines, roofs of bus stops or train stations) • In a skiing area (e.g., avalanche barriers, ski lifts) • On a roof of a large consumer in the residential community (e.g., industry, school, indoor swimming pool)
Provider	• A local club or association • The electricity provider at your place of residence • The municipality of the PV plant • A start-up • A local farm • A large company
Purchasing modality	• Via a form sent by the project managers • During a meeting with project managers • Registration forms are available at retailer checkouts • Via web shop • Within the scope of an information event • Additional option when buying an electric appliance or electric car
Price per module	• 200 CHF • 250 CHF • 300 CHF • 350 CHF

Source: Brückmann et al. (2024).

At the start of the conjoint module in the survey, respondents saw the introduction text shown in Figure 3.1 as to explain to them what CPPs are. While CPPs are primarily framed as a financial investment in this study, other benefits for climate change or energy security are also emphasised:

Today, all persons, i.e. for example house and apartment owners but also tenants, have the opportunity to invest in solar power, even without owning their own roof. This is the case, for example, with **participation investments**, in which various people together finance a solar power project.

An investment in solar power projects offers a possibility for everyone to contribute to climate change mitigation, environmental protection and to securing energy supply at all times of the year.

In the following, we present different variants of such solar power projects to you. Please imagine that these are **offers for a co-investment**. You can **co-finance** these projects yourself with a **one-time investment**. By financing one or more solar modules, you can **participate with small financial contributions, but also invest larger amounts**. The energy produced by a solar module with an area of 1 m² corresponds to the annual energy consumption of 2 standard refrigerators or an electric car can drive 1000 km with the electricity produced.

You will see **5 times** in a row **2 participation options** to choose from. The projects differ in terms of different characteristics. Please consider in each case **which project you prefer and how many of those solar panels you want to invest in under these conditions**.

Figure 3.1: Screenshot of the introduction to the choice experiment

In order to cover multiple aspects of social acceptance, I include three dependent variables which reflect respondents' evaluations of CPP characteristics. The three items were asked separately after the presentation of each of the five CPP comparisons⁵ (an example of such a scenario comparison is depicted in Appendix 3.6.3) and were formulated as follows:

- Which project do you choose? – *Choice between project A and project B*
- In how many solar modules with an area of 1m² each of your chosen project do you want to invest? (please enter as number/s) – *Open question, (afterwards recoded to range from) 0-300 modules*
- Regardless of whether you invest in these projects or not, would you support their implementation? – *For both projects separately: Choice along 5-point-Likert-scale ranging from “certainly approve” to “certainly disapprove”*

The first dependent variable, *project choice*, captures a respondent's preferred project. Regarding the *number of chosen modules*, respondents act as consumers by “purchasing” a self-indicated

⁵ More methodological information can be found in chapter 3.3.3.

number of solar PV modules. This variable was capped at 300 modules in order to exclude nonsensical answers. These two variables are measures of willingness to invest, i.e. a precursor to market acceptance. Lastly, for *project rating*, a measure of socio-political acceptance, respondents are asked to evaluate both projects, independent of their decision to invest. This broad collection of social acceptance best mimics real-world support of and investment decisions in solar PV.

Further, to account for potential group differences in CPP acceptance, I split the sample into different education groups as well as into respondents with varying degrees of solar PV experience. Regarding *education*, I divide respondents into low and high education groups.⁶ For *solar PV experience*, three subgroups were created: One that has no experience with solar PV, one that has installed solar PV on their own roof and one that has already invested in a CPP. Sample descriptives of these two characteristics can be found in Appendix 3.6.2.

3.3.3 Method

I apply conjoint analysis, which is used to measure the effect of various CPP configurations on the two dimensions of social acceptance.⁷ In short, conjoint analysis serves the purpose of causal preference estimation (Leeper et al., 2020). This method takes into account that, in reality, people make decisions based on multiple criteria instead of isolated factors. Allowing for the testing of combined effects of CPP characteristics thwarts the often voiced criticism concerning oversimplification of choice behaviour in survey contexts and reduces the risk of social desirability bias (Auspurg and Hinz, 2014; Hainmueller et al., 2014). In this study, each respondent saw five paired scenarios, where two projects were opposed to each other (see Appendix 3.6.3), inviting respondents to evaluate each scenario based on the five displayed attribute levels, which varied randomly both between respondents and scenarios.⁸ As the same respondent is exposed to multiple hypothetical scenarios, i.e. project configurations, counterfactual observations are created. Even though past studies demonstrated that conjoint analyses predict real-world behaviour very well (Hainmueller et al., 2015), one should still keep the experimental survey setup in mind regarding potential issues with external validity.

To estimate the effect of certain CPP attributes on the two dimensions of social acceptance, I calculate *Marginal Means* (MMs), whereas the previously standard *Average Marginal Component*

⁶ The lower education group comprised everyone without complete education, those who finished compulsory school and respondents who did a professional apprenticeship or vocational school. I counted schools leading to a (vocational) BA or teaching diploma, higher vocational training, higher technical schools and university degrees as higher education.

⁷ No other individual control variables were included in the models due to the experimental nature of conjoint analysis.

⁸ This fivefold repetition of scenario comparison corresponds to standard practice in conjoint analysis (see Bansak et al. (2017)).

Effects (AMCEs) are provided in the Appendix.⁹ Marginal means capture “the level of favourability toward profiles that have a particular feature level, ignoring all other features” (Leeper et al., 2020, p.210). They “represent the mean outcome across all appearances of a particular conjoint feature level, averaging across all other features. In forced choice conjoint designs with two profiles per choice task, MMs by definition average 0.5 with values above 0.5 indicating features that increase profile favourability and values below 0.5 indicating features that decrease favourability. For continuous outcomes, MMs can take any value in the full range of the outcome” (Leeper, 2020). Therefore, and as opposed to AMCEs, MMs do not rely on a reference category or baseline and the effect between two attribute levels becomes directly apparent. This renders them especially helpful to analyse subgroup differences, as they technically calculate interactions between individual (respondent) characteristics and CPP attributes (Leeper et al., 2020).

3.4 Results

3.4.1 Socio-political acceptance

Starting with the dependent variable of **project rating** (ranging from 1-5), which captures socio-political acceptance, it first of all becomes apparent that average project rating is lower for less educated (low: 3.44, high: 3.72) and for less solar PV experienced respondents (no: 3.59, roof: 3.62, project: 3.7). The full sample rates a project on average with 3.6. Despite signalling slight support, this mean indicates that CPPs are less popular than rooftop solar PV (mean: 4.5) but marginally favoured over open-space PV (mean: 3.49).

Figure 3.2 displays the MMs for respondents’ rating of CPPs.¹⁰ While the project attributes of *purchasing modality* and *price*¹¹ do not matter for the full sample, other attributes prove more relevant. The form of *reimbursement* shows positive coefficients for credit vouchers and tax deductions and negative effects for solar vignettes and investments in developing countries. *Location* is positively evaluated when panels would be installed on traffic infrastructure or large consumer roofs but negatively judged when placed on farms or in skiing areas. Favourable *providers* are electricity providers and the solar plant’s community whereas large companies appear undesirable.

⁹ AMCEs represent “the marginal effect of [an] attribute averaged over the joint distribution of the remaining attributes” (Hainmueller et al., 2014, p.10), which thus only allows the formulation of relative statements.

¹⁰ AMCEs are listed in Appendix 3.6.4.

¹¹ Only the level of 200 CHF per module barely increased project acceptance.

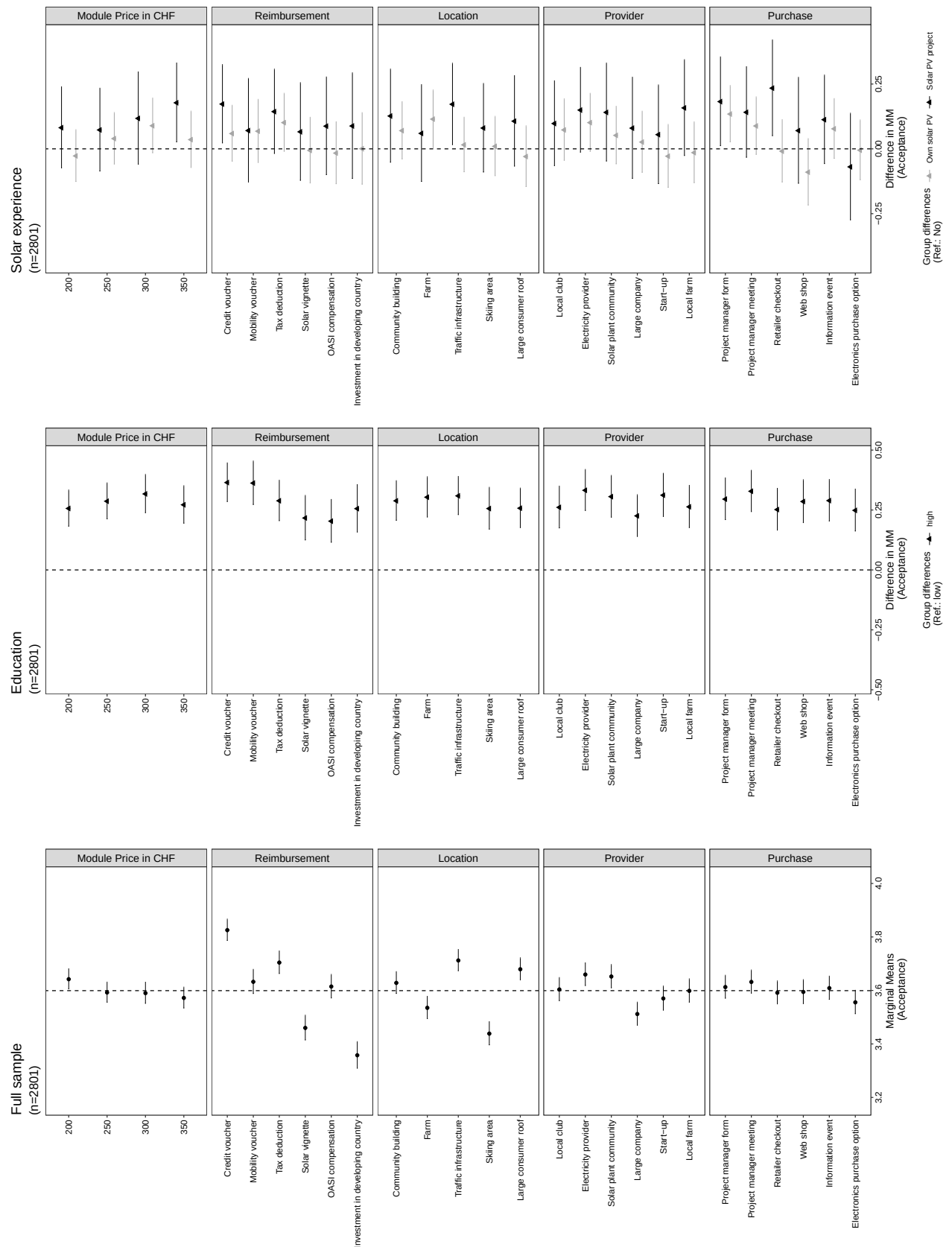


Figure 3.2: Marginal means or difference in MMs for project rating

Data source: Stadelmann-Steffen et al. (2022), own calculations and depiction.

Further, Figure 3.2 shows the differences in MMs between those with low and high education degrees. The MMs for both categories separately can be found in Appendix 3.6.5.¹² As all differences are significantly different from zero, it can be concluded that all attribute levels lead to higher project ratings, i.e. acceptance, for those more educated.

However, these differences are much less pronounced for respondents with varying degrees of solar PV experience (see Figure 3.2).¹³ Compared to those without any experience, those with rooftop PV only rate a project better when it is *located* on a farm and the *purchasing modality* is a project manager form. Those who already have CPP experience evaluate a project more favourably when *priced* at 350 CHF per module, *reimbursed* via credit voucher, *located* on traffic infrastructure or *purchased* via project manager form or retailer checkout.

In summary, for all potentially significant differences in attribute levels, the more educated or experienced a respondent, the higher also their project acceptance. While effect direction is similar, the significant differences across the two variables still vary, as different attribute levels relate differently to project rating, depending on the subgroup comparison.

3.4.2 Market acceptance

Project choice

Turning to **project choice** (see Figure 3.3), a form of willingness to invest and hence a precursor to market acceptance, the full sample prefers projects *priced* at 200 CHF per module and dislikes those priced at 350 CHF.¹⁴ *Purchasing modality* also matters for potential investments: Project manager meetings and information events are positively, retailer checkouts and web shops are negatively evaluated. For *reimbursement*, the patterns mostly remain the same as for project rating, but federal payments into the old-age and survivor's (OASI) compensation fund are now also judged positively. No preference changes are observed for *location*. For *providers*, start-ups now also negatively impact project choice.

Again looking at the differences in MMs between the two education groups (see Figure 3.3), most of the differences observed for project acceptance disappear, or the effect even changes direction, e.g. for *reimbursement* via solar vignette or OASI compensation for those more educated, which now leads to non-choice of a project.¹⁵ This is also true for the *purchasing modality* of the retailer checkout. On the other hand, a *reimbursement* via credit or mobility voucher more often leads to project choice for more educated respondents.

¹² AMCEs are listed in Appendix 3.6.6.

¹³ This might partially be due to smaller sample sizes for those more experienced. Further, marginal means are listed in Appendix 3.6.7, AMCEs in Appendix 3.6.8.

¹⁴ AMCEs are listed in Appendix 3.6.4.

¹⁵ Marginal means are listed in Appendix 3.6.5, AMCEs in Appendix 3.6.6.

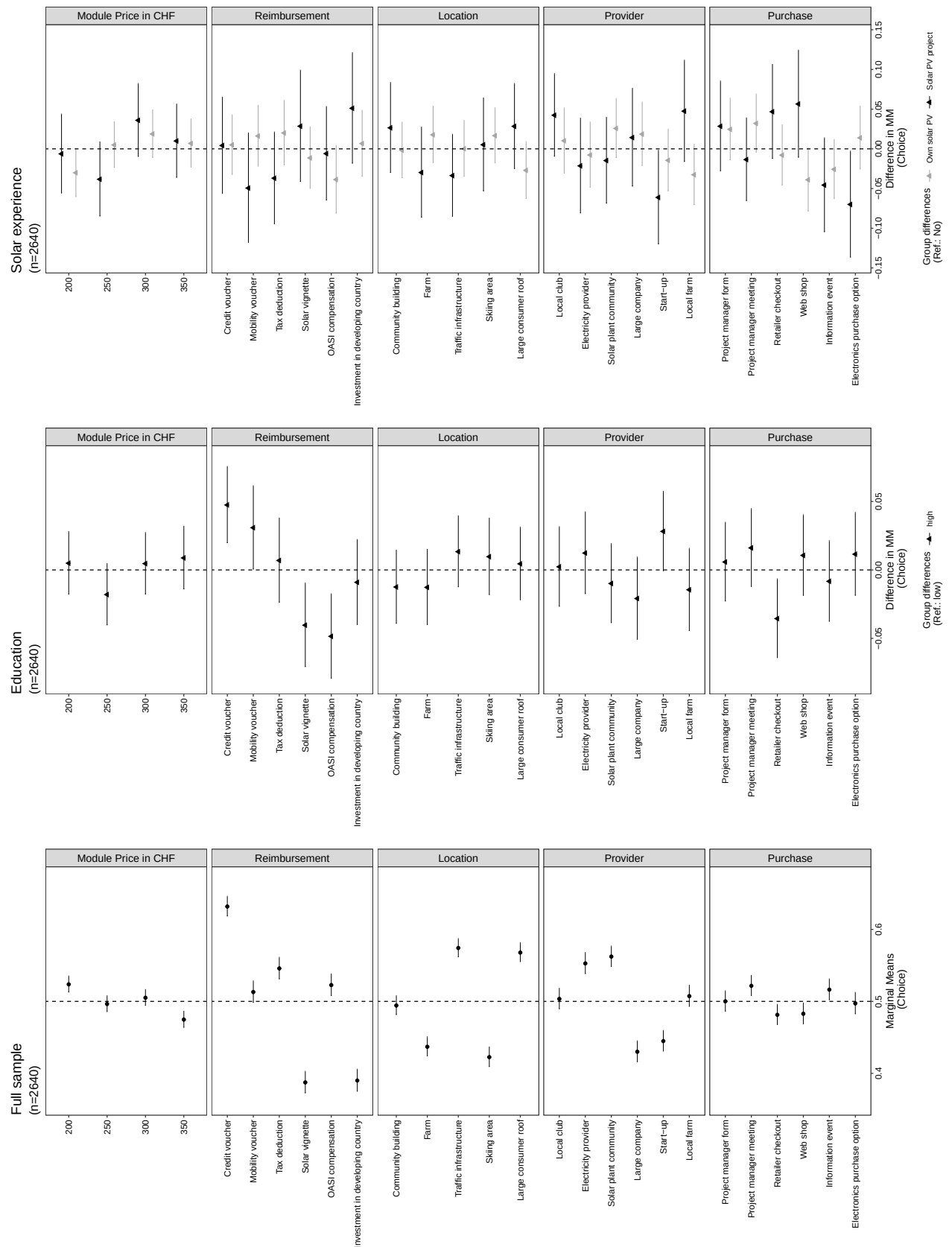


Figure 3.3: Marginal means or difference in MMs for project choice

Data source: Stadelmann-Steffen et al. (2022), own calculations and depiction.

Differences are once again much less pronounced for those with different solar PV experiences (see Figure 3.3): Compared to respondents without experience, only individuals with project experience seem to abstain from choosing a project when the *provider* is a start-up or when the *purchasing modality* is via an electronics purchase option.¹⁶

Summarising the results for project choice, it becomes evident that the differences between those with low vs. high education and those without vs. those with solar PV experience are, yet again, not identical, indicating that the two variables incorporating forms of abstract and concrete knowledge are, in fact, different. For example, while more education negatively relates to reimbursements like solar vignettes or OASI compensation, this proves irrelevant for solar PV experience.

Number of chosen modules

The second variable measuring willingness to invest in CPPs is a respondent's indicated **number of chosen modules**. Descriptively, on average, the full sample chose to buy 9.61 modules. This number is slightly higher for more educated respondents (high: 10.25, low: 8.64). However, non-linear results appear for solar PV experience: While those without any experience chose 8.85 modules, those with rooftop PV chose 12.3 modules, which is even higher than for those with CPP experience (11.75 modules). These descriptive differences might also be attributed to the fact that persons with project experience already possess project panels and hence exhibit a lower further willingness to invest, while simultaneously upholding their high socio-political acceptance.

Looking at the MMs of the full sample again, the number of modules is not significantly impacted by any attribute level (see Figure 3.4).¹⁷

Here, differentiating between various population groups proves most insightful (see Figure 3.4).¹⁸ The number of modules is higher for more educated respondents when a project is *priced* at 250 CHF or 350 CHF, *reimbursed* via credit voucher or OASI compensation, *located* on community buildings, farms or traffic infrastructure, the *provider* is a local club or the solar plant community or for the *purchasing modalities* of project manager forms, retailer checkout or web shops.

¹⁶ Marginal means are listed in Appendix 3.6.7, AMCEs in Appendix 3.6.8.

¹⁷ AMCEs are listed in Appendix 3.6.4.

¹⁸ Marginal means are listed in Appendix 3.6.5, AMCEs in Appendix 3.6.6.

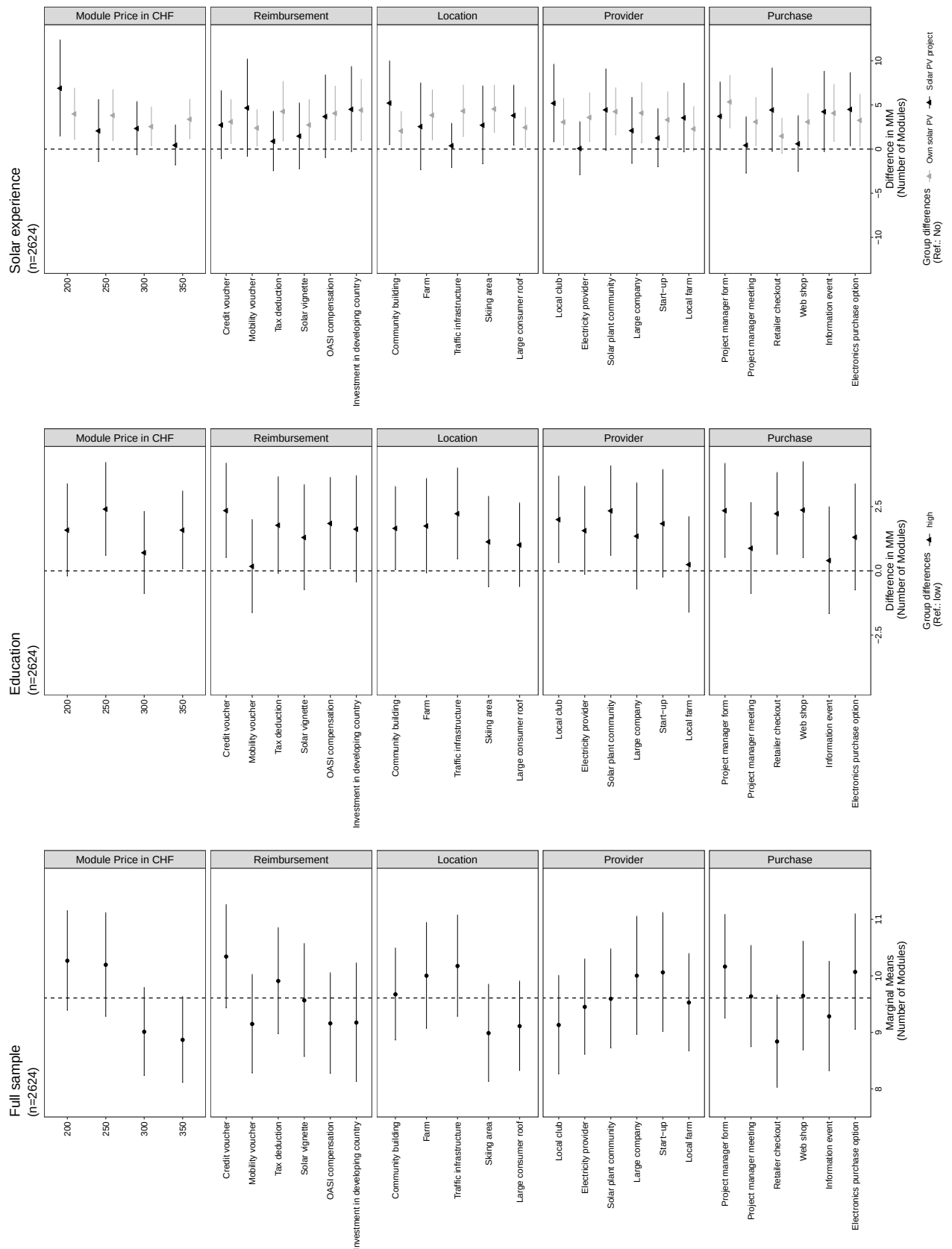


Figure 3.4: Marginal means or difference in MMs for the number of chosen modules

Data source: Stadelmann-Steffen et al. (2022), own calculations and depiction.

Interestingly, the differences in MMs are most pronounced between those without any and those with rooftop experience (see Figure 3.4), as the latter indicate a higher willingness to invest over almost all attribute levels.¹⁹ These diverging preferences could be an early indication that relevant differences in CPP perception also exist between those with rooftop and project experience, as the latter might have a more “true” outlook on the matter, which is also mirrored in their lower average of purchased modules.

In summary, significant subgroup differences are not identical between the two variables. But, as was the case for project acceptance, effect directions are again more homogeneous than for project choice.

To conclude, even though education and experience with solar PV are supposedly related concepts (Kaplan, 1999, but see also Appendix 3.6.1), the attribute levels leading to either socio-political or market acceptance are still often different between the two variables and their corresponding subgroups. An interesting observation also lies in the fact that for project choice, where respondents had to make a more “black-or-white” decision, results vastly differ between the two variables but also from the results obtained for project acceptance or the number of chosen modules, where respondents were able to answer on a more fine-grained scale. This suggests that different project attributes are relevant depending on the stage of a potential CPP investment, i.e. the basic decision of whether or not to invest at all and, later-on, on the size of an investment into this chosen project.

3.5 Conclusion and policy implications

The main goal of this paper was to investigate whether abstract and concrete knowledge about solar PV leads to different CPP attribute preferences in Switzerland. Specifically, two dimensions of knowledge, i.e. education and solar PV experience, were analysed and compared with respect to their relationship with socio-political and market acceptance of various CPP attributes. An investigation into the matter was warranted by, one, the pressing need to transition the energy system towards more independent and renewable energy sources. While solar PV is generally well-studied, less is known about CPPs, which are both a good way to invest in a renewable energy source and an alternative option for individuals to contribute to climate change mitigation. And two, due to their correlation, past research has sometimes treated education and experience as proxies for each other, so this study aimed to detect potential preference differences not just within one but also between the two variables.

Results for the full sample show that the project attributes of reimbursement, location and (to a lesser degree) provider matter most for potential investors. Stable patterns, i.e. for all three

¹⁹ Marginal means are listed in Appendix 3.6.7, AMCEs in Appendix 3.6.8.

DVs, are not observed, as no attribute level significantly predicts the number of modules. The findings further suggest that social acceptance of CPPs is present overall, but more pronounced for highly educated respondents and those with more solar PV experience. For project rating, subgroup differences are very conspicuous for education but less evident for solar PV experience. Regarding the number of chosen modules, differences primarily appear between those without any and those with solar rooftop experience, but also between education groups. For project choice however, subgroup differences are either nonexistent, much smaller or even opposite in effect direction than observed for the other two DVs. In summary, while higher education or more experience lead to higher levels of CPP acceptance, subgroup differences are neither always significant nor identical.

These findings bear important implications for policy-making: To come back to the theoretically made distinction between abstract and concrete forms of knowledge pertaining to social acceptance of CPPs, despite the established relationship between education and solar PV experience (Kaplan, 1999), these new findings suggest to henceforward not treat education and experience as substitutes for each other anymore, as their effects are shown to vary a lot. While some of their project attribute preferences are in line, certain differences appear in the data, hence leading to varying policy implications, such as tailoring project design to different target groups. Further, for less educated and less experienced individuals, increasing awareness about CPPs by launching information campaigns might be essential to get them involved in the first place. For those more educated, reducing bureaucratic hurdles and aligning project designs with people's preferences is most crucial, as they already seem to be more open to the idea of investing in such projects. Those who already invested in CPPs could provide a "best-practice" model from which providers could learn.

Despite its contributions, this paper is not without shortcomings: One, the results obtained in the course of this study are limited to the chosen attributes and their levels. Naturally, one might argue that, despite carefully choosing attribute levels with the help of PV-experts, other features should have been included as well (e.g. project scale, time frame of an investment, social involvement). Two, even though conjoint analysis captures causal effects, especially for the solar PV experience subgroups, a longitudinal study would prove immensely insightful in order to establish whether attitudes towards CPP attributes actually change with growing experience. Another possibility is that those who already invested were more open towards CPPs to start with. As of now, I can therefore only make statements about those with and without past solar PV experience, however, the preference change in those with solar PV experience could pinpoint the "true" preferences research is looking for. In the same vein, I could not control for the quality of someone's experience with CPPs, which might also influence their support. Three, the sample sizes for those with rooftop solar PV and CPP experience are rather small. This results in large confidence intervals which could possibly mask some of the now insignificant effects. With 161 respondents, the subsample-analyses of those with PV project experience yields a statistical power of 0.64, thus being somewhat below the statistically conventional thresholds (Schuessler

and Freitag, 2020).²⁰ Four, despite Switzerland being a “microcosm”, generalisability outside of Switzerland cannot be guaranteed, as Switzerland poses a most-likely case and no other contexts were examined. Hence, findings should still only be transferred tentatively. And five, one should keep the survey context in mind. Naturally, this survey only captured hypothetical willingness to invest in CPPs, as participants could not invest real money. While coming as close to measuring market acceptance as surveys allow, in the end, biases such as social desirability cannot be fully excluded. For future research, I therefore suggest the investigation of real-life investment behaviour of various population groups with regard to CPPs as well as the measurement of pre- and post-investment preferences in order to capture potential effects of solar PV experience and associated attitude changes.

Even with these limitations in mind, this paper is able to advance research on CPPs by shedding new light on the project attribute preferences of Swiss citizens in general and of different education and solar PV experience subgroups in particular. It finds that, in addition to the already established high social acceptance of rooftop solar PV, CPPs are also supported by the broad population, which dispels some of the previous doubts about large-scale solar PV installations. Policymakers and CPP providers should keep their target group in mind when drafting policies or deploying such projects, as the findings differ between the full sample and the two variables’ subgroups as well as between the different aspects of social acceptance. This could potentially attract more investors, which in turn would also accelerate the energy transition.

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²⁰ This was determined using “cjpowR” by Freitag and Schuessler (2020).

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3.6 Appendix

3.6.1 Frequency table: education and solar PV experience

	No solar experience	Rooftop solar PV	citizen-financed PV project
Low education	933 (33.310%)	174 (6.212%)	62 (2.213%)
High education	1230 (43.913%)	296 (10.568%)	106 (3.784%)

p-value: 0.000, Goodman-Kruskal's Gamma = 0.121

Data source: Stadelmann-Steffen et al. (2022), own calculations. Displayed are the results of a chi-square test of independence.

3.6.2 Sample descriptives

Variable	Category	Frequency	Percentage
Age category	18-30 years	411	14.73
	31-40 years	465	16.66
	41-50 years	535	19.17
	51-60 years	700	25.08
	61-70 years	506	18.13
	71-80 years	173	6.20
	above 80 years	1	0.04
Gender	Female	1269	51.23
	Male	1201	48.49
	Diverse	7	0.28
Income category	under CHF 5,000	429	15.63
	CHF 5,001 to CHF 7,000	627	22.84
	CHF 7,001 to CHF 9,000	576	20.98
	CHF 9,001 to CHF 13,000	669	24.37
	over CHF 13,001	444	16.17
Education	no education	22	0.79
	comp. education	112	4.00
	apprenticeship/vocational	1035	36.95
	BA/PH	276	9.85
	Higher vocational	359	12.82
	Higher technical school	274	9.78
	University/ETH	723	25.81
Education (binary)	Low	1169	41.74
	High	1632	58.26
Solar PV experience	No	2163	77.22
	Own solar PV	470	16.78
	Solar PV project	168	6.00
Political orientation	0 - Left	40	1.46
	1	56	2.04
	2	178	6.48
	3	339	12.34
	4	355	12.92
	5	758	27.58
	6	355	12.92
	7	381	13.86

Variable	Category	Frequency	Percentage
Region	8	197	7.17
	9	54	1.97
	10 - Right	35	1.27
	Swiss Plateau	1858	66.64
	The Alps	659	23.64
	The Jura	271	9.72

Data source: Stadelmann-Steffen et al. (2022), own calculations.

3.6.3 Conjoint example

Comparison 1 out of 5: Given these two projects, in which one would you invest?

	Project A	Project B
Provider	A large company	A local farm
Location of the solar power plant	On a roof of a large consumer in the residential municipality (e.g. industry, school, indoor swimming pool)	On a building in the residential municipality
Type of reimbursement to you	The federal government pays the same amount into the OASI compensation fund	The federal government pays the same amount to an energy project in a developing country
Purchasing modality	Within the scope of an information event	Via web shop
Price per module	200 CHF	300 CHF

Which project do you choose?

Project A ☐	Project B ☐
------------------------------------	------------------------------------

In how many solar modules with an area of 1 m² each of your chosen project do you want to invest? (please enter as number/s)

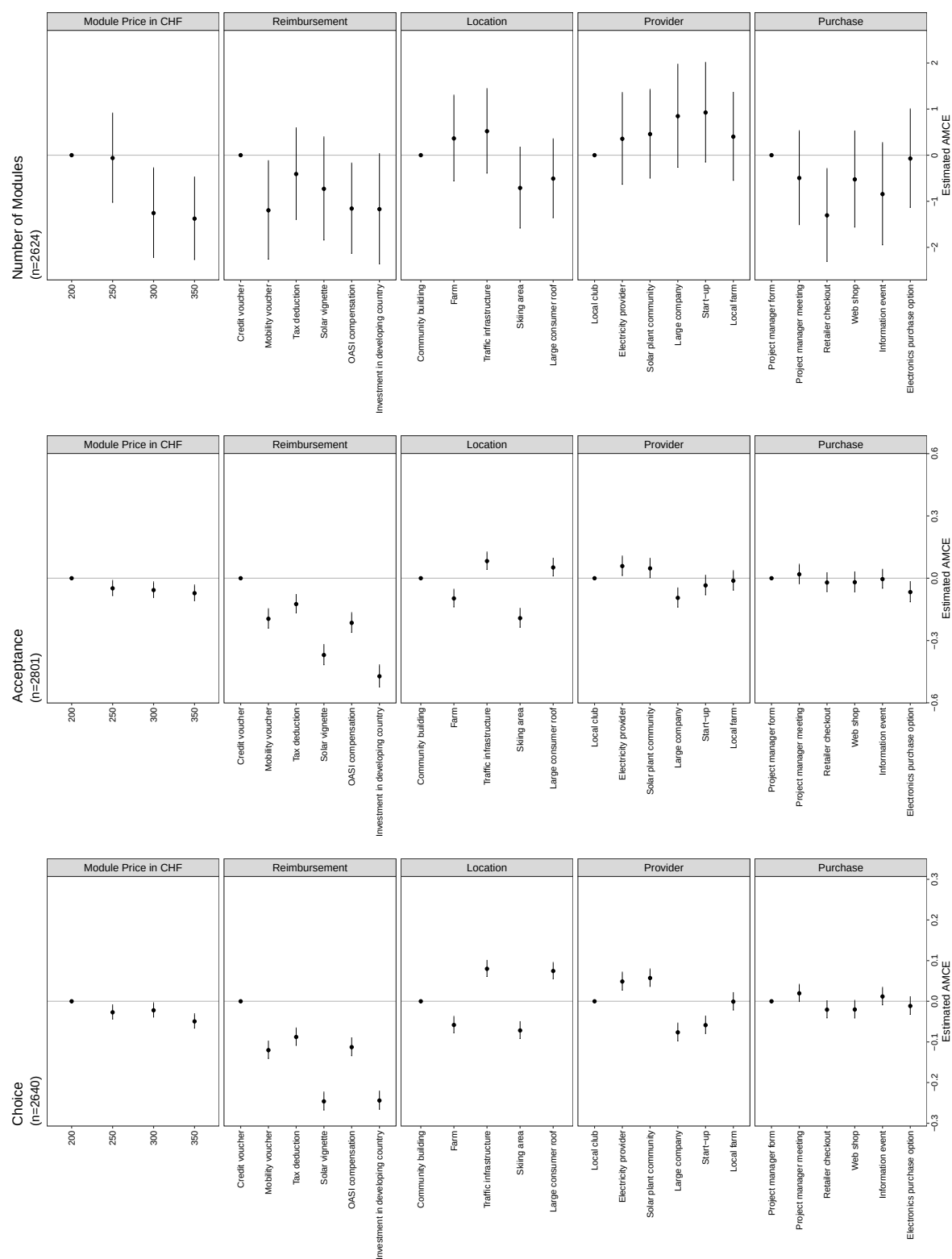
 module(s)

Regardless of whether you invest in these projects or not, would you support their implementation?

	Certainly reject	Rather reject	Neither	Rather approve	Certainly approve
Project A	☐	☐	☐	☐	☐
Project B	☐	☐	☐	☐	☐

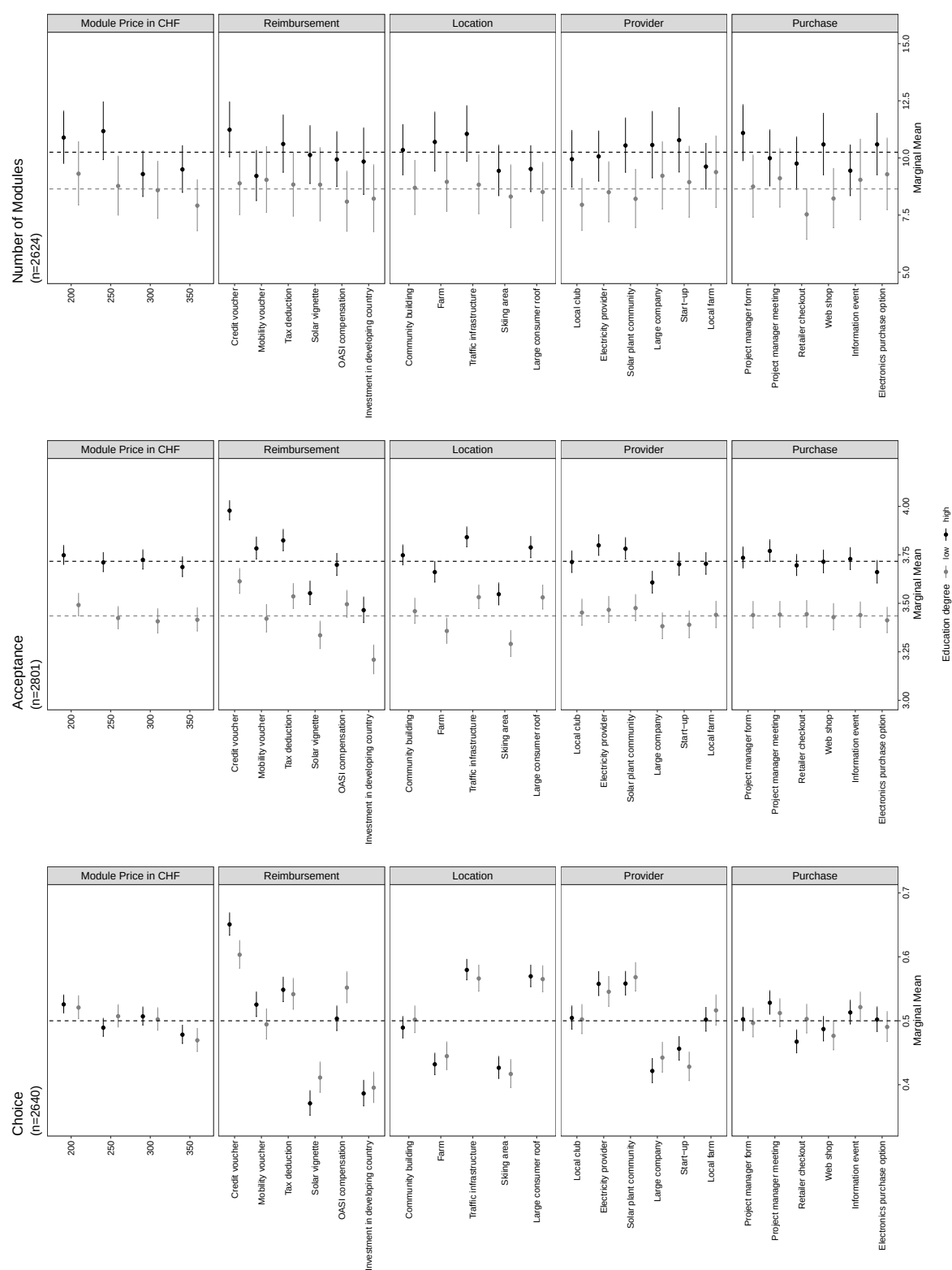
Example of the conjoint experiment as presented to respondents (Brückmann et al., 2024)

3.6.4 AMCEs – full sample



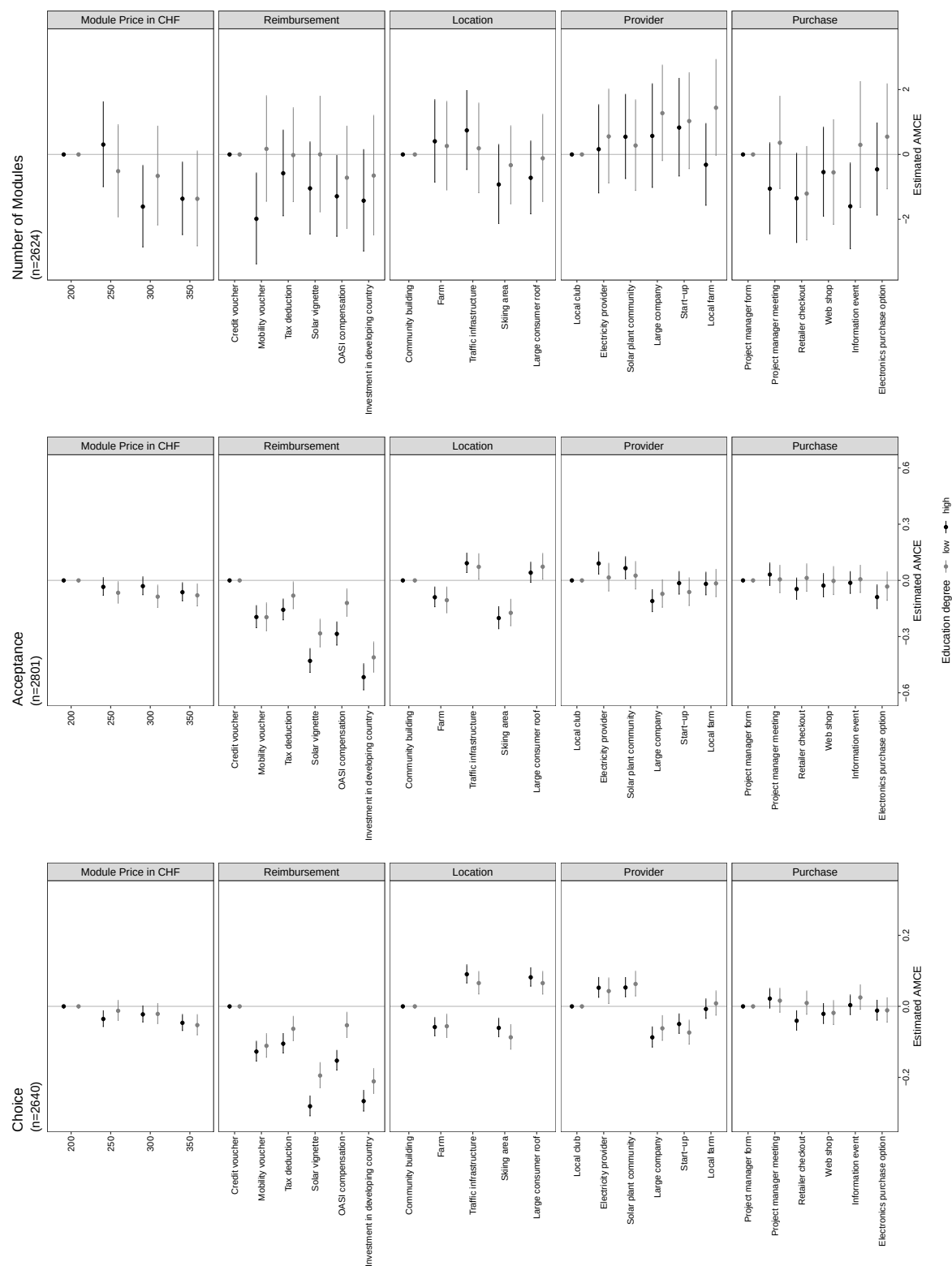
Data source: Stadelmann-Steffen et al. (2022), own calculations and depiction.

3.6.5 Marginal Means – education



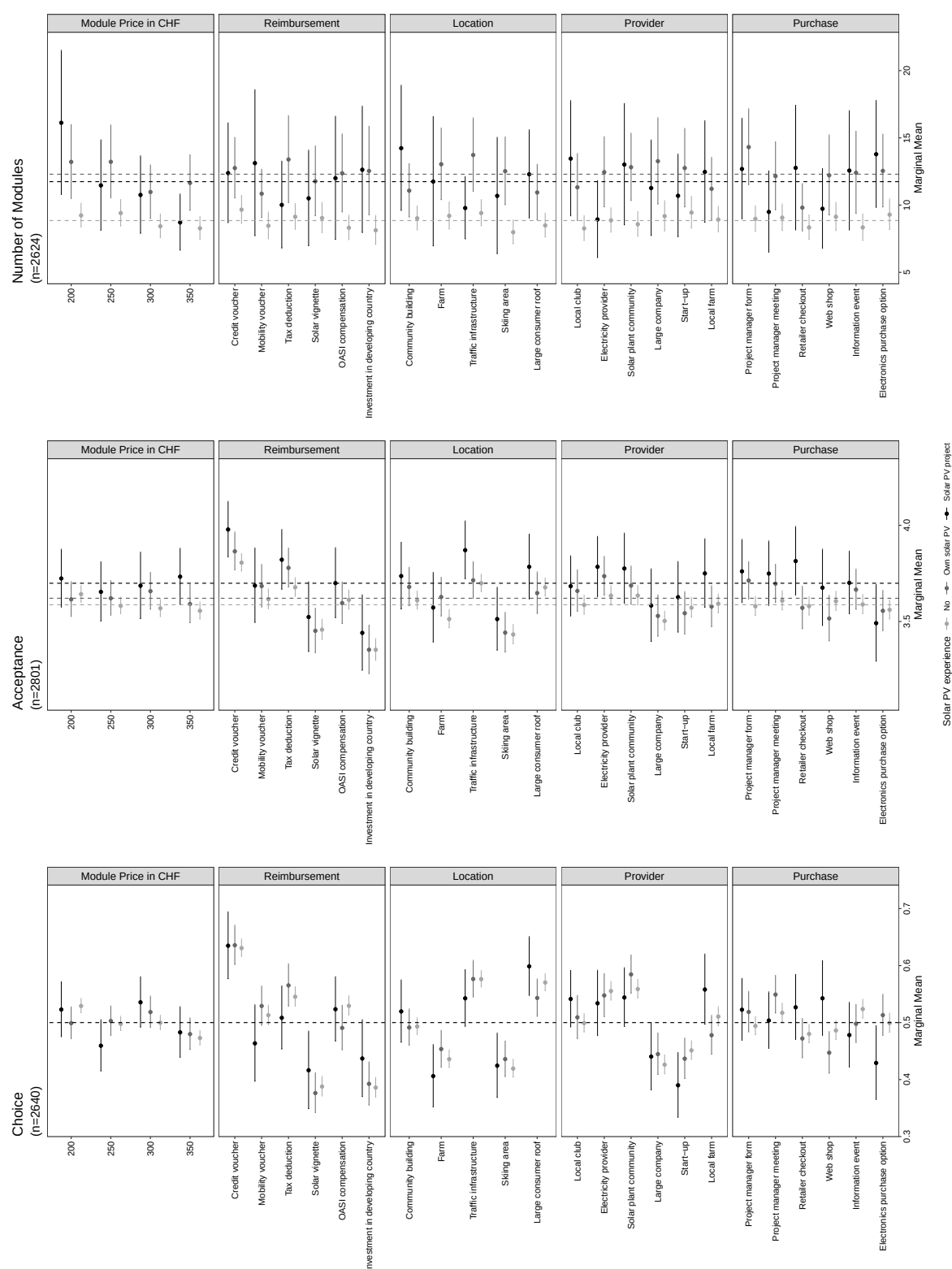
Data source: Stadelmann-Steffen et al. (2022), own calculations and depiction.

3.6.6 AMCEs – education



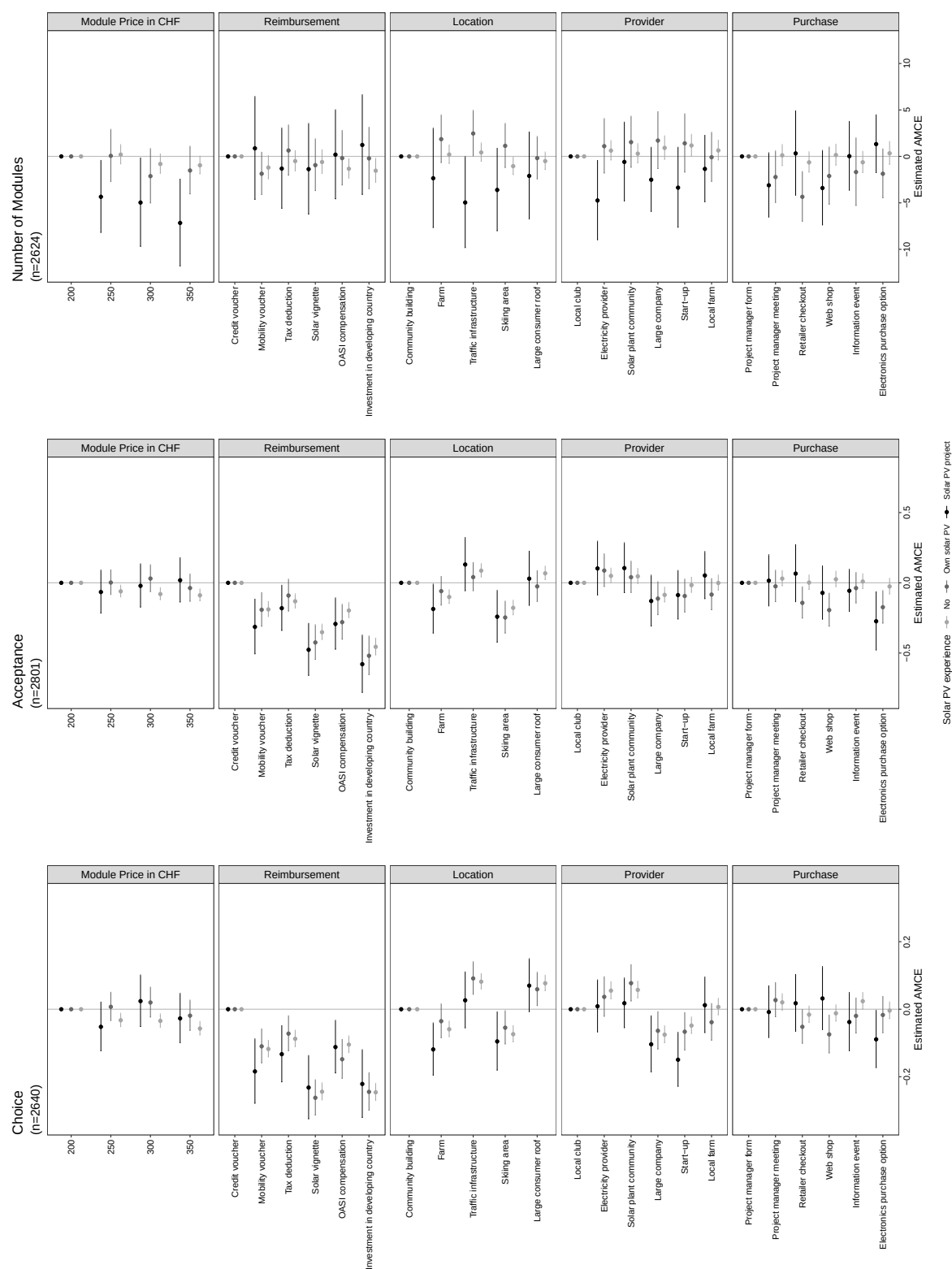
Data source: Stadelmann-Steffen et al. (2022), own calculations and depiction.

3.6.7 Marginal Means – solar experience



Data source: Stadelmann-Steffen et al. (2022), own calculations and depiction.

3.6.8 AMCEs – solar experience



Data source: Stadelmann-Steffen et al. (2022), own calculations and depiction.

4 Article 3: The role of vote advice application in direct-democratic opinion formation: an experiment from Switzerland

This chapter is identical with the following article published in *Acta Politica*:

Stadelmann-Steffen, Isabelle, Rajski, Hannah and Sophie Ruprecht. 2022. The role of vote advice application in direct-democratic opinion formation: an experiment from Switzerland. *Acta Politica* 58: 792–818. DOI: 10.1057/s41269-022-00264-5.

Abstract

In an increasingly digitised world, vote advice applications (VAAs) seem to be effective in providing voters with personalised information about their own positions vis-à-vis parties' positions and specific policies. Even though electoral research has increasingly paid attention to the role VAAs play in voter's opinion formation, very few studies have examined VAAs in the context of direct-democratic decisions. This article fills this gap by providing new insights into how VAAs affect individual decision-making in popular votes theoretically and empirically. We use novel data from the referendum campaign on the 2017 new energy law in Switzerland: a VAA experiment carried out in the framework of a three-wave panel survey. In the third wave, which took place a week before the referendum, respondents were randomly assigned to a treatment group and a control group; only the former was shown the VAA and made to use it. The results indicate two main takeaways. First, that using a VAA has a tangible effect inasmuch as the share of undecided voters is smaller among the treatment than among the control group. Second, VAA usage can have both a persuasive effect (i.e. it can change vote intentions) and an intensifying effect (i.e. it can strengthen voters' pre-existing intentions).

Keywords: Vote Advice Application, Referendum, Vote, Vote Intention, Opinion Formation

4.1 Introduction

According to Robert Dahl’s understanding of an “enlightened democracy”, people make political decisions in an informed way (see Mayer and Wassermair, 2010, p. 173). However, public opinion research in general and research on voter decisions in direct democracy in particular, have repeatedly argued that this is a very challenging goal, because in reality voters are neither capable nor willing to process all necessary information and, consequently, are most likely to make decisions based on low levels of knowledge or to rely on cues (Christin et al. (2002, p. 759), Colombo (2016); Colombo and Kriesi (2017); Neijens and de Vreese (2009)).

We argue that vote advice applications (VAAs) can be an effective tool in our increasingly digitised context, because they provide voters with personalised information about their own positions vis-à-vis the positions of parties or policies. Like other decision aids (Neijens and de Vreese, 2009; Neijens et al., 1992), VAAs do not only provide (new) information but also potentially help voters to more efficiently structure their opinions about an issue or a person. While research on the role VAAs play in voters’ opinion formation has increased over the years (Alvarez et al., 2014; Ladner, 2012), it has almost exclusively focused on the electoral context, i.e. on situations when citizens vote for parties or candidates. In contrast, very few studies examine the role VAAs play in citizens’ opinion formation in direct-democratic decisions.

This study fills this gap by providing new insights into how VAAs affect individual decision-making in direct democracy both theoretically and empirically. More precisely, we ask *whether and how the use of VAAs affects individuals’ opinion formation in a referendum context*.

We draw on the literature on VAAs in the electoral context and on studies on individuals’ opinion formation in direct-democratic decisions to conceptualise a vote advice application as a “question and answer” tool. Users first answer questions about their stances on certain topics; the application then compares these stances to the positions of parties or candidates or to specific issues (Alvarez et al., 2014; Ladner, 2012; Sudulich et al., 2014). Ideally, the use of a VAA thus facilitates opinion formation and eventually even helps voters make decisions based on their “true” preferences.

The relevance of our study is at least twofold. First, it provides new insights into the role of VAAs in individuals’ opinion formation in the context of direct-democratic decisions. In contrast to elections, where most people have an initial idea about what party to vote for thanks to long-lasting party affiliations or some degree of closeness to a particular party, many voters enter direct-democratic campaigns in a state of relative ignorance (Converse, 1964; Fishkin and Luskin, 2005). This is reflected not least in high shares of undecided voters at the beginning of a campaign (regarding the referendum under investigation in this study, see Dermont and Stadelmann-Steffen (2019)). VAAs may therefore be even more important to voters’ opinion formation in such campaigns than they are in electoral contexts. All the more so because voting on ballot proposals may look like a simple yes/no decision but is the result of multidimensional choices. A specific

ballot proposal consists of various elements; a voter may like some of those and reject others: She is faced with trade-offs. Decision making thus becomes a complex endeavour, whereby individuals require information to weigh the pros and cons of each proposal (Dermont and Stadelmann-Steffen, 2019; Stadelmann-Steffen and Dermont, 2018). The use of direct-democratic instruments is steadily growing around the world, which calls for additional research, especially as far as the mechanisms behind VAAs' role in individuals' voting decisions are concerned. Moreover, VAAs may be also attractive in contexts where direct-democratic instruments are used relatively rarely or have only recently been introduced, as they may compensate for the (still) lacking direct-democratic campaign structures in these environments (Heidbreder et al., 2019).

Second, we go beyond existing research by examining two potential mechanisms through which a VAA can influence voters' opinion formation: The first relates to the mere *use* of a VAA, while the second refers to the *message* it conveys, i.e. the degree to which the user agrees with the policy at stake. Moreover, we differentiate between a *persuasive effect* (i.e. the idea that VAAs provide voters with new information or information that is different from what they would have at their disposal without the VAA) and an *intensifying effect* (i.e. the phenomenon of the VAA affirming voters' original positions and therewith strengthening their vote intentions). It is worth noting that similar mechanisms are likely also at play during electoral campaigns (see Holbrook and McClurg, 2005, p. 689), who refer to a similar mobilising effect with respect to voter turnout), so our results may also be relevant to the role VAAs play in the electoral context.

We use novel data from the referendum campaign on the new energy law in Switzerland, which was collected in May 2017. Our analysis is based on a three-wave panel survey and a VAA experiment that was implemented in its last wave. In this third wave, which took place a week before the referendum, respondents were randomly assigned to a treatment and a control group. Only the former were shown the VAA and made to use it. A comparison of the treatment and the control groups provides evidence that the *use of a VAA* affects vote intention. Moreover, our analysis of respondents who had not yet voted by post (i.e. those respondents whose vote intentions could still be changed by their participation in the VAA) suggests that the VAA's *message* could generate both a "persuasive effect" and an "intensifying effect", depending on respondents' original vote intentions and party affiliations.

4.2 Theoretical background

4.2.1 State of research

VAAs are designed to inform users about their optimal vote choice by supplying information about issues or party positions (Alvarez et al., 2014; Sudulich et al., 2014), thereby focusing on the outcome of decision-making (Price and Neijens, 1998, p. 147f.). Existing VAAs and previous research on the topic have been almost exclusively limited to the context of elections, where VAAs

“match” voters and parties. In so doing, VAAs usually compare voters’ and parties’ positions on numerous policy statements and indicate the degree of agreement between voters and parties. The selection of statements is pivotal, as the number of questions and their wording decide how well the different issues and their related aspects and positions are covered. Most VAAs also allow users to weight issues according to each issue’s perceived importance to the user. VAAs apply matching to calculate similarity scores (Mendez, 2014) and existing research has demonstrated that, at least for salient issues, VAAs’ matching mechanisms work reasonably well (see Wagner and Ruusuvirta, 2012).

The main questions surrounding VAAs thus come down to whether and how VAAs affect voters and their behaviour. The optimistic account expects that VAAs guide users’ political opinions in independent and impartial ways (Holleman et al., 2016). The notion of proximity voting inherent to VAAs (Mendez, 2014) is closely related to issue voting, which assumes that a voter’s proximity to the position of a party or an issue determines her vote choice (Garzia and Marschall, 2019; Ladner, 2012). The latter has become more relevant since the 1970s, when previously stable social cleavages started to lose importance. Furthermore, VAAs are theorised to strengthen the relationship between parties, citizens and (in some cases) the media, as a VAA positions itself squarely where these three players interact (Krouwel et al., 2014).

A more skeptical view, however, emphasises that VAAs could foster unequal exclusion or “short-cut” decision-making. On the one hand, those unable to use the technology cannot benefit from VAAs; on the other hand, the voters who exclusively rely on VAAs for their decision-making reduce their democratic involvement to the last step of making a yes/no decision on an issue (Cedroni, 2010). Furthermore, even though they bolster issue proximity, VAAs disregard other forms of representation, such as politicians’ and parties’ credibility and accountability (Wagner and Ruusuvirta, 2012). More generally, existing research may have overestimated VAAs’ effects by failing to employ an experimental design and account for self-selection effects (Munzert and Ramirez-Ruiz, 2021).

Empirically, a large number of studies focusing on different dependent variables, such as party preferences, party choice and electoral participation, have been conducted in various countries and produced mixed results. While some have found VAAs to have no effects or only small effects (e.g. Enyedi, 2016; Israel et al., 2016; Mahéo, 2016; Marschall and Schmidt, 2010; Ramonaite, 2010; Walgrave et al., 2008), others have documented more meaningful and stronger relationships (Andreadis and Wall, 2014; Christensen et al., 2021; Garzia et al., 2014, 2017; Gemenis and Rosema, 2014; Germann and Gemenis, 2019; Kamoen et al., 2015, 2019; Ladner and Pianzola, 2010; Munzert and Ramirez-Ruiz, 2021; Pianzola et al., 2019; Ruusuvirta, 2010; van de Pol et al., 2019; Wall et al., 2014). In the 2007 Swiss elections, for example, VAA use had a self-reported influence on the vote choices of 66.5% (Fivaz and Nadig, 2010) to 70% (Ladner, 2012) of their users. In the Netherlands, recent studies have shown that voters are more likely to choose a party when it has been recommended by a VAA (Kleinnijenhuis et al., 2019; Wall et al., 2014).

To the best of our knowledge, a single study has so far examined the influence of VAA use on a non-party vote, namely on voting in the Brexit referendum. According to this study, voters were more likely to vote to “leave the EU” if they received policy information indicating that they were indeed closer to the “leave” side of the referendum (Trechsel et al., 2017).

In the following, we delve deeper into the role VAAs play in individuals’ opinion formation in a direct-democratic decision by applying and further developing existing arguments and findings from VAA research focusing on the electoral context.

4.2.2 Theoretical argument and hypotheses

Based on existing research, we conclude that a VAA may affect an individual’s opinion formation through *two different mechanisms*. First, we expect that the mere use of a VAA can make a difference. Obviously, this is the basic idea of a VAA, which has received empirical support, e.g. in Switzerland (Ladner, 2012), but it is also in accordance with the general expectation that receiving more information affects people’s opinion (Luskin et al., 2002). We should thus observe differences between the vote intentions of voters who use a VAA and those who do not use it. Second, the specific message a VAA conveys can also be significant. In this case, we would expect to see varying reactions to the VAA among its users, contingent on what the VAA’s recommendation looks like and how it relates to a voter’s original vote intention.

Moreover, we further theorise potential VAA effects and argue that the latter can be both *persuasive* (i.e. VAAs can affect voting intentions by providing voters with new or additional information about their own positions) and *intensifying* (namely, VAAs can affirm voters’ original positions and further encourage them to vote for a specific party – or, in the context of direct democracy, to cast a “yes” or a “no” vote on a proposal). We suggest that differentiating between these two effects may be particularly important in a referendum vis-à-vis an electoral context because ballot decisions are inherently more directly related to (new) issues. Every ballot vote addresses a specific issue and question, on which some voters may have some prior knowledge and positions, while others may enter the referendum campaign in a state of relative ignorance. It is logical to expect that VAAs affect these two groups of voters differently.

Both the use and the message of a VAA can theoretically generate a persuasive and an intensifying effect. If the mere use of a VAA has a persuasive or an intensifying effect, we should observe that voters who have used a VAA find it easier to form a clear opinion on the ballot proposal. As a result, the share of undecided individuals should be lower in this group than in the group of voters who have not used the application. Furthermore, regardless of whether it recommends a “yes” or a “no” vote, the VAA can be expected to influence the final vote intentions of those who use it, either through its intensifying effect or through its persuasive effect.

Based on these considerations, our first two general hypotheses are:

Hypothesis 4.1 *VAA use decreases the likelihood that a voter remains undecided about a ballot proposal (usage effect).*

Hypothesis 4.2 *The stronger a VAA message is, the more likely an individual is to follow it (message effect).*

In an attempt to delve deeper into the effect of a VAA’s message – i.e. to differentiate between the aforementioned persuasive and intensifying effects – we consider that the role of the VAA is moderated by an individual’s original vote intention and whether the VAA recommendation is in accordance or in conflict with it and with party cues.¹

We first focus on those *voters who do not have a clear original vote intention*. Studies have shown that the more surprising a VAA’s recommendation is, the higher the likelihood of the voter changing their vote choice is (Ladner, 2012; Vassil, 2011). This is in accordance with findings from research using Choice Questionnaires, indicating that individuals without a clear prior opinion are most reactive to new information (Bütschi (2004, p. 317f.), Van Knippenberg and Daamen (1996)). Undecided voters are, by definition, either not yet sure how to vote or simply have not informed themselves. A “surprising” VAA result – one that provides some new information about their positions—might therefore be particularly influential (Neijens and de Vreese, 2009; Zaller, 1992). For these voters, the persuasive effect manifests in the VAA’s message replacing their prior state of being undecided. Indeed, existing research offers empirical evidence that initially undecided voters are especially likely to cast their votes in accordance with their VAA results (Ruusuvirta, 2010). These findings also lend support to the view that as the relevance of cleavage voting shrinks, VAAs could become an important means of overcoming voters’ lack of party identification (Mahéo, 2016) and predispositions. The corresponding hypothesis thus reads:

Hypothesis 4.3 *The association between the VAA’s message and voters’ final vote intentions is stronger for initially undecided voters than it is for voters with an original vote intention (persuasive message effect).*

Individuals with an original vote intention can have the VAA result either confirm or challenge their original vote intentions (Vassil, 2011). We discuss both scenarios. If the advice matches the voter’s original vote intention, the user should perceive this as a confirmation of their initial intention, which should, therefore, be intensified. These dynamics are in line with the theory of “motivated reasoning”: People have directional goals they want to achieve; therefore, they tend to seek information that confirms their preexisting opinions in an effort to avoid cognitive dissonance (see Festinger, 1962). Not all studies have been able to identify such effects, but many

¹ Our data do not allow us to differentiate between a persuasive and an intensifying use effect, so we only differentiate between the two in the context of the VAA’s message.

have and they conclude that whenever VAA results match voters' original vote intentions, voters are further inclined to vote accordingly (Neijens et al., 1992; Talukder et al., 2021; Wall et al., 2014). These dynamics played out in the study about the use of VAAs in the context of the Brexit referendum: Those who received information that confirmed their original vote intentions were more likely to act on these intentions (Trechsel et al., 2017).

Prior vote intentions are often linked to an individual's party affiliation or party preference. In this context, recent research on direct-democratic decisions has examined how party heuristics and specific policy information interact (Colombo and Kriesi, 2017; Dermont and Stadelmann-Steffen, 2019). Theoretically, party and policy information can be conceptualised as two different modes of information processing. Whereas systematic processing entails that one thoroughly understands and evaluates all (policy) information available, heuristic processing requires much less cognitive effort or motivation. For example, one can simply rely on one's party position to reach a decision. Additionally, two principles underpin this model: the "least effort principle" and the "sufficiency principle" (Chaiken and Ledgerwood, 2012). The former suggests that individuals try to form their decisions as efficiently as possible, investing minimal effort, time and cognitive resources in reaching conclusions. The "sufficiency principle", however, states that individuals strive to enhance their judgmental confidence and therefore put a great deal of effort into thinking about an issue. Furthermore, heuristic and systematic information processing can interact to influence evaluations (Gawronski and Creighton, 2013). In this context, VAA results can be seen as (easily available) policy information. If the individual consults a VAA, she gathers and evaluates more information about her personal attitudes. Doing so could refer to a more systematic dimension of information processing, as the VAA provides cognitive arguments. Similar to our reasoning about voters' original vote intentions, their preferred parties' positions on a direct-democratic ballot proposal matching the VAA's output can also be expected to strengthen their decision to vote accordingly. This discussion leads to the following hypotheses:

Hypothesis 4.4 *Congruence between the VAA's message and respondents' original vote intentions is associated with intensified original vote intentions (intensifying message effect).*

Hypothesis 4.5 *Congruence between the VAA's message and respondents' preferred party's position is associated with intensified original vote intentions (intensifying message effect).*

The situation is more complicated if the VAA's advice does not match voters' original vote intention or the party cue. When this is the case, two reactions are possible: The users could either ignore the new advice or consider it and possibly change their vote choice. The former scenario is consistent with motivated reasoning and the idea that individuals tend to disregard conflicting information (see Kunda, 1990) and avoid cognitive dissonance (see Festinger, 1962). Similarly, individuals with strong prior attitudes are harder to influence (e.g. Neijens and de Vreese, 2009; Zaller, 1992). The latter relates to Dahl's (1989) understanding that individuals are rational information processors who choose information based on accuracy goals and with the goal of

reaching an enlightened decision. If individuals hold prior opinions about an issue, they use these opinions to “anchor” their evaluations of the new information available to them, which, if credible, is then used to update these prior opinions (Taber and Lodge, 2006). When a conflict between the VAA’s information and voters’ prior vote intentions emerges, some individuals will eventually decide to change their vote choice, while others will retain their prior intentions. Hence, while both reactions suggest varying ways of handling VAA information, we assume that, on average, a VAA result that challenges a prior vote intention will reduce the likelihood of the voter eventually voting according to her original intention:²

Hypothesis 4.6 *Incongruence between the VAA’s message and voters’ original vote intentions is associated with a higher likelihood of them changing said vote intentions (via-à-vis respondents who receive a congruent VAA recommendation) (persuasive message effect).*

4.3 Research Design

4.3.1 Case selection

Our case is a popular vote on a new energy law that took place in May 2017 in Switzerland. We argue that Switzerland in general and this vote in particular are suitable cases for our analysis for several reasons. First, Switzerland is home to the greatest number of direct-democratic decisions in the world (Altman, 2010) and VAAs exist for all national and many subnational elections³ (but not for direct-democratic votes). This presents some analytical advantages. Even though VAAs are not available for direct-democratic votes, the idea of using VAAs is common and citizens are used to it. Moreover, carrying out the VAA experiment during a real direct-democratic campaign makes the VAA exercise in the survey even more realistic. Overall, this setting benefits both the internal and the external validity of the study. Second, a single national decision was taken in May 2017, which rarely happens in Switzerland. Campaigns on different issues interfere with one another if several proposals are on the ballot on the same day. In contrast, individuals’ decision-making on this specific issue can be analysed in isolation, which allows us to rule out any interferences by parallel campaigns.

Overall, we argue that Switzerland in general and the ballot proposal on the new energy law in particular provide the ideal conditions for us to investigate our hypotheses as far as internal validity is concerned. However, we do acknowledge the need to be cautious when we generalise our findings to other contexts, votes or issues. In particular, policy information and, thus, VAA

² We refrain from formulating a corresponding hypothesis on the incongruence between party cues and the VAA message because we cannot test it empirically due to the small number of cases.

³ <https://www.smartvote.ch/de/home>

information is, of course, specific to each ballot question. Hence, we cannot rule out that our results are case-specific, i.e. vote- or issue-specific, as well.

4.3.2 Data

This analysis is based on a three-wave panel survey. The first wave collected 2,891 responses, the second wave - 1,841 and the third wave - 1,253. Overall, we have full data on 1,181 respondents who participated in all three waves. The three waves were conducted 10 weeks, a month and a week before the vote, respectively. The first wave took place in a pre-campaign setting. At the time of the second wave, the campaign had just started to get into its “hot” phase, obvious in the start of paid media (newspaper) advertisements. It also generally coincided with the distribution of the postal ballots to all citizens. The ballot boxes for elections and popular votes close on Sunday at 12 p.m., but most voters return their ballots by mail before Sunday. The last wave took place in the last week of the campaign when many people had already cast their votes or reached a decision.

We used Qualtrics to collect the sample from online panels and targeted people over the age of 18 living in Switzerland. The sample used language, age, gender and cantonal (subnational) unit quotas to be representative. The survey was carried out in all three official languages of Switzerland: German, French and Italian. Nevertheless, recruiting enough Italian speakers for the repeated cross sections proved challenging and as a result, the samples were only representative of the French and German parts of Switzerland. The sample was fairly similar to the Swiss population in terms of age and gender. Nevertheless, like in most surveys – the groups with low education and low income were somewhat underrepresented (Federal Statistical Office, 2019, 2020).

The VAA treatment was implemented in the third wave. Respondents were randomly assigned into a treatment group and a control group; the VAA was used by the treatment but not by the control group. As Appendix 4.6.1 demonstrates, the treatment and control groups did not significantly differ in terms of respondents’ sociodemographic composition and original vote intentions (see also Table S2 in the Supplemental Online Information (SI)). This uniformity suggests that randomisation worked well.

The treatment group was presented with ten statements about the new energy law (for further details, see Appendix 4.6.2). Respondents could use a slider to indicate positions ranging from 0 (clearly disagree) to 100 (clearly agree) (see Figure S1 in the SI). Moreover, respondents had to weight the importance of each statement – they had to indicate whether a statement was “not important”, “of average importance” or “very important” to them. The VAA score was then calculated as a weighted sum of these answers: the degree of agreement with each statement s

was multiplied by its weight w (either 50 (“not important”), 100 (“of average importance”) or 200 (“very important”)).⁴ This sum was then divided by the sum of the weights:

$$v = \frac{\sum_{i=1}^{10} s_i \cdot w_i}{\sum_{i=1}^{10} w_i}$$

Respondents were then shown the individual percentage score of how much they agreed with the objectives of the law. The VAA score thus ranged from 0 to 100. Figure S3 in the SI depicts the distribution of the VAA scores. After receiving the VAA score, respondents were asked whether the result aligned with their expectations and whether it was relevant to them.

This setup implies that while the assignment to the VAA, its use in having respondents react to the ten statements and their receiving their personal score make up an experimental setup, the treatment content, i.e. the VAA’s *message*, does not. In fact, the VAA recommendations shown to respondents naturally were realistic assessments of the latter’s positions based on the VAA items. Therefore, these assessments did not constitute a randomly defined information treatment.

Our main dependent variable is individuals’ vote intentions. We measured how respondents intended to vote in the referendum at the beginning of the survey in all three waves. In wave 3, we also asked whether they had already cast a vote (by postal voting). Moreover, an additional question at the end of the survey asked those respondents in the treatment group who had not yet voted by postal ballot about their vote intentions after receiving the information in the survey (namely, the VAA).⁵ The question in wave 1 included the answers “yes”, “no”, “undecided” and “don’t know”. In waves 2 and 3, everyone except those who had already cast their votes (i.e. the early voters in wave 3) received a question about their likelihood of voting “yes” or “no”. To compare vote intention over time, values below 31% in waves 2 and 3 were coded as an intention to vote “no”, values between 31% and 74% as “undecided” and scores equal to or greater than 75% were considered an intention to vote “yes”. We chose these asymmetric thresholds to account for the effects of social desirability bias – namely, in order to avoid counting too many respondents as “yes” voters if they were not (quite) certain that they would actually vote “yes”. This coding resulted in realistic groups as per the pre-ballot surveys and, eventually, the ballot result.

Figure 4.1 shows voters’ mobility across the three waves, i.e. individuals’ vote intentions at different points in time, before any VAA treatment was set. The number of undecided voters decreased over time. At the same time, the proportions of those intending to vote in favour of

⁴ Using 50, 100 and 200 as weighting factors is, of course, arbitrary to a certain extent. While the exact values do not matter as such (we could have also used 0.5, 1, 2), their relative sizes do. A weight of 50 basically means that a statement is only half as important as a statement of average importance. As Figure S2 in the SI illustrates, however, the distribution of weights is rather similar across the different VAA items and only very few respondents assigned low importance to any of the statements.

⁵ Unfortunately, an identical post-treatment question is not available for the control group.

and against the law, increased. Not unlike the actual referendum, in which 58.2% of the valid ballot papers were in favour of the law,⁶ a majority of the respondents indicated that they cast a “yes” vote. A comparison of the first and the third waves suggests that the campaign helped individuals form an opinion on the issue – the number of undecided voters greatly decreased.

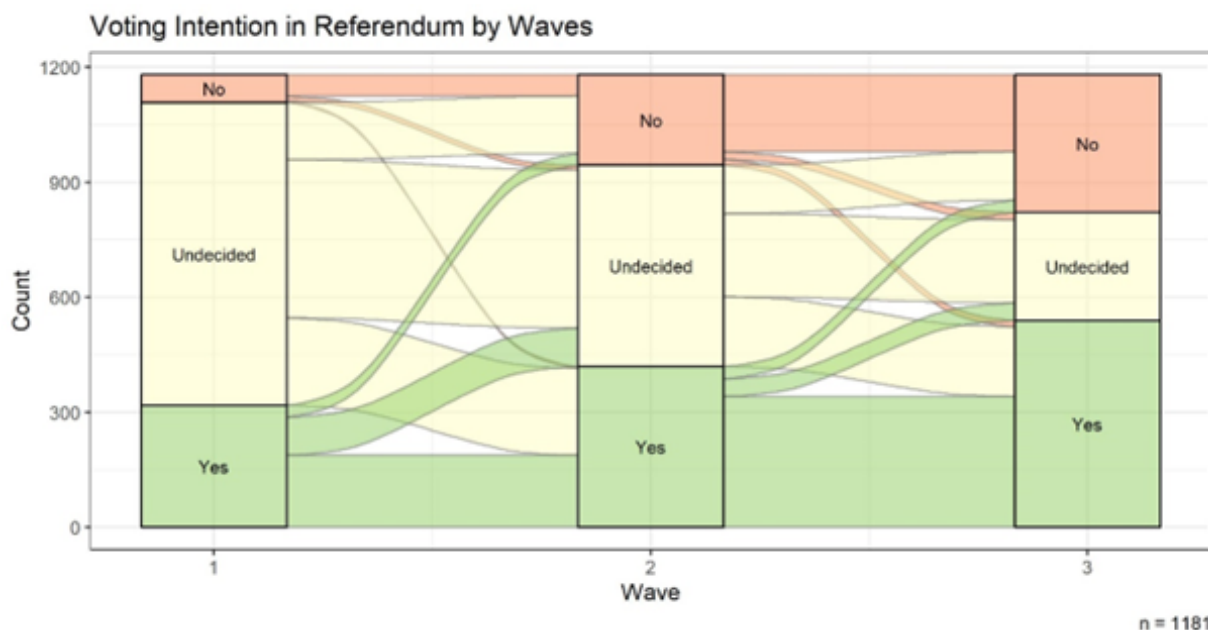


Figure 4.1: Vote intentions over the course of the campaign

Note: The figure depicts respondents’ vote intentions in each of the three waves and mobility across the three waves for the sample ($n = 1,181$) before any treatment was set.

We faced the problem that when the VAA was deployed in the third wave of the survey, 280 respondents in the treatment group and 268 respondents in the control group had already cast a vote by post. These members of the treatment group were not asked about their vote intentions after the treatment, because they had already voted. Moreover, we can assume that these voters might have been less prone to react to the VAA anyways, since they would have wanted to hold on to the vote they had already cast. For this reason, our analysis excludes these early voters. Hence, the results we present in the following pages are based on the 633 respondents who indicated their vote intentions in all three waves and had not yet cast their votes. Out of these individuals, 326 (including 53 who did not have the right to vote) saw the VAA and were asked about their post-treatment vote intentions.⁷

In the first empirical part, we rely on descriptive statistics and regression analysis to assess the effect of using a VAA (Hypothesis 4.1). We compared the treatment group’s vote intentions

⁶ <https://www.bk.admin.ch/ch/d/pore/va/20170521/det612.html>

⁷ Appendix 4.6.1 suggests that the whole treatment group (including the early voters ($n = 606$) and the utilised subgroup of non-early voters ($n = 326$)) did not systematically differ from each other with respect to most sociodemographic variables and, importantly, political ideology and VAA outcome.

in wave 3 before and after using the VAA to the vote intentions of the control group in the same survey wave. Following Hypothesis 4.1, we hereby focus on whether the likelihood of being undecided differs between the treatment and the control groups.

In the second empirical part, we delve deeper into the mechanisms of the *VAA's message* (Hypotheses 4.2-4.5), concentrating on the treatment group, i.e. on those respondents who used the VAA. We employ OLS regression. We use the panel structure of the data and focus on within-individual variation in vote intentions – namely, on the change between a respondent's vote intention in wave 1, which we consider her original vote intention, and her vote intention in wave 3 after she has used the VAA. We use respondents' probabilities of casting a “yes” vote as a dependent variable and also account for their socio-demographics (education, age, sex and household income), as well as their levels of political interest, their party identification and party preferences (as measured in wave 1). To test the robustness of our results, we replicated the main models using respondents' original vote intentions measured in waves 2 and 3, respectively, instead of those measured in the first wave. In fact, given that people's vote intentions varied over the course of the campaign (especially among the initially undecided), the wave to which we choose to compare respondents' final vote intentions may influence our results. At the same time, our theory does not inform us which comparison is most relevant to our study. Using the first wave, as we did in our main analyses, enables us to specifically investigate how initially undecided voters reacted to the VAA. Conversely, opting for wave 2 or 3 would probably allow us to distinguish the effect of the VAA from other campaign effects. We therefore present these models in the Supplemental Information (Tables S4 and S6).

More information about the variables, their operationalization and their distributions can be found in Appendix 4.6.1.

4.4 Results

4.4.1 Testing the effect of using a VAA – Comparing the vote intentions of the control and the treatment groups

Figure S4 and Table S2 in the SI document the self-reported voting intentions of the treatment and the control groups over the three waves. We observe that the two groups of voters were very similar in their vote intentions in waves 1 and 2. In the third wave, the treatment group was slightly more likely to oppose the ballot proposal than the control group (25% vs. 22%), before completing the VAA, however, this difference proved not to be statistically significant in an ordinal logistic regression. While the group of undecided voters was slightly larger in the control group, approximately 33% of the respondents in each group were in favour of the law. Presaging the actual ballot outcome, the “yes” voters formed the majority in both groups. Overall, these data suggest that the treatment and the control groups were similar before the treatment. We

proceed to look at the effect of *using a VAA* and more specifically at whether, as Hypothesis 4.1 posits, completing the VAA decreased one's likelihood of being undecided.

Table 4.4.1 presents the results of the logistic regression models. The dependent variable is the likelihood that a respondent is undecided in wave 3. We use two slightly different measures. Models (1a) and (1b) use the vote intentions of the treatment and the control groups at the beginning of wave 3, i.e. *before the VAA treatment*. Those who indicated that they were undecided were coded 1 and all others are coded 0. We apply the same binary coding in Models (1c) and (1d), but this time we use the vote intentions of the treatment group *after the treatment*.

Table 4.4.1: The effects of VAA use on the likelihood of being undecided in wave 3

	Dependent variable			
	Undecided pre-treatment		Undecided post-treatment	
	(1a)	(1b)	(1c)	(1d)
VAA treatment	-0.132 (0.160)	0.185 (0.315)	-0.158 (0.161)	0.323 (0.312)
Undecided		0.962*** (0.267)		0.962*** (0.267)
VAA treatment*undecided		-0.444 (0.368)		-0.669* (0.366)
Intercept	-0.189* (0.115)	-0.879*** (0.229)	-0.189* (0.115)	-0.879*** (0.229)
Observations	633	633	633	633
Log Likelihood	-433.225	-424.179	-432.557	-424.959
Akaike Inf. Crit.	870.451	856.357	869.113	857.917

Note: Log odds; standard errors in brackets. *p<0.05, **p<0.01, ***p<0.001

The main explanatory variable in all models is the use of the VAA – whether a respondent was in the treatment group and, thus, completed the VAA. Moreover, Models (1b) and (1c) control for respondents' vote intentions in wave 1 and include an interaction between VAA use and vote intention in wave 1 to allow for the possibility that the effect of using a VAA is contingent on respondents' original vote intentions. These models would confirm a significant treatment effect if there were a significant VAA effect in models (1c) and (1d) but not in models (1a) and (1b). We would interpret such results to mean that the likelihood of being undecided does not differ between the treatment and the control groups *before* the treatment, but a significant difference between the two does emerge *after* the treatment.

Empirically, Models (1a) and (1c) do not lend support to such a pattern. The VAA variable is not statistically significant in either model. Models (1b) and (1d), however, reveal that when we account for whether individuals were undecided in wave 1, the effect of using the VAA (i.e. the treatment effect) differs significantly between respondents who were undecided in wave 1 and those who already had a vote intention at that early stage of the campaign. In fact, among the initially undecided, the likelihood of still being undecided shortly before the referendum was lower in the treatment group than in the control group. Conversely, individuals who had already

indicated a vote intention in wave 1 exhibited a slightly higher likelihood of being undecided in wave 3 if they completed the VAA (however, here, the difference between the treatment and the control groups was not significant). The right panel of Figure 4.2 illustrates the interaction effect using the post-treatment vote intention, while the left panel plots the interaction effect for the pre-treatment vote intention. The comparison of the two plots reveal that the overall patterns are similar in both cases. Thus, while the difference among the initially undecided is only significant after the treatment, which corroborates a VAA *usage* effect, the similar patterns imply that this treatment effect should not be overrated.

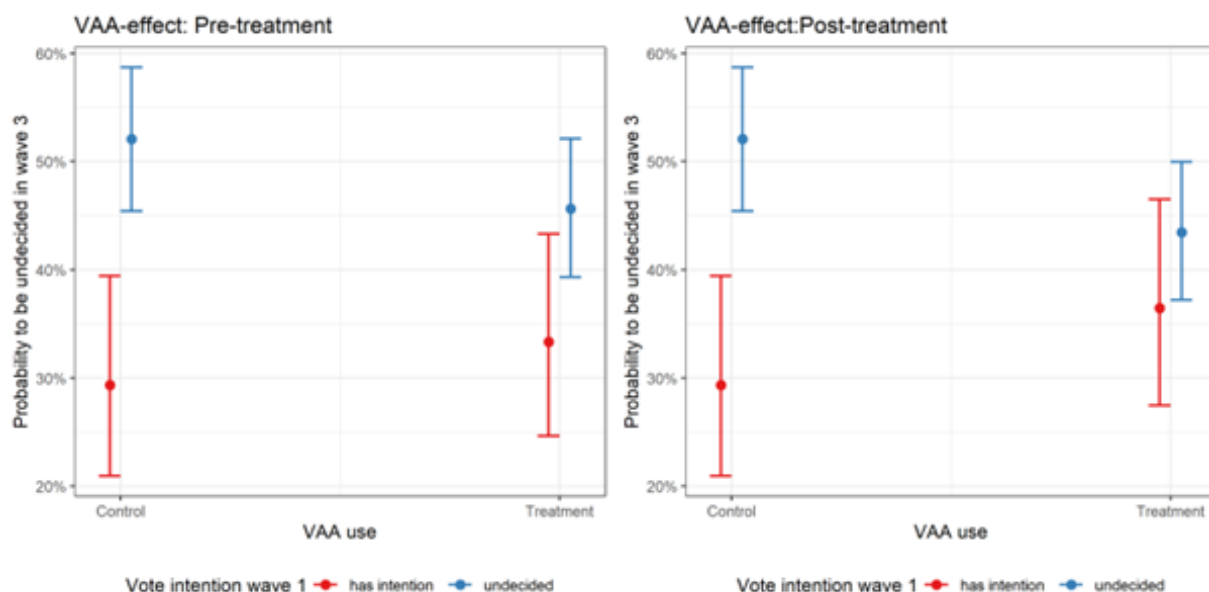


Figure 4.2: The effect of VAA use contingent on original vote intention

Note: Predicted values based on Models (1b) (left panel) and (1d) (right panel).

4.4.2 Testing the effect of the VAA's message within the treatment group

We proceed by delving deeper into the *VAA's message mechanism*. The OLS estimations (Table 4.4.2, Models 1–3) initially lend support to Hypothesis 4.2: The more the VAA result bolsters a “yes” vote (or a “no” vote, respectively), the likelier an individual is to vote “yes” (or “no”, respectively). Hence, the VAA revealing that respondents’ issue-related attitudes are highly consistent with the ballot proposal is associated with a stronger post-treatment intention to vote “yes”. This pattern holds even when we control for original vote intentions.

As far as respondents’ original vote intentions are concerned, unsurprisingly, an original intention to vote “yes” (measured in wave 1; the reference category is “undecided”) is positively associated with a propensity to eventually cast a “yes” vote. In contrast, the coefficient of an original intention to vote “no” is no longer significant when the model controls for the VAA scores (from

Model 3 onwards). This might be because the number of intended “no” voters was very small in the first wave.⁸

Hypotheses 4.3, 4.4 and 4.5 go a step further by considering the interaction between respondents’ initial vote intentions and the specific message that the VAA conveys to those who use it. In this context, Figure S7 in the SI plots the degree to which respondents perceived the VAA result to be in line with their original vote intentions (Figures S5 and S6 in the SI compare the objective, rather than the subjective correlation between respondents’ VAA results and their original vote intentions and confirm the following conclusions). According to Figure S7, a majority of respondents indicated that the VAA mostly confirmed their initial positions on the referendum proposal. It is unreasonable to assume that the VAA led these individuals to change their vote intentions (i.e. a persuasion effect); however, their certainty in their vote intentions could have increased (i.e. an intensifying effect, as suggested by Hypothesis 4.4).⁹

Conversely, the VAA provided new information to a substantial minority (roughly 30% of respondents) – i.e. it showed them that their prior vote intentions possibly did not reflect their issue-specific preferences. More specifically, 17.2% had expected a weaker agreement with the energy law and 12% a stronger one (7.7% did not know what to expect). This means that we can expect the VAA to have potentially changed this group’s final vote intentions, i.e. to generate a persuasive effect, either by pushing formerly undecided individuals to adopt a “yes” or a “no” intention (Hypothesis 4.3) or by triggering a change in their vote intentions from an original “yes” to a later “no” and vice versa (Hypothesis 4.5).

While these descriptive results suggest that all three hypotheses have potential, we proceed to test their specific mechanisms. Model (4) in Table 4.4.2 corroborates that the VAA’s message effect is indeed contingent on whether an individual had an original vote intention.

Figure 4.3 plots this interaction and lends (only) partial support to Hypothesis 4.3 – that originally undecided voters are most strongly affected by the message of the VAA. The slope is steeper for undecided individuals than it is for “yes” voters, but the relationship between respondents’ VAA results and their final vote intentions is not significantly weaker for those who had originally intended to vote “no” (for a similar finding and the use of an information and choice

⁸ The results are identical when we use respondents’ original vote intentions from wave 2. When we use respondents’ vote intentions at the beginning of wave 3, their original vote intentions are significantly correlated with their final vote intentions, regardless of the direction of their votes and the VAA outcome remains statistically significant (see Table S4 in the SI).

⁹ We further asked the respondents placed in the treatment group about their perceptions of the relevance of the VAA. Even though in most cases the VAA matched individuals’ original vote intentions, Figure S8 in the SI shows that almost 60 percent perceived the VAA as relevant, whereas only a quarter of the respondents indicated that they did not care about it. Furthermore, a majority of 58.3% wanted to consider the VAA when they formed their opinions. These findings corroborate the notion that the VAA can be considered relevant even if it documents a result that aligns with respondents’ own positions on the ballot proposal.

Table 4.4.2: Linear regression models: probability of intending to vote “yes”

Predictors	(2)		(2a)		(3)		(4)		(5)		(6)		(7)	
	Estimates	p	Estimates	p	Estimates	p	Estimates	p	Estimates	p	Estimates	p	Estimates	p
Intercept	-27.65	< 0.001	58.26	< 0.001	-28.88	< 0.001	-40.28	< 0.001	-37.6	< 0.001	-11	0.436	-10.5	0.474
VAA outcome (range 0 to 100)	1.38	< 0.001			1.37	< 0.001	1.55	< 0.001	1.47	< 0.001	1.03	< 0.001	1.02	< 0.001
Voting intention: no (ref = undecided)			-29.83	0.001	4.99	0.458	13.86	0.381	17.31	0.276	19.85	0.277	21.28	0.248
yes			13.57	0.001	6.5	0.031	51.32	< 0.001	45.9	0.001	47.14	< 0.001	41.25	0.002
VAA outcome x voting intention no							-0.11	0.751	-0.19	0.601	-0.25	0.524	-0.28	0.476
VAA outcome x voting intention yes							-0.66	0.001	-0.6	0.002	-0.61	0.002	-0.54	0.005
Favourite energy party: left (ref = none)									5.87	0.154	-29.36	0.091	-29.08	0.095
centre									6.03	0.15	-33.6	0.06	-33.14	0.067
right									-6.07	0.195	-38.54	0.036	-41.74	0.023
no answer									1.39	0.736	-15.89	0.378	-17.98	0.319
VAA outcome x left											0.56	0.034	0.57	0.031
VAA outcome x centre											0.63	0.021	0.61	0.028
VAA outcome x right											0.54	0.073	0.61	0.042
VAA outcome x no answer											0.29	0.308	0.3	0.286
Observations	326		326		326		326		326		326		326	
$R^2 / R^2_{adjusted}$	0.486 / 0.485		0.077 / 0.071		0.494 / 0.489		0.513 / 0.505		0.527 / 0.514		0.538 / 0.519		0.566 / 0.533	

Note: Full results including control variables can be found in Table S3 of the SI.

questionnaire, see Neijens and de Vreese (2009)).¹⁰

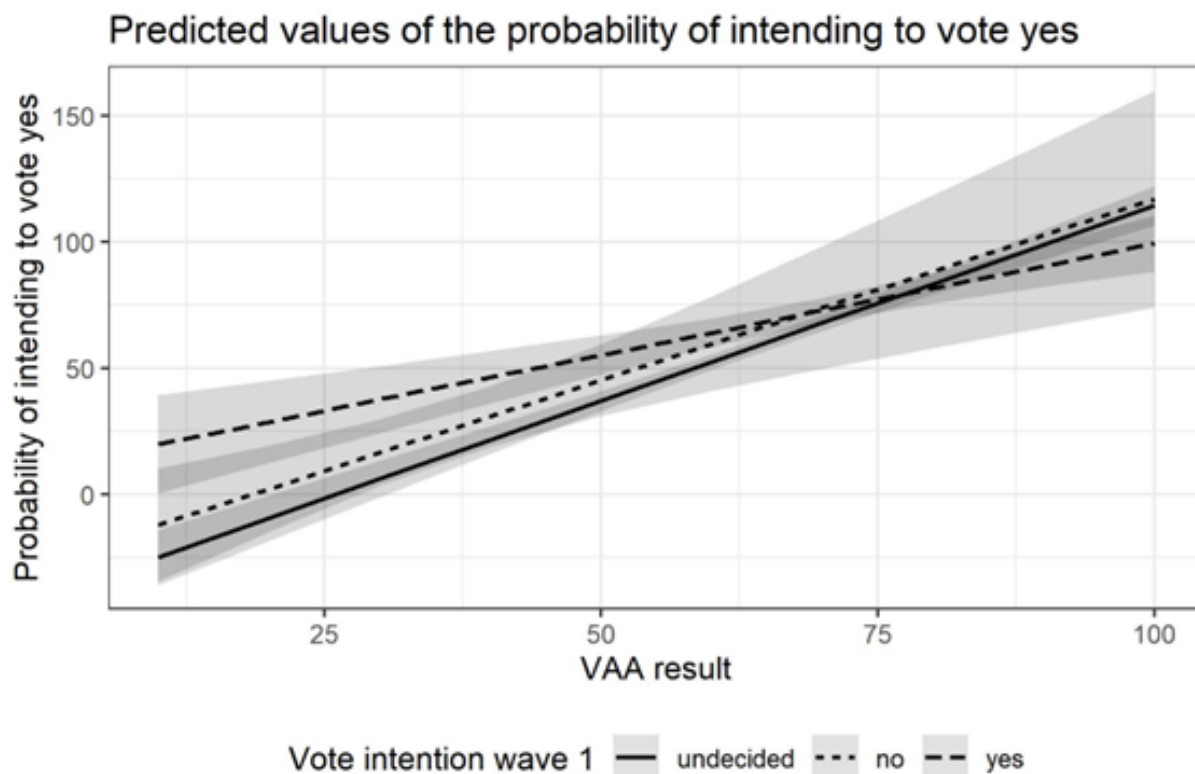


Figure 4.3: The VAA’s effect contingent on original vote intention

Note: Predicted probabilities calculated based on Model (4), Table 4.4.3.

These findings also provide a first indication that the VAA’s message can have both an intensifying effect (namely, a high VAA result can solidify an original intention to vote “yes”) and a persuasive effect (i.e. it can provide some new (potentially contrasting) information, as Hypothesis 4.4 and Hypothesis 4.5 suggest). More explicitly, we test the validity of Hypothesis 4.4 and Hypothesis 4.5 in two steps. First, we follow Hypothesis 4.4 and look at the role of party affiliation (Models (6) and (7) in Table 4.4.2). Then, we delve deeper into the role of respondents’ original vote intentions (Table 4.4.3).

As far as party affiliation is concerned, Models (6) and (7) in Table 4.4.3 show that party affiliation and its interaction with respondents’ VAA results are indeed associated with final vote intentions. Overall, respondents who favour right-wing parties were likelier to reject the ballot proposal. Importantly, however, we observe positive interaction terms between respondents’ VAA scores

¹⁰ The low number of respondents who originally (wave 1) intended to vote “no” could prevent the interaction term from gaining statistical significance and could thus explain the lack of difference between original “no” voters and undecided respondents. However, this low number could not explain the similar marginal effects between the undecided respondents and those with an original intention to vote “no”.

and all party groups. Respondents who adhered to a party had a stronger reaction to the VAA's message than those who did not have or indicate a party preference. A high VAA result thus greatly increased the likelihood of a respondent eventually voting "yes" on the proposal across the entire political spectrum (from left to the right).¹¹

All presented results are robust to the inclusion of additional sociodemographic and socioeconomic variables (Model (7)). Moreover, these variables increase the explained variance in the probability of a final intention to vote "yes" (with an adjusted R^2 of 0.531).

To gain more insight into the interaction between respondents' VAA results and their original vote intentions, we create a new variable that more specifically captures these two features. The VAA score was coded as: 0–30 - "no", 31–74 - "undecided" and 75–100 - "yes".¹² These VAA scores were then cross-tabled with respondents' initial vote intentions, which resulted in a variable with nine possible outcomes: "no (vote intention) & no (VAA result)", "no & undecided", "no & yes", "undecided & no", "undecided & undecided", "undecided & yes", "yes & no", "yes & undecided" and "yes & yes". All outcomes could be observed in our sample, except the "yes & no" combination (an original intention to vote "yes" and a VAA recommendation to reject the proposal). The probability of a respondent intending to vote "yes" after receiving the treatment continues being our dependent variable.

Table 4.4.3 presents these regression results and confirms that the association between the VAA's recommendation – its message – and respondents' post-treatment vote intentions is significant. The more fine-grained analysis reveals that, depending on its result, the VAA can lead users' opinions to move in both directions (towards both a "yes" or a "no" vote). As the results above and Hypothesis 4.3 would lead us to expect, we observe that the correlation between the VAA's message and originally undecided voters' final vote intentions is rather strong. Compared to undecided voters with an undecided VAA result, a VAA score below 31 is associated with a significantly and substantially lower probability to eventually vote "yes", whereas a VAA outcome between 75 and 100 goes hand in hand with a significantly and substantially higher likelihood of accepting the ballot proposal. These results also hold when we control for age, sex, household income and education. Hence, the findings confirm that the aforementioned aggregate trend towards a "yes" vote did not stem from VAA-induced biased opinion changes, but from the fact that many (undecided) individuals exhibited attitudes that came close to a "yes" vote and which were made visible to them by the VAA.

In a similar vein, the estimation results identify an intensifying effect for those respondents with congruent original vote intentions and VAA results. If a respondent intended to vote "no" and

¹¹ We also considered a three-way interaction including original vote intention. However, the number of cases, especially that of original "no"-voters, is too small.

¹² Similar to the coding of the vote intentions, we again opt for an asymmetric coding for the purpose of consistency but also because very few respondents received a very low VAA result.

Table 4.4.3: Linear regression models – original vote intentions and VAA outcomes combined

Predictors	Estimates	p	Estimates	p
Intercept	48.22	< 0.001	44.52	< 0.001
Voting intention (w1) vs. VAA (ref = undecided & undecided) no & no	-48.22	< 0.001	-46.41	< 0.001
no & undecided	-9.85	0.287	-7.72	0.408
no & yes	42.78	0.095	40.4	0.116
undecided & no	-43.55	0.004	-45.96	0.002
undecided & yes	41.36	< 0.001	41.58	< 0.001
yes & undecided	12.82	0.002	11.88	0.004
yes & yes	41.36	< 0.001	41.62	< 0.001
Control variables included	No		Yes	
Observations	326		326	
$R^2/R^2_{adjusted}$	0.393 / 0.380		0.426 / 0.394	

Note: Full results including control variables are available in Table S5 of the SI.

the VAA presented a similar result (i.e. <31), the latter reinforced the former. Conversely, based on the model, when an original intention to vote “yes” is combined with a VAA score above 74, the probability of the voter declaring an intention to vote “yes” increases by more than 41 percent vis-à-vis the reference category. This lends support to Hypothesis 4.4.

Finally, our data do not allow us to provide systematic empirical support to the hypothesis that using a VAA leads to changes in respondents’ vote intentions, i.e. from an original intention to vote “no” to a final “yes” vote or vice versa (Hypothesis 4.5). While no original “yes” voter received a really low VAA result, there was a small group of original “no” voters with moderate-to-high VAA results. However, group sizes are too small for us to identify significant differences.

Our robustness tests – when we use respondents’ original vote intentions from waves 2 and 3 instead of wave 1 (see SI, Tables S4 and S6) – largely confirm our results. Across all these models, the coefficient of the VAA’s message becomes somewhat smaller if we use respondents’ vote intentions at the later stages of the campaign, rather than in wave 1. This suggests that some changes in vote intentions stemmed from campaign effects, which might be related to the VAA outcome. For example, during the campaign, a previously undecided but right-leaning voter may be exposed to campaign information that pulls her in the direction of a “no” vote (i.e. provides the same directional information as a low VAA score). It is important to note that the VAA variable remains significant across all of these models. Hence, the outcome of the VAA remained a significant predictor of respondents’ final vote intentions even when we controlled for and considered voters’ vote intentions in the middle and at the end of the campaign.

4.5 Conclusion

While previous research on VAAs has almost exclusively focused on electoral decisions, this paper joins the very few studies examining the role of VAAs in direct-democratic votes. We have used data from a three-wave survey on the 2017 referendum on the new energy law in Switzerland to investigate how using a VAA and receiving its message affects respondents' final vote intentions. The most important findings can be summarized as follows.

First, our analysis lends some empirical support for a VAA *usage* effect: However, while we do not observe a general treatment effect, we find that for the subgroup of initially undecided, the likelihood of still being undecided shortly before the referendum is lower in the treatment group than in the control group. Second, our analyses quite consistently point to a VAA *message* effect. Most generally, when respondents see their VAA results, they tend to declare a final vote intention strongly aligned with these results. This pattern holds across different groups – namely original “no” voters, original “yes” voters and formerly undecided respondents. The results provide consistent empirical support for the idea that a VAA can have both an *intensifying effect* (i.e. one that assures voters with original vote intentions that they have “gotten it right” and, thus, reinforces their intentions) and a *persuasive effect* mainly on formerly undecided voters (i.e. one that enables these respondents to form a vote intention by virtue of the VAA, providing them with new or additional information).

Third, the main implication of these findings is that VAAs have the potential to facilitate voters' opinion formation in direct-democratic votes. A large share of voters enter a direct-democratic campaign in a state of relative ignorance. This share reflects the large proportion of undecided voters at the beginning of the campaign. Our results demonstrate that these individuals can use the information from the VAA to reach a decision on the ballot proposal, which may, eventually, also increase the likelihood that these individuals participate in the vote. Similarly, like party cues, VAAs may help reduce the uncertainty even of voters with prior vote intentions by reassuring them that they have made the right choice on an often complex ballot proposal.

Our study is not without limitations. First, we have analysed vote intentions, rather than actual (reported) voting decisions. Nevertheless, we assume that our set-up constitutes a very conservative setting to test for VAA effects, because VAA information may be particularly relevant to last-minute decisions by as-of-yet undecided voters. Second, we have focused on a single referendum in a single country (and have thus analysed one particular VAA on a specific topic). Therefore, we cannot rule out the possibility that the results are driven by our chosen case. In particular, while on aggregate, our VAA users shifted towards a “yes” vote, we have no way of knowing whether the latter resulted from our VAA instrument or whether policy information increased popular support for ballot proposals on environmental and energy policy (see Dermont and Stadelmann-Steffen, 2019). Hence, we could confirm that our VAA facilitated users' opinion formation, as suggested by the VAA literature (Alvarez et al., 2014; Sudulich et al., 2014), but

we would not go as far as saying that it made voters find their “true” or optimal vote choice. Further research should therefore analyse the use of VAAs across different ballot decisions and topics. A third limitation has to do with the placement of the VAA shortly before the actual vote. While we sought to present the VAA to respondents at a stage when they had already reflected on the issue on their own, the disadvantage of our timing was that there were many early voters for whom we could no longer observe a change in intentions as a result of the VAA. Even when these changes were observed, they were short term and we could not be sure that the VAA’s effect would persist over a longer period of time (i.e. for days or weeks). Fourth, our study also revealed some more general challenges related to the study of VAAs. The VAA results of a majority of respondents agreed with their original vote intentions. While this fact might be interpreted as a validation of the VAA instrument, it also means that for many respondents, a VAA could not conceptually lead to a behavioural change (i.e. a persuasive message effect for voters with original vote intentions). Empirically, this singles out a small number of cases in which VAA studies might be most interesting - namely where the VAA result diverges from an individual’s original vote intention and/or preferred party position, but where – as in our study – a lack of data does not allow for further investigation.

Nevertheless, we argue that our study is relevant despite these limitations and beyond our specific case. Most important, it documents, both theoretically and empirically, the need and relevance of investigating the role of VAAs in a direct-democratic context. We show that, compared to an electoral setting, it is particularly important to differentiate between VAA use and VAA message but also between a persuasive and an intensifying effect. More substantively, our results specifically point to the important interaction between original vote intention (or the absence of it), party cues and the VAA. Future research should theoretically distinguish group-specific VAA effects and also collect larger comparative samples that allow for more fine-grained empirical analyses that consider context-specific variation.

Supplementary information

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On behalf of all authors, the corresponding author states that there is no conflict of interest.

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4.6 Appendix

4.6.1 Variables and descriptive statistics per group

Variable	Question	Treatment Group	Control Group	Non-postal Voters in TG	Population (2016)
Vote intention	vox1.dec forced response How do you think you will vote on the amendment to the Energy Act (EnG) (Energy Strategy 2050)?	Wave 1 No = 39 (6.44%) Yes = 167 (27.56%) Undecided = 400 (66%)	Wave 1 No = 34 (5.91%) Yes = 151 (26.26%) Undecided = 390 (67.83%)	Wave 1 No = 14 (4.29%) Yes = 82 (25.15%) Undecided = 230 (70.55%)	
	vox1.decc (for noncitizens) forced response How would you vote on the amendment to the Energy Act (EnG) (Energy Strategy 2050) if you were eligible to vote and participated?	Wave 2 No = 123 (20.3%) Yes = 224 (36.96%) Undecided = 259 (42.74%)	Wave 2 No = 114 (19.83%) Yes = 195 (33.91%) Undecided = 266 (46.26%)	Wave 3—pretreatment No = 83 (25.46%) Yes = 106 (32.52%) Undecided = 137 (42.02%)	
	Response categories in wave 1: Yes (1) I have not decided yet (3) No (0)	Wave 3—pretreatment No = 189 (31.19%) Yes = 277 (45.71%) Undecided = 140 (23.1%)	Wave 3 No = 171 (29.74%) Yes = 262 (45.57%) Undecided = 142 (24.7%)	Vote intention (metric, overall) Mean = 57 SD = 32 Min = 0 Max = 100	
	Don't know / No response (98) Responses in waves 2 and 3: Likelihood to vote yes, 0–100% Recorded:	Wave 3—pretreatment (metric) Mean = 31 SD = 37 Min = 0 Max = 100	Vote intention (metric, overall) Mean = 31 SD = 36 Min = 0 Max = 100	Wave 3—posttreatment No = 66 (20.25%) Yes = 125 (38.34%) Undecided = 135 (41.41%)	
	Probability of voting “yes” ;31: “No”			wave 3 – posttreatment (metric) Mean = 60 SD = 32 Min = 0 Max = 100	
	Probability of voting “yes” 31–74%; “Undecided”				
	Probability of voting “yes” 75% and higher: “Yes”				

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Variable	Question	Treatment Group	Control Group	Non-postal Voters in TG	Population (2016)
Treatment	Has the individual received the treatment (VAA)?	Treatment: 100%	Control: 100%	Treatment: 100%	
VAA score	vaareult Weighted mean of the ten VAA-items, which can take values between 0 and 100. High VAA values mean that a respondent is close to a yes-position (in favor of the new law); low values indicate proximity to a no-position on the law.	Mean = 64.07 SD = 17.73 Min = 10 Max = 100		Mean = 63.98 SD = 16.4 Min = 10 Max = 100	
Age	agecat force response What is your age?	18-24 = 53 (8.75%) 25-44 = 228 (37.62%) 45-64 = 208 (34.32%) 65+ = 117 (19.31%)	18-24 = 44 (7.65%) 25-44 = 205 (35.65%) 45-64 = 199 (34.61%) 65+ = 127 (22.09%)	18-24 = 27 (8.28%) 25-44 = 143 (43.87%) 45-64 = 106 (32.52%) 65+ = 50 (15.34%)	18-24 = 9.99% 25-44 = 28.61% 45-64 = 35.29% 65+ = 26.11%
Education	educ force response What is the highest education you have completed with a certificate or diploma?	Secondary 1 = 29 (4.79%) Secondary 2 = 325 (53.63%) Tertiary = 241 (39.77%) NA = 11 (1.82%)	Secondary 1 = 31 (5.39%) Secondary 2 = 317 (55.13%) Tertiary = 223 (38.78%) NA = 4 (0.70%)	Secondary 1 = 17 (5.21%) Secondary 2 = 170 (52.15%) Tertiary = 131 (40.18%) NA = 8 (2.45%)	Only ages 18+ Secondary 1 = 15% Secondary 2 = 47% Tertiary = 38%
Sex	sex force response What is your gender?	Female = 287 (47.36%) Male = 319 (52.64%)	Female = 254 (44.17%) Male = 321 (55.83%)	Female = 168 (51.53%) Male = 158 (48.47%)	Female = 50.44% Male = 49.56%

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Variable	Question	Treatment Group	Control Group	Non-postal Voters in TIG	Population (2016)
Party	partyenviron (randomized order of answers, force response) Which party's goals and demands correspond most closely to your own preferences in energy policy? Categorized: None: "none" Left: "SP", "GPS", "PdA" Center: "CVP", "GLP", "CSP", "EVP", "BDP", "FDP" Right: "SVP", "Lega dei Ticinesi", "MCG" NA: NA, others	Left = 164 (27.06%) Center = 154 (25.41%) Right = 95 (15.68%) None: 86 (14.19%) NA = 107 (17.66%)	Left = 159 (27.65%) Center = 158 (27.48%) Right = 83 (14.43%) None = 91 (15.83%) NA = 84 (14.61%)	Left = 82 (25.15%) Center = 73 (22.39%) Right = 45 (13.8%) None = 51 (15.64%) NA = 75 (23.01%)	
Income	revenu force response Finally, we need information on the net monthly income of your household. Think of your own income or pension, but also of the income or pension of any other persons in your household. Rest assured that this information will be treated strictly confidentially and anonymously.	<5001 CHF = 211 (34.82%) 5001-9000 CHF = 177 (29.21%) >9000 CHF = 112 (18.48%) NA = 106 (17.49%)	<5001 CH = 201 (34.96%) 5001-9000 CH = 189 (32.87%) >9000 CH = 95 (16.52%) NA = 90 (15.65%)	<5001 CH = 119 (36.50%) 5001-9000 CH = 93 (28.53%) >9000 CH = 54 (16.56%) NA = 60 (18.4%)	<5001 CH = 51.2% 5001-9000 CH = 37.7% >9000 CH = 9.9%

4.6.2 VAA items

The ten items were selected and formulated based on the arguments and conflicts present in the preceding parliamentary debate as well as in the referendum campaign. The ballot vote on the new energy law was framed and perceived not only as a vote on the specific law but more broadly on the Federal Council's Energy Strategy 2050. For this reason, we also included several rather general items, e.g. whether respondents believed in human-induced climate change and whether the government should at all regulate energy production.

German	English Translation
Wir werden nun Ihre Meinung zu zehn Argumenten erfragen, welche in Zusammenhang mit der Abstimmung über das neue Energiegesetz (Energiesstrategie 2050) stehen. Geben Sie jeweils an, wie stark Sie den Aussagen zustimmen.	We are now going to ask your opinion about ten arguments related to the vote on the new energy law (Energiesstrategie 2050). Please indicate how much you agree with each statement.
Die öffentliche Unterstützung erneuerbarer Energien fördert Innovation und technologische Entwicklung.	Public support for renewable energy sources fosters innovation and technological development.
Es sollen keine neuen Kernkraftwerke gebaut werden.	No new nuclear power plants should be built.
Finanzielle Unterstützungen für energetische Gebäudesanierungen sind nötig.	Financial support for energy-efficient renovations is necessary.
Den Energieverbrauch zu senken ist notwendig und machbar.	Decreasing energy consumption is necessary and feasible.
Subventionen zur Förderung erneuerbarer Energien sind aktuell sinnvoll, sollen aber später durch ein Lenkungssystem abgelöst werden.	Subsidies to foster renewable energy sources are currently sensible but should later be replaced by a steering system.
Es ist nicht Aufgabe des Staates, die Energieproduktion zu steuern.	It is not up to the government to regulate energy production.
Erneuerbare Energien werden trotz staatlicher Investitionen die Energieversorgung nicht sicherstellen können.	Despite government-funded renewable energy sources, energy supply cannot be guaranteed in the future.

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German	English Translation
Die mit der Energiestrategie 2050 verbundenen Regulierungen schaden der Wirtschaft.	The regulations related to the new energy law (Energiestrategie 2050) are harming the economy.
Durch die Förderung von Windenergie und Photovoltaik wird die Zerstörung natürlicher Lebensräume und die Zersiedelung vorangetrieben.	The promotion of wind energy and solar energy expedites the destruction of natural habitats as well as urban sprawl.
Es gibt keinen vom Menschen verursachten Klimawandel; deshalb sind die Massnahmen der Energiestrategie unnötig.	There is no human-induced climate change; therefore, the measures of the energy strategy are unnecessary.

Note: These ten items were presented to and evaluated by respondents in a randomised order. On each of these items, respondents first had to indicate their agreement or discontent with the item and then whether they deemed the item important or not. The figure below provides one example.

5 Article 4: Bridging the gap: The influence of information and education on acceptance of environmental taxes in Switzerland

This chapter is identical with the following article published in Environmental Research Communications:

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Abstract

Mitigating climate change remains a challenge for politics since efficient instruments such as environmental taxes are widely unpopular, with one determinant of objection being a lack of knowledge. Trying to increase environmental tax acceptance, previous studies found positive, negative as well as no effects of information treatments about environmental taxes. Contributing to this inconclusive research, I apply MOSAiCH 2020 panel data from Switzerland, calculating the causal effect of receiving an environmental tax information treatment on willingness to pay them. While the information effect was inconsistent for the full sample, information significantly increases green tax acceptance of less educated people. This subgroup effect hence offers an explanation for previous inconsistencies by showing that information does not affect everyone equally. Especially for less educated people, receiving information about the functioning of environmental taxes might therefore prove crucial for policymakers to gain majority support of environmental taxes necessary for their implementation.

Keywords: Social Acceptance, Environmental Taxes, Information Deficit Model, Knowledge, Education

5.1 Introduction

Climate change is progressing rapidly and its consequences are starting to impact earthly life both more frequently and more visibly. Tackling global warming has proven to be challenging in the past, as it is costly and therefore unpopular for governments to implement accurate measures to reduce greenhouse gases. In the context of environmental policymaking, one of the most efficient ways to steer behaviour and to address climate change is by implementing environmental taxes (e.g. Goulder, 1995; Fremstad et al., 2022; Rafique et al., 2022).¹ Introducing such taxes however usually leads to massive public resistance: As green taxes attach a price to polluting activities, this leads to the internalisation of previously externalised costs (e.g. environmental pollution), so the taxed goods get more expensive. This price increase should, economically speaking, intuitively discourage consumers from purchasing them. Also, like most push-measures, i.e. instruments penalising unwanted behaviour (Steg et al., 2006), it has been argued that green taxes are widely unpopular because, amongst other reasons, most people do not understand the concept of redistributing tax revenues and only perceive the extra costs generated (e.g. Bachus et al., 2019; Carattini et al., 2017; Hammerle et al., 2021; Jagers and Hammar, 2009; Steg et al., 2006; Umit and Schaffer, 2020). One of the main challenges that politicians therefore face is showing citizens that acting environmentally friendly does not always go hand in hand with higher costs and on the contrary, green tax redistribution even has the potential to decrease inequality and poverty, therefore bringing most benefits to those who especially fear price increases due to such taxes (Budolfson et al., 2021). The question that climate and political scientists have been answering so far was to identify the factors leading to low support of climate change measures that are limiting attempts at reducing the carbon footprint. Despite knowing what causes resistance to environmental taxes, politically and scientifically, there is still no consensus on how these taxes could be made more socially accepted.

Amongst other determinants, past studies found that a lack of knowledge was one of the main causes for low environmental tax acceptance (Sturgis and Allum, 2004; Leiserowitz et al., 2021) and that accordingly, information has the potential to improve support of environmental taxes (e.g. Feldman and Hart, 2018). Following Robert Dahl (1989)'s enlightened understanding of democracy, such a lack of information becomes problematic whenever people would change their opinion if presented with more information. Consequently, providing citizens with sufficient and comprehensible information is necessary for them to effectively participate in public debates (Sturgis and Allum, 2004). Or as Ajzen et al. (2011, p. 10) put it: "A well-informed citizenry is the essential backbone of a free society, and few would dispute the value of more and better information." Hence, communication is essential in informing people about climate change and possible measures to mitigate it in order for people to decide whether and what measures to introduce, one of them being environmental taxes (Rowan et al., 2021).

¹ The terms "environmental taxes" and "green taxes" are used synonymously.

Information could certainly be a way to increase knowledge about and support of environmental taxes, however, existing research remains highly inconclusive. Apart from positive information effects (e.g. Fremstad et al., 2022; Heres and Galarraga, 2017), negative (e.g. Carattini et al., 2017; Stadelmann-Steffen, 2019) as well as non-significant findings (e.g. Bernauer and McGrath, 2016; Kallbekken et al., 2011) have been identified, too. One reason for these previous inconsistencies could be owed to subgroup effects, meaning that the information effect varies across different population subgroups. For example, differently educated people could be more or less receptive to information about environmental taxes, which is a cognitively rather complex issue. Accordingly, past research has shown that education itself relates positively to green tax acceptance (Bachus et al., 2019), which inevitably leads to a gap in green tax acceptance between different education groups. Getting approval of less educated voters might hence be crucial to gain majority support of green tax proposals and information might be key in changing less educated citizens' opinion on them. Hence, identifying potential group differences is fundamental in order for governments to carry out information campaigns more efficiently by catering more precisely to specific group needs (Bareinz and Uebelmesser, 2020).

To sum up, due to their pricing mechanism, environmental taxes are a highly efficient policy instrument to tackle decarbonisation and therefore the global problem of climate change, yet actual implementation of green taxes remains sparse. As of June 2023, and independent of potential emissions trading systems, only 27 countries worldwide have implemented national-level carbon taxes (The World Bank, 2023a).² Distributing information on these taxes has the potential to improve green tax acceptance, possibly even for population groups who previously rejected them, such as less educated people, thus in the best case generating the majority support necessary for more widespread implementation of green taxes. Accordingly, my research question can be stated as follows: *Can information about environmental taxes change citizens' willingness to pay them and does this information effect vary across different education groups?*

This research question is tested in Switzerland. While regime type itself does not seem to correlate with a country's environmental policy ambitiousness per se (see Kammerlander and Schulze, 2021), due to Switzerland's high degree of direct democracy and its concomitant voter veto power, testing the above-mentioned research question in this setting particularly makes sense. In 2020, Switzerland collected 10 billion CHF in environmental tax revenue (1990: 5bn CHF), so green taxes are not completely new to Swiss residents (Federal Statistical Office, 2022b). Still, with Switzerland also needing to adhere to the 2015 Paris Agreement goals and having to

² There are two main forms of carbon pricing: Carbon taxes and emissions trading systems (ETS). In general, carbon pricing is a measure intended to capture the external costs of greenhouse gas emissions. These costs are internalised by attaching a price to the source, usually a price on CO₂. This holds those responsible for the emissions accountable and incentivises them to emit less CO₂. Carbon taxes put a fixed price on a unit of emitted CO₂. Here, the emission reduction outcome is not pre-defined. Emissions trading systems however set this target a priori. ETS create a market where emissions units are traded according to demand and supply, so the price remains flexible (The World Bank, 2023b).

introduce further decarbonisation policies, expanding environmental taxation is crucial. Due to the country's high degree of direct democracy, further green taxation however depends on citizens' willingness to support such measures at the ballot, where costly policies such as (environmental) taxes are often rejected. One prominent example is the Swiss CO₂-law from June 2021, which, amongst other policy instruments, wanted to introduce a tax on carbon emissions and therefore probably did not gain majority support in the vote. Hence, whereas taxes in other democratic countries can be imposed without voters' explicit approval, giving them a chance to experience taxes and adapt their opinions on them, in Switzerland, citizens first have to be convinced about a tax' benefits before policymakers can actually implement them. In order to gain broad support of unpopular but cost-efficient measures such as environmental taxes, it is therefore of utmost importance for voters to comprehend how environmental taxes work and how their revenue is used. Findings from Switzerland could, one, also be used to make climate change measures more palatable in other countries, and two, be applied to different policy contexts.

The contribution is as follows: Cross-sectional research on the influence of information and acceptance has been conducted in many fields of (environmental and political) science, still, there does not seem to exist a systematic longitudinal analysis on one of the most efficient tools to combat climate change, namely environmental taxes. While a lot is known about the personal and contextual determinants of environmental tax acceptance and their societal unpopularity, barely any research about how information about said taxes can change people's willingness to pay them exists. This study, analysing the two-wave MOSAiCH 2020 dataset, treats citizens with neutral information as opposed to politically-ideologically charged information treatments, as has been done in most previous studies (e.g. Kahan, 2010). Hence, it could be considered a "most likely"-case for information effects. In accordance with existing studies, I only find an inconsistent information effect for the full sample across different models. One possible explanation for this inconsistency could lie in heterogeneous or even diverging subgroup effects. Hence, I investigate the possibility of an education moderation effect, which has not been examined previously either. With results showing a positive information effect only for less educated citizens, this non-universality offers an explanation for the inconsistent information effects found in the past, pointing to the need to hereafter differentiate information effects between population subgroups. The results also give valuable insights into how policymakers especially in (direct-)democratic countries can distribute information about environmental taxes in order to make them more comprehensible and therefore more popular and implement them to tackle climate change more efficiently. Specifically, stating and explaining the functioning and use of taxes seems to bridge the gap between different education groups regarding acceptance of environmental taxes.

5.2 Theory

5.2.1 Controversy around environmental taxes

As mentioned, (environmental) taxes are as unpopular as they are controversial, emphasising the need to look more closely at the reasons behind this. In general, taxes have three functions: First, taxes generate revenue, which allows governments to finance public goods. The second goal is redistribution in order to decrease inequality. And third, consumption taxes always regulate behaviour (Avi-Yonah, 2006). Environmental taxes primarily address this third goal, as described by Albrecht (2006, p. 88): “Environmental taxes penalise the production and consumption of ‘bads’ while generating revenues that can offset existing taxes on ‘goods’ like labour. Higher prices for energy, wastes and environmental damages provide clear incentives for consumers and producers to search for technologies that can minimise or eliminate the environmental penalties”. Taxing the externality-generating behaviour should incentivise behavioural change since higher prices mean less consumption and hence, less emissions (Jagers and Hammar, 2009), therefore “getting the price right” (Goulder, 1995, p. 157). One example deemed to drive decarbonisation is the Swiss CO₂-tax, which is collected on all fossil thermal fuels and therefore incentivises the use of more carbon-neutral energy sources (Federal Office for the Environment, 2021). Empirically, it has in fact been shown that countries employing environmental taxes have, both short- and long-term, smaller ecological footprints (Rafique et al., 2022), alluding to both their economic and ecological efficiency.

However, despite the need to fulfil the 2015 Paris Agreement goals and to reduce carbon emissions, environmental taxes are still underused as they are met with broad rejection (e.g. Umit and Schaffer, 2020). People prefer softer policy measures such as information campaigns (Douenne and Fabre, 2020) or subsidies over hard policy instruments like taxes when dealing with environmental problems (Heres and Galarraga (2017), but see also Banerjee et al. (2021)). The following reasons explaining green tax unpopularity have been proposed: One, it stems from the economic logic that, like all taxes, they decrease individual budget (Jagers and Hammar, 2009)³ and are often perceived as an infringement on freedom of choice (Kim et al., 2013), as coercive (Bachus et al., 2019) and unfair (Jagers and Hammar, 2009), e.g. for residents from rural areas (Ewald et al., 2022). Fear of negative impacts to low-income households is also a factor which leads to the rejection of green taxes (Carattini et al., 2018; Fremstad and Paul, 2019). Another issue is that people tend to believe that Pigouvian taxes are not effective (Baranzini et al., 2014) because they have trouble understanding taxes in general (Ewald et al., 2022) or seeing the true costs and benefits specifically (Steg et al., 2006). People fear that governments only want to increase fiscal revenue and that environmental taxes do not discourage climate-harming behaviours after

³ This assumption is not undisputed: Kallbekken and Sælen (2011) found that, in Norway, it is not economic self-interest that makes environmental taxes unpopular but rather beliefs about environmental consequences that determine whether people are in favour or against environmental taxes.

all (Carattini et al., 2018). Also, the more visible taxes are, the more adverse people react to them, which, by mischance, is the case for most environmental taxes (Bachus et al., 2019). And further, as initially mentioned, low science literacy and a lack of understanding about how environmental taxes work also account for insufficiently high levels of green tax acceptance (e.g. Sturgis and Allum, 2004; Leiserowitz et al., 2021).

5.2.2 Information and acceptance of environmental taxes

Hence, one way to possibly change acceptance of environmental taxes is by exposing citizens to more information on them. It is a commonly spread belief that new knowledge changes attitudes or behaviours (Marteau et al., 2008). Although widely criticised for being too simplistic (Nisbet and Scheufele, 2009), the knowledge or information deficit model could help to theoretically explain the association between people's amount of information (and in the best case, therefore, knowledge) on environmental taxes and their support of said taxes. Despite the criticism, the model still persists today since, and amongst other factors, it works well for policy design and offers a narrow framework (Bidwell, 2016; Stoutenborough and Vedlitz, 2014).

In the information deficit model, two beliefs are inherent: First, public scepticism towards science is caused by a lack of scientific knowledge. Public ignorance and science illiteracy are the main problems for a lack of acceptance of a multitude of scientific issues (Nisbet and Scheufele, 2009; Rowan et al., 2021) because then, “people fall back on mystic beliefs and irrational fears of the unknown” (Sturgis and Allum, 2004, p. 57). And the second model assumption states that this lack of knowledge can be overcome by experts providing additional and more comprehensible information to lay people (Nisbet and Scheufele, 2009; Rowan et al., 2021).

Existing research on the topic remains inconclusive and appears to be highly context-dependent. In line with the information deficit model, researchers from various scientific disciplines have empirically proven that receiving information or having more knowledge leads to higher acceptance, support or willingness to pay of whatever the information tries to convey. For example, broadly testing the influence of scientific knowledge on attitudes towards science, Bak (2001) as well as Sturgis and Allum (2004) found positive and significant relationships. Or more concretely, Abunewah et al. (2020) show that the provision of disaster risk information indeed leads to better disaster preparedness of citizens. The same goes for receiving energy efficiency information and higher willingness to pay more for eco-friendly apartments (Carroll et al., 2016), information on pesticides and higher willingness to pay for organic food (McFadden and Huffman, 2017), information on water consumption and people's water saving behaviour (Céspedes Restrepo and Morales-Pinzón, 2020) or information on alternative fuels and their social acceptance (Offermann-van Heek et al., 2020). Regarding renewable energy acceptance, being more knowledgeable on the topic (Guo et al., 2014; Han et al., 2020; Hojnik et al., 2021; Stoutenborough and Vedlitz, 2014) or receiving positive information about solar panels (Bekker et al., 2017) and other renewable

forms of electricity (Bidwell, 2016; Dubois et al., 2019) was proven to enhance people's opinions on them.

Regarding income tax acceptance, possessing more tax knowledge seems to increase willingness to pay them (Ali and Nasaruddin, 2020). Focussing specifically on environmental tax acceptance, there also exists evidence suggesting a positive relationship between either information (Brouwer et al., 2008; Feldman and Hart, 2018; García-Maroto et al., 2015; Heres and Galarraga, 2017; Jagers and Hammar, 2009) or knowledge (Douenne and Fabre, 2020; Weinstein Agrawal et al., 2010) and support for (paying) environmental taxes. Furthermore, acceptance of environmental taxes seems to be especially high when their revenue is explicitly earmarked for environmental purposes (Baranzini et al., 2014; Baranzini and Carattini, 2017; Carattini et al., 2017), for income redistribution (Gevrek and Uyduranoglu, 2015), for the mitigation of environmental impacts due to climate change or the financing of renewable energy projects (Rotaris and Danielis, 2019) or climate projects (Maestre-Andrés et al., 2021). Informing people simultaneously about the real costs of different instruments such as taxes and subsidies also seems to be conducive to green tax acceptance (Jagers and Hammar, 2009). Additionally, research has shown that, in the absence of political messaging, information about carbon pricing and tax rebates has a positive effect on public support (Fremstad et al., 2022; Zumofen and Bühlmann, 2023). In summary, by giving people information about how environmental taxes work, what their purpose is and that refrains from using political-ideological messaging, acceptance of green taxes could be increased. Since I focus on a balanced information treatment, i.e. one that lists scientific facts in an apolitical manner, building upon these previous findings as well as the information deficit model, the first hypothesis can therefore be summarised as follows:

Hypothesis 5.1 *Information about environmental taxes increases acceptance of these taxes.*

5.2.3 Information effects, environmental taxes and education

Apart from this positive information effect and as mentioned earlier, research has also identified negative (e.g. Carattini et al., 2017; Stadelmann-Steffen, 2019) as well as insignificant (e.g. Bernauer and McGrath, 2016; Kallbekken et al., 2011) information effects. One explanation for these previously inconclusive findings on information effects could be due to its non-universality. The posited information effect might not persist throughout the full sample and could vary across different population groups, such as unequally educated people. So far, research has not sufficiently considered this possibility of interaction effects with information treatments, neither for education nor other factors. Arguing along the lines of the information deficit model again, since a lack of knowledge is expected to negatively correlate with acceptance of scientific issues or technologies due to unfamiliarity (e.g. Bekker et al., 2017; Qu et al., 2011), it seems plausible that these information effects vary across education groups. As people with higher formal education should have acquired more knowledge about scientific topics already (e.g. Hoffmann and Muttarak, 2017), due to the logic of marginal utility, providing additional information on how

environmental taxes work might bring more benefit to less educated people (e.g. Kahan et al., 2012; Zhou and Dai, 2020). Accordingly, the next hypothesis reads as follows:

Hypothesis 5.2 *The information effect of environmental taxes is stronger for less educated people.*

On the other hand, acquiring more information about environmental taxes could also be more conducive to green tax acceptance for those with higher education than it is for those with lower educational attainments. As this would widen the knowledge gap instead of narrowing it, more instead of less inequality between the different education groups would be the consequence. This unintended ‘Matthew effect’, i.e. “the fact that advantage begets further advantage” (Perc, 2014), would hence polarise society even more (see Gustafson and Rice, 2016). Such effects have been observed in past information experiments (Sturgis et al., 2010). Since education on its own relates positively to general scientific attitudes (Bak, 2001) as well as disaster preparedness (Hoffmann and Muttarak, 2017), environmental support (Ehret et al., 2017), acceptance of renewable energies (Han et al., 2020; Ntanos et al., 2018; Qu et al., 2011) and even paying environmental taxes (Bachus et al., 2019; Baranzini and Carattini, 2017; Ewald et al., 2022; Goh and Matthew, 2021) as well as due to them having better intellectual processing abilities (Parisi et al., 2012), giving more information on environmental taxes could result in a weaker information effect for less educated people. The counterhypothesis to Hypothesis 5.2 can thus be summarised as:

Hypothesis 5.3 *The information effect of environmental taxes is weaker for less educated people.*

5.3 Research Design

5.3.1 Sample

The research question is studied in Switzerland. As mentioned earlier, Switzerland is highly direct-democratic and frequently votes on ballot proposals, i.a. on environmental issues such as green taxes. In this aspect, Switzerland already has some experience (e.g. taxes on emissions, energy or transportation (Federal Statistical Office, 2022b)) but, like in most countries, they are insufficient to reach the Paris Agreement goals. Due to their ideological connotation and perceived economic burden, these ballot proposals are usually controversial and often rejected, such as the CO₂ Act in 2021, which aimed at an encompassing expansion of the Swiss “cap and dividend”-system to further decrease greenhouse gas emissions (Federal Statistical Office, 2021). Hence, gaining popular support is especially critical in this country to implement more measures such as green taxes to effectively tackle climate change.

In order to test the hypotheses outlined above, the ‘Measurement and Observation of Social Attitudes in Switzerland (MOSAiCH) 2020’ dataset from Staehli et al. (2021a) is employed, which is

publicly available. This two-wave web-based survey was conducted from February to July 2020⁴ and consists of a randomly selected sample of 1'155 adults who participated in both waves. On average, the time between the two waves amounted to 65.43 days. All respondents live in Switzerland. In accordance with the ISSP 2020 module on environment, the first wave primarily asked respondents about their environmental attitudes as well as sociodemographic characteristics. In the second wave, more than 70% of the respondents from the first wave participated once more, i.a. partaking in an experiment about environmental taxes (Staehli et al., 2021b). As table 5.3.1 illustrates, the panel sample is virtually identical to the full sample regarding respondents' characteristics, indicating that panel attrition does not happen systematically. Compared to the Swiss population, the MOSAiCH data slightly overrepresent males, those from higher income groups and with higher vocational education as well as voters from the GLP, GPS and SP. Also, people with secondary education or less, university graduates and SVP-voters are somewhat underrepresented in the sample. To exclude potential confounding between educational attainment and party choice, which are typically highly interrelated, correlation analysis has been carried out. With a Pearson correlation index of 0.147, pointing at a negligibly small relationship between higher education and voting for a more leftist party, this concern can be allayed. Appendix 5.6.1 further shows the political-ideological composition for all education groups.

5.3.2 Variables

Within the scope of the experiment, the following information treatment was randomly assigned to 50% of the sample at the beginning of the second wave:

With environmental taxes, we want to influence people's behaviour. When electricity is taxed, the price of electricity goes up. As a result, we consume less energy because it costs more. The tax on electricity allows the state to receive money. For example, it can use that money to promote renewable energy, such as hydro, solar and wind power. Some scientists say that it is a good thing that money from an electricity tax is redistributed to the population: "People are rewarded for using less electricity. And it doesn't cost the government anything."

Consequently, the independent variable consists of this information dummy where 0 denotes that the person has not received the information about environmental taxes and 1 denotes that the person has received said information. As Nisbet and Scheufele (2009) suggested, this statement abstains from using partisan info or words such as 'climate change', therefore, this kind of framing might appeal to more people. It can be classified as a balanced information treatment, since the information given is stated in a neutral manner but still stresses certain scientific facts (see

⁴ The invitation to take part in the second wave was received by the end of April 2020. All respondents who completed at least 50% of the first questionnaire by 20 April 2020 were invited again (Staehli et al., 2021b).

Table 5.3.1: Sample and population descriptives

Variable	Full sample	Panel sample	Switzerland
Age	19-64 years: 76.88% 65 years+: 23.12%	19-64 years: 77.98% 65 years+: 22.02%	20-64 years: 76.69% 65 years+: 23.31%
Gender	Male: 51.06% Female: 48.94%	Male: 54.16% Female: 45.84%	Male: 49.6% Female: 50.4%
Party strength	SVP: 19.64% BDP: 2.31% FDP: 16.35% CVP: 9.65% GLP: 11.66% EVP: 1.84% GPS: 17.83% SP: 20.71%	SVP: 18.43% BDP: 2.84% FDP: 16.04% CVP: 10.13% GLP: 13.20% EVP: 1.82% GPS: 17.29% SP: 20.25%	SVP: 25.6% BDP: 2.4% FDP: 15.1% CVP: 11.4% GLP: 7.8% EVP: 2.1% GPS: 13.2% SP: 16.8%
Income	<3'300 CHF: 9.18% 3'300-4'299 CHF: 8.35% 4'300-5'299 CHF: 10.56% 5'300-6'399 CHF: 10.34% 6'400-7'499 CHF: 9.93% 7'500-8'799 CHF: 12.03% 8'800-10'299 CHF: 12.94% 10'300-12'199 CHF: 10.87% 12'200-15'599 CHF: 8.82% Min. 15'600 CHF: 6.99%	<3'300 CHF: 5.69% 3'300-4'299 CHF: 5.88% 4'300-5'299 CHF: 10.06% 5'300-6'399 CHF: 10.34% 6'400-7'499 CHF: 11.48% 7'500-8'799 CHF: 12.90% 8'800-10'299 CHF: 13.38% 10'300-12'199 CHF: 12.81% 12'200-15'599 CHF: 9.30% Min. 15'600 CHF: 8.16%	Max. 3'000 CHF: 21% 3'001-4'000 CHF: 11.3% 4'001-5'000 CHF: 17.2% 5'001-6'000 CHF: 16.3% 6'001-7'000 CHF: 11.3% 7'001-9'000 CHF: 11.6% 9'001-10'000 CHF: 3.2% 10'001-12'000 CHF: 3.5% 12'001-15'000 CHF: 2.1% Min. 15'001 CHF: 2%
Education	Mandatory: 12.36% Secondary: 37.52% Higher vocational: 32.29% University: 17.83%	Mandatory: 10.46% Secondary: 33.56% Higher vocational: 34.1% University: 21.88%	Mandatory: 11% Secondary: 44.6% Higher vocational: 14.8% University: 29.6%

Note: The coding of some variables in this table does not correspond to the variable coding in the analyses. To make the MOSAiCH data as comparable as possible to official data from Switzerland, they were (to some degree and only in the context of this table) recoded accordingly in order to check for representativeness. However, especially the variables of income and education were measured significantly differently, therefore, these comparisons should only be seen as proxies.

Data sources: Federal Statistical Office (2019, 2022a,c,d); Staehli et al. (2021a) (own calculations).

Xafis et al., 2015). Also, clearly mentioning the benefit of population redistribution (Budolfson et al., 2021) as well as earmarking the revenue for environmental purposes, thus emphasising the costs and (often overlooked) benefits, might prove essential to gain societal support (e.g. Baranzini et al., 2014). This item therefore combines multiple findings of previous studies by both earmarking the tax' environmental benefit and comprehensibly explaining its functioning.

The moderator variable, which measured a respondent's highest educational attainment, was coded as follows: 'secondary education or less', 'higher vocational education', 'university degree'.

Due to the panel structure of the dataset, the dependent variable was collected twice, once per wave. The corresponding item asked respondents both times *"How willing would you be to pay*

much higher taxes in order to protect the environment?” and was coded to range from -2 ‘very unwilling’, -1 ‘fairly unwilling’, 0 ‘neither willing nor unwilling’, 1 ‘fairly willing’ up to 2 ‘very willing’. In the second wave, this item was not immediately asked after the information treatment, which reduces the risk of a social desirability bias. The wording of this item asks for ‘willingness to pay’, which can be seen as an indirect measure of support for policy instruments such as taxation (Bachus et al., 2019).⁵ The strong wording of the item was chosen on purpose as to only capture willingness to pay green taxes of people who definitely agree with this measure (Staehli et al., 2021b).

The codebook including all variables used can be found in Appendix 5.6.2.

5.3.3 Methods

Following the logic of the difference-in-differences approach (see Wooldridge, 2016), a mean comparison is first presented. Then, to analyse the causal effect of the information treatment on acceptance of environmental taxes in more detail, a fixed-effects model with robust standard errors is estimated. Since fixed-effects models cannot include any time-constant covariates, no further control variables are added in the main model (see Angrist and Pischke, 2009; Wooldridge, 2016).⁶ However, as a robustness check, the dependent variable will also be modelled as the change in willingness to pay higher environmental taxes between the two points in time and analysed in a linear regression model, which also includes control variables. Formally, the fixed-effects model (where Y_{it} stands for the dependent variable of willingness to pay higher green taxes, β_1 for the constant, $(\beta_2 * I_{it})$ for the information effect, δ_t for the time effect, α_i for all time-invariant variables and ϵ_{it} as the error term) can be summarised as:

$$Y_{it} = \beta_1 + (\beta_2 * I_{it}) + \delta_t + \alpha_i + \epsilon_{it}$$

To answer the second part of the research question, the information treatment variable is interacted with the highest level of a respondent’s education. This moderation effect was then also regressed on acceptance of environmental taxes in a fixed-effects model with robust standard errors as well as in a model including the dependent variable as the change in willingness to pay higher environmental taxes.

⁵ While (social) acceptance is more passive and at least defined as ‘lack of objection’, support includes a more active dimension because citizens have to actively agree to something (Batel et al., 2013). They are used synonymously in this paper.

⁶ Control variables other than the classic time-constant variables like age and gender, such as attitudinal variables, were only measured once and could therefore not be included either for the fixed-effects model.

This fixed-effects model including the interaction effect between the information treatment and the educational attainment ($\beta_3 * I_{it} * E_i$) can be formalised as:⁷

$$Y_{it} = \beta_1 + (\beta_2 * I_{it}) + (\beta_3 * I_{it} * E_i) + \delta_t + \alpha_i + \epsilon_{it}$$

5.4 Results

Before addressing the results from the fixed-effects models, some descriptive findings in figure 5.1 should be discussed.⁸ First, it depicts an overall increase in the mean acceptance of environmental taxes between the first (t_1) and second (t_2) survey wave, despite still being on the reluctant side of paying environmental taxes. Differentiating this t_2 -effect between respondents having received the environmental tax information treatment and those who have not proves even more insightful: On average, participants without additional information expressed almost nine times more negative opinions towards environmental taxes. This variance in responses lends support to further analyses regarding this information effect.

What is more, there seem to be stark disparities between education groups, both before and after they were presented with the environmental tax information treatment. In t_1 , on average, less educated people voiced much more reluctance to paying higher taxes for environmental purposes than other education groups. Overall, only respondents with a university degree were inclined to accept these higher environmental taxes in t_1 already. In t_2 , the two lower education groups, regardless of having received the information treatment, uttered more positive opinions about environmental taxes, which might suggest that either an outside event or the survey itself influenced all respondents to improve their support to some degree between the first and second survey wave. University graduates seem to pose a special case however: In t_1 , the treatment and control group already differ drastically in their willingness to pay green taxes, which might be problematic for fixed-effects model assumptions. It further shows that, for those university respondents without the information treatment, their previously slightly negative willingness to paying green taxes changed minimally onto the positive side. However, for those having received the information treatment, willingness to pay green taxes even decreased. To determine whether these descriptive findings are of substantial importance, the results from the fixed-effects models will later-on prove insightful.

⁷ Due to education being time-invariant, there is no separate coefficient for education, as its effect is captured in α_i . This also becomes evident in the model in Appendix 5.6.6.

⁸ More detailed descriptive statistics about the tax-variable can be found in Appendix 5.6.3.

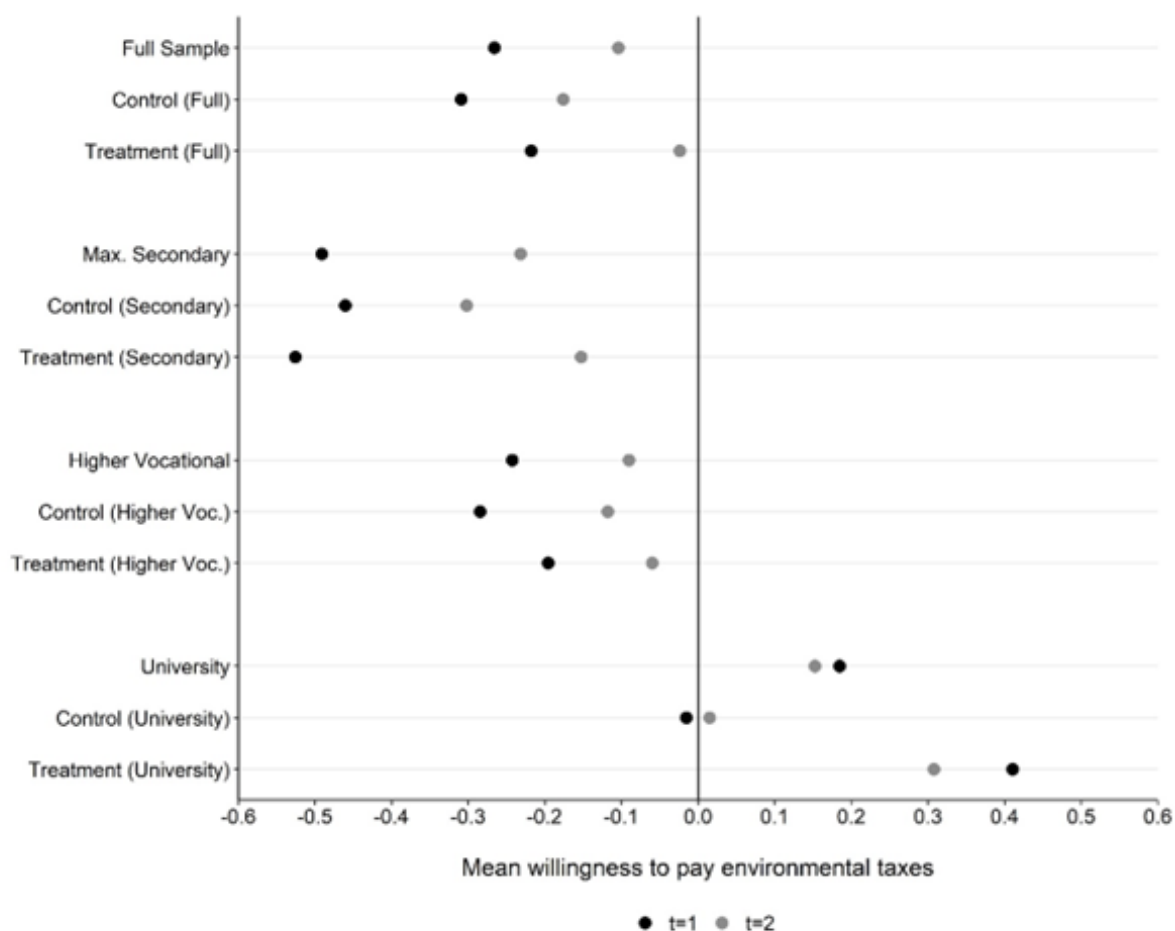


Figure 5.1: Descriptive findings

Data source: Staehli et al. (2021a), own calculations and depiction.

Figure 5.2, displaying a difference-in-differences model, shows that willingness to pay green taxes increased for both groups but slightly more so for the treatment group, which could be indicative of an information effect.

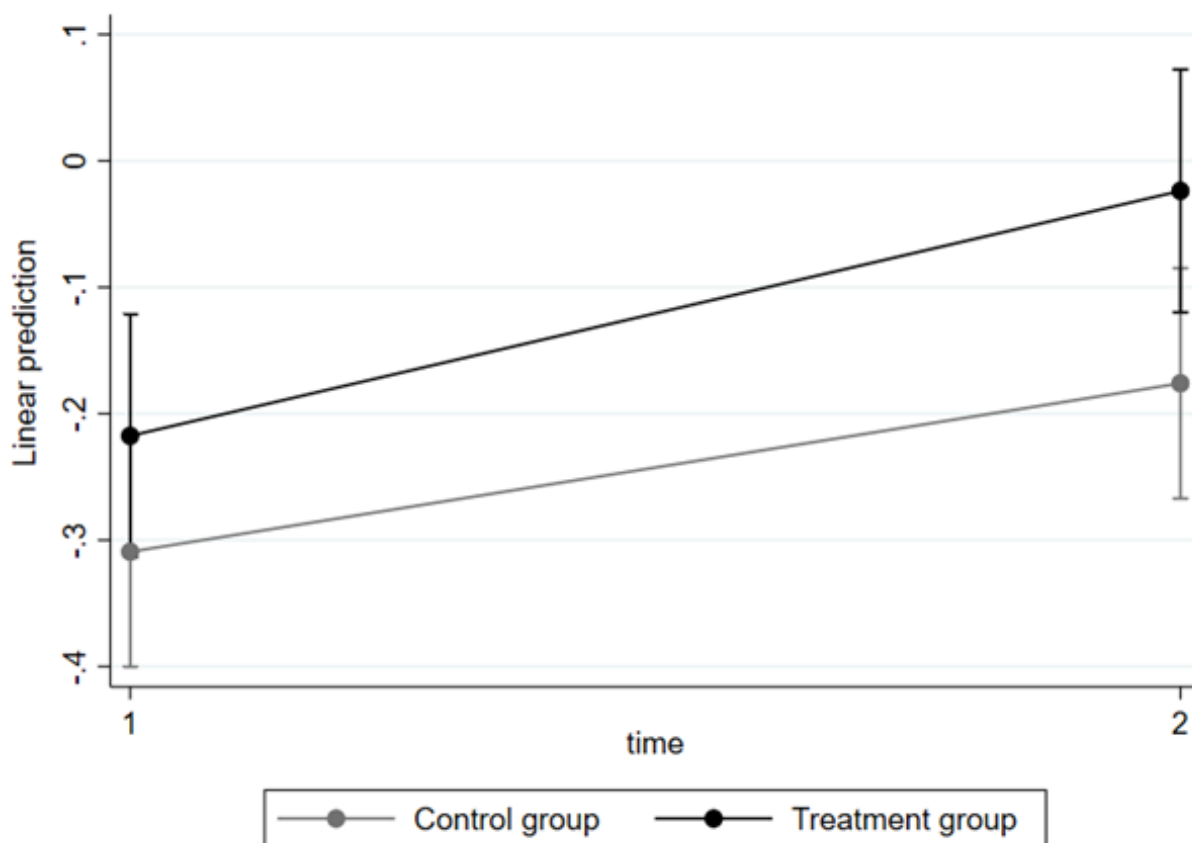


Figure 5.2: Difference-in-differences model

Data source: Staehli et al. (2021a), own calculations and depiction.

The fixed-effects model (see table 5.4.1) however shows that, regardless of belonging to the treatment or control group, over time, people increased their willingness to pay higher environmental taxes by 0.13 scale points (p-value: 0.001). The information effect amounted to 0.06 but proved to be statistically insignificant (p-value: 0.303). As previously stated, additionally and as a robustness check, models including the dependent variable as the change in willingness to pay green taxes between the two points in time were calculated. The empty model naturally confirmed the findings from the fixed-effects regression (Appendix 5.6.4), however, the model including control variables altered results somewhat (see Appendix 5.6.5). Here, respondents of the treatment group were, on average, 0.12 scale points more willing to pay higher environmental taxes than those of the control group (p-value: 0.095). Due to falling short of conventional statistical thresholds, Hypothesis 5.1, stating that information about environmental taxes increases acceptance of these taxes, is rejected. Still, it might be an indication of a possible information effect and its practical implications should not be completely disregarded. Serving as a sign that the broad public might not fully understand the functioning of environmental taxes, policymakers should encourage a broader provision of such information to increase their chances of gaining majority support regarding green taxes.

Table 5.4.1: Fixed-effects model

	Acceptance of paying much higher environmental taxes				
	Coefficient	Robust SE	$P > t $	95% confidence interval	
Information effect	0.0606	0.0587	0.303	-0.0547	0.1758
Time effect	0.1332	0.0394	0.001	0.0558	0.2106
Constant	-0.2658	0.0146	0.000	-0.2945	-0.2371
Sigma_u	1.0326				
Sigma_e	0.7030				
Rho	0.6833				
$R^2(overall)$	0.0064				
Number of observations	2'310				
Number of groups	1'155				

Data source: Staehli et al. (2021a), own calculations.

After having established that there does not seem to exist a general information effect for green tax acceptance, coming back to the descriptive differences found earlier, the question remains as to whether differently educated people are unequally affected by the information treatment. As previously stated, since environmental taxes are not trivial to grasp per se, better educated people might have an advantage to understanding them, thus profiting more from additional information. On the other hand, the information effect could be especially strong for less educated people as they might profit most from additional information. Turning to the results of the fixed-effects interaction model, they confirm Hypothesis 5.2. Compared to respondents with secondary education degrees or less, those with higher vocational education or even a university degree seem to benefit less from reading information about environmental taxes (see Appendix 5.6.6 for the full model and Appendix 5.6.7 for average marginal effects). However, as depicted in figure 5.1, especially for university graduates, the control and treatment groups might not have been identical before the group assignment. Therefore, as a robustness check, another model including the dependent variable as the change in willingness to pay higher environmental taxes and a variety of control variables to account for group differences is analysed (see Appendix 5.6.8). These results corroborate the fixed-effects findings, indicating that, compared to people with a secondary education degree or less, respondents with higher vocational education and university graduates profited less from reading the information treatment by 0.27 (p-value: 0.091) and 0.39 (p-value: 0.028) scale points, respectively. The average marginal effects in figure 5.3 (Appendix 5.6.9) visualise that treated respondents with a maximum of secondary education were, on average, 0.21 scale points (p-value: 0.015) more willing to pay higher environmental taxes than their counterparts without additional information. With the tax acceptance variable's standard deviation being 0.99, the coefficient's effect size amounts to 22% of it. Hence, this information effect clearly stresses the relevance of what Robert Dahl's (1989) enlightened understanding of

democracy pointed at.

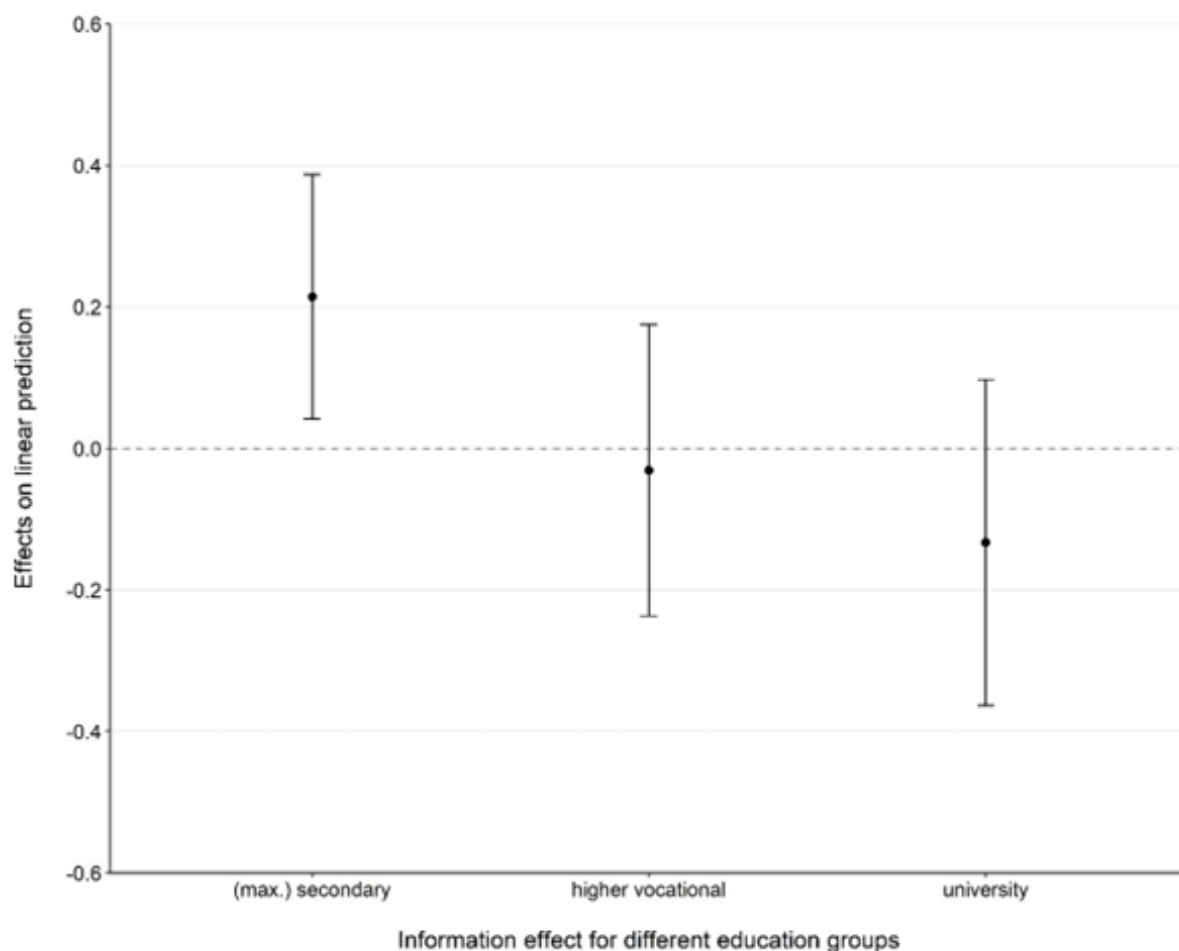


Figure 5.3: Average marginal effects

Data source: Staehli et al. (2021a), own calculations and depiction.

To sum up, the data at hand produced an inconsistent information effect regarding willingness to pay higher environmental taxes for the full sample. This coincides with existing research, which partially identified information effects. I argued that this previous disunity might stem from a non-universal information effect which only affects parts of the population. This presumption seemed to be correct, as the information effect in this study differed depending on the respondent's degree of education. The findings are also in line with Robert Dahl's (1989) enlightened understanding of democracy and were able to reduce the knowledge gap, pinpointing to the need for better informing less educated people, since the information treatment was able to improve these respondents' opinion on environmental taxes. This, of course, is also relevant from a policymaking perspective. While this design could not explicitly test for the framing of the information treatment, results still indicate that there is a good chance that highlighting the often misunderstood aspect of tax redistribution and revenue use leads to higher willingness to pay these taxes, at least for less educated people. With taxes being one of the most efficient

measures in changing behaviours, policymakers should make use of this finding in order to better combat climate change.

5.5 Conclusion

5.5.1 Summary

To briefly summarise the results, first, it could be shown that respondents who received information about environmental taxes were not consistently more willing to pay them than respondents without this information treatment across various models. However, splitting up the sample into different education groups proved relevant. The environmental tax information effect was positive for the least educated respondent group at the 5% level but insignificant for respondents with higher vocational education and university degrees.

5.5.2 Limitations

The article at hand is certainly not without limitations. A first point of criticism concerns the dependent variable, willingness to pay higher environmental taxes. Despite its strong item formulation, which only intended to capture people who were truly willing to pay higher green taxes, it still asks for respondents' subjective assessment and hence cannot guarantee real-life willingness to pay them. Another issue might arise due to attrition bias and sample representativeness: While around 4'300 citizens took part in the first survey wave and around 3'100 in the second wave, only 1'155 respondents answered all necessary questions needed for both waves. Despite showing that the panel sample does not differ substantially from the full sample regarding various sociodemographic variables, some groups, such as voters from green parties, are slightly overrepresented compared to the Swiss population. And secondly, despite other research pointing to durable information effects in the context of climate change education (see Ranney and Clark, 2016), this experiment only measured rather short-term information effects and nothing is known about the longevity of them in real-life situations. Whether these results are generalisable outside of Switzerland or, if at all, only apply to countries similar in respect to degree of democracy or familiarity with other environmental taxes remains open.

5.5.3 Policy implications

These results have both scientific and practical policy implications. As stated, since environmental taxes are deemed to be one of the most efficient ways to alleviate climate change and its negative implications, it is of crucial importance to find the extrinsic drivers of boosting environmental tax acceptance that go beyond personal characteristics, which are, per definition, hard to change. By introducing a soft policy instrument like information, citizens can learn about

the functioning and purpose of environmental taxes and adapt their opinion on them. Since information effects were identified for the least educated respondent group, i.e. they updated their opinion on environmental taxes, this stresses the importance of ‘enlightening’ people (Dahl, 1989). It is also in line with the assumptions of the information deficit model: While it cannot be denied that other personal and contextual factors contribute at least to initial attitude *formation*, receiving information still proves influential for some population groups when it comes to attitude *change*. At least this was the case when respondents were presented with this balanced information treatment. This has two implications: First, policymakers in general should provide the public with more information about the functioning and purpose of green taxes. And second, despite being unable to specifically test for framing effects in this study, this finding could translate into the suggestion for policymakers to abstain from using political-ideological messaging as much as possible when distributing information about a new policy instrument (for example in the Swiss voting booklet distributed for all ballot proposals). Instead, as stated, the functioning and purpose of environmental taxes should be formulated more factually in order to gain societal support.

From a societal point of view, keeping in mind that since average willingness to pay environmental taxes was still slightly negative even for participants having read information about these taxes, the impact of this information effect for less educated people should not be overly emphasised. Nonetheless, as information indeed seems to bridge the gap between education groups regarding acceptance of green taxes, this implies that information is an effective tool to prevent the formation of an even wider gap between different education groups. I therefore recommend conducting further subgroup analyses, also for contexts apart from the field of environmental taxes, since this study managed to offer an explanation for the heterogeneity of previous research regarding information effects.

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5.6 Appendix

5.6.1 Frequency table (in %)

	(max.) secondary education	Higher vocational	University	Total
SVP	12.45	5.56	1.67	19.68
BDP	1.06	0.92	0.20	2.18
FDP	7.61	5.63	3.31	16.54
CVP	5.22	3.24	1.16	9.62
GLP	4.06	4.26	3.41	11.73
EVP	0.61	0.95	0.24	1.81
GPS	6.62	6.45	4.64	17.70
SP	9.79	6.86	4.09	20.74
Total	47.41	33.87	18.72	100

Data source: Staehli et al. (2021a), own calculations.

5.6.2 Codebook

Variable	Item Formulation	Coding
Environmental tax acceptance	How willing would you be to pay much higher taxes in order to protect the environment?	-2 – very unwilling -1 – fairly unwilling 0 – neither willing nor unwilling 1 – fairly willing 2 – very willing
Information treatment	With environmental taxes, we want to influence people's behaviour. When electricity is taxed, the price of electricity goes up. As a result, we consume less energy because it costs more. The tax on electricity allows the state to receive money. For example, it can use that money to promote renewable energy, such as hydro, solar and wind power. Some scientists say that it is a good thing that money from an electricity tax is redistributed to the population: "People are rewarded for using less electricity. And it doesn't cost the government anything."	0 – no treatment received 1 – treatment received
Education	What is the highest level of education that you have attained?	1 – (max.) secondary education 2 – higher vocational 3 – university
Age	In which year were you born?	1 – aged 19-29 years 2 – aged 30-39 years 3 – aged 40-49 years 4 – aged 50-59 years 5 – aged 60-69 years 6 – aged 70-79 years 7 – aged 80-90 years

Continued on next page

Table 5.6.1 – *Continued from previous page*

Variable	Item Formulation	Coding
Income	Before taxes and other deductions, what on average is your own total monthly income? (net income)	1 – Less than CHF 3'300 2 – CHF 3'300 to less than CHF 4'300 3 – CHF 4'300 to less than CHF 5'300 4 – CHF 5'300 to less than CHF 6'400 5 – CHF 6'400 to less than CHF 7'500 6 – CHF 7'500 to less than CHF 8'800 7 – CHF 8'800 to less than CHF 10'300 8 – CHF 10'300 to less than CHF 12'200 9 – CHF 12'200 to less than CHF 15'600 10 – CHF 15'600 or more
Party choice	For which party did you vote at the last federal elections in October 2019?	1 – SVP 2 – BDP 3 – FDP 4 – CVP 5 – GLP 6 – EVP 7 – GPS 8 – SP
Place of living	Would you describe the place where you live as...?	1 – urban 2 – agglomeration 3 – rural
Main problem	Which of these issues is the most important for Switzerland today?	1 – economy 2 – environment 3 – poverty 4 – immigration 5 – health care 6 – education 7 – crime / terrorism

Continued on next page

Table 5.6.1 – *Continued from previous page*

Variable	Item Formulation	Coding
Environmental concern	Generally speaking, how concerned are you about environmental issues?	1 – not at all concerned 2 - 3 - 4 - 5 – very concerned

Source of “item formulation”: Staehli et al. (2021a), own recoding.

5.6.3 Descriptive statistics for taxes

Tax acceptance of...	Number of observations	Mean	Standard deviation	Minimum	Maximum
Overall	2'310	-0.1848	1.1493	-2	2
T1: overall	1'155	-0.2658	1.2114	-2	2
T1: no information	608	-0.3092	1.1944	-2	2
T1: with information	547	-0.2176	1.2293	-2	2
T2: overall	1'155	-0.1039	1.0782	-2	2
T2: no information	608	-0.1760	1.0725	-2	2
T2: with information	547	-0.0238	1.0799	-2	2
T1: (max.) secondary education (overall)	501	-0.4910	1.1447	-2	2
T1: (max.) secondary education (no information)	265	-0.4604	1.1544	-2	2
T1: (max.) secondary education (with information)	236	-0.5254	1.1352	-2	2
T1: higher vocational education (overall)	388	-0.2423	1.2085	-2	2
T1: higher vocational education (no information)	204	-0.2843	1.1942	-2	2
T1: higher vocational education (with information)	184	-0.1967	1.2258	-2	2
T1: university degree (overall)	249	0.1847	1.2239	-2	2
T1: university degree (no information)	132	-0.0151	1.2293	-2	2
T1: university degree (with information)	117	0.4103	1.1829	-2	2
T2: (max.) secondary education (overall)	501	-0.2315	1.0575	-2	2
T2: (max.) secondary education (no information)	265	-0.3019	1.0586	-2	2
T2: (max.) secondary education (with information)	236	-0.1525	1.0529	-2	2
T2: higher vocational education (overall)	388	-0.0902	1.0709	-2	2
T2: higher vocational education (no information)	204	-0.1176	1.0718	-2	2

T2: higher vocational education (with information)	184	-0.0598	1.0721	-2	2
T2: university degree (overall)	249	0.1526	1.0966	-2	2
T2: university degree (no information)	132	0.0152	1.0841	-2	2
T2: university degree (with information)	117	0.3077	1.0944	-2	2

Data source: Staehli et al. (2021a), own calculations.

5.6.4 Model with DV “change in tax acceptance between two points in time”

	Acceptance of paying much higher environmental taxes				
	Coefficient	Robust SE	$P > t $	95% confidence interval	
Information effect	0.0606	0.0586	0.302	-0.0544	0.1755
Constant	0.1332	0.0403	0.001	-0.0541	0.2123
R ²	0.0009				
Number of observations	1'155				

Data source: Staehli et al. (2021a), own calculations.

5.6.5 Model with DV “change in tax acceptance between two points in time”, including control variables

	Acceptance of paying much higher environmental taxes		
	Coefficient	Robust SE	$p > t $
Information effect	0.1174	0.0702	0.095
Age	-0.0005	0.0022	0.813
Sex: female	0.0177	0.0727	0.807
Education: (max.) secondary			
higher vocational	-0.0798	0.0840	0.343
university	-0.1211	0.0960	0.207
Income	-0.0257	0.0139	0.066
Main problem: economy			
environment	-0.2077	0.1445	0.151
poverty	0.2621	0.1947	0.179
immigration	-0.0830	0.1730	0.631
health care	-0.1227	0.1374	0.372
education	-0.1750	0.1603	0.275
terrorism / crime	-0.3680	0.4118	0.372
Party: SVP			
BDP	-0.1318	0.2294	0.566
FDP	-0.0663	0.1340	0.621
CVP	0.1470	0.1482	0.321
GLP	-0.0546	0.1402	0.697
EVP	0.0532	0.3141	0.866
GPS	-0.3617	0.1435	0.012
SP	-0.2285	0.1295	0.078
Environmental concern	-0.0379	0.0398	0.341
Place of living: Rural			
Agglomeration	-0.0281	0.1053	0.790
Urban	-0.0508	0.0781	0.515
Constant	0.7367	0.2333	0.002
R^2	0.059		
Number of observations	805		

Data source: Staehli et al. (2021a), own calculations.

5.6.6 Fixed-effects interaction model

	Acceptance of paying much higher environmental taxes			
	Coefficient	Robust SE	$p > t $	95% confidence interval
Information effect	0.2400	0.0767	0.002	0.0892 – 0.3903
Time effect	0.1331	0.0398	0.001	0.0551 – 0.2111
Education	Omitted due to collinearity			
Information * Education (baseline: (max.) secondary)				
Information * higher vocational	-0.2370	0.1014	0.020	-0.4359 – -0.0381
Information * university	-0.4754	0.1061	0.000	-0.6835 – -0.2674
Constant	-0.2583	0.0146	0.000	-0.2870 – -0.2297
Sigma_u	1.0462			
Sigma_e	0.6980			
Rho	0.6920			
R^2 (overall)	0.0000			
Number of observations	2'276			
Number of groups	1'138			

Data source: Staehli et al. (2021a), own calculations.

5.6.7 Fixed-effects interaction model — average marginal effects

	Acceptance of paying much higher environmental taxes			
	Coefficient	Robust SE	$p > t $	95% confidence interval
Information * secondary education	0.2398	0.0767	0.002	0.0894 – 0.3901
Information * higher vocational education	0.0028	0.0869	0.975	-0.1676 – 0.1731
Information * university	-0.2357	0.0923	0.011	-0.4166 – -0.0547
Number of observations	2'276			

Data source: Staehli et al. (2021a), own calculations.

5.6.8 Interaction model with DV “change in tax acceptance between two points in time”

	Acceptance of paying much higher environmental taxes			
	Coefficient (Rob. SE)	$p > t $	Coefficient (Rob. SE)	$p > t $
Information effect	0.2144 (0.0882)	0.015	0.3034 (0.1095)	0.006
Education: (max.) secondary				
higher vocational	0.0082 (0.0921)	0.929	0.0407 (0.1058)	0.701
university	-0.1282 (0.1013)	0.206	0.0619 (0.1271)	0.627
Information * secondary education				
Information * higher vocational education	-0.2452 (0.1371)	0.074	-0.2699 (0.1597)	0.091
Information * university	-0.3473 (0.1467)	0.018	-0.3909 (0.1777)	0.028
Age			-0.0007 (0.0022)	0.754
Sex: Female			0.0143 (0.0725)	0.844
Income			-0.0250 (0.0139)	0.072
Main problem: economy				
environment			-0.2106 (0.1430)	0.141
poverty			0.2671 (0.1933)	0.167
immigration			-0.0775 (0.1721)	0.652
health care			-0.1085 (0.1361)	0.426
education			-0.1638 (0.1586)	0.302
crime/terrorism			-0.3162 (0.4127)	0.444
Party: SVP				
BDP			-0.1133 (0.2247)	0.614
FDP			-0.0564 (0.1337)	0.673
CVP			0.1545 (0.1481)	0.297
GLP			-0.0602 (0.1398)	0.667
EVP			0.0789 (0.3102)	0.799
GPS			-0.3464 (0.1432)	0.016
SP			-0.2240 (0.1299)	0.085
Environmental concern			-0.0354 (0.0395)	0.371
Place of living: Rural				
Agglomeration			-0.0387 (0.1051)	0.713
Urban			-0.0532 (0.0779)	0.495
Constant	0.1585 (0.0588)	0.007	0.6391 (0.2362)	0.007
Number of observations	1'138		805	

Data source: Staehli et al. (2021a), own calculations.

5.6.9 Interaction model with DV “change in tax acceptance between two points in time” — average marginal effects

	Acceptance of paying much higher environmental taxes			
	Coefficient	Robust SE	$p > t $	95% confidence interval
Information * secondary education	0.2144	0.0882	0.015	0.0414 – 0.3874
Information * higher vocational education	-0.0308	0.1050	0.769	-0.2368 – 0.1752
Information * university	-0.1329	0.1173	0.258	-0.3630 – 0.0973
Number of observations	1'138			

Data source: Staehli et al. (2021a), own calculations.

6 Conclusion

6.1 Summary

With this dissertation, I intended to research different factors which determine or alter social acceptance of various energy policies and technologies. Given the political will to transition the Swiss energy system towards more sustainable and renewable grounds, this thesis' insights point out possible solutions or facilitating measures to achieve this goal. As initially argued, the energy transition is a crucial step to mitigate climate change. Furthermore, national policies have to be drafted and implemented to fulfil international agreements. During the research process, I have adhered to the following guiding principles: In a democratic country like Switzerland, it is imperative for political elites to engage with public opinion, i.e. respecting the will of the people and operating within these boundaries. In some cases, however, parts of society form opinions that are not optimal for the collective outcome, such as not supporting climate change mitigation. Whereas science has long come to a consensus about the threats of its implications, winning majority support for more stringent measures often proves challenging, especially when (perceived) individual costs are involved. According to Dahl (1989), "true" public opinion can only be observed when people have all information needed to form a balanced opinion. When assuming that a lack of information is at least partially responsible for low policy support, the provision of more (scientific) information can be seen as a legitimate and promising attempt to convince hitherto reluctant parts of society, whilst still respecting democratic statutes. In line with this argumentation, I conducted four studies whose findings all serve to advance the energy transition in Switzerland.

Article 1 examines the following interconnected research questions: One, *how should citizen-financed PV projects be designed for high social acceptance, especially socio-political and market acceptance, among tenants?* And two, *what role do ideological predispositions and different project frames play for tenants' social acceptance of citizen-financed PV projects?* Making use of a conjoint experiment, we show that project design does not really matter for willingness to invest. Tenants however choose projects more often when they are materially reimbursed to compensate their investments, such as credit vouchers. Further, projects are preferred when located close to the respondent, e.g. on existing traffic infrastructure or large consumer roofs in the respondent's municipality. Projects are also better evaluated when provided by a public supplier. These results have direct practical implications: First, they support previous findings by placing citizen-financed PV projects on existing infrastructures instead of in valued landscapes. Similarly with returns on investments, where material forms are preferred over symbolic ones. Since Switzerland's energy market is not fully liberalised, the preference for public providers can also be

explained. Overall, this suggests that project design primarily matters for general aspects of social acceptance as opposed to specific investment decisions. Regarding the framing experiment, analyses show that being presented with a frame that emphasises electricity supply improves project acceptance for individuals with an energy motivation, encompassing those who perceive energy supply as the main problem in society. Irrespective of the framing, individuals concerned with climate change always evaluate projects more favourably. Further, politically right-leaning individuals intend to purchase a higher number of PV modules when the collective participation character of such projects is emphasised. No combination of the two framing dimensions seems more effective than others. Altogether, these analyses show that citizen-financed PV projects are a good alternative or complement to include other population groups than homeowners, such as tenants, in the energy transition. Yet, project design has to correspond to investors' preferences in order to be sufficiently attractive to foster involvement and investment. But, as argued in the paper, this alone may not be enough and further efforts to increase visibility and advertising individual benefits are likely needed.

Article 2 used the same conjoint design and dataset as Article 1 but looked at it from a slightly different angle by asking: *What is the role of general and concrete knowledge pertaining to the relationship between citizen-financed PV project attributes and social acceptance of such projects?* Descriptive analyses indicate that socio-political acceptance of such projects is lower for less educated and less PV-experienced individuals. For market acceptance, i.e. the number of purchased PV modules, more educated respondents intend to buy more modules. However, those who had installed rooftop PV would purchase more modules than both those with project and those without any PV experience. The conjoint analysis for the full population sample and for socio-political acceptance (project rating) shows that material forms of reimbursement, locations like existing municipal infrastructure and more public and local providers are the most preferred project attributes. Regarding one indicator of market acceptance, low prices, some personal forms of learning about the project and similar preferences regarding location, reimbursement and provider could be identified as decisive for project choice. As for the other form of market acceptance, i.e. the amount of chosen modules, project design did not matter whatsoever. Preference differences regarding education subgroups primarily show up for socio-political acceptance (project rating), where more educated respondents are found to indicate higher levels of support over all project attributes. For project choice, most differences between education groups disappear, or even change direction compared to socio-political acceptance. Regarding the amount of chosen PV modules, preference differences show up again for various project attributes. Preference differences regarding various levels of past experience with solar PV are not as pronounced and only appear sporadically (e.g. for socio-political acceptance for some forms of reimbursement, location, price or purchasing modality). Turning to market acceptance, i.e. project choice, preference differences between experience subgroups pretty much all disappear. Regarding the number of PV modules, preference differences are most pronounced between those without any and those with rooftop PV experience. In summary, there are clearly subgroup

differences present, indicating that the way in which knowledge is measured indeed matters. The lack of differentiating between various forms of knowledge analysed in research is something that has been previously criticised by Wolak (2022), for instance. More generally, it reiterates the need for more subgroup analyses, as e.g. suggested by Arceneaux et al. (2013), Bayes et al. (2023) or Vuichard et al. (2021). Further, the full sample and subgroup analyses show that PV project determinants for the two forms of social acceptance under study vary. Therefore, depending on the stage of the investment, other citizen-financed PV project attributes prove relevant. Overall, this indicates that tailoring project design to specific target groups could attract most investors. This also involves the launch of information campaigns for those previously uninvolved, reducing bureaucratic hurdles and learning from “best practice” models, i.e. those with project experience. As indicated by both Article 1 and 2, citizen-financed PV projects hold great potential to get a wider spectrum of people involved in the energy transition.

Article 3 asked *whether and how the use of VAAs affects individuals’ opinion formation in a real-world referendum context*. The first part of the research question can be affirmed. The analyses show a significant VAA usage effect, i.e. that using a VAA significantly decreases the share of undecided voters in the treatment group, compared to the control group. Turning to a potential VAA message effect, overall, results indicate that the more the VAA suggests a certain vote intention, the more likely the user is to vote accordingly. Most respondents indicate that the VAA confirmed their original vote intention, which signals an intensifying effect. Further, the analyses support the existence of a persuasive effect, since the VAA message effect was strongest for originally undecided voters. In addition, users who identify with a political party were found to be more affected by the VAA’s message than those without party affiliations: The higher the VAA-score, thus signalling a “yes”-vote, the more likely the person is to vote “yes” (across the entire political spectrum). The VAA does, however, not manage to persuade initial “no”-voters with a VAA indicating a “yes”-vote to actually change vote intention. These findings are in line with findings from Druckman (2022), who shows that people typically seek confirmatory information and are resistant to later arguments. The main implication is that VAAs clearly have the potential to aid citizens with political opinion formation, especially in times with low political participation rates,¹ which naturally undermines the idea of direct-democracy. The provision of a VAA therefore bears the potential to increase voter turnout rates by reducing voters’ uncertainty.

¹ In Switzerland, in 2023, just 42.5% of eligible citizens participated in the only ballot vote that year (3 ballot proposals: OECD taxation Act, climate and innovation Act, COVID19-Act) (Federal Statistical Office, 2024). In the OECD, mean political participation for parliamentary elections amounted to about 65% (OECD, 2019, p. 129). In Switzerland, in 2023, only 47% of citizens participated in the federal election (Federal Statistical Office, 2023). This below-average election participation rate can however be explained by the many direct-democratic instruments that allow Swiss voters to “correct” political decisions during a legislation period (see e.g. Vatter, 2020).

Finally, Article 4 addresses the following research question: *Can information about environmental taxes change citizens' willingness to pay them and does this information effect vary across different education groups?* As the information effect found in my full sample model falls slightly short of conventional statistical thresholds, it can only be taken as a potential indication of an information effect in the broad public. However, as citizens might not understand the functioning of environmental taxes well enough, the more wide-spread distribution of scientific green tax information could still serve as an important policy instrument to increase social acceptance thereof. By analysing three different education subgroups, I show that information does significantly raise willingness to pay higher environmental taxes for those least educated. The absence of an information effect for more educated respondents could also mirror findings from e.g. Chong and Mullinix (2022), Taber and Lodge (2006) and Wolak (2022), who find that individuals who already possess higher levels of (political) knowledge are more close-minded or too stubborn to listen to further information. Apart from this, the subgroup findings could first of all explain the hitherto inconsistent evidence of information effects. Second, it primarily highlights the relevance of Robert Dahl's (1989) enlightened understanding of democracy, as the provision of more information does change opinions on environmental taxes, alluding to the problem of previously "false" or suboptimal opinions. From a policy-making perspective, this means that a) highlighting scientific consensus and b) explaining the benefits of environmental taxes has the potential to decrease the knowledge gap between education groups and accordingly raise total popular support. In turn, this would allow policymakers to add a highly effective instrument to the policy mix to combat climate change.

To sum up, this dissertation contributes to both research and policy-making in at least the following ways: By looking at a single context, Switzerland, I can give a more encompassing overview of the situation regarding and the factors affecting social acceptance of policies and technologies targeting the Swiss energy transition. As persuasive communication effects differ vastly across contexts, focusing on a single case makes sense to get a clearer and bigger picture thereof instead. Due to Switzerland's high degree of direct democracy, getting citizens on board of the energy transition by knowing public preferences is inevitable. In this cumulative dissertation, I study three aspects that potentially contribute to the energy transition. First, I look into socially accepted attributes of citizen-financed PV projects, which are a promising alternative to conventional rooftop PV, especially for those without the means to install the latter on their own. Secondly, I establish that VAAs can be helpful for opinion formation, which was tested for the Swiss EnA ballot proposal. And lastly, I show that scientific information provision on environmental taxes can partly increase people's willingness to pay them. These are therefore three further solutions to advance the energy transition, at least in Switzerland. I do not only investigate thematically diverse aspects, I also look into various theoretical concepts, such as opinions, preferences or behavioural intentions. The close relationship between behavioural intentions and actual behaviour (see Chapter 1.2) should therefore, to a reasonable degree, also allow for inferences of the results obtained herein. I test all of my research questions with ei-

ther novel and originally collected data or by taking advantage of untapped potential of existing datasets. Relatedly, another benefit lies in the experimental and/or longitudinal study setups, which all allow for causal interpretations. While one study analyses the use of an information tool (the VAA) to form one's vote intention (Article 3), another tests the influence of scientific information provision on willingness to pay higher environmental taxes (Article 4). Yet another study combines a conjoint with a framing experiment, something which has rarely been done so far and, to the best of my knowledge, not at all in this specific context of energy politics (Article 1). These analyses are complemented by subgroup investigations, either by looking at a specific population segment (such as tenants in Article 1), moderating factors (e.g. problem perceptions, political orientations or vote intention, see Article 1 and 3) or by splitting up effects based on various knowledge-subgroups (education and experience, as done in Article 2 and 4). Findings indicate that effects are not homogeneous and that targeting respective population groups with specific policies may prove more efficient.

In conclusion, by providing insights into the determinants of social acceptance of certain energy policies and technologies, by studying various population segments and by showing how persuasive communication alters existing attitudes, I expand existing research by adding new insights into public opinion on energy politics in Switzerland.

6.2 Limitations and future research

“You look for the solution of some more or less idealised set of problems, somewhat divorced from the real world, and constrained sufficiently so that you can find a solution. [...] And that leads to more and more fragmentation of science. Whereas the real world demands [...] a more holistic approach. Everything affects everything else, and you have to understand that whole web of connections.” – M. Mitchell Waldrop (1993, p. 60-61)

Despite every researcher's best effort to advance science and to contribute to solving society's many problems, in the end, we must all bear in mind that the real world operates in a more complex setting than what any model can approximate. I am under no illusion that this dissertation is an exception thereof. Hence, I have to address some limitations that my studies are subject to and propose avenues for future research:

The first three points concern limitations that are generally present whenever studying public opinion and persuasion. Starting with issues surrounding public opinion, as mentioned by Herbert Blumer (1948), the “one person, one vote”-measurement of public opinion is prone to miscalculate “true” public opinion. Which, he argued, seems more so reflected by a rather small group of influential citizens, i.e. those most knowledgeable and attentive to public affairs (Bardes and Oldendick, 2012). Similarly, Philip Converse (1987) also noted that measured and effective

public opinion are not the same, yet, they still are often reasonably convergent. Further issues concern social desirability bias, stated vs. actual opinions, the fact that measurement determines the outcome and the problem that, most often, opinion intensity is not captured (e.g. Weissberg, 1976; Wolak, 2022). In summary, we have to come to terms with the fact that, while in reality, not all opinions matter equally (e.g. preferences are often expressed very thoughtlessly), one can only count as public opinion what also surfaces in the public forum and what the government takes seriously (Erikson and Tedin, 2007). Despite using datasets which are representative for the Swiss population, it is not guaranteed that the public opinion captured in my analyses is “true”.

While capturing public opinion is certainly important, especially in democracies, we should also keep in mind that underlying processes might not be unidirectional but that both political elites and the public can affect each other mutually. Such dynamic phenomena are known as policy feedback processes (see e.g. Jones and Baumgartner, 2012). Somewhat relatedly, opinions might also be dynamic in a “thermostatic way”, where citizens regulate policy-making by calling for adjustments when policies steer too far off from public preferences (see e.g. Atkinson et al., 2021; Soroka and Wlezien, 2009). I also could not account for such potential feedback processes. While the data for Article 3 was collected in 2017, i.e. in times where not one topic alone dominated public problem perception,² in 2020, when data for Article 4 was collected, the COVID19-crisis was omnipresent and suppressing all other problems.³ And in 2022, the most important issue present during data collection for Article 1 and 2 was environment and climate change (Golder et al., 2022).⁴ While at least keeping the country-context constant, the long time frame as well as varying parliamentary party strengths between 2017 and 2022 could have also led the public to change their opinions if presented with the opportunity to answer each survey during different years.

Next, as adumbrated, persuasion studies have long observed some limitations inherent in their research. First, there exists no consensus on the durability of persuasion effects (Druckman, 2022). In all my articles, I only check for post-treatment attitudes directly after treatment reception, therefore, I cannot make any long-term claims. Another limitation to my research is something I already addressed in the introductory chapters, i.e. that both information but especially framing effects are highly heterogeneous and context-dependent, and that moderating factors can completely alter outcomes (e.g. Arceneaux et al., 2013; O’Keefe, 2004). Accordingly, it remains open whether the persuasion effects identified in my articles would be replicable in other policy areas or contexts. This also relates to a more practical issue, as in reality, information

² In 2017, the five biggest problems the Swiss perceived were: Old age and survivor’s insurance (OASI), unemployment, immigration, health and health insurance, European integration (Golder et al., 2017).

³ Following COVID19, the other most important problems perceived were old age and survivor’s insurance (OASI), unemployment, environment / climate change and immigration (Golder et al., 2020).

⁴ This was followed by old age and survivor’s insurance (OASI), energy politics / nuclear energy, European integration and inflation (Golder et al., 2022).

is never delivered in such an isolated way, and people are typically exposed to a variety of messages or competing frames, which can clash or cancel each other out (see Druckman, 2022, p. 77). Associatedly, and as noted by Lipset et al. (1954, p. 1158), those who were most influenced during an experiment are also those who do not listen in reality. In my articles, this problem would primarily concern initially undecided voters (Article 3) as well as those with low education levels (Article 4), as these people were most influenced in the experiments. This explains why effects in experiments are often larger than in reality, as in the first case, everyone is “forced” to listen to the information provided therein (Hovland, 1959). These issues harbour great potential for future research: For one, more long-term testing of effect durability should be conducted and replicated in real-life scenarios such as ballot votes or actual investments. And two, the complexity surrounding information effects will likely have to be accepted, as indicated by Waldrop’s (1993) quote above. However, I do not wish to imply to discard information as a politically relevant instrument. Instead, in order to maximise the impact of one’s information provision, each political actor and scientist should be aware of these specificities, look up evidence on similar past research and choose their words consciously, responsibly and deliberately.

Somewhat related, another limitation pertains to the concepts listed in Chapter 1.2. As explained, the concept under study also affects the level, direction and significance of the finding. Since I adhere to the line of research that claims attitudes as latent constructs, it also remains unknown whether the information and framing treatments actually change people’s attitude, or whether it only affects opinions and preferences, which are more prone to such manipulation and also more short-lived. In other words, they might have been spontaneous expressions. Because I cannot conduct any long-term studies, this question regarding longevity remains open. Relatedly, owed to the survey context, I cannot capture actual behaviours. However, according to Ajzen (1991), behavioural intentions are a person’s best antecedent thereof, and O’Keefe (2021) show that outcomes are very similar. Despite the fact that all my analyses focus on the non-behavioural level and inferences to actual behaviours should be drawn with caution, they should still serve as a good indication but be thoroughly tested in future studies.

While subgroup analyses offer additional insight into the data and give information about the robustness of effects, they also split the sample into smaller subsamples. Especially in Article 2, for the subgroup “experience with citizen-financed PV projects”, sample size is rather small and representativeness of the sample itself might not have been given anymore. Despite the novelty of looking at past experience and the hope to take findings from these groups as “best practice”-evidence for further projects, it would be ideal to replicate such analyses with bigger samples to allow for more generalisable statements. A second limitation corresponding to subgroup analyses, or more specifically, the study of knowledge effects, refers to findings that knowledge batteries in surveys are not always useful. For example, knowing exact political facts is not needed to make good vote choices. Put differently, a mismatch of the knowledge tested and the knowledge necessary to make choices can, in the worst case, render results non-meaningful (see e.g. Wolak, 2022). In two of the articles, I had to make due with the variables included in the datasets and

chose education as a proxy to abstract knowledge about either environmental taxes (Article 4) or citizen-financed PV projects (Article 2). The latter however complemented the analyses with a form of more specific knowledge, i.e. experience, about the issue at hand. Accordingly, the results should only be interpreted considering these aspects and future research is advised to delve deeper into the role of respectively relevant forms of knowledge.

Further, while I include various and relevant aspects of energy policy, I am aware that even a complete implementation of the solutions derived here will not solve the whole issue surrounding the energy transition and climate change mitigation. As expressed by Waldrop's (1993) quote, this will not be sufficient and there is still a great need to research further options to address this millennium problem. The three energy policies and technologies under study merely represent a few approaches among many to combat climate change. It is not my intention to suggest that they are the sole means of achieving long-term climate neutrality. Due to the interconnectedness of different spheres of life, further environmental but also social and even economic policies will be required to alleviate concomitant ramifications, fears or inequalities.

And lastly, while purposely only focusing on Switzerland to keep the context of my analyses constant due to the variability of framing and information effects, this is of course also a limitation at the same time. Switzerland is equipped with a variety of particularities when it comes to political but also social or regional aspects, such as high degrees of direct democracy and federalism, the existence of four national languages and their related cultures or the country's geological diversity (see e.g. Freiburghaus and Vatter, 2023; Rokkan, 1974). Even though Switzerland can be seen as this "microcosm" from which findings could be extrapolated to other countries, it is still not advisable to blindly generalise the findings. Instead, replications in other countries should be conducted to test for robustness.

6.3 Broader implications

Despite recognising the limits, I feel confident in being able to contribute to public opinion research on Swiss energy politics. As has long been recognised by science, environmental problems are mostly human-made (e.g. Cox and Depoe, 2015; Downs, 1972), therefore also requiring solutions that address this social aspect to induce change. In this vein, my main takeaways from this dissertation concern two interrelated domains: Policies and personal responsibility.

Addressing the aspects surrounding policies, I would like to note the following points: First of all, citizen-financed PV projects seem to posit a socially acceptable alternative to conventional rooftop PV, as sufficient levels of societal support are present, given the right project characteristics. Especially since large-scale PV installations are still faced with more opposition, as was recently observed in Oberiberg (canton of Schwyz), where voters dismissed a planned proposal to install an alpine PV system (EWS, 2024), which represents a textbook example of insufficient community acceptance. Since the expansion of renewable energies is one of the pillars of the Swiss Energy Act

(see The Federal Council, 2016), exhausting all current options to produce more carbon-neutral energy and simultaneously working towards developing and implementing new technologies is indispensable. As citizen-financed PV projects might be part of the solution, politics should strive to enhance their visibility in the broad population and, if needed, introduce accompanying measures to foster further acceptance of, engagement with and investments in said projects.

Second, and more generally, policies targeting the energy sector should of course not exclusively focus on the expansion of PV and incorporate a broad range of non-fossil energy sources and technologies. Recently, there have even been renewed discussions about whether the ban on nuclear power plants in Switzerland should be lifted in order to keep this energy source in future energy mixes. The European Union, for example, deems nuclear energy “as [an] environmentally sustainable [...] activity” under certain circumstances (European Parliament, 2022). However, even if this ban were to be lifted in Switzerland, the installation of new nuclear power plants still seems unlikely, given the challenges of low community acceptance and, similarly, the long-lasting inability to agree on an underground location to dispose of radioactive waste. So far, it is more probable that Switzerland would have to rely on imported nuclear electricity from neighbouring countries such as France. Due to this socio-political difficulty in finding compromises, it is also important to remain open to future technological innovations and policies to further the energy transition. Similarly, policies surrounding renewable energy expansion are accompanied by other questions, like their more complicated storage due to seasonal fluctuations, for example. Therefore, research should also address such related aspects to find socially accepted solutions that could secure energy supply in the future.

Apart from a diverse spectrum of renewable energy sources, policy instruments should be combined as well. Having to rely on only information would, in all probability, not be sufficient. As a soft instrument, their effect is often limited, heterogeneous and context-dependent. In a broader sense, however, the way in which information is conveyed may require reconsideration, as politically right-leaning people react differently to left-leaning people. Especially when trying to get previously hesitant population segments on board of the energy transition, it seems imperative to communicate in a manner that catches people’s underlying motivations. For instance, stressing the need to secure electricity supply instead of climate change mitigation generates more support among right-minded voter segments. While yet to be researched, this could potentially also explain the unusually high acceptance rate of the recent Swiss federal act to secure electricity supply (see The Federal Council, 2024). Apart from information and communication, other policy instruments like bans, subsidies or taxes should also be considered. While (financial) incentives have been shown to work well in steering behaviours, especially taxes are heavily politicised, contested and often unpopular, as was again shown with environmental taxes in this thesis. Exemplary, the planned introduction of taxes on flights generated enough opposition to reject the CO₂-law in 2021 (see Federal Office for the Environment, 2021). One of the primary concerns expressed was that the implementation of the tax would result in flying becoming a privilege reserved for those with greater financial means. From this perspective, albeit being

maximally infringing, the introduction of bans might even be more popular in society, due to affecting everyone identically and thus being perceived as more fair.⁵

Related to this last point, another notable aspect concerns the influence of information provision. This includes and affects both education in general and political education in particular. Differing levels of knowledge seem to co-occur with different levels of support for environmental policies, such as citizen-financed PV projects or environmental taxes. This raises the question of whether and how this knowledge inequality should be counteracted. As previously discussed, while information does seem to change opinions experimentally, which was also observed for citizen-financed PV project framing, a novel VAA or support for environmental taxes in the scope of this dissertation, real-life effects are often more modest. Whether large-scale information campaigns actually reach the intended target groups therefore remains open. Further, those least (politically) educated are typically also those who participate the least in politics. Consequently, a shift in opinion does not necessarily imply a corresponding increase in support for more stringent environmental policies, owed to their higher likelihood of political abstention. Due to the often sizeable cost of such efforts to increase awareness, financial aspects also have to be weighted against the anticipated efficiency of these campaigns. Independent of such considerations, more effort to increase political education of young citizens should be undertaken. If adolescents get interested and involved in the political system at an early age, it is more likely for them to develop the habit of regularly participating in politics, something that is crucial for democracies to survive. Relatedly, one specific policy suggestion concerns the development of a vote advice application for all national ballot proposals, analogue to vote suggestions for elections (like smartvote in Switzerland). Such programs offer a low-threshold service to aid with political opinion formation in a neutral and party-independent way. In the best case, voters form their opinion according to their underlying personal interests and become less dependent on party cues or heuristics when casting their ballot vote.

The last aspect on policies concerns the role of science. Especially in current times, where disinformation and illegitimate manipulation attempts are omnipresent in politics globally,⁶ the generation and distribution of well-balanced and scientific information should be given even greater weight. As was the case during the COVID19-pandemic in Switzerland and as is more common in Germany overall, for instance, it might be more effective to give scientists a more prominent and official platform to discuss various environmental issues and how to best tackle them, based on scientific considerations. In other words, science might serve as a mediator between political elites and society, which I also observe partly to be the case for the information treatment stressing scientific consensus on environmental taxes. Simultaneously, this raises the

⁵ Such ideas have been brought forward in the past, see e.g. Prof. Dr. Isabelle Stadelmann-Steffen in an interview with Elektrizitätswerke des Kantons Zürich (2023).

⁶ To name two prominent examples, apart from Vladimir Putin's many untruths (Vock, 2024), the term "alternative facts" used by Kellyanne Conway is also representative for Donald Trump's presidency (Southern Illinois University, 2023).

issue of scientific accuracy and consensus. While some environmental problems seem beyond controversy at this point, e.g. human causes of climate change, other aspects are both more politically polarising and socially disputed. In addition to this, unintended side effects can further add fuel to the fire of already heated debates about climate change policies. For instance, recent research has brought up the subject of whether lower aerosol concentrations in the atmosphere may have unintentionally contributed to the warming of ocean temperatures (see e.g. Diamond, 2023; Kusakabe and Takemura, 2023; Takemura, 2020).⁷ Such unforeseen knock-on effects can not only harm science’s reputation but also trigger deeper leanness in society towards further action to mitigate climate change, protect the environment or transition the energy system. In order to circumvent such adverse reactions, it seems vital for governments and foundations to keep on financially supporting scientific programs to enable scientists to continuously conduct interdisciplinary, holistic and high-quality research.

Turning to the second domain, I argue that if the collective goal of climate change mitigation is to be achieved, each individual has to assume more personal responsibility as well. While accepting policies that expand renewable energies or enhance energy efficiency is instrumental in transitioning the energy system, more active support for other policies is also necessary, such as saving energy, which constitutes another key element of the EnA (see The Federal Council, 2016). Accordingly, identifying the barriers and incentives that either hinder or drive people’s will to save more energy, or act more environmentally-friendly in general, seems to be another crucial avenue for future interdisciplinary research. The “politics of small steps”-approach taken in Switzerland rarely allows for the introduction of drastic policy changes. Instead, small changes should first of all get citizens used to new ideas and policies, which are later-on expanded when acceptance levels have risen. In June of 2024, such a phenomenon might again have occurred when close to 70% of Swiss citizens supported the federal act to secure electricity supply (see The Federal Council, 2024). This was the first time that voters supported a legislative that included specific measures to advance the energy transition, therefore, this could potentially be viewed as a turning point in Swiss energy politics. After years of having had to gain voters’ trust and increase awareness of the urgency to implement measures tackling climate change, this seems to be a promising indication that future policies might also face less opposition and that, overall, Switzerland might soon be able to fulfil its share of the 2015 Paris Agreement.

⁷ Specifically, the studies looked into the levels of sulfate concentrations in the atmosphere and their role of contributing to ocean warming. While the naval industry was under pressure to become less emission-intensive, thus leading to lower levels of atmospheric sulfate concentrations, sea temperatures have still risen since. Despite being responsible for acid rain, sulfate also reflects solar radiation, thus cooling the climate in the short term. Hence, research has looked into the possibility that the reduction of sulfate levels might have unwillingly increased ocean temperatures (Diamond, 2023; Kusakabe and Takemura, 2023; Takemura, 2020).

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Bern, July 22, 2024