

Consumer Adoption of Electric Vehicles

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Abstract

Decarbonization of transport is central for fulfilling global climate goals. The electrification of passenger road vehicles has, currently, the largest potential to help achieve these goals. Policymakers and increasingly so industry actors have thus been promoting battery electric vehicles (EVs). Although EV market share is finally growing, it needs accelerating. With largely overcome technological barriers and conducive contextual conditions, consumer adoption has become decisive for further EV diffusion. We thus need to better understand how adoption intentions of consumers that are currently entering the market are formed, what mechanisms they operate on and what are their determinants so that targeted, more effective strategies to foster EV purchases can be proposed. This dissertation contributes to this endeavor with three research papers that each address one of the above aspects of adoption intentions through original empirical research.

Paper I studies the formation of adoption intentions by investigating the vehicle purchase process. It generates a novel conceptual framework that includes five stages, both pre- and post-purchase, and that is determined by differentiated decision-making strategies. The validity of the framework is tested and confirmed in an online survey with Swiss consumers. The study identifies the most important external influences and appropriate touchpoints at relevant stages of the process within which targeted interventions to promote EV adoption are proposed.

Paper II analyzes product bundling and the mechanisms, namely those of familiarity and convenience, that operationalize its effect on EV adoption intentions of Swiss consumers. The between-subject design experiment finds that bundles of EV and charging services can increase EV purchase willingness, however only of those consumers with low familiarity with relevant components. A choice experiment identifies three segments within current adopters. The largest one prefers a convenient bundle of an EV with a plurality of additional services.

Paper III investigates the role of culture and symbolic meanings of EVs pertaining to gender as unconscious determinants of EV adoption. A regression analysis finds that countries whose cultures are characterized by relatively high femininity based on Hofstede's cultural dimensions have a significantly higher EV market share. The online survey applying an implicit association test (IAT) concludes that German consumers unconsciously associate EVs with femininity. This association is particularly strong among male EV non-adopters, showing that excessive femininity of EVs might represent a barrier to EV adoption among certain consumer segments.

Based on these insights, this dissertation provides recommendations to policymakers and industry actors how to promote EV adoption among consumers that are currently entering the market and thus to foster further EV diffusion.

Zusammenfassung

Die Dekarbonisierung des Verkehrs ist von zentraler Bedeutung für die Erreichung der globalen Klimaziele. Die Elektrifizierung von Personenkraftwagen hat dafür derzeit das größte Potenzial. Politische Entscheidungsträger/innen und Akteure der Industrie fördern daher Batterie-Elektrofahrzeuge (EV). Obwohl ihr Marktanteil nun zunimmt, muss dieses Wachstum beschleunigt werden. Mit der Überwindung technologischer Hindernisse und zunehmend förderlichen Rahmenbedingungen ist die Akzeptanz der Verbraucher/innen entscheidend für die weitere Verbreitung von EV geworden. Wir müssen daher besser verstehen wie die Kaufbereitschaft von Neukund/innen beeinflusst wird und auf welchen Mechanismen sie beruht, um gezielte sowie effektive Strategien zur Förderung von EV-Käufen vorschlagen zu können. Die Dissertation trägt zu diesem Bestreben durch drei Forschungsartikel bei, die jeweils einen der oben genannten Aspekte der Kaufbereitschaft empirisch untersucht.

Artikel I erforscht die Bildung der Kaufbereitschaft, indem der Prozess des Fahrzeugkaufs analysiert wird. Es wird ein neuartiger konzeptioneller Rahmen entwickelt, der fünf Phasen umfasst - sowohl vor als auch nach dem Kauf - und welcher durch differenzierte Entscheidungsstrategien bestimmt wird. Die Gültigkeit des Modells wird durch eine Online-Umfrage von Schweizer Verbraucher/innen getestet und bestätigt. Die Studie identifiziert die wichtigsten externen Einflüsse und geeignete Stellen an unterschiedlichen Phasen des Prozesses, in denen gezielte Interventionen zur Förderung der Kaufbereitschaft von EV vorgeschlagen werden.

Artikel II analysiert Produktbündelungen und Mechanismen, welche sich auf die Kaufbereitschaft der Schweizer Verbraucher/innen auswirken. Das interindividuelle Experimentdesign zeigt, dass Bündelungen von EV und Ladediensten die Kaufbereitschaft für EV erhöhen, jedoch nur bei Verbraucher/innen mit geringen Vorkenntnissen. Durch ein Wahlexperiment werden drei Kundensegmente identifiziert, wovon das größte ein Bündel von EV und eine Vielzahl zusätzlicher Dienste bevorzugt.

Artikel III untersucht die Rolle von Kultur und symbolischen Bedeutungen von EV hinsichtlich des Geschlechts als unbewusste Determinante der Kundenakzeptanz von EV. Eine Regressionsanalyse zeigt, dass Länder deren Kulturen durch eine relativ hohe Weiblichkeit gekennzeichnet sind, einen signifikant höheren Anteil an EV haben. Durch einen impliziten Assoziationstest (IAT) wird gezeigt, dass deutsche Verbraucher/innen EV unbewusst mit Weiblichkeit assoziieren.

Basierend auf diesen Erkenntnissen schlägt die Dissertation politischen Entscheidungsträger/innen und Akteuren der Industrie Empfehlungen vor, wie die Akzeptanz von EV bei Verbraucher/innen erhöht und damit die weitere Verbreitung von EV gefördert werden kann.

Introductory Chapter

1. Background and research motivation

A critical step to achieving global climate goals is the decarbonization of transport (IEA, 2020b; UNFCCC, 2015). The transport sector, which is almost entirely dependent on fossil fuels (Pettifor, Wilson, Axsen, Abrahamse, & Anable, 2017; Rodrigue, 2020), represents one quarter of all global carbon dioxide (CO₂) emissions (IEA, 2020a; Teter, 2020). Certain modes of transport are however more polluting than others. Passenger road vehicles are with 44.4% of the sector's emissions its most polluting segment (IEA, 2020c). Decarbonization efforts should thus primarily focus on this transport mode.

The currently most promising option to reduce emissions from passenger road transport is the application of novel propulsion technologies, namely that of battery electric vehicles (EVs) (Bicer & Dincer, 2018; Miotti, Supran, Kim, & Trancik, 2016). EVs have the lowest carbon footprint over their lifecycle compared to other vehicle technologies, internal combustion engine (ICE) vehicles in particular (Bauer & Cox, 2019; Hoekstra, 2019; Miotti et al., 2016; Poliscanova, 2021). Since EVs are solely charged by electricity, the share of renewable energy in the electricity mix is decisive for their carbon footprint. The environmental benefits of EVs (Bauer & Cox, 2019; Miotti et al., 2016) are thus expected to further grow with the anticipated decarbonization of electricity mixes as part of national and global climate strategies (Bundesrat, 2018; C2ES, 2019; EC, 2019a; Messagie, 2014).

Electric vehicles offer many additional benefits too. With no tailpipe emissions, EVs substantially reduce air pollution in urban areas (Lazzeroni, 2021; Requia, Mohamed, Higgins, Arain, & Ferguson, 2018). Lower noise levels and higher safety compared to conventional ICEs bring further environmental and health benefits, thus increasing the overall quality of life for consumers (Larsson, Andersson, & Mellander, 2017; Orban et al., 2016; Pyko et al., 2015). Finally, higher application of EVs within the transport system lowers its dependence on fossil fuels. The potential increase in domestic electricity generation can enhance the energy security of countries that have to import oil (Kester, Noel, Z., & Sovacool, 2018; Yong, Ramachandaramurthy, Tan, & Mithulananthan, 2015) and offers opportunities for the development of new industry sectors, thus potential job creation and economic growth (Gersdorf, Schaufuss, Schenk,

& Hertzke, 2020; Malmgren, 2016; Yong et al., 2015).

Because of their environmental, societal, and economic benefits, policymakers worldwide have substantially supported EVs. First, regulation in favor of EVs has been implemented, either by restricting the emissions of a newly sold fleet (EC, 2019b; Mathieu & Poliscanova, 2020) or by imposing a quota system determining the share of EVs on the road (Brown Jr, 2018; Zhang & Qin, 2018). Financial incentives are the most common type of EV support measures (Martínez-Lao, Montoya, Montoya, & Manzano-Agugliaro, 2017; Rietmann & Lieven, 2019). They range from direct subsidies for purchasing EVs to tax incentives, such as exemption from import and value-added tax to the limitations of motor and road use taxes (BFE, 2019; Holtsmark & Skonhoft, 2014; Mersky, Sprei, Samaras, & Qian, 2016). An increasingly popular taxation system is the bonus-malus system which reduces taxation on low-polluting cars and increases it for high-polluting ones (d'Haultfoeuille, Givord, & Boutin, 2014; Engström, Algers, & Hugosson, 2019; Poliscanova, 2021). Finally, many soft-policy tools have been applied to promote EV purchases, such as information campaigns, test drives, and car labeling to increase the level of knowledge about EVs and to highlight their environmental benefits (CEM, 2019; EC, 2021a; EnergieSchweiz, 2019). Policymakers have also increasingly used nudging techniques such as allowing EV drivers to use bus lanes, providing them with preferential parking, and free charging (Holtsmark & Skonhoft, 2014; Mersky et al., 2016), and introducing green license plates to increase the visibility of EVs (UKGov, 2020; UNEP, 2018).

Industry actors have also become increasingly active in the field of electric mobility (Bohnsack, Kolk, Pinkse, & Bidmon, 2020; Gersdorf et al., 2020). Initially, the market saw newcomers focused solely on EVs (BYD, 2021; Tesla, 2019) and new types of actors such as electric utilities and technology providers (Axpo, 2020; EM, 2019; Plug'nRoll, 2020b) that saw electric mobility as a new business opportunity (Frei, Sinsel, Hanafy, & Hoppmann, 2018). Prompted by these developments and governmental interventions, even traditional car manufacturers started entering the field (Bohnsack et al., 2020; Buss, 2019; VW, 2021). Some made the move to only-electric mobility (Smart, 2019) or announced plans to do so (Ewing, 2021). As a result, the number of EV models on the market has rapidly increased and is expected to more than double by the end of 2021 compared to 2019 (Mathieu & Poliscanova, 2020). McKerracher, Izadi-Najafabadi, O'Donovan, and Albanese (2020) actually forecast

more than 500 EV models being on the market by 2022. The latter diversify in the types and classes offered, covering a broad range of customer needs (Gersdorf et al., 2020; Hertzke, Müller, Schaufuss, Schenk, & Wu, 2019). This shift to electric mobility has been accompanied by a growing marketing of EVs. The advertisements not only increased in number, but also diversified their focus from environmental only to affective and status enhancing messaging, emulating aspects of traditional successful car advertising (Gavran, 2021; Gurskiy, 2019; Steg, 2005).

The EV technology has also been quickly developing, increasing the appeal of EVs to consumers and diminishing the effect of this previously major barrier to EV purchases (Rezvani, Jansson, & Bodin, 2015; Steinhilber, Wells, & Thankappan, 2013). First, the growing battery range of up to 500 km (Tesla, 2021; Vanderwerp, 2020) is able to cover more than 90% of habitual driving distances (Meinrenken, Shou, & Di, 2020; Melliger, van Vliet, & Liimatainen, 2018; Needell, McNerney, & Chang, 2016). Second, the density of the public charging infrastructure has been found to be sufficient, even exceeding the recommended targets, and is expected to keep up with projected EV growth (Muzi, 2018). Third, it has been widely concluded that the total cost of ownership (TCO) of EVs is lower than that of comparable ICEs, mainly thanks to the minimal maintenance and charging costs coupled with governmental incentives (BEUC, 2016; Lévy, Drossinos, & Thiel, 2017; Weldon, Morrissey, & O'Mahony, 2018). Additionally, the EV purchase price is also expected to reach parity in selected segments with that of ICEs by 2022 (Bullard, 2019).

After years of timid growth, EV market share is finally growing. As can be seen in Figure 1, EV market share in 2020 reached double digits in a number of countries, namely Norway (51.6%), Iceland (26.2%) and the Netherlands (20.2%) (EAFO, 2021). Despite this success of mainly Nordic countries (Ashmore, Pojani, Thoreau, Christie, & Tyler, 2018; Noel, de Rubens, Kester, & Sovacool, 2020), the European EV market share is in 2020 expected to reach only 5.7% (EAFO, 2021). Globally, EV purchases are even lower, with the combined market share of EVs and plug-in hybrid electric vehicles (PHEV) in 2020 expected to be 4.2% (Irle, 2021). To fulfill global climate goals (IEA, 2020b; UNFCCC, 2015), the diffusion of EVs has to rapidly accelerate.

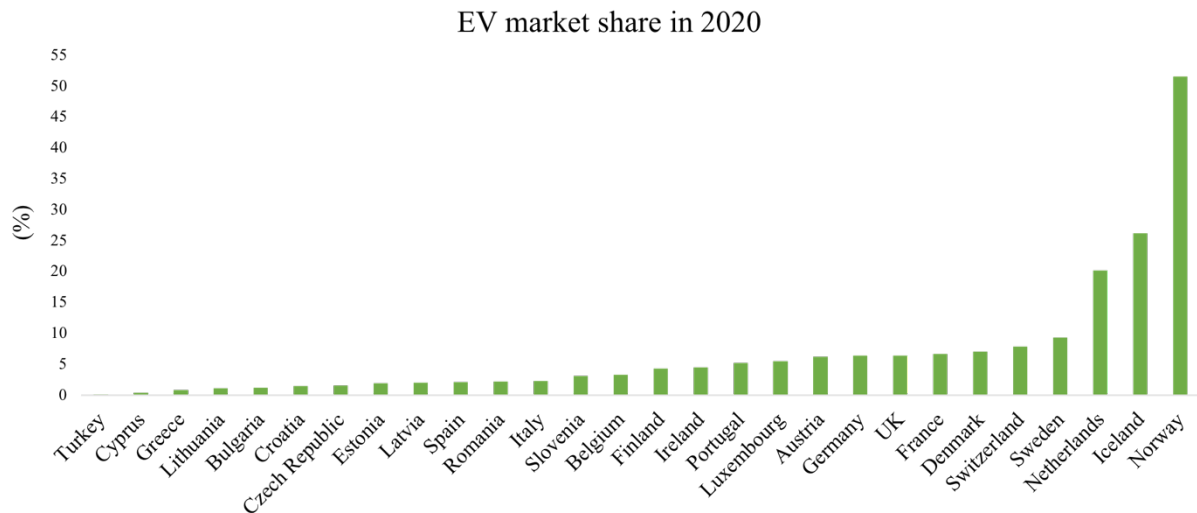


Figure 1. EV market share in 2020 of selected countries (own illustration). Source: EAFO (2021).

2. Research objective and dissertation outline

The objective of this dissertation is to investigate consumer adoption of EVs. With largely overcome technological barriers and conducive contextual conditions, consumer adoption has become decisive for further EV diffusion. Limited adoption intentions of consumers however represent a common barrier for diffusion of innovations, despite their technological strengths and objective advantages (Blackwell, Miniard, & Engel, 2006; Rogers, 2003). Investigation of consumer adoption is even more relevant at the current stages of EV diffusion process, in which EVs are not yet fully established in society (Barth, Jugert, & Fritsche, 2016; Ng, Law, & Zhang, 2018). Additionally, with the growing EV market share, broader adopter groups are entering the market in most countries (EAFO, 2021; IEA, 2020b), whose characteristics, preferences and needs differ from the first innovative EV adopters (Moore, 1991; Rogers, 2003). Therefore, we have to better understand the adoption intentions of particularly those consumers that are currently entering the market, namely how they are formed, what mechanisms they operate on and what are their determinants. Based on this enhanced knowledge, targeted interventions addressing the characteristics and preferences of current adopters and their individual segments can be proposed to more effectively foster EV purchases and thus further EV diffusion.

The objective of this dissertation is to be fulfilled by means of three research papers that each address one of the three aspects of consumer adoption intentions outlined above. Concretely, *Paper I* analyzes how EV adoption intentions are formed by investigating the vehicle purchase process, including its individual stages, employed

decision-making processes and external influences. *Paper II* identifies the mechanisms, namely those of familiarity and convenience, that operationalize the effect of bundles of EV and additional services to help overcome one of the largest remaining barriers to EV purchases to date, that of perceived complexity of charging. It also analyzes the preferred set-up of bundles of EV and additional services for individual consumer segments of current adopters. Finally, *Paper III* studies the role of culture and symbolic meanings of EVs pertaining to gender as unconscious determinants of EV adoption intentions. Since individual adopter groups differ in their characteristics and preferences (Moore, 1991; Rogers, 2003), the papers focus on the countries with similar EV market shares to generate in depth insights about adoption intentions of specific consumer segments adopting EVs in a particular stage of the diffusion process. The markets of Switzerland and Germany were selected, mainly for their fairly similar EV market share in 2020 (7.9% and 6.4%, respectively), that is also very close to the European average (5.7%) (EAFO, 2021). The findings of the individual papers thus have an informative value beyond the specific country cases studied. The papers apply a variety of quantitative research methods that were carefully selected to best correspond and thus deliver their individual research objectives. All three papers employ explicit measures of inquiry, namely online survey methods. *Paper II* additionally applies two online experiments, between-subject design and choice experiment. *Paper III* conducts a regression analysis and employs an implicit association test (IAT). It thus also uses implicit methods of inquiry to help identify the unconscious processes that determine EV adoption intentions.

This dissertation is relevant for both academia and industry. It enriches the EV adoption literature thematically and methodologically, analyzing the wider adopter groups that are currently entering the market and studying the lesser investigated determinants of EV adoption intentions such as those related to culture and EV-gender associations. The dissertation also applies a variety of research methods, among others an IAT. It is thus one of the first contributions (Bennett & Vijaygopal, 2018) to investigate unconscious processes that determine EV adoption intentions. Second, the research also provides insights to policymakers and industry actors by suggesting and, in selected cases also empirically testing, interventions how to more effectively promote EV adoption among consumers that are currently entering the market.

Before presenting the three research papers, the introductory chapter reviews the

relevant literature from consumer behavior and innovation diffusion research streams that inform the conceptual foundations of the dissertation. While Section 4 outlines the research context, Section 5 introduces the three research papers. Section 6 elaborates on the research methods employed by each of the papers. Section 7 concludes the introductory chapter by reflecting on the main findings and implications of the conducted research for academia and practice and outlines the encountered limitations, which invite for further research.

3. Theoretical foundations

3.1. Consumer behavior

3.1.1. Rational choice theories

Human behavior has traditionally been conceptualized through theories of rational action. Originating in microeconomics and formalized in the Expected Utility Theory (Mongin, 1997; Von Neumann & Morgenstern, 1947), behavior is perceived as being a result of a cost-benefit analysis of information relative to the decision context. Since consumers are expected to act in their own best interest, which is predicated on economic incentives, the preferences and expected outcomes of the decision-making process are seen as being universal, irrespective of their situation and wider social context. The role of individual decision making is central to the models, with changes in behavioral outcomes dependent only upon providing more information or changing economic incentives (Darnton, 2008; Savage, 1974). Thanks to the premise of the stability and predictability of behavioral outcomes, rational choice models have become central to policymaking, including measures to promote EVs (DellaValle, 2019; Holtsmark & Skonhoft, 2014; Rezvani et al., 2015; Rietmann & Lieven, 2019).

3.1.2. Behavioral economics

Enriching the foundations of economic theories by insights from psychology, behavioral economics concludes that rational choice models are unable to explain and predict human behavior because of the limitations inherent to human cognition. Simon's Bounded Rationality pioneered this strand of research (Simon, 1957, 1990). The author stipulates that in reality, human cognition is constrained by number of aspects, namely time, lack of information, and cognitive limitations of the decision-making process.

Thus, rather than seeking for optimal solutions, people opt for “satisficing”, i.e., acceptable outcomes (Simon, 1957, 1990).

The idea of human rational behavior as limited by biases inherent to the cognitive process has become central to behavioral economics. Heuristics, the mental shortcuts that help people make decisions, especially in situations of time pressure, risk and uncertainty, represent this very notion (Tversky & Kahneman, 1974). Although they allow people to make quick decisions to solve complex problems, these rules of thumb also lead to systematic biases and may result in suboptimal decisions (Ibid.). The Prospect theory (Kahneman & Tversky, 1979) highlights one heuristic type, namely the asymmetric perception of losses and gains in situations of uncertainty. This perception of asymmetry then leads to differentiated strategies in relation to probable and certain choices, leading to risk-averse behavior when the situation is perceived as bringing potential gains, and risk-seeking behavior when the situation is perceived as bringing potential losses. Tversky and Kahneman (1981) also brought attention to the role of framing, the differentiated behavioral outcomes based on the way how information is presented. Besides the role of loss and gain framing (Kahneman & Tversky, 1979; Spence & Pidgeon, 2010), the literature observes a different impact if messages are, among others, framed positively or negatively (Van de Velde, Verbeke, Popp, & Van Huylenbroeck, 2010), or in relation to peers or the locality where people live (Plananska, 2020). Kahneman (2011) summarizes the insights on the cognitive processes leading to suboptimal decisions in his seminal book “Thinking, Fast and Slow”. The author concludes that human behavior is guided by two cognitive systems—System 1 and System 2. Mostly working in collaboration, System 1 is automatic and activated subconsciously. It is overall more prevalent, especially for quick, intuitive reactions. While beneficial, especially since it saves time and cognitive capacities when solving even complex problems, System 1 oftentimes leads to suboptimal decisions due to its implied cognitive biases. By contrast, System 2 is deliberative and logical, activated for decisions that require conscious consideration. While more precise, it requires more effort, it is time consuming and can be indecisive, not leading to solutions even after long deliberation process (Kahneman, 2011).

The concept of nudging applies the insights from behavioral economics to policymaking (Thaler & Sunstein, 2008). Nudges alter choice architecture with the aim of influencing decisions of individuals to increase their welfare “as judged by

themselves” (Ibid., p. 5). The interventions are neither restrictive regulations nor financial incentives. Despite being avoidable, thanks to the understanding of human cognition and the processes it is built on, they have proven effective and thus popular to foster human welfare in practice (BIT, 2021a; OECD, 2021; Thaler & Sunstein, 2008). The proponents mostly praise the practicality of nudges, proven by their successful implementation in many different areas, ranging from increasing financial and retirement savings (BIT, 2021b; Thaler & Benartzi, 2004) and healthier food choices (Campbell-Arvai, Arvai, & Kalof, 2014; Carroll, Samek, & Zepeda, 2018) to motivating pro-environmental behavior (Allcott & Kessler, 2019; BIT, 2013; Chassot, Wüstenhagen, Fahr, & Graf, 2017), including the use of low-carbon transport options (Lehner, Mont, & Heiskanen, 2016). These interventions have also often proven to be cheap and easy fixes, yet with large-scale and long-term effects (Arno & Thomas, 2016; Benartzi et al., 2017). Nudges are also seen by many as a legitimate and justified form of policymaking, since they are non-intrusive and thus people can opt out from their intended direction (Benartzi et al., 2017; Croson & Treich, 2014; Sunstein, 2014).

Despite its popularity, nudging has faced criticism, mainly relative to its ethical foundations (Bovens, 2008; Hausman & Welch, 2010). Some question the principles of libertarian paternalism, concluding that nudges in fact limit recipients’ freedom (Mills, 2018; Scott, 2016) and that the choice architect cannot presume what is in the “best interest” of the population (Rebonato, 2012). The second line of critique pertains to the nudges’ theoretical foundations, namely its understanding of human behavior as flawed by cognitive biases. Many authors conclude that human behavior indeed diverges from the assumptions of rational choice theories. The employed heuristics are however not seen as deficits, but rather as an “adaptive toolbox” (Gigerenzer & Selten, 2002) inherent to human decision-making. If applied within suitable contexts, these “simple heuristics” (Gigerenzer & Todd, 1999) can even enhance cognitive processes thanks to optimization strategies and lower cognitive load. Building on this understanding of human behavior, the authors suggest a different type of interventions informed by insights from behavioral science, namely that of boosting. Boosts aim to foster the competencies of individuals so that they can make their own decisions to enhance their welfare (Grüne-Yanoff & Hertwig, 2016; Hertwig & Grüne-Yanoff, 2017). By enhancing skills, knowledge, and decision-making tools, the interventions are believed to have a long-lasting effect on recipients even if removed (Grüne-Yanoff & Hertwig,

2016; Hertwig & Grüne-Yanoff, 2017). While its application in practice might be very similar to nudging (Münscher, Vetter, & Scheuerle, 2016; Sims & Müller, 2019), their theoretical foundations are more realistic, understanding human behavior as prone to irregularities and as being context-specific, as also seen in social psychology theories discussed next.

3.1.3. Social psychology theories

Social psychologists highlight that human behavior is determined by more than individual decision-making processes that aim to maximize one's utility. Scholars point out that people's actions reflect many other factors such as values (Stern, Dietz, Abel, Guagnano, & Kalof, 1999), social norms (Cialdini & Trost, 1998; Olson & Zanna, 1993; Schwartz, 1977), affect and emotions (Loewenstein, Weber, Hsee, & Welch, 2001), or culture and identity (Kahan, Braman, Gastil, Slovic, & Mertz, 2007; Malinowski, 1936). Social psychologists also see decision-making processes as being influenced by unconscious processes resulting from one's past experiences and implicit memory, and which are not available for conscious introspection (Greenwald & Banaji, 1995; Jacoby, Lindsay, & Toth, 1992; Roediger, 1990).

The Theory of Planned Behavior (TPB) is one of the most popular and influential social psychology theories (Ajzen, 1991, 2005). It reflects the assumption that more factors than conscious attitudes only influence human behavior (LaPiere, 1934; Wicker, 1969). TPB was derived from the Theory of Reasoned Action (TRA), that Icek Ajzen coined with Martin Fishbein (Ajzen & Fishbein, 1980; Fishbein & Ajzen, 1975). These two theories represent the first attempts to conceptualize a more complex behavioral model. Both of them see behavior as determined by behavioral intention, which is composed of attitude and subjective norm. TPB adds a third component—perceived behavioral control (PBC) (see Figure 2). Attitudes are positive or negative evaluations of the behavior in question and its expected consequences for the person (Greenwald & Banaji, 1995; Insko & Schopler, 1967). Subjective norm stands for the normative beliefs, i.e., whether the individual believes that peers and society expect them to engage in the behavior. The more the person believes the behavior is approved in the society and constitutes a norm, the more likely they are to engage in it (Ajzen, 1991; Wicker, 1969). Finally, PBC is defined as a person's perceived ability to perform the behavior. This ability is composed of not only their internal skills and capacities but also the external factors, be they facilitators or barriers (Ajzen, 1991, 2005; Wallston, 2001). Ajzen added

the concept of PBC to better model the situations wherein the performed behavior goes contrary to the expressed attitudes (Ajzen, 2005). In contrast to the TRA, which assumes behavior to be under the total volitional control, TPB addresses the discussion in the field that personal attitudes and intentions cannot always predict human behavior (Ajzen, 1991; Armitage & Conner, 2001; Darnton, 2008).

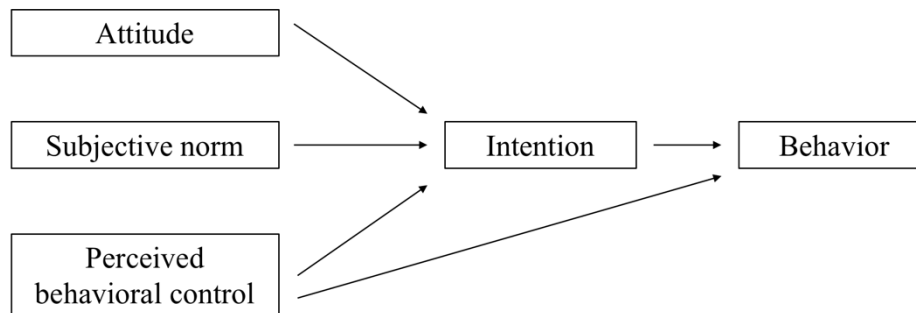


Figure 2. Theory of Planned Behavior (TPB) (own illustration, adapted from Ajzen (1991)).

Attitudes have traditionally been central to social psychology, seen as an indispensable and key concept to explain human behavior (Allport, 1954; Cohen, 1965). Yet, an increasing number of contributions have suggested that the concept is incapable of fully explaining human behavior (Ajzen, 1991; Darnton, 2008). The researchers also identified the so-called “attitude-behavior gap”, a mismatch between attitudes and behavior. This gap has been commonly observed in relation to pro-environmental behavior that remains low despite increasingly positive attitudes to pro-environmental action among the population (Claudy, Peterson, & O’Driscoll, 2013; Cousse, Kubli, & Wüstenhagen, 2020; Kollmuss & Agyeman, 2002).

To address this gap, authors developed comprehensive theories that increased the number of factors to explain human behavior. Most of them directly build on TPB and enrich it by additional factors to increase its predictive capacity (Armitage & Conner, 2001; Bagozzi, Gurhan-Canli, & Priester, 2002; Tanwir & Hamzah, 2020). Darnton (2008) however points out that the increasing complexity of these models compromises their usefulness and applicability for an empirical research. Second, despite their complexity, these models are still not able to fully explain human behavior. Many assign this shortcoming to the fact that the models do not account for unconscious processes and implicit social cognition. Building on clinical psychology, researchers started pointing out that human behavior is not only determined by conscious cognitive processes (Greenwald & Banaji, 1995; Greenwald, McGhee, & Schwartz, 1998; Jacoby et al., 1992). Attitudes are also activated unconsciously, being initiated by subliminal

messages (Greenwald, Klinger, & Liu, 1989) and stimulated quicker than if conscious means operated alone (Bargh, Chaiken, Govender, & Pratto, 1992). Another reason that the models of human behavior are unable to capture implicit social cognition is because the studies use direct, self-reported measures of inquiry (Greenwald & Banaji, 1995). Consequently, the authors call for the development and application of indirect measures of implicit social cognition that would identify these key processes that determine human behavior.

3.2. Innovation adoption and diffusion

3.2.1. Technology Acceptance Model

The literature on innovation adoption is extensive. One of the most common frameworks is the Technology Acceptance Model (TAM) (Davis, 1989). It analyzes the adoption of new technologies in an organizational context; namely, computer and internet use behavior of company employees. Building on TRA (Fishbein & Ajzen, 1975), this model sees the intention to use the innovation as constituted by two beliefs about the technology—its perceived usefulness and perceived ease of use (see Figure 3). The former expresses users' belief about the potential benefits of the technology, i.e., if the technology would enhance their performance and would be advantageous for them. The latter denotes users' expectations about whether it would be difficult to adopt and use the technology in terms of physical and mental effort (Davis, 1989; Pantano & Di Pietro, 2012). Davis (1989) and other contributions found that the effect of perceived usefulness is larger than that of the perceived ease of use. While the effect of the former is direct, perceived ease of use rather moderates the effect of perceived usefulness on use intentions (Hegner, Beldad, & Brunswick, 2019; Tella & Olasina, 2014).

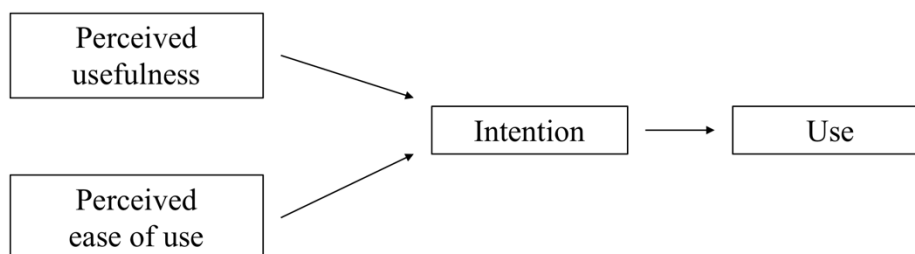


Figure 3. Technology Acceptance Model (TAM) (own illustration, adapted from Davis (1989)).

Davis and his colleagues continually expanded TAM to increase its predictive value. First, they identified the determinants of the perceived usefulness (TAM 2) and perceived ease of use (TAM 3) (Venkatesh & Bala, 2008; Venkatesh & Davis, 2000).

While the former is seen to be formed by image, job relevance, output quality, result demonstrability, and subjective norm mediated by experience and voluntariness, the latter is defined by anchor and adjustment. Of these factors, subjective norm is believed to be the most important since it is the only determinant that also directly influences the intention to use the technology. Synthesizing TAM with additional theories of technology acceptance research (Compeau, Higgins, & Huff, 1999; Rogers, 2003), Venkatesh, Morris, Davis, and Davis (2003) proposed a comprehensive Unified Theory of Acceptance and Use of Technology (UTAUT). It identified performance expectancy, effort expectancy, social influence, and facilitating conditions as four key constructs determining behavioral intention. The authors further expanded the model, leading to UTAUT 2, which also included the affective factors of hedonic motivation, price value and habit (Venkatesh, Thong, & Xu, 2012). The effect of these factors in both models is moderated by users' age, gender, and experience.

TAM and its extensions have become popular to analyze innovation adoption in a variety of fields, ranging from information technology (Bruner & Kumar, 2005; Martins, Oliveira, & Popović, 2014; Pantano & Di Pietro, 2012), to tourism (Escobar-Rodríguez & Carvajal-Trujillo, 2014; San Martín & Herrero, 2012) and healthcare (Aggelidis & Chatzoglou, 2009; Holden & Karsh, 2010). Acceptance of EVs has been investigated by TAM and its extensions as well (Müller, 2019; Sovacool, 2017). Most of these studies start with the initial models yet expand them with additional factors that they see as determining the intentions to adopt the technology in that particular context. The increasing number of factors incorporated in these models naturally enhances their predictive capacity (Venkatesh et al., 2012). Yet, they also become so complex as to compromise their applicability, similar to the extensions of TPB (Darnton, 2008). Bornholt and Heidt (2019) thus call for researchers to analyze the antecedents of identified determinants, as this knowledge might prove more fruitful to understanding the dynamics of new technology adoption.

3.2.2. Diffusion of Innovations Theory

The models of technology adoption described above, while informative and including a plurality of acceptance factors, are centered around the innovation (King & He, 2006; Marangunić & Granić, 2015). By concentrating on the technology, researchers overlook the broader dynamics of the adoption process, namely those represented by the wider societal context and the adopters themselves. The Diffusion of

Innovations Theory (Rogers, 2003) attempts to provide a more inclusive view of innovation adoption. Unifying the widespread diffusion research, the theory has been applied to analyze the innovation adoption process in many different fields, ranging from information technologies (Cheng, Kao, & Lin, 2004; Doyle, Garrett, & Currie, 2014) and drugs and public health interventions (Haider & Kreps, 2004) to pro-environmental innovations such as EVs (Noel, Sovacool, Kester, & de Rubens, 2019; Schuitema, Anable, Skippon, & Kinnear, 2013; Van der Kam, Meelen, van Sark, & Alkemade, 2018).

Rogers (2003) sees the innovation adoption process as composed of four main elements, besides the innovation also communication channels, time, and the social system. Five attributes define the speed of adoption, namely its relative advantage, compatibility with the existing system, complexity, trialability, and observability. The more complex the technology, the less likely it is to be widely adopted; the remaining four aspects positively correlate with innovation adoption (Rogers, 2003). The society is represented in the model mainly by the role of communication channels. The author sees communication between individuals that are different in terms of knowledge and technological competence as a key precondition for a successful innovation diffusion. The core component of Rogers' theory is however his division of adopters into five categories that he calls innovators, early adopters, early majority, late majority, and laggards (Rogers, 2003). The groups differ in their level of innovativeness, i.e., the socio-demographic characteristics and technical capacities that predispose them to adopt the innovation sooner or later in contrast to the other groups. Rogers (2003) further analyzes the decision-making process that adopters go through when they consider adopting an innovation. The author divides the process into five steps: knowledge (learning about the innovation), persuasion (consideration of arguments), adoption decision, followed by implementation and confirmation (the support seeking from peers) in case the innovation is adopted.

Many researchers build on the Diffusion of Innovations Theory. Among them, Moore (1991) studied the diffusion of high-tech products, mainly with the intent of identifying marketing strategies to promote them on the mass market. In doing so, the author observed a qualitative difference between the visionary, tech-oriented customers and the mainstream market (see Figure 4). Moore (1991) found that while the former enthusiastically adopt innovations thanks to their openness to technology and anything

new, the mainstream market is increasingly skeptical, preferring convenient and wholesome solutions targeted to their specific needs. The author calls this junction the chasm. For the innovation to succeed on the mass market, the chasm has to be overcome. To achieve that, the attitudes and characteristics of consumers on the mass market have to be understood and the products tweaked to address them (Moore, 1991).

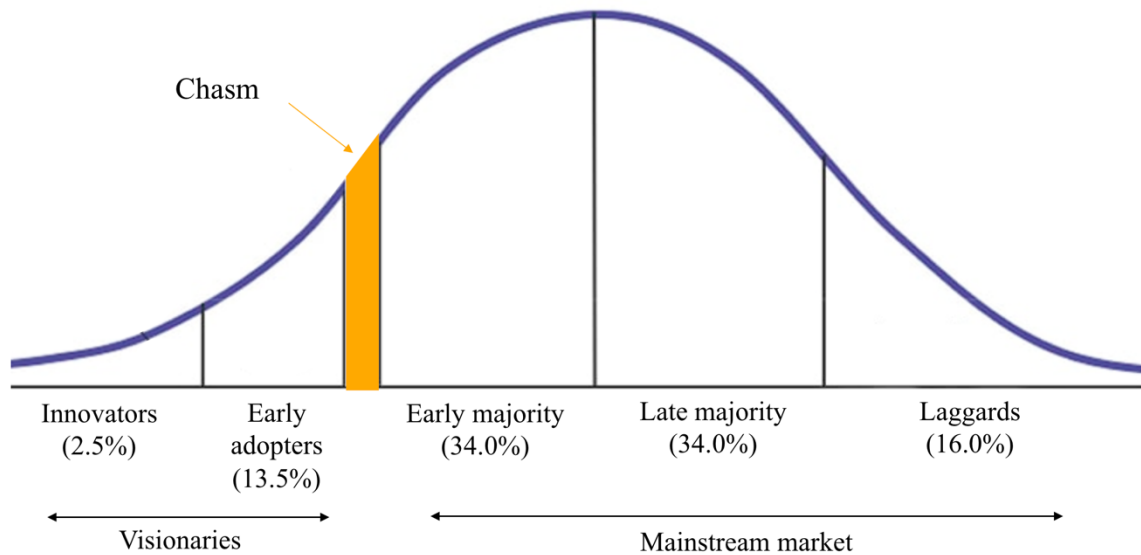


Figure 4. Chasm within innovation adopters (own illustration, adapted from Moore (1991) and Cockburn (2019)).

Despite its popularity, Diffusion of Innovations Theory has faced criticism. First, the researchers point out that the individual adopter groups are too narrowly defined. They claim that adopters are distinguished by more aspects than socio-demographic and economic factors only (Gärling & Thøgersen, 2001; Lyytinen & Damsgaard, 2001). Lyytinen and Damsgaard (2001) further find that the division of adopters into five separate groups is too schematic and does not correspond to their interconnections in reality. Second, Rogers' theory is criticized for perceiving consumers as rational actors who make the adoption decisions mainly based on the individually perceived utilitarian benefits of the innovation. As many authors point out (Darnton, 2008; Kemp & Volpi, 2008; Noel, Sovacool, et al., 2019; Tversky & Kahneman, 1974), the behavior of humans and their adoption intentions are in fact influenced by many other factors such as emotions, social norms, or symbolism. Rogers' focus on adopters and the understanding of the diffusion as a linear process are seen as final shortcomings of the theory. Gartner (2019) concludes that the process of innovation diffusion progresses through ups and downs. Michie, West, Campbell, Brown, and Gainforth (2014) also state that the number of people adopting an innovation does not only increase but can

also decrease over time. The socio-technical approach is particularly informative in this regard since it focuses on the systemic embeddedness of innovation diffusion process. The theories highlight the critical role of other actors than adopters only, such as policymakers, industry actors, peers, and wider social networks (Bijker, Hughes, Pinch, & Dougals, 2012; Geels & Johnson, 2018). In the multi-level perspective, Geels (2002) understands the process of innovation diffusion as happening by the interaction of three levels—the niche (the level of innovation), existing socio-technical regimes (industry actors and policy environment), and the wider socio-technical landscape (global, exogenous context). Technology adoption is then a product of a complex set of processes that promote or inhibit the integration of the innovation in the system.

3.3. Conceptualization of EV consumer adoption

The above literature review shows that, in contrast to the mainstream economic theory and common assumptions in practice, humans are not *homines economici* (Darnton, 2008) that optimally pursue subjective utilitarian goals resulting from cost-benefit analysis. In fact, human cognition is determined by both automatic and deliberative processes that are based on a broad range of heuristics inherent to decision-making. It is a product of not only conscious, but also unconscious processes outside of one's awareness. Second, human decisions reflect a broad range of influences beyond individually determined economic utility, such as emotions, social norms, and culture. These also apply to the reasons to adopt an innovation, that go beyond its usefulness and include aspects such as ease of use or convenience. Finally, the process of innovation adoption does not reflect only the adopter, their decision-making process, and the innovation. The former is embedded in broader societal context that is determined by systemic conditions and additional actors such as peers, social networks, policymakers, and industry actors. The process of innovation adoption is thus context and individual specific, reflecting the broad range of motivations, cognitive processes, and systemic context of any given situation. The dissertation and its individual papers comprehend and approach consumer adoption of EVs against this backdrop.

4. Research context

4.1. Electric vehicles

This dissertation focuses on the electrification of passenger road vehicles since, currently, it has the largest potential to help decarbonize the transport sector. First, passenger road vehicles account for 44.4% of the transport sector's emissions, making them the most polluting segment (IEA, 2020c). This share is substantiated by their dominance on the road, representing 70% to 80% of all registered motor vehicles (Biedermann & Schmid, 2018; Parry, 2020). Second, in contrast to other highly polluting types of vehicles and transport segments, such as heavy-duty freight vehicles, aviation and shipping (Bows-Larkin, 2015; IEA, 2020c), the technology to decarbonize passenger road vehicles already exists and is widely marketable (Meyer, 2017; Tran et al., 2020).

From the available technologies, the dissertation focuses on battery electric vehicles (EVs), mainly for their decarbonization potential (Bauer & Cox, 2019; Miotti et al., 2016). These vehicles run solely on electricity provided from a battery that has to be externally charged from the power grid (Chan, 2007; Larminie & Lowry, 2012). The CO₂ emissions that result from their operation thus depend solely on the electricity mix. Its carbon intensity is in the majority of countries substantially lower than that of fossil fuels (BFE, 2020; EC, 2021b; Moro & Lonza, 2018), and, thanks to the growth of renewable energy generation, expected to further decrease (C2ES, 2019; EC, 2019a). Many analyses provide evidence that EVs bring the largest environmental benefits over their lifecycle compared to other vehicle technologies, especially ICEs but also hybrid vehicles and other alternative fuel vehicle (AFV) technologies (Bicer & Dincer, 2018; Thomas, 2009), both in terms of CO₂ emissions and pollution (Bauer & Cox, 2019; Hoekstra, 2019; Lazzeroni, 2021; Miotti et al., 2016).

The focus on EVs in contrast to other types of electric vehicles, namely PHEV and hydrogen fuel cell electric vehicles (FCV), was taken also in view of the current market dynamics and expected industry development. First, EVs are the dominant type of AFVs, representing almost 75% of electric car sales in 2018 (Bunsen et al., 2019) and 64% of the global electric car fleet (Chen, de Rubens, Noel, Kester, & Sovacool, 2020). In 2020, EV sales exceeded those of PHEVs in the majority of the European markets, which have long been dominated by the sales of the latter (BFS, 2021; Kane, 2020).

While there are many expectations for the success of FCVs (Kendall, 2018; Manoharan et al., 2019), the technology is still nascent, and their sales are only a fraction of those for EVs (EAFO, 2021). The introduction of FCVs to the passenger vehicle market is mainly hindered by large costs and insufficient fueling infrastructure. However, even when these initial barriers are overcome, the technological properties of FCVs rather predispose the technology to be used in heavy-duty and long-distance transport, such as freight, shipping, and aviation (BloombergNEF, 2020; Hasan, 2020). These dynamics help explain why the majority of current car manufacturers focus on EVs (Ewing, 2021; Tesla, 2019; VW, 2021), which represent a majority of AFV models in their portfolios (Gersdorf et al., 2020).

The final reason for focusing solely on EVs was their need for a specific and a different level of behavioral change compared to other AFVs, especially in relation to charging and driving patterns. FCVs would keep the charging and driving patterns almost unchanged since the driving range and fueling time is fairly similar to those of ICEs (Gayton, 2018; Manoharan et al., 2019). The level of adjustment for PHEV users would depend on how much they want to use the electric motor. The presence of the combustion engine, however, decreases the need for charging. A number of studies actually found that PHEV drivers charge their vehicles only rarely (Björnsson & Karlsson, 2017; Boston & Werthman, 2016; Chakraborty, Hardman, & Tal, 2020). By contrast, adopters of battery electric vehicles have to completely adapt their charging and driving patterns. EVs only have an electric motor run by a rechargeable battery that to date has a lower driving range than conventional ICEs (Andwari, Pesiridis, Rajoo, Martinez-Botas, & Esfahanian, 2017; Martínez-Lao et al., 2017). These changes range from needing to plan routes for longer travel distances to navigating between a plurality of charging types (private, semi-private and public) (Anfinsen, Lagesen, & Ryghaug, 2019; Žitnik & Mehle, 2013). These required behavioral changes for EV use, especially range anxiety and perceived lack and complexity of charging, actually remain some of the largest barriers to EV adoption to date (Noel et al., 2020; Noel, de Rubens, Sovacool, & Kester, 2019).

4.2. Purchase behavior

This dissertation analyzes EV purchase behavior since the large majority of registered passenger road vehicles are privately owned (usually 75% to 85%) (CBS, 2020; CSO, 2020). Private mobility is also expected to remain dominant in the future.

First, the peak car, the expected demise of private car ownership in view of the falling car sales in early 2010s (Newman & Kenworthy, 2011; Puentes & Tomer, 2008), has been rather short-lived. The car sales recovered to the levels before the economic crisis of 2008 as soon as in 2013 (Mohr et al., 2013). Schwanen (2013) additionally highlights that the peak car discussion was very Western-centric and omitted developments in emerging economies. In fact, the car sales in these markets were growing over the whole analyzed period (Mohr et al., 2013; Smith, 2016).

The COVID-19 pandemic served to further highlight the dominance of a privately owned passenger vehicle. Due to physical distancing and public health measures, the use of public transport and ride-hailing services dropped across the globe with expected long-term consequences (Fleming, 2021; Liu, Miller, & Scheff, 2020; Paul, 2020). While car sales also decreased due to lockdowns and an economic downfall in the first half of 2020, the industry trends in the second half of the year encouraged positive market prognoses (Gül, Gerner, & Paoli, 2020; IBM, 2020). In fact, the intent to purchase a privately owned car has even increased compared to the pre-COVID-19 pandemic levels among certain consumer segments, especially among young professionals (EY, 2020; Hausler et al., 2020; Jacob, 2020).

5. Research papers

As discussed above, the objective of this dissertation is to be fulfilled by the means of three research papers. They investigate the process how EV adoption intentions of current adopters are formed (*Paper I*), the mechanisms they operate on (*Paper II*) and their determinants (*Paper III*). This section in detail introduces each of the papers, including the reasons for the selection of their particular foci, research goals and main results. This is followed by Table 1 that summarizes main components of the papers including their co-authors and publication status.

5.1. Paper I: Vehicle purchase process

Literature has identified many factors that determine consumers' EV adoption intentions, ranging from socio-demographic and psychological characteristics of adopters to technological components and wider contextual factors (Coffman, Bernstein, & Wee, 2016; Li, Long, Chen, & Geng, 2017; Mukherjee & Ryan, 2020; Rezvani et al., 2015; Singh, Singh, & Vaibhav, 2020). These contributions, however,

study and perceive the aspects as isolated from time and the dynamics of the EV adoption process. Klöckner (2014) raises attention to this shortcoming and highlights it on the studies analyzing EV purchases. The extant research has mainly seen a purchase as a point in time in which individuals and households make a decision to purchase an EV or not. The choice is seen as influenced by the factors that the studies identify and analyze (Oliver & Lee, 2010; Peters, Gutscher, & Scholz, 2011). Building on Bamberg's stage model of behavioral change (Bamberg, 2013b), Klöckner (2014) urges to analyze the temporal dynamics of the vehicle purchase process, in particular the cognitive processes that underline the individual stages and motivate the transitions between them (Klöckner, 2014).

The goal of *Paper I* is to study the dynamics of the vehicle purchase process, namely how many stages it is composed of and what cognitive processes underline them. Additionally to Klöckner (2014) and emerging literature in this field (Mueller & de Haan, 2009; Taylor & Fujita, 2018; Xu, Miwa, Morikawa, & Yamamoto, 2015), the paper enriches the analysis by selecting aspects from marketing, namely the AIDA model (Betancur Botero, 2014; Hanlon, 2013) and touchpoints (Baxendale, Macdonald, & Wilson, 2015; Hogan, Almquist, & Glynn, 2005; Stein & Ramaseshan, 2016), and investigates the role of external influences. Such an enhanced understanding of the vehicle purchase process serves as an entry point to identifying better-informed policy interventions within the most appropriate touchpoints, which can more effectively promote EV purchases among consumers that are currently entering the market.

To achieve that, *Paper I* studies the relevant literature in the field and conducts an online survey of 553 Swiss respondents. First, the paper proposes a novel conceptual framework of the vehicle purchase process that consists of five stages, both pre- and post-purchase, which are subsequently empirically tested. The paper contributes to both academia and practice by addressing some of the discussions within the literature, namely the number of stages of the vehicle purchase process (Klöckner, 2014; Mueller & de Haan, 2009; Taylor & Fujita, 2018; Xu et al., 2015). Second, the empirical testing of the model identifies its most important external influences. Car dealers stand out among them, but they also represent a key barrier to EV purchases. The online survey also enabled to identify and understand the components of and the most appropriate touchpoints to promote EV purchases among current adopters. This identification led to proposing more effective policy interventions at relevant stages; namely, fostering the

accessibility of specific information sources (search stage), car dealer training programs (alternative evaluation stage), and supporting charging infrastructure (post-purchase stage).

5.2. Paper II: Bundling of EV with additional services

The majority of extant studies on EV adoption intentions investigate their influencing factors, yet not the mechanisms on which the latter operate (Coffman et al., 2016; Egbue & Long, 2012; Mukherjee & Ryan, 2020; Rezvani et al., 2015). Range anxiety and the perceived lack and complexity of charging remain some of the largest barriers to EV adoption (Chen et al., 2020; Noel et al., 2020; Noel, de Rubens, et al., 2019), despite the objectively sufficient and practical technological capacities of EVs and charging services (Muzi, 2018; Needell et al., 2016; Vanderwerp, 2020). Coupled with the lower technological savviness and willingness to learn about EV components of consumers that are currently entering the market in contrast to the first innovative EV adopters (Rogers, 2003), the improving technological capacities of EVs might not translate into increased EV purchases if they are not geared towards the specific needs and preferences of the latter (Moore, 1991; Noel et al., 2020; Priessner, Sposato, & Hampl, 2018).

One option how to foster EV adoption intentions among current adopters is to increase the convenience of EV purchase and use (Moore, 1991; Rogers, 2003), among others by offering bundles of EV and additional services. Bundled offerings are a widely used marketing strategy to promote sales of pro-environmental products (BIT, 2013; Carroll et al., 2018) and have been increasingly applied in practice to promote EV purchases (BMW, 2020; Plug'nRoll, 2020a). The number of studies analyzing product bundling in relation to EV adoption has been recently growing (Cherubini, Iasevoli, & Michelini, 2015; Hinz, Schlereth, & Zhou, 2015; Priessner & Hampl, 2020; Stauch, 2021). The reason for the sporadic analysis of convenience in the EV adoption literature (Han, Wang, Zhao, & Li, 2017; Liao, Molin, Timmermans, & van Wee, 2019) might be due to the fact that the first innovative EV adopters did not attach a particular importance to this dimension. However, as highlighted by Rogers (2003) and others (Moore, 1991; Wüstenhagen, Markard, & Truffer, 2003), the consumers that are currently entering the market are more convenience-oriented, increasingly preferring wholesome and complete solutions. Consequently, the research about convenience and its effect on EV

adoption intentions has become relevant and its importance will further grow in the future.

The goal of *Paper II* is to investigate whether bundles of EV and additional services could increase EV purchase willingness of consumers that are currently entering the market and what the bundle preferences of their individual segments are. To do so, we conduct an online study with 313 Swiss respondents. It combines two empirical approaches, a between-subject design experiment and a choice experiment. The former finds that bundles of EV and the necessary charging services increase EV purchase willingness of consumers; however, only of those with low familiarity with the components necessary to operate and use an EV. The latter method finds that there are three consumer segments with differentiated bundle preferences. While one does not desire a bundle offer at all, the second prefers the narrow bundle of EV and charging services only. The third, also the largest, segment representing more than half of the sample are convenience-oriented consumers. They derive the largest value from the most complete bundle that includes EV with a plurality of additional services. The results of *Paper II* point to the mechanisms that operationalize EV adoption intentions of current adopters, namely familiarity and convenience. They also lead to recommendations to policy and industry, namely administrative and financial support of EV-charging bundles for the former and the pursuing of a mixed-bundling strategy for the latter.

5.3. Paper III: Culture and symbolic meanings of EVs pertaining to gender

Culture (Morren & Grinstein, 2016; Pelau & Pop, 2018) and gender identities (Brough, Wilkie, Ma, Isaac, & Gal, 2016; Dietz, Kalof, & Stern, 2002) have been shown to have a major role in explaining pro-environmental behavior. Yet, only recently have authors started analyzing the effect of these two factors on consumers' EV adoption intentions (Anfinsen et al., 2019; Ashmore et al., 2018; Sovacool, Kester, Noel, & de Rubens, 2019). Culture and gender have been a part of narratives about cars and mobility. John Urry (2004) famously coined the term automobility to denote the self-perpetuating system of technological components and symbolic meanings centered around a private ownership of a fossil fuel car. The author sees this system as a key globalization force, forming and shaping identities and values worldwide around a

masculine-centered car culture (Urry, 2004). Masculinity has been a cornerstone of automobility since its emergence at the beginning of the 20th century. Male identities and car culture have been co-constructed around the perceptions of technology, speed, power, privilege and freedom (Ivory & Genus, 2010; Morgan, 2009; Scharff, 1992; Wachs, 1987). The embeddedness of a masculinity-dominated automobility culture within people's identities that is centered around private ownership of fossil fuel vehicles is also seen as one of the major barriers to sustainable mobility transitions (Paterson, 2006; Sovacool, 2017; Urry, 2004).

Paper III aims to study these under-researched, yet critical determinants of EV adoption intentions. To do so, we conduct two studies, a country-level and a consumer-level analysis. The regression analysis used for the former applies an increasingly popular conceptualization of national culture, that of Hofstede's cultural dimensions (Hofstede, 1984; Hofstede, Hofstede, & Minkov, 2010). The author classifies national culture along six dimensions, one of them being masculinity–femininity. We conduct regression analysis on a global sample of 40 countries to identify the effect of femininity of national culture on EV market share. We also investigate the role of the remaining five Hofstede's cultural dimensions and other aspects commonly related to EV market share such as GDP per capita and car ownership per capita (McKinsey, 2014) to set the role of cultural aspects, femininity in particular, in a broader context. The goal of the latter study is to see if consumers perceive EVs as feminine and how the strength of this association relates to their EV purchase intentions. To do so, we run an online survey with 429 German respondents that incorporates an IAT to identify the strength and direction of consumers' unconscious association between EVs and femininity. The test is followed by explicit measures of inquiry, namely a seven-point Likert scale question, to measure the dependent variable of the study, consumers' EV purchase intentions.

The results show that culture and gender are important determinants of consumers' EV adoption intentions. First, femininity is shown to be a significant predictor of EV market share at a country level, the most important of all Hofstede's cultural dimensions and remaining significant when GDP and car ownership per capita are controlled for. The relationship between femininity and EVs is confirmed at the consumer level, since consumers hold an unconscious association between EVs and femininity. However, we observe significant differences between men and women, with male EV non-adopters having the strongest unconscious EV-feminine association. These results show that

remaining EV-feminine stereotypes might hinder EV adoption among specific consumer segments. However, the fact that EV adopters of both genders hold an almost identical, slight, EV-feminine association points to the evolving, converging EV-gender narratives between men and women that might be more conducive to electric mobility futures. These findings inform recommendations for more culturally sensitive policymaking and targeted interventions cognizant of EV-gender associations.

Table 1. Overview of the dissertation papers.

No.	Title	Authors	Research objectives	Theoretical frameworks	Methods	Publication status
I	Touchpoints for electric mobility: Investigating the purchase process for promoting sales of electric vehicles in Switzerland	Jana Plananska ^a	Investigate the vehicle purchase process, including its stages and decision-making processes Identify the most important external influences of the process Suggest touchpoints and interventions in individual stages to promote EV adoption	Social psychology – Stage models of behavioral change, namely vehicle purchase process models Behavioral economics – Cognitive processes Marketing literature – the AIDA model, touchpoints	Online survey (N = 553)	Published in <i>Energy Research & Social Science</i>
II	Product bundling for accelerating electric vehicle adoption: A mixed-method empirical analysis of Swiss customers	Jana Plananska ^a Karoline Gamma ^a	Analyze the effect of EV-charging bundles on EV purchase willingness Identify the preferred set-up of bundles of EV and additional services for individual segments of current EV adopters	Diffusion of Innovations Theory Marketing literature – Product bundling	Online survey (N = 313) with two experiments: (1) Between-subject design experiment (2) Choice experiment	Submitted to <i>Renewable & Sustainable Energy Reviews</i>
III	Gender associations with electric vehicles as determinants of consumer adoption	Jana Plananska ^a Rolf Wüstenhagen ^a Emanuel de Bellis ^b Andreas Herrmann ^c	Study the role of culture (measured by Hofstede's cultural dimensions) on EV market share at the country level Identify consumers' unconscious association between EV's and gender Analyze the relationship between EV-gender perceptions and EV purchase intentions of consumers	Social psychology theories of behavior – Role of gender identities and role of culture Hofstede's cultural dimensions	(1) Regression analysis (global sample of 40 countries) (2) Online survey (N = 429) including implicit association test (IAT)	Under Review in <i>Transportation Research Part D: Transport and Environment</i>

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6. Methodology

The quantitative research methodology was deemed the most appropriate to answer the research questions of individual papers and thus to fulfill the objective of the dissertation (Leedy & Ormrod, 2019; Queirós, Faria, & Almeida, 2017; Williams, 2007). The papers present original research that was carried out by collecting and analyzing primary research data and, in one case, secondary data collected from official databases and international institutions. The papers apply a plurality of quantitative research methods that were carefully selected to best address their research goals. They include not only the traditional explicit measures of stated preferences, such as surveys and experiments (Coffman et al., 2016; Li et al., 2017; Rezvani et al., 2015; Singh et al., 2020). The research also employs indirect measures of inquiry, namely an IAT (Carpenter et al., 2019; Greenwald et al., 1998). Its application reflects calls in the literature to go beyond the direct measures of stated preferences that can, especially in sensitive areas such as pro-environmental behavior, suffer from social desirability and other biases (Chrysochou, 2017; Coffman et al., 2016; Goerres & Prinzen, 2012; Kester et al., 2018; Sovacool, 2014). In what follows, the individual research methods are presented, including an overview of the statistical tools and methods applied to analyze the data.

6.1. Explicit methods

6.1.1. Surveys

All three papers applied a survey. The survey method was chosen since it offered a reliable yet convenient way how to generate the desirable data (Chrysochou, 2017; Queirós et al., 2017). The main goal of the survey in *Paper I* was to validate the newly generated conceptual framework of the vehicle purchase process, to identify its most important external influences and to indicate the most appropriate touchpoints within the process to promote EV purchases. The surveys conducted in *Paper II* and *Paper III* aimed to collect data that would enrich and complement the results obtained by the other research methods used, namely experiments and an IAT (both methods will be explained later).

All three conducted surveys were online, computer-assisted web interviews (CAWI). This survey type is increasingly replacing other data collection techniques, namely telephone or mail, mainly due to its practicality. Additionally, thanks to the increasing

internet coverage and development of online survey tools, their design, administration, and distribution is both relatively easy and cost-effective (Chrysochou, 2017; Queirós et al., 2017). Professional market research agencies were hired to recruit participants and distribute the surveys. This was done since the selected agencies are specialized on consumer research and thus have large pools of hundreds of thousands of respondents from which, based on stratified random sampling, representative samples of the studied population could have been obtained (Innofact, 2021; Intervista, 2021; ResponDi, 2018). Concretely, *Paper I* and *Paper II* recruited a representative sample of the Swiss population ($N = 553$ and $N = 313$, respectively), stratified by gender, age, and language. Due to the specificities of the Swiss population (BFS, 2020), studies representative of the country have to consider the differentiated linguistic geographic representation. *Paper III* surveyed German population ($N = 429$) that was stratified by sex and age.

The surveys were designed using three different online survey tools; Unipark (Unipark, 2021), Sawtooth Software (SawtoothSoftware, 2021) and Qualtrics (Qualtrics, 2021). This was done since Sawtooth Software and Qualtrics allow to integrate research methods that were used for the purposes of the research methodologies of *Paper II* and *Paper III*, namely choice experiment by the former (Orme & Chrzan, 2017) and IAT by the latter (Carpenter et al., 2019). All three tools, however, offered all the needed functionalities to generate the desirable data, mainly by using single-, multiple-choice and Likert scale type of questions. The data generated by the surveys were analyzed in the statistical analysis software SPSS (IBM, 2021). A plurality of descriptive and, primarily, inferential statistical research methods was used, such as principal component analysis (PCA), analysis of variance (ANOVA), t-tests and regression analyses (single and multiple regression models). The applied statistical methods were carefully selected to best suit the given research question and generated data (Dobson, 1983; Freedman, 2009).

6.1.2. Experiments

Paper II embedded two experimental designs in its survey. First, the between-subject design experiment was conducted since it allows to identify potential causal relationships between the variables of interest (Chrysochou, 2017; Williams, 2007). The between-subject design was chosen over the second most common type of experimental set-up, the within-subject design, mainly since the former limits the carry-over effect (Allen, 2017; Price, Jhangiani, & Chiang, 2015). The main goal of the experiment was

to identify the effect of the bundle of EV and charging services on EV purchase willingness of respondents in contrast to highlighting the individual components needed to operate and use an EV. The exposure to both experimental conditions in the within-subject design experiment would however bias the results; this experimental design was thus not selected.

In view of this objective, the between-subject design experiment had two treatment conditions (bundle and individual components) and a control condition that did not expose the respondents to any treatment. The participants were randomly assigned to one of the experimental conditions by Sawtooth Software within which the experiment was designed (SawtoothSoftware, 2021). The question about the dependent variable investigated the EV purchase willingness of respondents on a seven-point Likert scale; it was asked immediately after the exposure to the experimental conditions. The generated data were analyzed in SPSS, applying the PROCESS Macro regression analysis tool (Hayes, 2021). The tool was chosen since it allows to investigate both, the direct and interaction effects in a plurality of moderation and mediation models.

Second, a choice experiment was conducted as part of *Paper II* to elicit the preferences of respondents for a bundle of EV and additional services. A choice experiment is an ideal method to achieve that. Simulating a choice environment, it allows to identify consumers' preference structure for products composed of multiple attributes based on their product choices (Green & Srinivasan, 1990; Louviere & Woodworth, 1983). The products are offered to consumers in sets of three to four alternatives that vary along attribute levels. This set-up thus tests specific product details in a practical, realistic, comparison-based setting. Additionally, by generating data on the level of individual respondents, the choice experiment allows to identify consumer segments that share product preferences (Eggers, Sattler, Teichert, & Völckner, 2018). The tool has thus been widely used in marketing and increasingly so other areas to test innovative products and identify their preferred composition for market introduction and consumer segmentation (DeSarbo, Ramaswamy, & Cohen, 1995; Gustafsson, Herrmann, & Huber, 2013).

We designed the choice experiment to offer consumers three alternative bundle offers and a none option. We included the none option to allow the respondents not to choose any bundle offer; the experiment thus better corresponded a real life situation

(Eggers et al., 2018; SawtoothSoftware, 2017). The bundles were composed of seven attributes that included charging and additional services such as insurance and battery assistance. The respondents were randomly assigned to eight randomly generated choice tasks by the Sawtooth Software tool in which the experiment was designed and administered. The generated data were then analyzed directly in the Sawtooth Software interface, applying the two most commonly used data analysis methods of choice experiments. First, we employed Hierarchical Bayes analysis to identify the importance of individual attributes of the bundle on consumers' choice and the part-worth utilities they attach to its attribute levels (Chrzan, 2017; Hein, Kurz, & Steiner, 2020). Second, we conducted a latent class analysis to identify individual consumer segments and their differentiated bundle preferences (DeSarbo et al., 1995; SawtoothSoftware, 2020).

6.1.3. Regression analysis

The only study that used secondary data was the regression analysis conducted as part of *Paper III*. Its main goal was to identify the effect of masculinity–femininity Hofstede's cultural dimension (Hofstede, 1984, 2001) on EV market share on a country level. To identify the strength and direction of that relationship, we conducted single and multiple linear regression models in the SPSS statistical analysis software. To generate more robust results, we controlled for the effect of additional variables, namely the other five Hofstede's cultural dimensions and non-cultural aspects commonly associated with EV market share, namely GDP per capita and car ownership per capita (McKinsey, 2014).

For a successful regression analysis, the sample selection and the quality of the collected data are of the utmost importance (Lavrakas, 2008; Queirós et al., 2017). Therefore, we selected a sample of 40 countries from all five continents to represent different cultural backgrounds; the countries varied in terms of Hofstede's cultural dimensions (Hofstede, 1984, 2001) and many other variables such as GDP per capita and car ownership per capita (OurWorldInData, 2020; WorldBank, 2021). We collected the data on the studied variables from reliable sources, such as Hofstede Insights (HofstedeInsights, 2020), an analytical tool built on data from Hofstede's research, the International Energy Agency (IEA, 2020b), the World Bank (WorldBank, 2021) and the official database managed by the University of Oxford (OurWorldInData, 2020).

6.2. Implicit methods

6.2.1. Implicit association test (IAT)

Paper III also investigated whether consumers unconsciously associate EVs with femininity and how the strength of this relationship relates to their expressed EV purchase intentions. To achieve that, we applied indirect methods of implicit social cognition (Greenwald & Banaji, 1995; Greenwald et al., 1998). Gender being a sensitive topic (Brough et al., 2016; Régner, Thinus-Blanc, Netter, Schmader, & Huguet, 2019) about which people might not consciously think in relation to cars and their purchases (Egbue & Long, 2012; Hosseinpour, Chen, & Tang, 2015), the traditional explicit measures of inquiry might not adequately identify the existence and magnitude of this relationship (Chrysochou, 2017; Lane, Banaji, Nosek, & Greenwald, 2007). From the plurality of indirect research methods, we decided to apply an IAT, mainly since it is one of the most reliable ones with the highest validity and psychometric qualities (Bar-Anan & Nosek, 2014; Nosek, Greenwald, & Banaji, 2007; Pogacar, Carpenter, Shenk, & Kouril, 2019).

The objective of an IAT is to measure the strength of an unconscious association between a concept and an attribute in the presence of a contrasting pairing (Carpenter et al., 2019; Greenwald et al., 1998). This goal is achieved by an assignment task in which respondents are asked to match the stimuli representing the concepts and attributes, in our case *electric engine* and *feminine* (with the chosen opposites *internal combustion engine* and *masculine*) to the belonging pairs of concept and attribute that appear on the computer screen in compatible and incompatible pairs. The speeds and potential errors in assignments lead to the calculation of the standardized difference score, the so-called d-score, that represents the main IAT result (Nosek, Banaji, & Greenwald, 2002; Pogacar et al., 2019). For the IAT reliability, the stimuli selection is of the utmost importance (Greenwald et al., 2020; Pogacar et al., 2019). To do so, we conducted a mixed-methods research combining literature search and a pre-study with 14 participants that identified six stimuli that unequivocally represent each concept and attribute of the study.

We designed and administered the IAT using the iatgen tool (Iatgen, 2020). The tool was chosen since it allows to integrate the IAT into an online survey-software tool, namely that of Qualtrics (Qualtrics, 2021). We did so and used the resulting survey to

control for number of additional variables. One of them was the dependent variable of the study, that of EV purchase intentions, which was measured on a seven-point Likert scale. We calculated the d-score in the iatgen tool and then integrated it with the other data generated by the survey. We analyzed the data in the SPSS software, mainly through t-tests and analysis of variance (ANOVA).

7. Conclusion

Decarbonization of transport is central for fulfilling global climate goals (IEA, 2020b; UNFCCC, 2015). This dissertation contributed to this endeavor by studying consumer adoption of battery electric vehicles (EVs). Concretely, it investigated the formation, operating mechanisms and determinants of EV adoption intentions of consumers that are currently entering the market in Switzerland and Germany. This was achieved by three research papers that each addressed one of the above aspects of adoption intentions with original, empirical research. Namely, *Paper I* investigated the vehicle purchase process, *Paper II* analyzed the effect of bundles of EV and additional services on EV purchase willingness and the former's preferred set-up by individual consumer segments, and *Paper III* studied the role of culture and symbolic meanings of EVs pertaining to gender as unconscious determinants of EV adoption intentions.

7.1. Contributions to academia

The dissertation contributes to the EV adoption literature, both thematically and methodologically. Above all, by investigating adoption intentions of broader consumer segments that are currently entering the market, the dissertation enriches extant findings, which have mainly focused on the first innovative EV adopters (Hardman, Shiu, & Steinberger-Wilckens, 2016; Mukherjee & Ryan, 2020; Rezvani et al., 2015; Singh et al., 2020). The dissertation thus joins the growing number of authors who analyze the wider adopter groups (de Rubens, 2019; Priessner et al., 2018) and generates novel insights that open up avenues for further research.

7.1.1. Process perspective, post-purchase stage and car dealers

The dissertation contributes to the EV adoption literature with a process perspective by investigating the formation of adoption intentions in *Paper I*. In answering Klöckner's (2014) call, it expands the work of authors who perceive EV purchases as a temporal process (Bamberg, 2013a; Mueller & de Haan, 2009; Taylor & Fujita, 2018).

The paper concludes that the vehicle purchase process consists of five stages, four pre- and one post-purchase, which are underlined by differentiated decision-making strategies that move the consumer via two consecutively narrower choice sets to an eventual vehicle purchase. The paper thus addresses one of the main discussions within the vehicle purchase process literature, namely that of the number of stages involved. It not only shows, in contrast to some contributions (Klöckner, 2014; Mueller & de Haan, 2009), that the post-purchase stage is an integral part of the EV purchase process. It actually concludes that it is a critical stage for EV adoption since the main barriers and facilitators of EV purchase intentions are found at this stage, namely those related to charging. The paper thus demonstrates that despite the objectively sufficient density of the public charging infrastructure (Muzi, 2018; Vanderwerp, 2020), the perceived lack and complexity of charging by consumers remains one of the largest barriers to EV adoption among consumers that are currently entering the market (Chen et al., 2020; Noel et al., 2020; Rezvani et al., 2015).

The investigation of the external influences on the vehicle purchase process revealed that car dealers are the most important one of them. They play central role at all of its stages; they are the key purchase and information channel. Yet, at the same time, they represent a key barrier to EV purchases. They seldom offer EVs to consumers, especially to those who are not considering purchasing an EV. This finding joins the growing literature that highlights the importance of car dealers in increasing EV adoption, and that points to them as a significant barrier too (Cahill, Davies-Shawhyde, & Turrentine, 2014; de Rubens, Noel, & Sovacool, 2018; Matthews, Lynes, Riemer, Del Matto, & Cloet, 2017).

7.1.2. Familiarity and convenience to help overcome the perceived complexity of charging

The dissertation also expands the EV adoption literature by analyzing the mechanisms based on which interventions to foster EV adoption intentions operate. It thus addresses some of the shortcomings of extant contributions identified by Bornholt and Heidt (2019); Priessner et al. (2018) and others. Concretely, *Paper II* shows that familiarity and convenience are some of the central mechanisms that operationalize the effect of bundles of EV and additional services on EV purchase willingness of current adopters. We thus also help identify strategies how to overcome one of the largest remaining barriers to EV purchases to date, that of perceived complexity of charging

(Chen et al., 2020; Noel et al., 2020; Rezvani et al., 2015), that was also shown to be a barrier to EV purchases by *Paper I*.

Paper II expands the currently growing literature on the role of bundling on EV adoption (Cherubini et al., 2015; Hinz et al., 2015; Priessner & Hampl, 2020; Stauch, 2021). It is the first academic contribution to empirically study and test the effect of the narrow bundle type of EV and charging services on EV purchase willingness of consumers that are currently entering the market. Since this bundle is the most commonly applied in practice (BMW, 2020; Plug'nRoll, 2020a), understanding if and how it affects EV adoption is relevant. Second, by identifying that the familiarity with the components necessary for EV use and operation is a key moderating factor of bundle's effect, the paper brings further evidence to the role of knowledge on EV adoption (Li et al., 2017; Rezvani et al., 2015; Singh et al., 2020), additionally showing how the latter manifests itself. Third, the paper is one of the first contributions to identify individual segments within current EV adopters and to highlight their differentiated preferences, namely relative to the set-up of the bundle of EV and additional services. We thus highlight that consumers that are currently entering the market are increasingly heterogenous (Priessner & Hampl, 2020; Vuichard, Stauch, & Wüstenhagen, 2020; Wüstenhagen et al., 2003) and emphasize that further studies of EV adoption should aim to identify and better understand individual consumer segments and their preferences. Finally, by showing that the most convenient bundle that includes EV and a plurality of additional services is desired by the largest consumer segment, the paper identifies convenience as a mechanism potentially fostering EV adoption. This finding further confirms the growing importance of convenience among wider adopter groups (Rogers, 2003; Wüstenhagen et al., 2003), that will most likely further grow in later stages of EV diffusion. The paper and the present dissertation thus encourage its further analysis.

7.1.3. Culture and symbolic meanings of EVs pertaining to gender

Finally, the dissertation makes a contribution to the EV adoption literature by investigating two important, yet still under-researched determinants of EV adoption, namely those of culture and EV-gender perceptions. Next to Ashmore et al. (2018), *Paper III* is the first to study the effect of culture on EV adoption at the country level. We find that it is a key predictor of EV market share, remaining significant even if other factors commonly associated with EV diffusion are controlled for, such as GDP per capita and car ownership per capita (OurWorldInData, 2020; WorldBank, 2021). The

paper thus expands the work Ashmore et al. (2018) by confirming the role of culture in the presence of other, non-cultural, determinants of EV adoption. It thus also answers the calls in the literature (Rezvani et al., 2015; Sovacool & Axsen, 2018) for deeper cultural analyses of EV adoption.

Second, the paper expands the literature that studies the relationship between EV and gender. First, it shows that masculinity–femininity Hofstede’s cultural dimension is the most important cultural predictor of EV adoption (Hofstede, 1984; HofstedeInsights, 2020), with the relative femininity of national culture positively correlating with EV market share. We expand the literature associating EVs with femininity (Ivory & Genus, 2010; Morgan, 2009; Scharff, 1992; Wachs, 1987) by finding this effect on a country level. We thus provide further evidence for the role of femininity on pro-environmental engagement (Brough et al., 2016; Dingil, Rupi, Schweizer, Stasiskiene, & Aalipour, 2019; Pelau & Pop, 2018). Second, *Paper III* expands the literature analyzing EV-gender perceptions by investigating consumers’ unconscious gender associations with EVs and relating them to their expressed EV purchase intentions. Next to Bennett and Vijaygopal (2018), we are the first contribution to study unconscious processes determining EV adoption intentions. By showing that respondents unconsciously associate EVs with femininity and that this association is the strongest among male EV non-adopters, we further confirm the relationship between EVs and femininity observed in the country-level analysis and elsewhere as discussed above. We however also show that this relationship might pose an unconscious barrier to EV adoption among specific consumer segments. Finally, the finding that male and female EV adopters have very similar, slight unconscious EV-feminine association, points to the evolving, converging EV-gender perceptions among EV adopters that might be more conducive to electric mobility futures, as also observed by Anfinssen et al. (2019) and Sovacool et al. (2019).

7.1.4. Geographical scope and methods – Cross-country analysis and implicit association test (IAT)

Finally, the dissertation expands the EV adoption literature by its geographical scope and by applying a plurality of quantitative research methods. It thus answers the calls of Coffman et al. (2016); Rezvani et al. (2015) and others (Kester et al., 2018; Li et al., 2017) to diversify the extant contributions, ideally by combining different methods and conducting cross-country, cross-cultural research (Sovacool, 2014). First, focusing on Switzerland and Germany, the studies extended the scope of the EV adoption literature

that has so far mainly originated from the United States of America (USA) and the United Kingdom (UK) (Rezvani et al., 2015; Sovacool, 2014). *Paper III* also conducted a cross-cultural, cross-country study on a global sample of 40 countries from five continents. It thus expanded the only slowly growing body of literature analyzing EV diffusion cross-nationally, which however to date mostly focuses on Nordic countries (Norway, Sweden, Finland, Denmark and Iceland) (Chen et al., 2020; Kester et al., 2018; Noel et al., 2020). By answering the call of Sovacool (2014), it brings an important global perspective to the EV diffusion research that, with the growing EV adoption, will become more relevant in the future.

Second, the individual papers of the dissertation go beyond the most commonly applied research method of EV adoption literature to date, that of surveys (Coffman et al., 2016; Kester et al., 2018; Li et al., 2017). While making use of it, they further extend it by applying two experiments (between-subject design experiment and choice experiment), a regression analysis and an IAT. With an IAT, the dissertation enriches the EV adoption literature by indirect methods of inquiry. In contrast to the bulk of research (Li et al., 2017; Rezvani et al., 2015; Sovacool, 2014), the present dissertation answers the calls of psychologists who see the analysis of implicit social cognition by indirect research methods as crucial to capture the unconscious processes that determine human behavior (Greenwald & Banaji, 1995; Greenwald et al., 1998; Nosek et al., 2002). To better comprehend EV adoption intentions, the present dissertation applied an IAT and thus, with Bennett and Vijaygopal (2018), became one of the first contributions to the EV adoption literature to do so.

7.2. Contributions to practice

One of the main goals of the dissertation was to provide suggestions to policymakers and industry actors how to better target consumers that are currently entering the market to more effectively promote EV purchases among them and thus to foster further EV diffusion. The individual papers thus analyzed EV adoption intentions of current adopters on practical topics. Besides generating case-specific insights and identifying and testing ways how some of the largest remaining barriers to EV adoption to date can be overcome (*Paper II*), the papers delivered generally applicable tools (*Paper I*) and identified underlying principles (*Paper III*) on which practitioners should build future interventions.

7.2.1. Tool to target touchpoints in EV purchase process

Practitioners are encouraged to first specifically target their interventions. Before developing and implementing any new measure, they should critically assess the situation and broader context within which they operate and think whom (profile and needs) they wish to target, at what stage of the vehicle purchase process these consumers are, and what the intervention should achieve. The process of inquiry suggested by *Paper I* that outlines the individual steps and proposes navigating questions how to address each of them is particularly useful in that regard. Applying this tool, *Paper I* identified three most appropriate touchpoints at relevant stages of the vehicle purchase process and suggested interventions within them to promote further EV purchases. These are the generation of a platform coordinating specific information sources (to have the main effect in the search stage), obligatory training programs on EVs for car dealers (alternative evaluation stage) and support of charging infrastructure (post-purchase stage). What is telling is that these interventions differ and are applicable in contrasting stages of the vehicle purchase process than the most commonly implemented support measures of EV adoption to date, regulation and financial incentives (Mathieu & Poliscanova, 2020; Rietmann & Lieven, 2019).

The platform coordinating specific information sources might seem to confirm the role of information and knowledge on EV adoption (Li et al., 2017; Rezvani et al., 2015; Singh et al., 2020) and thus the benefit of information campaigns implemented to date (EnergieSchweiz, 2019; Khiat, 2017). Yet, the findings of *Paper I* also showed that not all information sources correlate with EV purchase intentions. Thus, the information platform and future information campaigns should be selective in what information they present. To more effectively communicate to wider adopter groups that are currently entering the market, we suggest the platform be convenient to navigate. The growing importance of convenience for wider adopter groups observed in literature (Moore, 1991; Rogers, 2003; Wüstenhagen et al., 2003) has also been confirmed by *Paper II*. It found that the largest consumer segment of current adopters, representing more than half of the sample, preferred the most convenient bundle of EV and a plurality of additional services. Consequently, the interventions aiming to promote further EV purchases should be built on, or at least consider, the principle of convenience.

The identification of car dealers as one of the main barriers to EV purchases highlights the role of external context, a plurality of actors and the systemic

embeddedness of the EV adoption process (Geels, 2002; Singh et al., 2020; Sovacool, 2017). To overcome this hurdle, we suggest implementing obligatory training programs about EVs for car dealers. This suggestion also builds on the findings of other literature that highlights that car dealers can be hesitant to promote EVs because they are not fully knowledgeable about this technology and its operation (Cahill et al., 2014; de Rubens et al., 2018; Matthews et al., 2017). These training sessions could be developed and implemented not only by policymakers, but also car manufacturers who aim to transition their companies toward electric mobility (Ewing, 2021; Kane, 2018; VW, 2021).

7.2.2. Charging infrastructure – Bundles of EV and additional services

A final suggestion of *Paper I* was to provide support for the charging infrastructure. Although the perceived lack and complexity of charging were the main concerns held by participants, their addressing represented the most promising way how to increase EV purchase intentions of the latter. Building on the results of *Paper II* and on insights from other literature (Noel et al., 2020; Skippon & Garwood, 2011; Žitnik & Mehle, 2013), this dissertation suggests focusing especially on private and semi-private charging, namely the bundles of EVs and additional charging services. We recommend that policymakers subsidize the bundles, either adding to or replacing the current financial subsidies given to EVs only. We also encourage them to implement legislation that would make it obligatory for any new housing development to include infrastructure conducive to EV charging. Lastly, policymakers should generate guidelines to which all providers would have to adhere, including training of technical personnel so that they acquire necessary skills to operate and maintain the charging infrastructure (EM, 2019; Mukherjee & Ryan, 2020).

We encourage car manufacturers and providers of charging infrastructure to also particularly focus on private and semi-private charging. We recommend they pursue a mixed-bundling strategy (Stremersch & Tellis, 2002), offering the charging components individually, in the narrow EV-charging bundles as the most commonly practiced to date (BMW, 2020; Plug'nRoll, 2020a) and including additional components such as insurance and battery assistance in broad, convenient bundles. As discussed above, the positive effect of convenient solutions for EV adoption is likely to further grow. We thus encourage industry actors to emphasize the latter, broad, bundle type. To construct such a bundle, cross-sectoral partnerships will be needed between different actors from previously separated silos, ranging from car manufacturers, electricity and technology

providers to banking and insurance. This need for partnerships highlights the key role of cooperation and broader systemic solutions to foster further EV adoption that should be more actively pursued in the future (Li et al., 2017; Noel et al., 2020).

7.2.3. Principles to build on – Culture and EV-gender associations

The specific targeting of interventions also concerns the principles that underline the concrete situation and the context within which practitioners operate. One such principle is culture. *Paper III* showed that national culture was a critical determinant of EV market share. This finding also helps explain why policies and interventions effective in one country do not always work in another one (Ashmore et al., 2018; Pelau & Pop, 2018; Rietmann & Lieven, 2019). The conclusions of *Paper III* also provide further evidence to encourage policymakers to refrain from direct policy transfer and adapt the interventions in view of any individual country culture (Hofstede, 1984; HofstedeInsights, 2020). The same applies to industry actors, who should target their strategies to the specific country they operate in and its national culture.

The second underlying principle of adoption intentions identified by *Paper III* is the association of EVs with gender and the role of gender in EV adoption. First, the relative femininity of national culture was observed to be the most important, positive, cultural determinant of EV market share at the country level. The activities promoting EVs in countries that are culturally more feminine should encourage the uptake of EVs; in more masculine countries, prescriptive policies and interventions such as emission regulations and financial incentives will be needed (Ashmore et al., 2018; Pelau & Pop, 2018). Second, the identified unconscious EV-feminine association of the general sample and the differences in its magnitude among individual consumer segments further highlight the need for careful targeting of interventions. We encourage a special attention when communicating to consumer segments that are still reluctant to purchase an EV. As found in *Paper III*, specific segments of male consumers relate the perceived excessive femininity of EVs to their undesirability. For these consumer segments, we recommend gearing the messages closer to the values of the traditional ICE-centered, masculine, car culture, such as speed, power, technological strength and freedom (Ivory & Genus, 2010; Morgan, 2009; Wachs, 1987). For consumers for whom the association between EVs and femininity does not pose a barrier to EV purchases, the communication can remain focused on the environmental and other benefits of EVs. However, for both of these consumer groups, we recommend enriching the communication by affective and

status-enhancing messaging, which effectiveness for EV advertising was proven elsewhere (Gavran, 2021; Gurskiy, 2019; Noel, Sovacool, et al., 2019).

7.3. Limitations and suggestions for further research

This dissertation contributed to both academia and practice. It enriched the EV adoption literature with a better understanding of adoption intentions of wider adopter groups that are currently entering the market. This knowledge helped suggest and test strategies practitioners can implement to more effectively promote consumer adoption of EVs and thus to foster further EV diffusion. The scope of this dissertation and its individual papers however could not have covered the entire breadth of the phenomenon studied, which resulted in certain limitations. Consequently, the present research invites scholars to build on its findings and address some of its limitations.

7.3.1. Deeper processes and mechanisms – Car dealers and gender

This dissertation encourages further studies to continue in its endeavor to investigate deeper mechanisms and processes on which the factors influencing EV adoption operate. It would be particularly insightful to inspect the direction and causality of the effect of car dealers as barriers to EV purchases. While extensive research has focused on the factors determining EV adoption intentions of consumers and the decision-making processes they employ (Li et al., 2017; Rezvani et al., 2015; Singh et al., 2020), little is known about car dealers, the cognitive processes they apply and the motivations and determinants of their relationship with EVs. Focus on car dealers as units of investigation is however crucial to getting a broader picture of the systemic conditions within which the EV adoption process occurs. It could be particularly insightful to apply the implicit methods of inquiry, such as an IAT, to investigate the unconscious associations car dealers have with EVs and to what extent these influence their willingness to offer this technology.

A second particularly interesting finding that deserves further investigation is the identified relationship between EVs and femininity and its implications for consumers' purchase intentions. It would be first insightful to identify the reasons for the existence of the unconscious EV-feminine association, especially the differences in its magnitude between individual consumer segments. Why are there such big differences between men and women in general and those who do not consider purchasing an EV, yet an almost identical unconscious EV-feminine association among EV adopters of both

genders? The understanding of the causality of the especially strong EV-feminine association of male EV non-adopters would be particularly important to help identify and propose strategies to overcome this potentially central unconscious barrier to EV adoption. It would be also interesting to study if various EV types and models are gendered differently or in the same way. This research might not only provide further information to better segment consumers and target measures to promote EV adoption. Due to the growing number of EV models entering the market (Mathieu & Poliscanova, 2020; McKerracher et al., 2020), inquiring the type of EVs consumers consider will become relevant for this and any future research of EV adoption.

7.3.2. From stated to revealed preferences

Similar to most literature to date (Coffman et al., 2016; Rezvani et al., 2015; Singh et al., 2020), the dissertation studied EV adoption intentions rather than analyzing real EV adoption, i.e., purchases of EVs and use behavior. The consumers that are currently entering the market importantly vary from the first innovative EV adopters (EAFO, 2021; Rogers, 2003). Consequently, the insights from EV purchases and use by first innovators would not be applicable to foster EV adoption among the wider adopter groups that are currently entering the market. However, as the EV diffusion progresses and an increasing number of consumers from later adopter groups adopt EVs, investigating real adoption behavior will become more relevant. This dissertation thus encourages future studies to move closer to the actual purchasing decision and to investigate the practices of EV adoption and use.

This dissertation also suggests further research to apply a plurality of research methods in addition to the ones used by the present studies. Although it extends the EV adoption literature methodologically (Coffman et al., 2016; Li et al., 2017; Rezvani et al., 2015), this dissertation did not apply qualitative research methods such as focus groups, interviews, or ethnographic studies. These methods could enrich the observed findings or answer some of the questions resulting from the research. For example, an ethnographic study following selected adopters throughout the vehicle purchases process or observing their daily EV use behavior would bring deeper insights into the EV adoption processes. Future research could also use other innovative research methods from data science such as chatbot surveys and data scraping (George, Osinga, Lavie, & Scott, 2016; Scarborough, 2018). These methods allow to ask different types of research questions and to investigate new phenomena by analyzing big data and

studying developments on social media; they can also deliver higher-quality data than traditional survey methods (Kim, Lee, & Gweon, 2019; Scarborough, 2018). If applied, we encourage researchers to pay a careful attention to the challenges and issues their application raises, namely ethical concerns about data security and privacy (Cuzzocrea, 2014; George et al., 2016).

Finally, it would also be insightful to develop the interventions suggested by the present dissertation and test their effectiveness in practice. To do so, we recommend policymakers and industry actors first conduct randomized control trials (RCTs) of chosen interventions on a smaller scale (Banerjee & Duflo, 2009; Kendall, 2003). Such pre-testing would allow them to identify in which context and for which target groups the interventions are the most effective, and to tweak them to better correspond to other target groups and situations. This dissertation would first suggest developing and testing the platform coordinating specific information sources, car dealer training programs, and the bundle of EV and additional services. Lastly, it would be insightful to implement various EV marketing campaigns in view of the findings of *Paper III*, i.e., to highlight different symbolic and affective meanings to recipients based on their differentiated unconscious EV-feminine associations.

7.3.3. Plurality of countries and longitudinal studies of EV adoption

Two aspects of this dissertation create new openings for further research. The present studies extended the geographical scope of the EV adoption literature. Yet, we are still missing deeper insights into adoption intentions of current adopters from a broader set of countries and cultural contexts. Consequently, this dissertation encourages conducting case studies also in other European regions (such as Central and Eastern Europe) and across different continents to get a better, global, understanding of the EV diffusion process.

The present research is also valuable to the academic community for its dynamic understanding of the EV adoption process. To achieve that, it employed cross-sectional studies analyzing consumers' adoption intentions at a particular point in time. This dissertation encourages further research to apply longitudinal studies and to measure certain phenomenon repeatedly over time to grasp its evolution (Menard, 2002; Sovacool, 2014). A particularly insightful topic could be to analyze the evolution of EV-gender associations. *Paper III* and other recent contributions (Anfinsen et al., 2019;

Sovacool et al., 2019) have observed an evolving relationship between femininity and EVs, especially among EV adopters. It would be interesting to study this topic further to see how the EV-gender relationship continues to evolve with more EV types and models on the market and the growing EV market share. Finally, studies conducted as part of this dissertation could be replicated with chosen time lags to observe the evolution of the concrete phenomena over time.

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Paper I

Touchpoints for electric mobility: Investigating the purchase process for promoting sales of electric vehicles in Switzerland¹

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Abstract

Electric vehicles (EV) are critical to fulfilling global climate goals. Despite their environmental and societal benefits, only 2.2% of cars sold worldwide in 2018 were electric. To understand the reasons for the low level of EV purchasing and help define measures for more effectively promoting their sales, the vehicle purchase process should be understood. For this purpose, we studied consumer behavior literature and conducted an online survey of 553 Swiss car owners. This resulted in the generation of a novel conceptual framework of the vehicle purchase process. This consists of five stages that are underlined by differentiated decision-making strategies. Second, the results show that car dealers play a critical role at all stages of the process, but remain a barrier to EV sales. Finally, the importance of a plurality of specific information sources and of the existence of charging options is significantly correlated to EV consideration. Based on these findings, touchpoints for electric mobility at relevant stages of the vehicle purchase process are identified, and policy interventions for more effectively promoting EV sales in Switzerland are suggested.

Keywords

Electric vehicles, Vehicle purchase process, Conceptual framework, Touchpoints, Car dealers, Information sources

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1. Introduction

Responsible for 25.9% of CO₂ emissions worldwide (IEA, 2018), the decarbonization of the transport sector is absolutely critical for meeting global climate goals (UNFCCC, 2015). From the technologies presently available, battery electric vehicles (EV) have the lowest carbon footprint throughout their life-cycle in the majority of European countries (Bauer & Cox, 2019). With the expected greening of electricity mixes and improvements in battery technology, their environmental benefits should further increase (BFE, 2015; Miotti, Supran, Kim, & Trancik, 2016). EVs can also deliver important societal benefits. They can improve the health of urban residents by reducing air pollution and noise levels; they have also been found to increase traffic safety (Calef & Goble, 2005; Rezvani, Jansson, & Bodin, 2015; Taylor & Fujita, 2018). However, strong institutional leadership is required to fully exploit these potential gains and avoid any unintended consequences of EV promotion, such as increased car ownership or the inequitable distribution of financial incentives in favor of more affluent citizens (Holtmark & Skonhoft, 2014; Sareen & Rommetveit, 2019; Sovacool, 2020).

Many governments have introduced measures to promote EV sales. The latter mainly include regulation, financial incentives, and information-based interventions. For example, the European Union (EU) has implemented regulations restricting average fleet emissions to a maximum of 95 g CO₂/km driven (EC, 2019). Regulators in California and China are attempting to determine the share of EVs on their roads using a quota system (Brown Jr, 2018; Zhang & Qin, 2018). Financial incentives encompass a plurality of measures, mainly including purchase-price subsidies, and tax and roadway toll discounts and exemptions (BFE, 2015; Lieven, 2015; Mersky, Sprei, Samaras, & Qian, 2016). Finally, information-based interventions such as labels and information campaigns are designed to motivate EV purchases by raising awareness about EVs and their environmental and technological benefits (EnergieSchweiz, 2016, 2018; Heinzle & Wüstenhagen, 2012; Langbroek, Franklin, & Susilo, 2016).

Switzerland extensively supports EV sales. Private mobility accounts for two-thirds of transport-related emissions, being the most polluting single sector of the Swiss economy (31.8% of CO₂ emissions) (Boulouchos et al., 2017). To achieve its decarbonization, the Swiss government in 2018 published an Electromobility Roadmap. The goal of the strategy is for 15% of newly registered cars in Switzerland to be electric by 2022 (UVEK, BFE, & ASTRA, 2018). To achieve this goal, a plurality of measures

has been implemented, including regulations complying with EU emission standards (BFE, 2018a) and a broad range of financial incentives such as exempting EVs from import tax, decreasing or eliminating motor vehicle taxes, and direct financial incentives related to EV purchase price (BFE, 2015, 2019; Flammer, 2019; St.Gallen, 2017). Finally, a variety of infrastructure- and information-based interventions have been implemented. These range from information campaigns that include gamification components and test drives to free parking for EVs and the development of charging infrastructure (Basel-Stadt, 2019; DIV, 2020; EnergieSchweiz, 2019; Keller, 2018; Khiat, 2017; St.Gallen, 2019; Swiss-eMobility, 2019). Additionally, all cars in Switzerland must be presented with an energy label showing their CO₂ emissions and energy efficiency, thus highlighting the environmental benefits of EVs (BFE, 2018b; St.Gallen, 2019).

Despite this extensive engagement, EV market share remains very limited. Only 2.2% of cars sold worldwide in 2018 were electric (Bunsen et al., 2019); in Switzerland this proportion was, at 1.8%, even smaller (BFS, 2019b). The former interventions are evidently not overcoming the barriers that prevent customers from purchasing EVs. To make progress, we need to better understand what really happens when consumers consider purchasing a vehicle, and what the key influences are that determine the outcome of this process.

Thanks to improving battery capacity and a record number of new EV models entering the market (Bunsen et al., 2019; Jolly, 2019; Transport&Environment, 2018), the technological aspects pose only a limited barrier to EV sales. In contrast, consumer preferences are becoming critically important, if not decisive, in relation to EV purchases (Taylor & Fujita, 2018). However, consumer attitudes are not constant. They evolve across time due to a multitude of developments and influences (Blackwell, Miniard, & Engel, 2006; Simon, 1957). We thus need to analyze the process consumers go through when they make decisions about vehicle purchases, including its individual stages, the cognitive processes employed therein, and the external factors that influence the outcome. Doing this will shed light on the complexity accompanying vehicle purchases and, most importantly, help identify the remaining bottlenecks that still hinder EV sales. These insights can support the identification of more effective policy measures for promoting EV purchases.

The literature on the consumer vehicle purchase process has grown in recent years. Authors agree on the complexity of the process, although opinions differ in relation to the number of stages it incorporates, which are claimed to range from two (Mueller & de Haan, 2009; Xu, Miwa, Morikawa, & Yamamoto, 2015), to four (Bamberg, 2013; Klöckner, 2014) and even five (Taylor & Fujita, 2018). The literature mainly focuses on the cognitive processes consumers employ as they proceed through the individual stages (Bamberg, 2013; Klöckner, 2014; Mueller & de Haan, 2009). The number of studies in which the external influences on the process are analyzed has also grown, with particular focus on the impact of car dealers (Cahill, Davies-Shawhyde, & Turrentine, 2014; de Rubens, Noel, & Sovacool, 2018; Hydro, Axsen, Bailey, & Kamiya, 2013; Matthews, Lynes, Riemer, Del Matto, & Cloet, 2017; Taylor & Fujita, 2018). These contributions conclude that car dealers represent a significant barrier to EV sales. This is mainly due to the limited profits dealerships make from EV sales, the lack of expertise of sales personnel who are hesitant to offer EVs to customers, and the unavailability of EVs in stores that prevents customers from experiencing and potentially test driving them (Cahill et al., 2014; de Rubens et al., 2018; Matthews et al., 2017; Taylor & Fujita, 2018). Taylor and Fujita (2018) call for further investigation into the complexities of the purchase experience at car dealerships.

The present research has two main objectives. First, it aims to increase understanding of the complexity of the consumer vehicle purchase process. Better knowledge of its individual components and determinants (namely, its individual stages and the external influences that determine them), would represent an important contribution to the growing literature on the topic, and may resolve some of the remaining debates. Second, the goal is to analyze the vehicle purchase process of Swiss car owners so that touchpoints for fostering EV sales in Switzerland can be identified, and related policy measures proposed. The present study thus has implications for both the scientific community and policymakers.

To achieve these goals, we reviewed the literature in the field and conducted an online survey of 553 Swiss car owners. The study of the topic using a Swiss case is highly relevant. First, the challenges in Switzerland are very representative of wider global problems. Despite increasing governmental support (BFE, 2015; UVEK et al., 2018), only 1.8% of newly sold vehicles in 2018 were electric (Bunsen et al., 2019). Second, with Switzerland's transport sector being responsible for one-third of country's

CO₂ emissions (BAFU & UVEK, 2019), yet one of the cleanest electricity mixes in Europe (Cox & Bauer, 2018), supporting EVs is highly relevant and can importantly help meet national energy and climate goals (Bundesrat, 2018).

The paper is organized as follows. Section 2 presents the literature review, based on which a novel conceptual framework of the vehicle purchase process is developed, and research questions are formulated. Section 3 describes the methodology of the online survey; Section 4 presents the results, and Section 5 discusses the implications of these in relation to individual research questions. Section 6 summarizes the paper's conclusions, suggests policy implications, and discusses the limitations of the present study and avenues for further research.

2. Theoretical background and research questions

2.1. Stage models of the vehicle purchase process

Drawing on influential models of consumer behavioral change – namely, the Engel-Kollat-Blackwell (EKB) Model (1968) and the transtheoretical model of behavioral change of Prochaska and DiClemente (1994), the majority of authors see the activity of purchasing a vehicle as a process that occurs over time and progresses through qualitatively distinct stages (Bamberg, 2013; Klöckner, 2014; Mueller & de Haan, 2009; Taylor & Fujita, 2018). The number of stages, however, differs within each model. Mueller and de Haan (2009) identify two such stages. First, customers quickly screen all possible alternatives from which the choice set of potential vehicles to purchase is preselected. At the second stage, these cars are subject to more detailed analysis, from which the final vehicle to purchase is chosen. Xu et al. (2015) similarly apply a two-stage model to study the choices of consumers in Japan before and after an eco-car promotion policy was implemented.

Building on the model of action phases of Gollwitzer and Heckhausen (Gollwitzer, 1990; Heckhausen & Gollwitzer, 1987), Bamberg sees behavioral change as progressing through four distinct stages – pre-decisional, pre-actional, actional, and post-actional. As described in his stage model of self-regulated behavioral change (Bamberg, 2013), progression through these is guided by the formation of goal intention between the pre-decision and pre-actional stage, behavioral intention between the pre-actional and actional stage, and implementation intention between the actional and the last, post-

actional stage. Applied by Bamberg to the decisions that guide consumers to reduce their car use (Bamberg, 2013), Klöckner further elaborated the model and directly employed it in an analysis of the decisions of Norwegian consumers interested in an EV purchase (Klöckner, 2014). While retaining the four stages, the author replaced the post-actional, maintenance stage, by a purchase stage. As he states, since an EV purchase is an important investment, once the car is purchased, it will not be returned. Therefore, Klöckner's model of the vehicle purchase process ends with the purchase of a vehicle, not with its maintenance and use (Ibid.).

Finally, Taylor and Fujita (2018) build directly on the work of Engel, Kollat and Blackwell and their followers (Blackwell et al., 2006; Darley, Blankson, & Luethge, 2010). They see the vehicle purchase process as composed of five stages; in line with the EKB model, they call these problem recognition, search, alternative evaluation, purchase, and post-purchase (Taylor & Fujita, 2018). In contrast to the majority of models for analyzing the vehicle purchase process (Klöckner, 2014; Mueller & de Haan, 2009), they do not see the alternative evaluation of pre-selected vehicles as directly leading to the final vehicle purchase. They rather perceive it as resulting in an evoked set, a very narrow set, usually including only one to two vehicles, that consumers are willing to purchase. Final selection, however, is subject to a set of additional influences beyond the consumer's preferences and attitudes. As such, Taylor and Fujita (2018) enrich the stage models by highlighting the role of additional influences on the vehicle purchase, such as car dealers and peers.

2.1.1. Cognitive processes

Multiple mechanisms guide the consumer through the different stages of the vehicle purchase process. As partially seen in the description of the two-stage model of the vehicle purchase process of Mueller and de Haan (2009), these can be classified into two main, consecutive, categories: the pre-choice screening of options, and choice-related evaluation. First, individuals go through all available options from the total set of available vehicles and quickly decide on those they will further consider for potential purchase. This pre-choice screening involves a so-called compatibility test that uses non-compensatory criteria to assess individual vehicles (Beach, 1993). Consumers focus on the most important attributes, about which they are not willing to compromise (Bettman & Park, 1980; Payne, 1976; Ursic & Helgeson, 1990). Not fulfilling any particular criteria or standard is considered a violation (Beach, 1993). Depending on the

number and severity of violations, the vehicle either passes the compatibility test or does not. Vehicles that pass the test are classified into a so-called consideration set, usually containing between five and six options (Hauser, Ding, & Gaskin, 2009; Taylor & Fujita, 2018). These vehicles consequently undergo deeper evaluation.

The second, so-called alternative evaluation stage of the decision-making process is based on a different set of criteria and processes. Moreover, it is also separate from the pre-choice screening (Hauser et al., 2009). As such, recorded differences between individual products are eliminated and the evaluation starts from zero (Beach, 1993). The decision-making processes applied at this stage are more complex than in the previous one, and involve comparing individual products along multiple attributes. Criteria are compensatory; they can be partially met, while failure to satisfy one can be compensated by fulfilling another one (Payne, 1976; Ursic & Helgeson, 1990). According to some contributions, this stage results in the vehicle purchase (Klößner, 2014; Mueller & de Haan, 2009). Other authors, like Taylor and Fujita (2018), identify an intermediate step between alternative evaluation and the purchase stage; this involves the creation of a so-called evoked set of preferred vehicles for purchase. This set is very small, usually consisting of only one to two cars. Which one is finally purchased is subject to a number of influences external to the customer's preferences and attitudes, such as the availability of the vehicle, purchase experience, or recommendations from peers (Taylor & Fujita, 2018).

2.2. Marketing literature – the AIDA model, its elaborations and touchpoints

Understanding the purchase process has been one of the key preoccupations of the marketing literature. One of the most common tools for its analysis is the so-called AIDA model. This defines the purchase process as a set of progressive steps, leading from Awareness, Interest and Desire, to Action (AIDA) (Hanlon, 2013). Being very general, many authors have refined the model to better correspond to the complexity of the consumer purchase process, one such iteration being Betancur's NAITDASE model (2014). Composed of seven consecutive stages (need, attention, interest, trust, desire, action, satisfaction / evaluation), the model provides a more accurate understanding of the individual steps within the purchase process. It thus helps marketers navigate the vehicle purchase process and suggests what objectives they should attempt to meet at

individual stages so that their products are accepted throughout the process and ultimately purchased.

Second, marketing literature enriches the understanding of the vehicle purchase process through the important concept of touchpoints. Touchpoints are any episodes of interaction between customers and the product (Baxendale, Macdonald, & Wilson, 2015; Hogan, Almquist, & Glynn, 2005; Stein & Ramaseshan, 2016), and are multiple and complex. To illustrate, Duncan (2005) identifies four general types of touchpoints: company initiated (e.g., company website, promotional messages), consumer initiated (e.g., inquiries by customers), intrinsic touchpoints (experienced while purchasing or using a product), and unexpected touchpoints (any experience with the product such as via media or discussions with friends). Baxendale et al. (2015) define six concrete touchpoints; namely, brand advertising, retailer advertising, in-store communication, word of mouth, peer observation, and traditional media.

In terms of utilizing touchpoints, authors point out that it is necessary to focus on a narrow sample that best fits the particular situation and group that is to be targeted (Hogan et al., 2005; O'Cass, 2002; Stephen & Galak, 2012; Trusov, Bucklin, & Pauwels, 2009). This observation is even more relevant for policymakers, who often have limited resources and face public scrutiny regarding the effectiveness of their interventions. Consequently, policymakers must make informed decisions about which touchpoints are the most applicable, at which particular stage of the purchase process customers should be targeted, and how to structure their messages to achieve their goals.

2.3. Conceptual framework of the vehicle purchase process

Combining insights from the stage models of the vehicle purchase process with a detailed analysis of the employed cognitive processes and concepts from the marketing literature leads to the generation of a novel conceptual framework of the vehicle purchase process (see Figure 1). This consists of five stages, in line with the EKB Model (Engel et al., 1968) and the findings of Taylor and Fujita (2018), specified as problem recognition, search, alternative evaluation, purchase, and post-purchase. The framework is illustrated using the funnel model adapted from the marketing literature (Clow, 2013; Mueller & de Haan, 2009). This indicates the individual stages of the vehicle purchase process, the cognitive processes that are involved therein, and the sets of vehicles that

are generated to guide the process. Additionally, components of the NAITDASE model are highlighted at the bottom of the funnel.

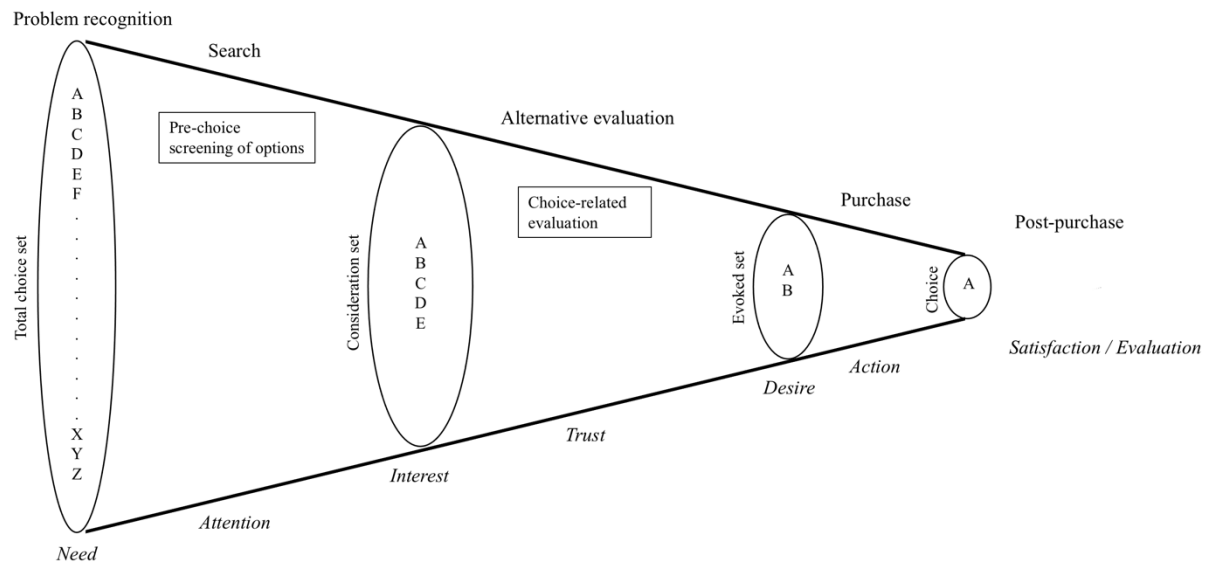


Figure 1. Conceptual framework of the vehicle purchase process.

Sources: Stages of the vehicle purchase process and vehicle sets (Blackwell et al., 2006; Darley et al., 2010; Engel et al., 1968; Taylor & Fujita, 2018), Decision-making processes (Beach, 1993; Bettman & Park, 1980; Hauser et al., 2009; Mueller & de Haan, 2009; Payne, 1976; Ursic & Helgeson, 1990), Aspects of marketing literature and touchpoint development (Baxendale et al., 2015; Betancur Botero, 2014; Hogan et al., 2005; Stein & Ramaseshan, 2016).

First, the need to purchase a new vehicle arises. Search and alternative evaluation follow, representing the core decision-making stages. In line with the majority of literature (Beach, 1993; Bettman & Park, 1980; Hauser et al., 2009; Payne, 1976; Ursic & Helgeson, 1990), the conceptual framework sees these as defined by differentiated decision-making strategies. A quick, pre-choice screening of all available options from the total choice set occurs during the search phase. This is based on non-compensatory criteria and results in a consideration set that usually consists of five to six preferred vehicles. These undergo deeper evaluation at the third vehicle purchase stage: alternative evaluation. Here, a more detailed, choice-related analysis of the pre-selected vehicles on the basis of multiple compensatory criteria is conducted. This step generates an evoked set of one to two vehicles that consumers are willing to purchase. In line with Taylor and Fujita (2018) and the NAITDASE model (Betancur Botero, 2014), the conceptual framework understands the fourth purchase stage as more complex than merely selecting a car from the evoked set for purchasing. Critical influences that are often outside of individuals' control, such as car dealers and peers, affect this stage and determine which vehicle is ultimately chosen.

Car dealers seem to be especially influential for car purchases. As highlighted by a number of contributions, they are a key channel through which consumers may gather knowledge and experience about vehicles and ultimately purchase them (Cahill et al., 2014; Hydro et al., 2013). At the same time, they currently represent a critical bottleneck with regard to EV sales. Cahill et al. (2014) conclude that dealerships are often not motivated to sell EVs due to the limited profit they can make from their sales, ranging from smaller premiums to the limited background financial flow derived from service-related activity. Matthews et al. (2017) and Taylor and Fujita (2018) confirm the lacking motivation of car dealerships to offer EVs to potential customers. They point out that even car dealerships that are certified to sell EVs do not always have them on display, and / or available for test drives (Matthews et al., 2017; Taylor & Fujita, 2018). Moreover, de Rubens et al. (2018) highlight that sales associates frequently lack knowledge about EVs and thus are unable to provide information to interested customers, potentially even discouraging them from purchasing an EV.

Finally, and in contrast to Klöckner's conclusions (2014), the conceptual framework sees the fifth, post-purchase stage, as critically important in the vehicle purchase process. Consumers' experiences with a vehicle and its use determine later purchase patterns. Moreover, individuals can influence the purchase intentions of their peers by sharing positive or negative vehicle evaluations (Jansson, Nordlund, & Westin, 2017; Taylor & Fujita, 2018).

2.4. Development of touchpoints for promoting EV purchases

The novel conceptual framework of the vehicle purchase process critically enlightens policymaking with regard to how to more effectively promote EV purchases. Understanding the individual stages consumers go through when they contemplate purchasing a vehicle and the cognitive processes they employ represents the critical structure on which policymakers may anchor their interventions. Even more importantly, relevant components of the marketing literature inserted into the framework can guide policymakers towards raising the vital questions required to identify touchpoints and develop corresponding interventions at each stage of the vehicle purchase process that will promote EV purchases.

Touchpoints are created in relation to the individual stages, relevant cognitive processes and aspects of the NAITDASE model. Their combination creates the

background that individual interventions target. To help develop the former, each touchpoint is matched with navigating questions that target specific stages and parts thereof. Successfully responding to these can help develop effective interventions that correspond to the individual characteristics of the respective touchpoints and thus effectively promote EV purchases. For the five touchpoints, their individual elements, and relevant navigating questions, see Table 1.

Table 1. Process of inquiry for developing touchpoints for promoting EV purchases.

Touch point	Stage	Cognitive process	NAITDASE model	Navigating questions
1	Problem recognition		Need	What are the reasons for the car purchase? What needs do customers want to have satisfied by their cars? How can the need for an EV be generated, rather than for other vehicles?
2	Search	Pre-choice screening of options	Attention	What are the major criteria based on which customers select the consideration vehicle set? What information sources do consumers consult when searching for information relative to their potential car purchase? What are the most important influences determining search phase? How and where can attention be attracted to EVs so that they are incorporated into the consideration set?
3	Alternative evaluation	Choice-related evaluation	Trust	What are the major criteria based on which customers select the evoked set? What information sources do consumers consult when evaluating pre-selected cars? What are the most important influences determining the alternative evaluation phase? How can trust be generated in the capacity of EVs so that they are incorporated into the evoked set?
4	Purchase		Action	What are the main vehicle purchase channels? How can we ensure that an EV is purchased?
5	Post-purchase		Satisfaction / Evaluation	What are the criteria determining customer satisfaction with car use? How can we make sure that customers are satisfied when using EVs, and positively evaluate them to their peers?

Note: The table is based on a synthesis of insights from the paper thus far; namely, the literature review summarized in Section 2.

2.5. Research questions

The aim of the research is to increase understanding of the complexity of the vehicle purchase process, and to identify touchpoints within it to help promote EV purchases in Switzerland. Following suggestions for more rigorous research (Sovacool, Axsen, & Sorrell, 2018), an online survey was chosen as the best method for achieving this

objective. The goal of the survey was to first confirm the validity of the generated conceptual framework of the vehicle purchase process. Following the ongoing debates in the literature, this especially concerns the number of stages it consists of. Second, the survey was designed to generate empirical data in relation to the vehicle purchase process of Swiss car owners; namely, to identify its main influences. Based on this knowledge, touchpoints for promoting EV sales in Switzerland can be identified.

Accordingly, the present research is guided by the following three research questions:

1. What does the consumer vehicle purchase process look like? Namely, how many stages does it consist of?
2. What are the most important factors influencing the vehicle purchase process?
3. What are the touchpoints through which EV purchases in Switzerland can be fostered?

3. Methodology

3.1. Survey and sample

The online survey was conducted in December 2018. The total sample consisted of 553 Swiss car owners. Data were collected by a market research company (respondi.com) that also recruited and compensated the respondents. To be eligible to participate, respondents were required to be between 20 and 70 years old, and their household had to possess at least one car. These conditions guaranteed that respondents had some experience with a car purchase.

Accordingly, a representative sample of the Swiss adult population in terms of sex, language regions, and education was recruited. The sample deviated only slightly from the Swiss average in terms of age; namely, within the youngest (21 - 30 years) and the oldest (61 - 70 years) cohorts. However, the disparity in favor of an older survey sample corresponds to the average age of car owners in Switzerland (for example, this is 49.6 years in the canton of St. Gallen). People who own EVs and hybrid cars are typically even older, with an average age of 52.1 and 57.2 years, respectively (SJD-StVA, 2018). For the summary of all sample characteristics and representativeness compared to the Swiss population, see Table 2.

Table 2 additionally shows that the sample was representative of the Swiss population in terms of number and type of cars owned. The resulting minimal share of EV owners in the sample is also the reason why the majority of the data analysis involves a comparison of respondents who had already considered purchasing an EV (hereafter, “EV adopters”) and those who had not (“EV non-adopters”), as opposed to EV owners and non-owners. The relevant survey question showed that the proportion of these two groups is comparable to that found by other studies in Switzerland (Cousse & Wüstenhagen, 2018).

Table 2. Sample characteristics of survey respondents and the Swiss population.

Source of information about the Swiss population: Sex, age and language region (BFS, 2017), Level of education (SAKE, 2017), Number of cars owned (Biedermann et al., 2017), Type of car engine (BFS, 2019a), EV consideration (Cousse & Wüstenhagen, 2018).

Category	Variable	Survey sample (N = 553)	Swiss population
Sex	Female	51.5%	50.4%
	Male	48.5%	49.6%
Age ^a	21-30	11.6%	18.7% ^b
	31-40	18.2%	21.2% ^b
	41-50	20.4%	21.5% ^b
	51-60	20.8%	22.4% ^b
	61-70	28.8%	16.3% ^b
Language region	German	72.3%	70.7%
	French	25.0%	24.7%
	Italian	2.2%	4.3%
	Rhaeto-Romanic	0.5%	0.3%
Level of education	Primary education	14.1%	12.2%
	Secondary education	41.2%	45.2%
	Tertiary education	44.7%	42.6%
Number of cars owned	1	60.0%	62.8%
	2	35.3%	29.5%
	3 and more	4.7%	7.7%
Type of car engine	Petrol	73.6%	67.7%
	Diesel	21.9%	29.9%
	Natural gas	0.5%	0.3%
	Hybrid	3.2%	1.7%
	Electric	0.8%	0.4%
EV consideration	Yes - “EV adopters”	32.7%	40.7%
	No - “EV non-adopters”	67.3%	59.3%

^a Despite the set age restrictions, one respondent was older than 70 years old (0.2%). Therefore, the figures in the column for the age category do not sum up to 100%.

^b The Swiss average was adjusted to the survey criteria (i.e., age between 20 and 70 years old). Including the whole population, the Swiss averages are: 12.5% (21-30 years), 14.1% (31-40 years), 14.3% (41-50 years), 14.9% (51-60 years) and 10.9% (61-70 years) (BFS, 2017).

3.2. Questionnaire and measures

The survey was divided into five sections. Respondents were first asked to select their preferred language (either German or French) and were introduced to the project as part of which the survey was conducted. Individual survey questions then followed, later to be divided into three groups - validation of the generated conceptual framework of the vehicle purchase process, the role of individual influences, and EV consideration. Finally, data about the socio-demographic characteristics of the respondents were collected. In total, the respondents were presented with 30 to 55 items, depending on their navigation within the survey (modified by survey-embedded filters related to the number of cars respondents owned, EV consideration etc.).

The first group of questions analyzed the validity of the conceptual framework by simulating the progress along the individual stages. Accordingly, the respondents were first asked about their vehicle ownership; namely, how many cars they possess, what type of motor(s) the car(s) have and, most importantly, via what channel and why they purchased them. Through this process, how the need for a new vehicle arises and the main purchase channels could have been identified, delivering important information that helped validate the ideas about the first and fourth stage of the vehicle purchase process. Second, questions relating to the search and alternative evaluation stage followed. Namely, the role of a multitude of information sources was tested. Moreover, the number of car models considered at each stage was analyzed with the goal of identifying the number of cars included in consideration and evoked vehicle sets. Questions relative to the post-purchase stage of the vehicle purchase process inquired into the determinants of customer satisfaction with car, in particular EV, use, giving hints about potential ways how to increase EV purchase willingness. For the list of questions applied to help validate each of the vehicle purchase process stages and their type, see Table 3.

Table 3. Questions and their type relative to the analysis of each stage of the vehicle purchase process.

Stage	Questions in the survey	Question type
Problem recognition	Why did you purchase your last car?	Multiple-choice
Search	Which information sources do you consider important when you search for information about cars? – General information about cars	Likert scale type (five-point)
	How many different car models did you look at (online or physically) when you were obtaining information about the purchase of your car?	Single-choice

Alternative evaluation	Which information sources do you consider important when you search for information about cars? – Car choice	Likert scale type (five-point)
	Among how many car models did you make the final purchase decision?	Single-choice
Purchase	Where did you purchase your last car?	Single-choice
Post-purchase	Why did you not purchase an EV? (question asked to people who had already considered purchasing an EV)	Multiple-choice
	How helpful would each of the following items be in relation to increasing your willingness to purchase an EV?	Likert scale type (five-point)

Second, the role of individual influences on the vehicle purchase process was tested. Besides the information sources that were directly relevant to the vehicle purchase process stages, the influence of the energy label for cars, car dealers, and peers was analyzed. Questions relative to each of the three latter influences and their type can be seen in Table A1 in Appendix A. Finally, the third group of questions was designed to help with the analysis of the process of EV consideration, including the reasons for and against EV purchase willingness and how this may be increased. Relevant questions and their typology can be seen in Table A2 in Appendix A.

We analyzed the survey data using SPSS software. We applied linear regression models, mainly analysis of variance (ANOVA) and cross-tab analysis. Additionally, we performed principal component analysis (PCA) on a number of survey items. Responses to individual questions were mainly appraised through answers to single, multiple-choice, and Likert-scale-type questions. For the latter, a five-point scale was used (1 = very important, 2 = rather important, 3 = rather not important, 4 = not at all important, and 5 = not applicable). Consequently, the lower the overall score, the more important the survey respondents perceived the information source to be. For individual calculations, data validity was increased by excluding respondents who indicated “not applicable” (as a result, the total number of respondents per question varies).

4. Results

4.1. Validation of the conceptual framework of the vehicle purchase process

Questions simulating progress along the five stages of the newly generated conceptual framework of the vehicle purchase process were all considered relevant by respondents, thus confirming its validity. For the individual questions and corresponding answers, see Table 4.

First, the reason for purchasing a new car was identified in terms of a number of factors. The most important of these was the fact that a previous car had broken (29.0% of cars in the sample were purchased for this reason) or was technically obsolete (11.8%), followed by a regular replacement of a car (19.0%), new life situation (18.5%), appealing design (16.9%), and a good offer from a car dealer (12.1%).

The presence of the two core decision-making process stages - search and alternative evaluation - in which potential vehicles for purchase are analyzed, and preferred ones chosen, was also confirmed by the study. As can be seen in Table 4, the importance of individual information sources increased across these two stages, with the most important factors being test drives and personal meetings with car dealers. The phenomenon of the generation of a consideration and evoked set of preferred vehicles was also proven. To illustrate, 59.7% of respondents indicated that they had looked at 2 - 5 cars, and 11.8% at 6 - 10 cars when collecting information about a potential car purchase. These numbers significantly dropped in relation to the final purchase; 37.6% of respondents focused on one car only, while 47.9% made a decision between two cars. The literature confirms the survey outcomes, concluding that the consideration and evoked set typically consists of 5 - 6 and 1 - 2 cars, respectively (Hauser et al., 2009; Taylor & Fujita, 2018).

Third, the survey found that the purchase stage is critically dominated by car dealers; 73.8% of vehicles owned by respondents were purchased via the former. Other purchase channels are consequently less prominent; 8.1% of the vehicles were purchased via friends and family, the online environment (websites of the used-car stores, portals selling cars, and websites of the car brand) accounted for 9.0% of all vehicle sales.

The survey results also confirmed that the final vehicle purchase process stage, post-purchase, exists. Namely, the maintenance and service were identified as the fourth most important reason to visit a car dealer (as indicated by 11.4% of respondents) if the visit was not conducted in relation to the vehicle purchase. This stage appears to be especially important in relation to EV purchase willingness. When respondents were asked about the reasons for not purchasing an EV, the perceived limited range of EVs and the complexity of charging options were identified as the second and third most important barriers by 40.1% and 32.6% of respondents, respectively (the high price of EVs still represented the most important barrier, indicated by 72.7% of survey respondents).

Similarly, the availability of charging services was found to be key to increasing willingness to purchase an EV. More public charging options and charging stations located at the apartment buildings in which people live were considered the most important means of increasing EV purchase willingness (seen as very helpful by 55.7% and 42.8% of respondents, respectively), followed by the possibility to obtain charging options together with an EV at the point of sale (39.2%), and the option to return an EV after one month of use (31.7%).

Table 4. Responses to questions relative to each stage of the vehicle purchase process.

Stage	Questions in the survey	Responses
Problem recognition	Why did you purchase your last car? (n = 553)	Most important reasons for purchasing a new car: 1. Previous one broken - 29.0% 2. Regular car replacement - 19.0% 3. New life situation - 18.5% 4. Technical obsolescence of the previous car - 11.8% 5. Appealing design - 16.9% 6. Good offer from car dealer - 12.1%
Search	Which information sources do you consider important when you search for information about cars? – General information about cars (n = 551)	Most important information sources when searching for information about potential cars to purchase (the share of respondents choosing “very important” / overall score): 1. Test drives - 42.5% / 1.99 2. Personal meetings with car dealers - 29.4% / 2.21 3. Website of the car brand - 21.4% / 2.36 4. Friends and family - 16.3% / 2.59 5. Energy label for cars (Swiss EnergieEtikette) - 14.2% / 2.67 6. Online car configurators - 14.1% / 2.68
	How many different car models did you look at (online or physically) when you were obtaining information about the purchase of your car? (n = 553)	How many cars respondent looked at: 1: 23.7% 2 - 5: 59.7% 6 - 10: 11.8% 11 - 15: 1.8% 16 - 20: 0.3% 21 or more: 2.1%
Alternative evaluation	Which information sources do you consider important when you search for information about cars? – Car choice (n = 550)	Most important information sources when deciding on the final car to purchase (the share of respondents choosing “very important” / overall score): 1. Test drives - 52.4% / 1.77 2. Personal meetings with car dealers - 38.9% / 2.06 3. Website of the car brand - 24.2% / 2.34 4. Energy label for cars (Swiss EnergieEtikette) - 17.1% / 2.62 5. Friends and family - 16.2% / 2.58 6. Online car configurators - 16.2% / 2.63
	Among how many car models did you make the final purchase decision? (n = 553)	Among how many cars was the final decision made: 1 - 37.6% 2 - 47.9% 3 - 11.0% 4 - 0.5% 5 or more - 2.4%

Purchase	Where did you purchase your last car? (n = 553)	Channel for last car purchase: 1. Car dealer - 73.8% 2. Friends and family - 8.1% 3. Online: website of a used-car store - 7.3% 4. Used car store - 5.3% 5. Online: portal that sells cars - 1.1% 6. Online: website of the car brand - 0.6%
Post-purchase	Why did you not purchase an EV? (question asked to people who had already considered purchasing an EV) (n = 172)	Most important reasons why an EV was not purchased: 1. Too expensive - 72.7% 2. Range would not meet my needs - 40.1% 3. Charging too complicated - 32.6% 4. Unavailability of a model I would want - 26.7% 5. Would not fulfill my demands (technological) - 12.8%
	How helpful would each of the following aspects be in terms of increasing your willingness to purchase an EV? (n = 530)	Most important aspects to increase EV purchase willingness (the share of respondents choosing “very helpful” / overall score): 1. More public charging options - 55.7% / 1.73 2. The existence of charging options at my apartment building - 42.8% / 2.30 3. Charging options could be obtained together with an EV - 39.2% / 2.05 4. Option to return the EV after one month of use - 31.7% / 2.31 5. More charging options at my workplace - 28.7% / 2.76 6. Buying of used EV was possible - 21.5% / 2.59

4.1.1. Post-purchase stage and EV consideration

The post-purchase stage of the vehicle purchase process is critical in relation to EV purchase willingness. Responses to the last question in Table 4 are particularly informative in this regard. Besides the results discussed above, analysis of the former revealed statistically significant correlations between all 10 items offered as its individual responses. Consequently, we decided to conduct a principal component analysis (PCA), a widely used method in the social sciences, to increase the interpretability of datasets while preserving their informative value (Jolliffe & Cadima, 2016; King & Jackson, 1999). First, the PCA showed that the items can be differentiated into three components whose Eigenvalue is higher than 1. Each component contains several items that are positively associated with the component (cut-off point for the coefficient of 0.3, in line with the standards used elsewhere) (Northstone, Ness, Emmett, & Rogers, 2008; Todhunter, 2015). The items that contributed to the first component were all associated with charging options; namely, the desire for more public charging options, the possibility to purchase charging together with an EV, the existence of charging options at apartment buildings, and more charging options at respondents'

place of work. The second component involved personal contacts and included the items friends and family recommended an EV, and car dealer recommended an EV. In contrast, the third component was associated with the technical aspects of EVs; namely, the possibility to lease an EV, to lease a battery for the EV, to return an EV after one month of use, and to purchase a used EV. For data related to this PCA, see Appendix B.

Comparison of the importance of the three aforementioned components for EV adopters and EV non-adopters revealed important results. Component 1 (Charging options) and Component 3 (EV technical aspects) were significantly more important for EV adopters than EV non-adopters. In contrast, no statistically significant difference between the groups was found for Component 2 (Personal contacts). See Table 5 for the mean averages, standard deviations, and ANOVA.

Table 5. Means and ANOVA: Perceived importance of the three components related to EV purchase willingness; Comparison between EV adopters and EV non-adopters.

Component	Mean and standard deviation		ANOVA
	EV adopters (n = 181)	EV non-adopters (n = 349)	
1 Charging options	M = -0.27, SD = 0.80	M = 0.14, SD = 1.06	$F_{(1, 528)} = 21.23, p = .000$
2 Personal contacts	M = -0.87, SD = 1.04	M = 0.05, SD = 0.98	$F_{(1, 528)} = 2.07, p = .150$
3 EV technical aspects	M = -0.14, SD = 0.92	M = 0.07, SD = 1.03	$F_{(1, 528)} = 5.06, p = .025$

4.2. Influences on the vehicle purchase process

The survey analyzed the role of a number of influences on the vehicle purchase process; namely, differentiated information sources, car dealers, an energy label for cars, and peers. The data showed that a plurality of information sources and car dealers are the most important of these. Therefore, the following two sub-sections analyze these factors in detail, also with a view to their role in EV consideration.

4.2.1. Information sources

We tested the role of individual information sources in relation to the key decision-making stages: search, and alternative evaluation. The analysis showed that their perceived importance was very similar, albeit higher in the latter. To illustrate, 42.5% of respondents saw test drives as very important at the stage of search, and 52.4 % at the alternative evaluation stage. Personal meetings with car dealers were seen as very important by 29.4% of respondents at the former stage, and 38.9% in the latter. Second, the data revealed that perceiving an information source as very important was closely

related to considering it as important overall. For example, test drives were considered to be the most important information source overall, with a mean average of $M = 1.99$ at the search and $M = 1.77$ at the alternative evaluation stage. See Table 4 for detailed scores in relation to the most important information sources.

Analysis of the individual information sources revealed statistically significant correlations between them. As a result, we decided to implement PCA to see if they contributed to specific, more interpretable and generalizable, components. The first iterations of the PCA indicated that if three items are excluded (seeing an EV on the street, personal discussions with friends and family, and promotional materials from car dealers), three identical components emerge at both the search and alternative evaluation stage, with high coefficients of 0.5 and more. The exclusion of the former three items is additionally justified in view of touchpoints' identification, as will be seen in Section 5.3.

The PCA conducted for each stage of the vehicle purchase process thus included nine items that contributed to three components:

1. Specific information: Online car configurators, website of the car brand, objective car news in print media, objective car news in online media, energy label for cars
2. Personal experience: Personal meetings with car dealers, test drives
3. Generic information: Promotional materials from employer, social media

While the coefficients of individual items in each component differed slightly at the search and alternative evaluation stages, the component composition was identical. For detailed results from these two PCAs, see Appendix C and Appendix D, respectively. Comparison of the role of these three components for EV adopters and EV non-adopters highlighted important trends. The perceived importance of Components 2 (Personal experience) and 3 (Generic information) did not vary. However, Component 1 (Specific information) was considered significantly more important for EV adopters than EV non-adopters at both the stage of search ($p = 0.004$) and alternative evaluation ($p = 0.001$). For the mean averages of these three components, standard deviations, and ANOVA, see Table 6.

Table 6. Means and ANOVA: Perceived importance of the three components related to information sources; Comparison of EV adopters and EV non-adopters at the two tested stages of the vehicle purchase process.

Component	Stage*	Mean and standard deviation		ANOVA
		EV adopters (n = 180)	EV non-adopters (n = 370)	
1 Specific information	S	M = -0.18, SD = 0.98	M = 0.09, SD = 1.00	$F_{(1, 549)} = 8.55, p = .004$
	AE	M = -0.20, SD = 0.96	M = 0.10, SD = 1.00	$F_{(1, 548)} = 11.32, p = .001$
2 Personal experience	S	M = -0.03, SD = 0.95	M = 0.01, SD = 1.03	$F_{(1, 549)} = 0.18, p = .669$
	AE	M = -0.05, SD = 0.92	M = 0.03, SD = 1.04	$F_{(1, 548)} = 0.80, p = .372$
3 Generic information	S	M = 0.06, SD = 0.98	M = -0.03, SD = 1.01	$F_{(1, 549)} = 1.01, p = .314$
	AE	M = 0.09, SD = 1.05	M = -0.05, SD = 0.97	$F_{(1, 548)} = 2.34, p = .127$

* The abbreviations stand for: S – Search, AE – Alternative evaluation.

4.2.2. Car dealers

The survey revealed that overall, car dealers exert the most important influence on the vehicle purchase process. First, compared to all other factors tested, they are the most well-established for respondents, playing a role in all vehicle purchase process stages. Ninety-four percent of respondents had been to a car dealer, 64.9% of them had one car dealer they trust, and 57.7% had consulted a car dealer in relation to their last vehicle purchase. In contrast to this, 45.4% of survey respondents had seen the energy label for cars before the survey, and, even more importantly, only 4.5% of them stated that it had influenced their last vehicle purchase. Similarly, 5.6% of respondents indicated that they often consult their family and friends about cars.

This disparity is also clear when looking at the variable influence of information sources at the search and alternative evaluation stages. Personal meetings with car dealers are the second most important information source, seen as very important by 29.4% of respondents at the search and 38.9% at the alternative evaluation stage, respectively. However, their overall role is most likely much larger. As shown by the PCA related to information sources (see previous section), personal meetings with car dealers constitute a separate component together with test drives. If combined, these two information sources would be seen as very important by 71.9% of respondents at the search and 91.3% at the alternative evaluation stage. In contrast, survey respondents did not perceive energy label for cars, and personal discussions with friends and family, as so important. Only between 14.6% and 17.0% of the former perceived either of these two sources of information as very important.

Finally, car dealers are the key purchase channel, with 73% of vehicles owned by the sample purchased via the former. Their role also manifests itself at the post-purchase

stage, with service and maintenance representing the fourth most important reason to visit a car dealer (indicated by 11.4% of respondents) if the visit occurred for a different reason than the last vehicle purchase.

The data also revealed, however, that car dealers pose a barrier to EV sales. Of the respondents who had visited a car dealer in relation to their last vehicle purchase, only 5.3% indicated that the car dealer had offered them an EV during that visit. Even more interesting results are revealed if the answer is split according to EV adopters and EV non-adopters. Of the respondents who answered this question, an EV was offered to 13.8% of EV adopters, yet to only 0.5% of EV non-adopters (see Table 7). A Pearson chi-square test confirmed that the association between EV consideration and an EV being offered by car dealers to respondents during their last visit related to a car purchase was statistically significant ($Chi^2 = 24.119$, $df = 2$, $p = .000$). A likelihood Ratio chi-square test confirmed the strong statistical significance of the association ($Chi^2 = 25.131$, $df = 2$, $p = .000$).

Table 7. Cross-tab analysis between EV consideration and EV being offered by car dealers to respondents who visited a car dealer in relation to their last car purchase.

		EV offered by a car dealer to respondents during the last visit		
		Yes	No	Do not remember
Respondents	EV adopters (n = 109)	13.8%	82.5%	3.7%
	EV non-adopters (n = 191)	0.5%	94.8%	4.7%

5. Discussion and touchpoint suggestions

5.1. Research question 1: What does the consumer vehicle purchase process look like? Namely, how many stages does it consist of?

The survey proved the validity of the novel conceptual framework of the vehicle purchase process. It confirmed that it consists of five stages, both prior and post-purchase, that are guided by differentiated decision-making strategies and the generation of two vehicle sets. As such, the results contribute to the literature on stage models of the vehicle purchase process (Bamberg, 2013; Klöckner, 2014; Mueller & de Haan, 2009; Taylor & Fujita, 2018). The findings further affirm the claims about cognitive processes and the size of the individual vehicle sets. Importantly, by confirming the presence of the fifth stage, the paper addresses one of the main discussions within the literature; namely, concerning the number of stages involved in the process. As such, it

contrasts with some earlier work (Bamberg, 2013; Klöckner, 2014; Mueller & de Haan, 2009) but sides with the recent contribution of Taylor and Fujita (2018). Additionally, the findings show the critical importance of the post-purchase stage, especially for EV purchase willingness. In that, they contrast with the conclusions of Klöckner (2013), whose model ends with the purchase stage.

Second, the study expands the existing literature by adding insights from additional literature streams to the conceptual model of the vehicle purchase process; namely, marketing. These are especially valuable in relation to the identification of individual touchpoints and suggestions of policy interventions for promoting EV purchases, as will be seen in the latter part of this section.

5.2. Research question 2: What are the most important factors influencing the vehicle purchase process?

The analysis of a plurality of information sources and other influences on the vehicle purchase process (namely, car dealers, energy label for cars, and peers) showed that car dealers and the specific information sources play a key role in the final vehicle choice.

First, the relevant PCA indicated that the plurality of information sources that customers encounter at the search and alternative evaluation stages contribute to three groups. The first takes the form of a direct experience with a car provided by car dealers during personal meetings and test drives. The latter are the most important information sources overall, being equally important for both EV adopters and EV non-adopters. On the other side of the spectrum are generic information sources that are perceived by consumers (both EV adopters and EV non-adopters) as being of no particular importance; namely, car offers from employers and signals on social media. In the hypothetical middle are specific information sources; namely, online car configurators, the website of the car brand, objective car news in print and online media, and an energy label for cars. Consumers perceive all of these sources as relatively important. However, the component that they jointly contribute to is statistically significantly more important for EV adopters than EV non-adopters at both the search and alternative evaluation stage.

Second, the present study showed that car dealers represent the most important influence on the vehicle purchase process. It illustrated that the former play a critical

role during all vehicle purchase process stages, being the main purchase channel and source of information at both the search and alternative evaluation stage. Their overall role is most likely even larger, thanks to their potential joint influence with test drives. As shown by the relevant PCA, car dealers and test drivers contribute to a separate component. The present results, however, also showed that car dealers still represent an important barrier to EV sales. Only 5.3% of respondents indicated that a car dealer offered them an EV during the visit related to their last vehicle purchase. These findings support others from the literature (Cahill et al., 2014; de Rubens et al., 2018; Matthews et al., 2017; Taylor & Fujita, 2018).

5.3. Research question 3: What are the touchpoints through which EV purchases in Switzerland can be fostered?

Building on the novel conceptual framework of the vehicle purchase process and the results generated by the survey, the present research identifies three touchpoints and suggests related policy interventions for promoting EV purchases in Switzerland. For the illustration of the touchpoints identified within the relevant stages of the conceptual framework of the vehicle purchase process, see Figure 2.

The first touchpoint is based on the finding that the component comprising specific information sources (online car configurators, website of the car brand, objective car news in print and online media, and energy label for cars), is significantly more important for EV adopters than EV non-adopters. While this significant difference is also observed at the alternative evaluation stage, the present research supports the claim that this touchpoint has a greater impact at the search phase. In this stage, customers screen through all available options to gain preliminary insight into the compatibility of vehicles with their personal criteria. In contrast, a deeper analysis of vehicles occurs at the alternative evaluation stage. It involves a reduced criteria set, in relation to which a selected number of information sources rise in importance, especially test drives and car dealers (as seen in Table 4). To leverage the first touchpoint, policymakers are recommended to create a platform for coordinating the plurality of specific information sources. This platform would attract attention to all of them simultaneously, thus increasing their informative value and, in turn, consumer knowledge about EVs. Such a coordinated channel might also be more consumer friendly, with convenience having

been proven to be an important factor in EV purchases (Anderson, 1972; Priessner & Hampl, 2020).

The second suggested touchpoint builds on the finding that car dealers play a critical role in the vehicle purchase process yet represent a key barrier to EV sales. In line with the findings of the literature on this topic (Cahill et al., 2014; de Rubens et al., 2018; Matthews et al., 2017) and emerging practice in the field (EM, 2019; Kane, 2018), this paper recommends that Swiss policymakers make EV training programs obligatory for all car dealers that aim to operate in their territory. Increasing EV-related knowledge of the latter could make sales personnel less hesitant to promote EVs to potential customers, which presently occurs very infrequently, as attested by the present survey and findings of other literature (Cahill et al., 2014; de Rubens et al., 2018; Matthews et al., 2017). The knowledge obtained during such training events would be passed on by car dealers to customers during personal discussions, which are of a particular importance at the alternative evaluation stage.

Finally, the importance of the post-purchase stage of the vehicle purchase process, especially in relation to EV purchase willingness, highlights the role of use-based touchpoints in EV consideration. In view of the survey results, especially the relevant PCA showing that the component consisting of charging options was significantly more important for EV adopters than EV non-adopters, Swiss policymakers are recommended to support charging options. While one more component, that of EV technical aspects, was also significantly more important for EV adopters than EV non-adopters, policymakers do not have a leverage to influence the items that contribute to this component. Additionally, such a narrow focus is in line with the findings of other literature, suggesting to choose only touchpoints that are the most relevant in any particular situation (Hogan et al., 2005; O'Cass, 2002; Stephen & Galak, 2012; Trusov et al., 2009). Concretely, policymakers could increase the financing for the development of public charging infrastructure and facilitate the installation of charging stations in apartment buildings and workplaces. To achieve the latter goal, they could learn from the findings of the literature and emerging practice that recommend building codes include obligatory development of charging points for all new constructions, including public facilities and apartment complexes (Grayling, 2019; Lorentzen, Haugneland, Bu, & Hauge, 2017).

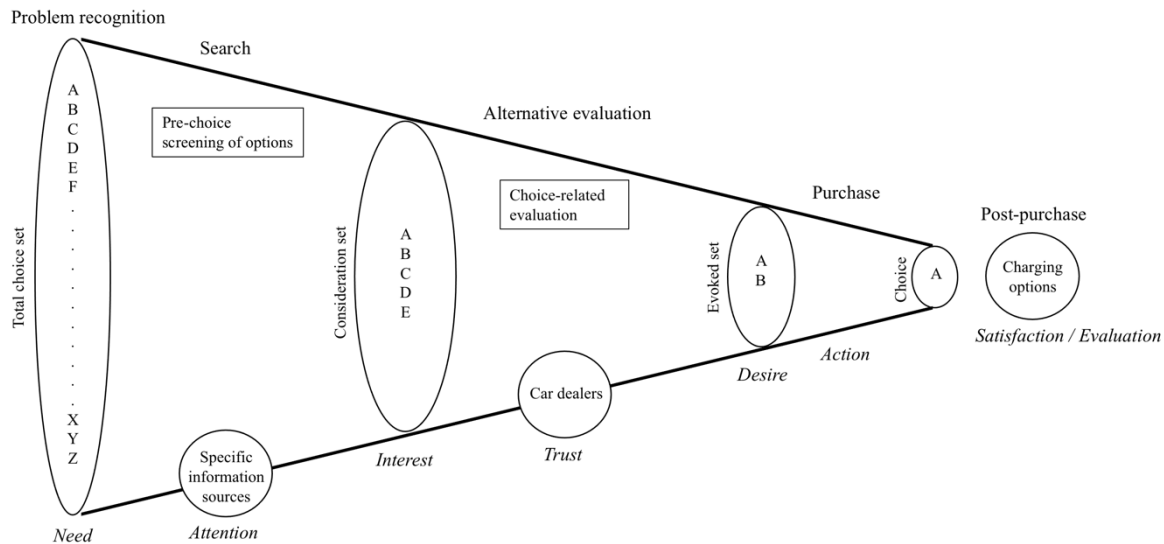


Figure 2. Suggested touchpoints for promoting EV purchases in Switzerland incorporated into the respective stages of the generated conceptual framework of the vehicle purchase process.

6. Conclusions and policy implications

6.1. General conclusions

EVs are critical to meeting global climate goals. Despite decreasing structural barriers and broad governmental support, EV sales remain very limited. The reasons for the low level of EV purchases can be identified only by analyzing the process customers go through when they decide to purchase a vehicle. Only by understanding the full complexity of the latter, including the individual stages, cognitive processes, and influences determining it, can we identify the remaining barriers to EV purchases. This knowledge, together with the tools for tackling them in the form of touchpoint understanding and way how to develop more effective interventions, can foster successful policymaking in favor of increased EV sales.

The present paper was designed with two objectives - to increase understanding of the complexity of the vehicle purchase process, and to help identify its influences and determinants in relation to Swiss car owners - so that touchpoints for promoting EV sales in Switzerland can be identified. For this purpose, the literature in the field was examined, leading to the development of a novel conceptual framework of the vehicle purchase process. The literature review also helped formulate three research questions, which were addressed by an empirical study consisting of an online survey of Swiss car owners.

The results importantly enrich the literature on stage models of the vehicle purchase process, and inform interventions for promoting EV sales in Switzerland. Namely, a novel conceptual framework of the vehicle purchase process was generated. This shows the complexity of the vehicle purchase process by highlighting its five stages, both prior and post-purchase, that are navigated through by a plurality of differentiated decision-making processes and the construction of two vehicle sets. What is especially novel about the framework is that it incorporates the aspects from marketing literature. All these components together guide policymakers in raising the vital questions to identify touchpoints and related policy interventions to successfully overcome low EV purchases.

Answering the second research question demonstrated that car dealers are the most important influence in the process. However, they were also found to represent a major bottleneck to EV sales, especially regarding those individuals who were not considering an EV purchase. Second, perceiving a plurality of information sources as very important was positively correlated with EV purchase consideration, with EV adopters seeing the component consisting of specific information sources as significantly more important than EV non-adopters. Similarly, they also saw the component comprising charging options as significantly more important than EV non-adopters. These findings indicate how the latter's EV purchase willingness can be increased.

Based on these findings, touchpoints for promoting EV purchases in Switzerland were identified and related policy interventions to overcome their specific challenges were recommended for Swiss policymakers. These involve fostering the consultation of selected information sources at the search phase, obligatory EV training programs for car dealers at the alternative evaluation stage, and supporting the development of charging options at the post-purchase stage. By that, the third research question of the present study was also responded.

6.2. Policy and practical implications

The study shows that policymakers who seek to promote EV sales should be aware of the complexity of the vehicle purchase process and its individual influences. Only through a process of inquiry leading to an understanding of the complexities of vehicle purchases in specific markets can they identify relevant touchpoints and design targeted interventions that will help them overcome the remaining barriers to EV purchasing.

This finding further confirms the observations of earlier literature that highlight the need for individual interventions to focus on particular customer segments and concrete stages of the vehicle purchase process to be effective (DellaValle & Zubaryeva, 2019; Hogan et al., 2005).

Second, and very interestingly, the identified touchpoints and suggested policy interventions for promoting EV purchases in Switzerland differ from the most commonly applied ones to date (i.e., regulation and financial incentives). They vary both in terms of the stage of the vehicle purchase process they target, and their content. The results presented herein could make policymakers aware of the complexity of the vehicle purchase process and the plurality of interventions that can be implemented at individual stages. Policymakers are encouraged to diversify their current portfolio according to this approach. They should remain especially aware of the remaining bottlenecks posed to EV purchases, particularly those created by car dealers. They are further encouraged to develop measures that protect consumers, especially vulnerable ones, such as those lacking the knowledge to engage in informed decision making, or those who have not yet considered purchasing an EV. As illustrated by the findings of the present research and relevant literature (DellaValle, 2019; Thaler, 2018), the role of car dealers as barriers to EV sales can be especially pronounced towards these particular individuals.

6.3. Limitations and further research

The present study encountered some limitations that invite for further research. The online survey delivered important insights about the vehicle purchase process of Swiss car owners that helped identify touchpoints for electric mobility within the relevant stages of the novel conceptual framework of the vehicle purchase process. Nevertheless, the empirical design of the survey could have benefitted from certain specifications. First, the time at which consumers purchased their last car and started considering an EV could be controlled for in similar future studies. The structural conditions of the market at the time of consumers' decisions and purchases might have an impact on the final vehicle choice, especially in relation to EV consideration taking into account the dynamically changing EV market (such as increasing availability of different EV models). Related to this point is the issue of the type and attributes of vehicles considered by survey respondents at different stages of the vehicle purchase process. Better knowledge of these could enrich generated data and findings, potentially allowing for clustering customers according to their preferred vehicle type and socio-

demographic characteristics. Differences in terms of the vehicle purchase process of such identified customer segments could thus be observed. Further research could consider incorporating this level of analysis.

Second, studying the topic using a Swiss case naturally limits the results and identified touchpoints to this country context. However, the case is strongly representative of a general problematic. The most important determinants of the vehicle purchase process that were identified; namely, car dealers and specific information sources, coincide with those found in other literature (Cahill et al., 2014; Chen, Xu, & Frey, 2016; de Rubens et al., 2018; Li, Long, Chen, & Geng, 2017; Matthews et al., 2017). Nevertheless, further studies in other country contexts should be conducted to confirm the general validity of the conceptual framework of the vehicle purchase process and the main study results. Of particular relevance for the applicability of the identified touchpoints would be implementing similar studies in countries with different EV market share, ranging from high (such as Norway and Iceland) to low (Italy or Belgium) (Bunsen et al., 2019; Kane, 2020).

Third, it would be desirable to investigate the effectiveness of the suggested interventions for promoting EV purchases in Switzerland in practice. To do this, Swiss policymakers could run randomized control trials (RCTs). Widely applied (Banerjee & Duflo, 2009; BIT, 2020; Kendall, 2003), RCTs allow for pre-testing the interventions on a smaller scale, thus supporting evidence-based policymaking that is consequently more effective. RCTs also facilitate creating the right conditions in which to evaluate the impact of interventions. This approach could also help overcome the last limitation of the present study. The suggested three touchpoints for promoting EV purchases in Switzerland are tailored towards specific stages of the vehicle purchase process. However, their applicability in relation to individual target groups is unknown. RCTs could also represent a means by which the effectiveness of individual interventions could be tested vis-à-vis specific target groups.

Declaration of competing interests

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

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Appendix A. Additional survey questions

Table A1. Questions and their type relative to the analysis of individual influences on the vehicle purchase process.

Influence	Questions in the survey	Question type
Energy label for cars	Which one of these is the energy label for cars?	Single-choice
	Did you see the energy label for cars before the survey?	Single-choice
	If yes, where did you see the energy label for cars?	Multiple-choice
	Did you see the energy label for cars in relation to the purchase of your last car?	Single-choice
Car dealers	Did the energy label for cars influence your last car purchase?	Single-choice
	Have you already been to a car dealer?	Single-choice
	Do you have a car dealer you trust?	Single-choice
	Did a car dealer influence your last car purchase?	Single-choice
	How strongly did the car dealer influence your last car choice?	Likert-scale type (five-point)
	How many car dealers did you visit in relation to your last vehicle purchase?	Single-choice
	What were the reasons for the visit of the car dealer? (visit relative to the last car purchase)	Multiple-choice
	What were the reasons for the visit of the car dealer? (visit not relative to the last car purchase)	Multiple-choice
Peers	Did the car dealer offer you an EV during your last visit? (visit relative to the last car purchase)	Single-choice
	I often discuss cars and which car I should purchase with my friends and family.	Likert-scale type (five-point)
	One of my friends or family members owns an EV.	Single-choice

Table A2. Questions and their type relative to the analysis of EV consideration and ways of increasing it.

EV	Questions in the survey	Question type
EV consideration	Which one of these is the energy label for cars?	Single-choice
	Did you see the energy label for cars before the survey?	Single-choice
	If yes, where did you see the energy label for cars?	Multiple-choice
	Did you see the energy label for cars in relation to the purchase of your last car?	Single-choice
	Did the energy label for cars influence your last car purchase?	Single-choice

Appendix B. Principal component analysis of items relative to the means of increasing EV purchase willingness

Table B1. Total variance explained, principal component analysis of items relative to EV purchase willingness. Three extracted components.

Initial Eigenvalues				Extraction Sum of Squared Loadings			Rotation Sum of Squared Loadings
Comp onent	Total	% of Variance	Cumulative %	Total	% of Variance	Cumul ative %	Total
1	3.639	36.386	36.386	3.639	36.386	36.386	3.071
2	1.078	10.782	47.169	1.078	10.782	47.169	2.045

3	1.029	10.294	57.463	1.029	10.294	57.463	2.496
4	.820	8.203	65.666				
5	.763	7.630	73.296				
6	.704	7.036	80.332				
7	.564	5.638	85.970				
8	.548	5.481	91.451				
9	.492	4.923	96.374				
10	.363	3.626	100.000				

Extraction Method: Principal Component Analysis.

Table B2. Pattern matrix, principal component analysis of items relative to EV purchase willingness. Direct Oblimin rotation method.

	Component		
	1	2	3
More public charging options	.808	.110	-.057
Possible to purchase charging together with an EV	.773	.019	-.004
Charging options at apartment buildings	.763	-.061	-.014
More charging options at the workplace	.639	-.014	.060
Friends and family recommended an EV	-.033	.858	.013
Car dealer recommended an EV	.046	.824	-.011
Possible to lease an EV	-.083	-.018	.844
Possible to lease a battery for EV	-.049	.074	.676
Possible to return EV after one month of use	.196	-.069	.672
Possible to purchase a used EV	.311	.122	.325

Extraction Method: Principal Component Analysis.

Rotation method: Oblimin with Kaiser Normalisation.

Table B3. Structure matrix, principal component analysis of items relative to EV purchase willingness. Direct Oblimin rotation method.

	Component		
	1	2	3
More public charging options	.821	.378	.337
Possible to purchase charging together with an EV	.778	.292	.345
Charging options at apartment buildings	.735	.205	.305
More charging options at the workplace	.661	.233	.339
Friends and family recommended an EV	.278	.851	.282
Car dealer recommended an EV	.333	.837	.281
Possible to lease an EV	.285	.231	.801
Possible to lease a battery for EV	.469	.222	.736
Possible to return EV after one month of use	.277	.280	.679
Possible to purchase a used EV	.498	.340	.503

Extraction Method: Principal Component Analysis.

Rotation method: Oblimin with Kaiser Normalisation.

Appendix C. Principal component analysis of information source items – Search stage

Table C1. Total variance explained, principal component analysis of information source items. Three extracted components.

Comp onent	Initial Eigenvalues			Extraction Sum of Squared Loadings			Rotation Sum of Squared Loadings
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumul ative %	Total
1	2.977	33.073	33.073	2.977	33.073	33.073	2.651
2	1.221	13.571	46.644	1.221	13.571	46.644	1.545
3	.999	11.097	57.741	.999	11.097	57.741	1.834
4	.869	9.658	67.399				
5	.693	7.695	75.093				
6	.612	6.795	81.889				
7	.597	6.633	88.522				
8	.571	6.347	94.869				
9	.462	5.131	100.000				

Extraction Method: Principal Component Analysis.

Table C2. Pattern matrix, principal component analysis of information source items. Direct Oblimin rotation method.

	Component		
	1	2	3
Online car configurators	.787	-.056	-.076
Website of the car brand	.728	.072	-.101
Objective car news in print media	.671	-.070	.202
Objective car news in online media	.590	.024	.262
Energy label for cars	.503	.052	-.018
Personal meetings with car dealers	-.110	.885	.001
Test drives	.151	.749	.028
Promotional materials from employer	-.101	.008	.893
Social media	.156	.035	.709

Extraction Method: Principal Component Analysis.

Rotation method: Oblimin with Kaiser Normalisation.

Table C3. Structure matrix, principal component analysis of information source items. Direct Oblimin rotation method.

	Component		
	1	2	3
Online car configurators	.747	.128	.185
Website of the car brand	.723	.116	.423
Objective car news in print media	.711	.239	.155
Objective car news in online media	.685	.197	.465
Energy label for cars	.510	.173	.159
Personal meetings with car dealers	.106	.858	.059

Test drives	.344	.789	.161	Extraction	Method:	Principal
Promotional materials from employer	.205	.080	.860			
Social media	.406	.151	.766			

Component Analysis.

Rotation method: Oblimin with Kaiser Normalisation.

Table C4. KMO and Bartlett's Test, principal component analysis of information source items.

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		.798
Bartlett's Test of Sphericity	Approx. Chi-Square	852.073
	Df	36
	Sig.	.000

Table C5. Component correlation matrix, principal component analysis of information source items. Direct Oblimin rotation method.

Component	1	2	3
1	1.000	.245	.340
2	.245	1.000	.109
3	.340	.109	1.000

Extraction Method: Principal Component Analysis.
Rotation method: Oblimin with Kaiser Normalisation.

Appendix D. Principal component analysis of information source items – Alternative evaluation stage

Table D1. Total variance explained, principal component analysis of information source items. Three extracted components.

Initial Eigenvalues				Extraction Sum of Squared Loadings			Rotation Sum of Squared Loadings
Comp onent	Total	% of Variance	Cumulative %	Total	% of Variance	Cumul ative %	Total
1	3.131	34.784	34.784	3.131	34.784	34.784	2.755
2	1.242	13.796	48.580	1.242	13.796	48.580	1.604
3	.917	10.184	58.763	.917	10.184	58.763	1.825
4	.807	8.969	67.732				
5	.678	7.533	75.265				
6	.623	6.920	82.185				
7	.602	6.692	88.976				
8	.544	6.046	94.922				
9	.457	5.078	100.000				

Extraction Method: Principal Component Analysis.

Table D2. Pattern matrix, principal component analysis of information source items. Direct Oblimin rotation method.

	Component		
	1	2	3
Online car configurators	.764	-.134	-.020
Website of the car brand	.728	-.040	.133
Objective car news in print media	.631	-.082	.274
Objective car news in online media	.624	.317	-.150
Energy label for cars	.461	.146	.047
Personal meetings with car dealers	-.159	.894	.158
Test drives	.300	.637	-.097
Promotional materials from employer	-.032	.074	.872
Social media	.206	.015	.714

Extraction Method: Principal Component Analysis.

Rotation method: Oblimin with Kaiser Normalisation.

Table D3. Structure matrix, principal component analysis of information source items. Direct Oblimin rotation method.

	Component		
	1	2	3
Online car configurators	.760	.159	.364
Website of the car brand	.722	.067	.128
Objective car news in print media	.697	.097	.471
Objective car news in online media	.660	.475	.063
Energy label for cars	.515	.270	.201
Personal meetings with car dealers	.127	.859	.146
Test drives	.437	.712	.026
Promotional materials from employer	.266	.104	.865
Social media	.438	.100	.781

Extraction Method: Principal Component Analysis.

Rotation method: Oblimin with Kaiser Normalisation.

Table D4. KMO and Bartlett's Test, principal component analysis of information source items.

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		.821
Bartlett's Test of Sphericity	Approx. Chi-Square	929.329
	Df	36
	Sig.	.000

Table D5. Component correlation matrix, principal component analysis of information source items. Direct Oblimin rotation method.

Component	1	2	3
1	1.000	.264	.319
2	.264	1.000	.044
3	.319	.044	1.000

Extraction Method: Principal Component Analysis.

Rotation method: Oblimin with Kaiser Normalisation.

Paper II

Product bundling for accelerating electric vehicle adoption: A mixed-method empirical analysis of Swiss customers¹

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Abstract

The adoption of electric vehicles (EVs) is accelerating. Already knowing what factors determine EV purchases by the first innovative adopters, we now need to better understand the preferences of wider customer segments that are currently entering the market. The bundling of EVs with the necessary services is one strategy for fostering EV adoption among the latter groups. While studies have concluded there is potential to increase EV customer acceptance with this strategy, empirical investigation of the most relevant and commonly applied bundle in practice, that of EV and charging services, is lacking. We address this gap by conducting an online study with future Swiss EV adopters. We applied two empirical approaches: an online experiment to study the effect of this essential bundle type on EV purchase willingness, and a choice experiment to identify the preferred bundle of individual customer segments. We find that bundling of EV with charging services can effectively increase the EV purchase willingness of respondents with low pre-existing knowledge of EVs. The choice experiment identified three customer segments that we name *Tech-oriented adopters*, *Convenience-oriented adopters*, and *Likely non-adopters*. They differ in the importance scores and part-worth utilities they attach to the individual attribute levels and general preferences for the bundle. Based on these results we recommend that policymakers financially and

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administratively support bundles of EV and charging services, and we propose avenues for further research.

Keywords

Electric vehicles, charging services, product bundling, knowledge, choice experiment, latent class analysis

Highlights

- Broader customer segments are purchasing electric vehicles (EVs).
- Online experiment, and choice experiment with a representative Swiss sample.
- EV-charging bundles increase purchase intent of customers with low EV knowledge.
- Three customer segments with differentiated bundle preferences.
- Financial and administrative support of EV-charging bundles recommended.

1. Introduction

Decarbonizing the transport sector is necessary for meeting global energy and climate goals (Gnann et al., 2018; IEA, 2020b; Li, Long, Chen, & Geng, 2017; Mukherjee & Ryan, 2020). To achieve this, strong focus should be put on private mobility, since this accounts for almost half of transport carbon dioxide (CO₂) emissions (Teter, 2020). Electric vehicles (EVs) are currently the most suitable technology for this purpose. Multiple studies have confirmed their environmental benefits compared to internal combustion engine (ICE) vehicles (Bauer & Cox, 2019; Hoekstra, 2019; Miotti, Supran, Kim, & Trancik, 2016). They are expected to further grow with the ongoing greening of electricity mixes and the improvements in battery technology (C2ES, 2019; Gomes, Perez, & Suomalainen, 2020; Martínez-Lao, Montoya, Montoya, & Manzano-Agugliaro, 2017; Scrosati, Garche, & Tillmetz, 2015).

The adoption of EVs is accelerating. The global EV market share in 2019 was 2.6% (IEA, 2020a), an increase of 18.0% on the previous year (Bunsen et al., 2019). Despite the COVID-19 pandemic, EV sales have continued to grow. The first projections for 2020 suggest that EV market share in Europe will reach 10.0% (Mathieu & Poliscanova, 2020). This substantial increase in EV sales also means that the group of potential EV customers is diversifying beyond the first EV buyers. The former however have different characteristics and product preferences (Moore, 1991; Rogers, 2003).

The existing literature has extensively mapped the socio-demographic characteristics of the first EV adopters and the factors determining their purchases of EVs (Gnann et al., 2018; Hardman, Shiu, & Steinberger-Wilckens, 2016; Li et al., 2017; Mukherjee & Ryan, 2020). Currently implemented policies, besides mandates and regulations, thus mainly involve the provision of financial incentives for EV purchase and information aimed at increasing consumers' knowledge about EV technology and their environmental profile (Brown Jr, 2018; Holtmark & Skonhoft, 2014; Kester, Noel, Z., & Sovacool, 2018; Lieven, 2015; Martínez-Lao et al., 2017; Zhang & Qin, 2018). Later adopters of innovations have however been observed to be more price sensitive, less technologically savvy, less interested to increase the related knowledge and more convenience-oriented (Janssen & Jager, 2002; Rogers, 2003; Wüstenhagen, Markard, & Truffer, 2003). Future policies should thus account for these characteristics to better stimulate EV purchases among later EV adopters, whose preferences the present study helps understand.

Product bundling has been observed to be a successful marketing strategy for promoting the purchases of pro-environmental products among later adopter groups (BIT, 2013; Carroll, Samek, & Zepeda, 2018; Deal, Cochran, & LaRocco, 2012). Bundles of EVs and additional services, especially charging, have thus been offered by car manufacturers and providers of charging services (BMW, 2020; Plug'nRoll, 2020a; Tesla, 2020). A number of studies have analyzed the role of this marketing strategy on EV customer acceptance. The authors conclude about the positive role of the latter (Bernhart, Zhang, & Wagenleitner, 2010; Bohnsack, Pinkse, & Kolk, 2014; Cherubini, Iasevoli, & Michelini, 2015; Priessner & Hampl, 2020; Stauch, 2021). They however either do not empirically analyze the effect of the suggested bundles (Bernhart et al., 2010; Bohnsack et al., 2014; Cherubini et al., 2015), or empirically test bundles not yet implemented in practice, such as EV together with photovoltaic solar panels (PV) and battery storage (Priessner & Hampl, 2020), community solar investments (Stauch, 2021), or car-sharing and other mobility services (Fojcik & Proff, 2014; Hinz, Schlereth, & Zhou, 2015). Empirical investigation of the bundles currently most commonly offered in practice – EVs and charging services – is still lacking. Considering the convenience orientation, weaker technological aptitude and relevant knowledge yet higher price sensitivity of prospective EV customers, this essential bundle type might become very relevant. This is why it is key to understand if this bundle can effectively increase the EV purchase willingness of future EV customers, and, if so, which bundle compositions are preferred by the individual consumer segments. We thus aim to answer the following three research questions in our investigation:

1. *Does bundling of EV with charging services increase the EV purchase willingness of future Swiss EV adopters?*
2. *What is the bundle composition preferred by future Swiss EV adopters?*
3. *What are the compositions of the bundles preferred by individual segments of future Swiss EV adopters?*

To answer the research questions, we conducted an online study that employed two empirical approaches - a between-subject design experiment, and a choice experiment. We designed the empirical investigation in collaboration with the project partner, a Swiss electric utility, with whom we developed the attributes and levels of the bundle of EV and charging services to test (Plug'nRoll, 2020a). The choice of Switzerland as a case study is appropriate for investigating the role of bundling for broader EV customer

groups. The EV market share in Switzerland is further increasing, having grown from 12.6% in 2019 to the (expected) 14.2% in 2020 (BFS, 2021). Bundling of EVs with charging services might thus be especially attractive for future Swiss EV customers who are transitioning from the early adopters to broader consumer segments (Rogers, 2003). Second, a number of providers offer bundles of EV and charging services in practice (BMW, 2020; Plug'nRoll, 2020a; Tesla, 2020), thus making the study more relevant to respondents.

The paper is structured as follows. Section 2 provides a literature review that elaborates on the characteristics of individual adopter groups, theories of product bundling and its analysis within EV adoption research. Section 3 describes the study, outlining its methodology and analyzes the data thereby generated. Section 4 summarizes the main results, which are discussed in Section 5. Section 6 concludes the paper by highlighting its implications for policy and practice, reflecting on the limitations of the study and proposing avenues for further research.

2. Literature review

2.1. Characteristics of individual adopter groups

The idea of categorizing consumers into adopter categories was famously coined by Everett Rogers in his Diffusion of Innovations Theory (Rogers, 2003). In analyzing the process of innovation diffusion across society, the author divided consumers into five groups based on the time when they adopt an innovation. He called the groups *innovators*, *early adopters*, *early majority*, *late majority*, and *laggards*. The *innovators* tend to be the most innovative, i.e., adopt the innovation first since they are more venturesome, technologically savvy, and possess a high level of knowledge related to the innovation and its complexities which they are eager to deepen (Rogers, 2003). Other authors also agree with Rogers that these consumers are only a small niche of the total population (approximately only 2.5%), typically being rather young, with higher socio-economic status than the majority of the population, thus also being less risk averse since they are capable of absorbing potential losses (Chen, de Rubens, Noel, Kester, & Sovacool, 2020; Hardman et al., 2016; Mukherjee & Ryan, 2020; Rogers, 2003). The level of innovativeness progressively decreases across later adopter groups, who are increasingly price sensitive, risk averse and less venturesome. Due to their limited technological orientation and interest in deepening the related knowledge, they

rely less on their own assessment of the technological capacities of innovations, and rather look for cues from social environment. These cues can also cater to their higher convenience orientation. Later adopter groups have been found to have a stronger preference for satisficing outcomes than for deeper engagement with products and investing time and effort into their assessment and understanding (Berry, Seiders, & Grewal, 2002; Candel, 2001; Harris & Blair, 2006; Moore, 1991; Rogers, 2003; Voli, 1998).

2.2. Product bundling – definition and effectiveness

Product bundling is a very common marketing strategy, successfully applied to motivate consumer choices in a broad range of areas such as hospitality, leisure and mobility (Adams & Yellen, 1976; Burstein, 1960; Stigler, 1963; Stremersch & Tellis, 2002). Stremersch and Tellis (2002) propose the most unified and accepted definition and typology of bundling to date, seeing it as “the sale of two or more separate products in one package” (Ibid., p. 55). The authors classify bundles according to two dimensions – form, and focus. While the former can be further divided into pure, mixed, and unbundled strategies (with the company offering either only a bundle, bundle and products separately, or only individual products), Stremersch and Tellis (2002) identify two focal types of bundles: price, and product. Individual bundle types differ in how they generate value for consumers. To illustrate, while the main advantage of price bundles is that they are cheaper than purchasing components individually, product bundles deliver value to consumers by strategically combining complementary aspects and components (Reinders, Frambach, & Schoormans, 2010; Stremersch & Tellis, 2002). It is thus a strategic decision of the company which form of bundle, and with which focus, to offer to customers. This choice depends on broader systemic conditions, the company’s competitive advantage, and the preferences of individual customer segments (Harris & Blair, 2006; Sharpe & Staelin, 2010; Wüstenhagen et al., 2003).

The literature agrees that the effectiveness of bundles is determined by three conditions – complementarity, risk, and convenience (Harlam, Krishna, Lehmann, & Mela, 1995; Reinders et al., 2010; Stremersch & Tellis, 2002). First, authors claim that bundles are more effective if they incorporate highly synergistic products, such as television sets or restaurant menus (Harris & Blair, 2006; Johnson, Herrmann, & Bauer, 1999; Karataş & Gürhan-Canli, 2020; Sharpe & Staelin, 2010). Harlam et al. (1995);

Reinders et al. (2010) also conclude that the willingness to adopt innovations is dependent on the level of the perceived fit between the combined components.

Second, bundles increase the value of products that involve a high level of risk. This is especially relevant for innovations that are novel to consumers, thus unfamiliar and associated with uncertainty (Rogers, 2003; Sarin, Sego, & Chanvarasuth, 2003). Reinders et al. (2010) show that the bundling of radical innovations with products that are already familiar to consumers may effectively promote the sales of the former. However, this effect was recorded only for consumers with a low level of prior knowledge of relevant components. The claim that product bundling is an especially effective and desirable strategy for consumers with low levels of pre-existing knowledge about the relevant components has been supported also by other authors (Harlam et al., 1995; Harris & Blair, 2006; Spiller & Zelner, 1997).

Third, bundles are seen as especially effective if they increase user convenience – i.e., by decreasing the time and effort spent on the purchase, be this cognitive or physical (Berry et al., 2002; Gehrt & Yale, 1993; Yale & Venkatesh, 1986). Harris and Blair (2006) focus on one particular aspect of the latter: search and assembly costs. Studying preferences for stereo equipment, the authors conclude that it is especially consumers that are less involved with a product and who are not motivated to search for information who prefer bundle offers to obtaining components individually. A similar conclusion was arrived at by Candel (2001), who identified a preference for convenience food products (such as TV dinners) among consumers who were not interested in food generally, and who did not enjoy cooking.

2.3. Bundling in EV adoption literature

The EV adoption literature concludes that many additional services are necessary for EV use and operation. Authors have started categorizing these, investigating their importance and potential for increasing EV adoption intention among customers. Cherubini et al. (2015) identify four sub-systems relevant for the operation of EVs – the vehicle, electronics on board, energy, and infrastructure. Similarly, Bernhart et al. (2010) divide essential value-added services included in mobility offers into four categories: financial & insurance, telematics, mobility & energy, and technical services. While the respective contributions find different elements to be of key importance, they generally agree that the inclusion of additional services in joint bundles with EVs at the

point of sale would increase EV customer acceptance (Bernhart et al., 2010; Cherubini et al., 2015; Ensslen et al., 2018; Krommes & Schmidt, 2017; Weiller, Shang, Neely, & Shi, 2013).

A number of contributions have analyzed bundles of EV and additional services in an experimental setting. Hinz et al. (2015) applied a two-step hybrid stated preference approach to identify the preferred components of German consumers. The authors identify IT-based parking and payment, intelligent charging stations, and augmented reality services via head-up displays as the most promising features for increasing EV customer acceptance. Two recent studies have focused on the bundling of EVs with renewable energy options. Priessner and Hampl (2020) analyzed a combined offer of an EV, PV, and battery storage for households. Also applying a stated preference approach, they found that the suggested bundle has a positive effect on the intention to adopt EV of EV adopters in Austria. Stauch (2021) conducted an online experiment that involved testing the effect of a bundle that combined an EV with community solar investment on the EV purchase willingness of German consumers. The author found that the bundle was preferred to purchasing only an EV, regardless of whether the bundle was discounted.

3. Methods and data

3.1. Methodology and sample

We conducted an online study that employed two empirical approaches: a between-subject design experiment, and a choice experiment. Data were collected from August 26 to September 10, 2019. The online experiment involved testing a bundle combining an EV with a private charging station to be accessed via an app, the installation thereof, access to the public charging network through pre-paid credit and a green electricity certificate. The bundle was developed in cooperation with the project partner, a Swiss electric utility, which at the time was offering these components only individually (and after the experiment implemented the bundle in practice (Plug'nRoll, 2020b)). The bundle examined in the choice experiment was larger, also including components identified in the literature and based upon discussions with the project partner as desirable to future EV adopters, such as vehicle insurance and battery assistance (Bernhart et al., 2010; Cherubini et al., 2015; Ensslen et al., 2018).

The total sample was 313 Swiss respondents; the conditions of participation included being older than 18 years old, and in possession of a driver's license. The sample was determined by an initial question about interest in EVs. Respondents who indicated no interest in EVs were screened out since consumers who have a negative attitude towards EVs are not likely to purchase an EV soon.

Respondents were recruited by a market research agency that distributed a financial reward upon participation. The sample was representative of Swiss adult population in terms of sex, age, and language spoken in the country. Since the German- and French-speaking regions represent 85.1% of Swiss population (BFS, 2020a), the study was run in the former two languages. See Table 1 for socio-demographic data of the sample and the Swiss population in general.

Table 1. Socio-demographic data of the study sample and Swiss population.

Category	Variable	Study sample (N = 313)	Swiss population
Sex	Female	50.8%	50.4%
	Male	49.2%	49.6%
Age*	18-29	17.6%	17.3%
	30-39	16.9%	17.4%
	40-49	18.2%	16.9%
	50-59	17.9%	18.3%
	60-69	13.1%	13.4%
	70+	16.3%	16.7%
Language region**	German	74.4%	73.0%
	French	25.6%	27.0%

Sources: Sex, age: (BFS, 2020b), Language region: (BFS, 2020a).

Note: * If all age categories are considered, the proportions of the individual age groups are: 18-29 (14.2%), 30-39 (14.3%), 40-49 (13.9%), 50-59 (15.0%), 60-69 (11.0%), 70+ (13.7%) (BFS, 2020b).

** If all languages spoken in the country are considered, the proportions are: German (62.2%), French (22.9%), Italian (8.0%), Rhaeto-Romanic (0.5%), Others (6.4%) (BFS, 2020a).

3.2. Between-subject design experiment – design and stimuli

To answer the first research question, we conducted a single-factor, between-subject design experiment with two experimental conditions and one control. All participants were first introduced to the choice situation through the following scenario: “Imagine that you need a new car. The car of your preferred brand and model is available with an internal combustion engine, or with an electric motor. Both vehicles are comparable in terms of price, especially if the total cost of ownership (TCO) is considered.” We stressed the availability of the preferred EV model and the comparability of the price of the two vehicle technologies to limit the effect of these two common barriers to EV purchases (Li et al., 2017; Plananska, 2020; Rezvani, Jansson, & Bodin, 2015).

After the introduction, participants directed to the first experimental condition were informed about the equipment needed to operate an EV – namely, a private charging station, its installation, access to the public charging network, a smartphone app to locate public charging stations, and a green electricity certificate. Respondents in this condition were told that all these components could be obtained from various individual providers before or after an EV purchase (see Appendix A for the information provided and a visual representation of Experimental condition 1). Making this information salient just before measuring the dependent variable of the study, the EV purchase willingness, and stressing that customers would need to search for appropriate providers of individual components, was used to demonstrate the complexity associated with the operation of an EV.

In the second experimental condition, respondents were exposed to the same information about the additional equipment necessary for EV operation. However, they were also told that they could obtain all of the individual components, together with an EV, in a bundle at the point of sale. The bundle was also graphically illustrated, as seen in Appendix B. Thus, the respondents of this experimental condition were informed about the complexity associated with an EV purchase, yet also provided with an easy solution for overcoming it.

The control group was not provided with any information about different charging equipment, or prompted about the components necessary for operating an EV. After the initial disclaimer, they were directly asked the dependent variable question that in the experimental conditions followed the information about charging equipment. Our dependent variable question inquired about respondents' EV purchase willingness. It was measured by a seven-point Likert scale ranging from definitely not to definitely yes, answering a question "Would you buy a car with an electric motor (brand and model correspond your preferences)?" The study also included other questions related to the topic of the study. Among others, we inquired about EV-related knowledge, one of the most important factors of EV adoption (Hardman et al., 2016; Kester et al., 2018; Li et al., 2017; Plananska, 2020; Rezvani et al., 2015). We measured EV-related knowledge also by seven-point Likert scale questions. One question asked respondents to self-assess their general knowledge about EVs. We also designed a six-item scale to identify knowledge about the individual components necessary for EV operation, such as the location of public charging infrastructure or companies that could install a private

charging station. See Appendix C for the questions employed in the study, and the Cronbach alpha for the six-item scale.

3.3. Choice experiment – method

To answer the second research question, we conducted a choice experiment (Green & Rao, 1971; Louviere & Woodworth, 1983; Luce & Tukey, 1964). This method has become very popular in consumer research and marketing for identifying the customer preference structure for products with multiple attributes, mainly thanks to its practicality and specificity (Eggers, Sattler, Teichert, & Völckner, 2018; Green & Srinivasan, 1990). Its construction permits the testing of very specific details about individual product attributes in a realistic, comparison-based setting. Choice experiments have thus mainly been applied to investigate consumer preferences for innovations and products new to market. Since the attributes of the latter are still under development, eliciting consumer preferences for their individual levels might directly contribute to product design (DeSarbo, Ramaswamy, & Cohen, 1995; Gustafsson, Herrmann, & Huber, 2013). The method has been used in a broad range of areas, including customer acceptance of pro-environmental products, such as green electricity tariffs and investments in renewable energy projects (de Brauwere & Cohen, 2020; Kim, Park, & Dubois, 2018; Petrovich, Hille, & Wüstenhagen, 2019; Salm, Hille, & Wüstenhagen, 2016; Van Rijnsoever, Van Mossel, & Broecks, 2015; Vuichard, Stauch, & Wüstenhagen, 2020). Electric vehicles (namely, the preferred combination of individual attributes and accompanying mobility services) have also been investigated using this method (Hackbarth & Madlener, 2016; Hidrue, Parsons, Kempton, & Gardner, 2011; Lebeau, Van Mierlo, Lebeau, Mairesse, & Macharis, 2012; Priessner & Hampl, 2020).

The choice experiment approach simulates the decision environment by exposing respondents to a series of choices among alternative products that consist of several attributes. These product offers vary in terms of the levels of each attribute (see a sample choice task in Figure 1). The set-up usually consists of a randomly generated 8-12 choice tasks of three alternatives, and a none option (SawtoothSoftware, 2017), with the instruction to respondents to choose their preferred variant. The inclusion of the none option is optional yet recommended to better correspond to a real decision environment in which respondents can opt out of choosing a product (Eggers et al., 2018; SawtoothSoftware, 2017).

Private charging station	Yes, with app	Yes, with app	Yes, without app	NONE: I would choose none of these options
Standard installation	No, without installation	Yes, with installation	No, without installation	
Access to the public charging network with pre-paid credit	Yes, with 30 CHF credit	Yes, with 100 CHF credit	Yes, with 150 CHF credit	
Green electricity certificate for one year	Yes, for 5,000 km a year	No, no green electricity certificate	Yes, for 10,000 km a year	
Battery assistance for one year	Yes, for Switzerland	Yes, for Switzerland	Yes, for Switzerland and Europe	
Price	3,500 CHF	4,500 CHF	4,000 CHF	
Insurance for a monthly fee	No, no insurance	Yes, insurance of the vehicle, private charging station and data for 100 CHF a month	Yes, insurance of the vehicle for 50 CHF a month	
	O	O	O	O

Figure 1. Choice task example (set-up used in the present study).

3.3.1. Hierarchical Bayes (HB) analysis

Data generated by choice experiments are most commonly analyzed by Hierarchical Bayes (HB) analysis. The method is seen as superior to other approaches of the estimation of individual utilities since it permits the generation of robust data at the level of individual respondents (Chrzan, 2017; Hein, Kurz, & Steiner, 2020). To estimate the fit of the HB model in relation to predicting the utility values of respondents' choice data, Root Likelihood (RLH) and percent certainty measures are controlled for (Kurz & Binner, 2012; Vuichard et al., 2020). These both range from 0 to 1; higher levels indicate the higher predictive capacity of the model. The former is a geometric mean of the predicted probability that one option will be chosen. If the choice experiment consists of four choices (as in our scenario), the lowest level of choice probability is 0.25. The latter measure describes the success of the model. It ranges from 0% to 100%, and indicates how successful the model is at predicting the utilities respondents attach to individual attributes and their levels (Kurz & Binner, 2012; SawtoothSoftware, 2017).

HB analysis gives two outputs: the relative importance weight of individual attributes and the part-worth utilities of their levels. The latter indicates how important an attribute is in product selection. The higher the score, the more important the attribute. The importance scores of all attributes sum up to 100; they can thus be converted to percentages. This also makes it possible to compare importance levels across individual attributes and rank them based on their relevance (Eggers et al., 2018; SawtoothSoftware, 2017). In contrast, the part-worth utilities of individual attribute levels do not allow for cross attribute comparison. Instead, they show which level of

each attribute is preferred. Their scores round up to zero, with both positive and negative values for each attribute level. The higher the positive score, the stronger the positive impact on the attribute level. A negative score for the attribute level indicates the opposite; the negative impact of the attribute level on product choice (Gustafsson et al., 2013; SawtoothSoftware, 2017).

3.3.2. Latent class analysis

Market segmentation, the identification of individual customer groups and their characterization based on their preferences for a specific product set-up, is one of the main strengths and objectives of choice experiments (DeSarbo et al., 1995; Eggers et al., 2018). Latent class analysis is the method most commonly applied for this purpose (Hidrue et al., 2011; Priessner & Hampl, 2020). There are two segmentation approaches – the post-hoc, and a-priori approach (Eggers et al., 2018; Petrovich et al., 2019). While the former starts with the choice data (i.e., groups respondents who express similar choices and identifies their preferred product composition), the latter's starting point is the ideal product composition. The a-priori approach then identifies customers that share this particular preference. We applied the post-hoc approach since it better fits the objectives of our study and is also the approach more commonly applied in literature (DeSarbo et al., 1995; Priessner & Hampl, 2020; SawtoothSoftware, 2020a).

A multiple-criteria approach should be applied to identify the ideal number of segments (DeSarbo et al., 1995; Eggers et al., 2018; SawtoothSoftware, 2012). First, the computation should be run multiple times until the solutions stabilize. This is done since the computation always starts from a different point and thus to eliminate potential bias (SawtoothSoftware, 2012). Second, three criteria should be analyzed – percent certainty, Consistent Akaike Information Criterion (CAIC), and chi-square (Eggers et al., 2018; Priessner & Hampl, 2020). The scores of percent certainty and chi-square identify the reliability of the solution. The higher their value, the more preferable the solution. In contrast, the desirable number of clusters is indicated by a lower CAIC (Eggers et al., 2018; SawtoothSoftware, 2012). Consequently, the generated data should be also assessed qualitatively by analyzing the changes between individual levels. A significant drop or increase in the score in relation to the previous level indicates a possible segmentation solution (SawtoothSoftware, 2020a).

3.3.3. Design of the choice experiment

We designed the choice experiment using the Sawtooth software Lighthouse studio, one of the most common tools used for this method (SawtoothSoftware, 2020b; Steiner & Meißner, 2018). The software permits not only to design and implement the study, but also to analyze data thereby generated directly in its interface. We thus also used the software to conduct HB and latent class analysis.

The choice task was introduced by a disclaimer: “Assume that the car of your choice (brand and model) is also available with an electric engine. Together with the electric vehicle you can purchase a bundle of different products for charging. You can purchase the following products with the given options.”. This was followed by a table that listed and described the attributes tested in the choice experiment and their levels (see Appendix D).

The choice experiment was composed of eight randomly generated choice tasks of three alternatives and a none option, as illustrated in Figure 1. We chose a balanced overlap approach for their generation, as recommended by Sawtooth Software (SawtoothSoftware, 2017). This approach ensures that the individual levels appear proportionately among respondents. A disclaimer above every choice task reminded respondents of the scenario (similar to the one presented at the beginning of the choice experiment) and informed them that if they were not interested in purchasing an EV at all, they should always choose the none option. The type of EV in the choice task was not further specified beyond this disclaimer. Since the goal of the choice experiment was to identify the preferred composition of bundles applicable to different types of EVs, further specification of the individual properties of the car was not necessary. Finally, participants could have used the mouseover feature of Sawtooth to gain additional information about individual bundle attributes (similar to the ones presented in the introductory table as seen in Appendix D).

The selection of attributes and attribute levels is critical in terms of the reliability of choice experiments (Eggers et al., 2018; SawtoothSoftware, 2017). We chose ours using a mixed-method approach consisting of a literature review, internet search, and thorough collaboration with the project partner. The literature review and internet search identified the components most relevant for EV operation and those most commonly applied in preexisting bundles (Bernhart et al., 2010; BMW, 2020; Cherubini et al.,

2015; Tesla, 2020). Such pre-selected attributes and potential levels thereof were contrasted with the insights and product offers of the project partner. An iterative process of joint meetings and discussions led to the final choice of attributes and their levels. These were pre-tested by ten participants, the related data collection and analysis of which confirmed the experimental set-up. The final list of attributes included the components essential for EV operation (private charging station operated by an app, its installation, and access to the public charging network) and aspects considered non-essential yet desirable when purchasing an EV (green electricity certificate, battery assistance, and insurance)³. The chosen attribute levels represent existing product offerings and price levels deemed the most appropriate by the iterative process described above.

4. Results

4.1. Between-subject design experiment

The sample for the analysis of the between-subject design experiment consisted of 186 respondents. We filtered out owners of EVs and hybrid cars ($N = 20$) and respondents who stated that they do not intend to buy a car ever again ($N = 9$). We can assume that both groups would not react to the experimental stimuli. Second, we compared the two experimental conditions to better correspond to a real-life situation. When considering an EV purchase, customers are sooner or later confronted with the complexity of operating an EV⁴.

³ The private charging station was included in the bundle as default. Respondents could have only chosen between obtaining it with or without a smartphone app to operate it. The large majority (70-80%) of current EV drivers own and charge their car primarily at private charging stations (Engel, Hensley, Knupfer, & Sahdev, 2018). Additionally, a number of studies have confirmed its greater impact on EV adoption intentions than public charging infrastructure (Mukherjee & Ryan, 2020; Skippon & Garwood, 2011). Thus, it was a component deemed relevant for inclusion by default.

⁴ Including the control group in our analysis ($N = 284$), we find that the experimental condition of providing a bundle and the knowledge of components necessary to operate an EV explained an equally large share of the variance in willingness to purchase an EV ($R^2 = .126$, $F(5, 278) = 8.046$, $p < .001$). Knowledge of components necessary for EV operation (Cronbach alpha = .822) increases willingness to buy this new engine technology ($B = .549$, $SE = .114$, $t = 4.826$, $p < .001$). Providing a bundle to the customer increases willingness to purchase an EV marginally ($B = .352$, $SE = .203$, $t = 1.731$, $p < .1$). This is not the case when individual components for charging are enumerated ($B = .218$, $SE = .206$, $t = 1.057$, $p > .1$). Experimental condition 1 (individual components) serves as the reference group. The effect of providing a bundle is significantly qualified by the customer's level of knowledge about the components necessary to operate an EV ($B = -.339$, $SE = .150$, $t = -2.253$, $p < .05$). For customers with a low level of knowledge, bundling is effective ($B = .807$, $SE = .292$, $t = 2.766$, $p < .01$). This effect, however, becomes only marginally significant with middle level of knowledge of components ($B = .352$, $SE = .203$, $t = 1.731$, $p < .1$) and is no longer significant for customers with a high level of knowledge of the components necessary to operate an EV ($p > .1$).

We conducted regression analyses to estimate the effects of the experimental conditions on willingness to purchase an EV. We also investigated if the effect of the experimental conditions on the dependent variable was moderated by knowledge about the components necessary for operating an EV. See Table 2 for result estimations.

Table 2. Regression results of the between-subject design experiment.

	EV purchase willingness			
	B	SE	t-value	p
<i>Experimental manipulation</i>				
Constant	4.803	.155	30.883	***
Knowledge of components for EV operation ^a	.549	.115	4.767	***
Experimental condition (individual components vs. bundle)	.352	.206	1.710	+
Experimental condition by knowledge of components	-.339	.152	-2.226	*
<i>Conditional effects for different levels of knowledge of components necessary for EV operation</i>				
Low knowledge about components (- 1 SD)	.810	.296	2.734	**
Middle knowledge about components (Mean)	.352	.206	1.710	+
High knowledge about components (+ 1 SD)	-.107	.286	-.375	n.s.

Notes: *** $p < .001$; ** $p < .01$; * $p < .05$, + $p < .1$. Experimental condition 1 (Individual components) coded 0, experimental condition 2 (Bundle) coded 1.

^aCronbach alpha of the six-item scale for N = 168: .823.

The effect of providing a bundle and knowledge about the components necessary for operating an EV explained a large share of the variance in willingness to purchase an EV ($R^2 = .134$, $F_{(3, 182)} = 9.407$, $p < .001$). We observe that knowledge about the components necessary for operating an EV is a critical success factor that fosters willingness to buy this engine technology ($B = .549$, $SE = .115$, $t = 4.767$, $p < .001$). The results also demonstrate that providing a bundle to the customer as a means of decreasing the complexity encountered when purchasing an EV increases willingness to purchase this engine technology only marginally ($B = .352$, $SE = .206$, $t = 1.710$, $p < .1$). However, this effect is significantly qualified by customers' level of knowledge about the components necessary for operating an EV ($B = -.339$, $SE = .152$, $t = -2.226$, $p < .05$). As shown by the conditional effects detailed in Table 2, it is customers with particularly low levels of knowledge for whom bundling is an effective strategy ($B = .810$, $SE = .296$, $t = 2.734$, $p < .01$). The benefit of providing a bundle is not sustained with increasing levels of knowledge (middle level: $B = .352$, $SE = .206$, $t = 1.710$, $p < .1$; high level: $B = -.107$, $SE = .286$, $t = -.375$, $p > .1$). As depicted in Figure 2, the effect of bundle is actually lower than that of individual components for consumers with high levels of knowledge of components necessary for EV operation. We can assume that such consumers are already well aware of the complexity of using an EV and thus

providing a bundle is not of added value to them. Yet, as seen above, this effect is not statistically significant.

The effect of experimental conditions on EV purchase willingness in relation to the level of knowledge about components necessary for EV operation

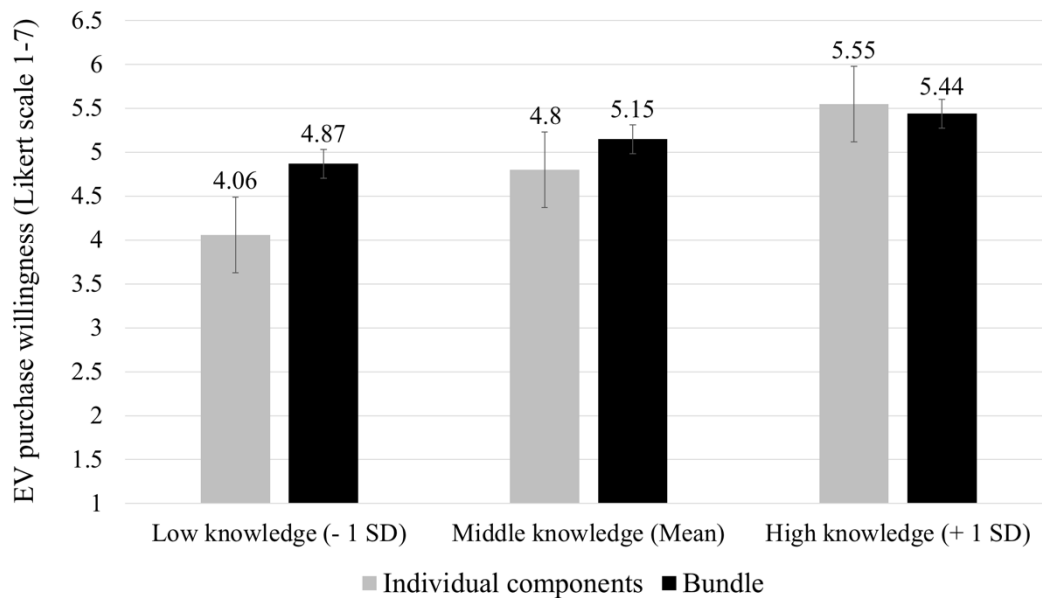


Figure 2. EV purchase willingness, the effect of experimental conditions and the level of knowledge about components necessary for operating an EV.

4.2. Choice experiment

The sample for the analysis of the choice experiment was 304 participants. From the total number of respondents ($N = 313$), we filtered out those who stated that they did not intend to buy a car in the future ($N = 9$), since the choice task would have been irrelevant to them. In contrast to the filter applied in the analysis of the between-subject design experiment, we included the owners of EVs and hybrid cars ($N = 20$). Since these respondents already have experience with operating an EV or a hybrid car, their choices can result from their experience and thus be even more relevant for the data analysis.

4.2.1. HB analysis – importance scores and part-worth utilities

The RLH and percent certainty measures show that the fit of the HB model is good, with the values 0.692 and 0.734, respectively. Consequently, we computed the importance scores of the attributes of the bundle and part-worth utilities of their levels (see Table 3). We observe that the importance of each attribute is relatively high, with scores ranging from 17.37 to 11.33. Insurance for a monthly fee is the most important factor (17.37%), followed by the installation of a private charging station (15.87%), and three closely ranked attributes: price (14.79%), green electricity certificate (14.67%),

and access to the public charging network using pre-paid credit (14.41%). Having an app for private charging station and battery assistance are perceived as the least important factors (11.56% and 11.33%, respectively).

Table 3. Hierarchical Bayes (HB) estimation, mean and standard deviation of the relative importance scores of attributes (in Italics) and part-worth utilities of attribute levels.

Attribute levels	Mean	Standard deviation
Insurance for a monthly fee (<i>m = 17.37%, SD = 8.82</i>)		
○ Insurance of your vehicle for 50 CHF a month	25.39	32.48
○ Insurance of your vehicle, private charging station and data for 100 CHF a month	-19.51	63.81
○ No insurance	-5.87	63.02
Standard installation (<i>m = 15.87%, SD = 10.51</i>)		
○ Yes, with installation	47.03	47.20
○ No, without installation	-47.03	
Price (<i>m = 14.79%, SD = 8.13</i>)		
○ 3,500 CHF	35.74	43.98
○ 4,000 CHF	2.76	29.07
○ 4,500 CHF	-38.51	44.01
Green electricity certificate for one year (<i>m = 14.67%, SD = 7.03</i>)		
○ 5,000 km	-8.01	29.11
○ 10,000 km	0.74	45.98
○ 20,000 km	12.48	41.39
○ No green electricity certificate	-5.21	53.39
Access to the public charging network with pre-paid credit (<i>m = 14.41%, SD = 4.96</i>)		
○ With 30 CHF pre-paid credit	11.93	37.44
○ With 100 CHF pre-paid credit	-10.24	42.27
○ With 150 CHF pre-paid credit	22.54	24.04
○ No pre-paid credit	-24.22	40.76
App for private charging station (<i>m = 11.56%, SD = 7.86</i>)		
○ With app	28.91	39.53
○ Without app	-28.91	
Battery assistance for one year (<i>m = 11.33%, SD = 6.66</i>)		
○ In Switzerland	8.27	30.02
○ In Switzerland and Europe	18.36	40.25
○ No battery assistance	-26.62	32.46
None	38.4	417.38

Table 3 shows that the preferred bundle composition for respondents would include the installation of the private charging station (47.03) with the app to operate it (28.91), access to the public charging network with the highest pre-paid credit of 150 CHF (22.54), the green electricity certificate for the longest driven distance of 20,000 km (12.48), the insurance of the vehicle only (25.39), and battery assistance in both Switzerland and Europe (18.36) – and this ideally for the cheapest price of 3,500 CHF (35.74). The none option is associated with a small positive value (38.4), yet it is much less than the sum of the individual attribute levels. This indicates that the bundle is

overall of value to respondents (Orme, 2018). The large standard deviation (417.38), however, shows that individual respondents vary in their assessment of the bundle and its individual attributes. The latent class analysis explains these differences.

4.2.2. Latent class analysis – customer segmentation

We applied latent class analysis to analyze individual customer segments and their bundle preferences. First, we identified the number of segments. Running the analysis multiple times showed that the ideal number is between two and five. We assessed the generated data by extrapolating percent certainty, CAIC and chi-square (see Table 4); we then identified the points at which the related values substantially changed. This multiple criteria approach led us to choose three segments. Although the highest values for percent certainty and chi-square converge on a five-segment solution, CAIC was the lowest with three. Additionally, while the values for percent certainty and chi-square increase from two to three segments by 12.21% and 10.86%, respectively, their respective growth from three to four segments is only 3.67% and 4.9%. We thus opted for three segments, the preferred bundle composition of which we then analyzed.

Table 4. Summary of best latent class replications; Percent certainty, CAIC and chi-square values.

Number of segments	Percent certainty	CAIC	Chi-square
2	24.58	5357.98	1657.65
3	27.22	5320.50	1835.87
4	28.49	5376.19	1920.93
5	29.75	5431.76	2006.09

We summarize the mean importance scores of bundle attributes and part-worth utilities that individual segments attach to their levels in Table 5. Based on the identified preferences, we call the latter *Tech-oriented adopters* ($n = 67$), *Convenience-oriented adopters* ($n = 170$), and *Likely non-adopters* ($n = 67$). We believe that members of the latter segment are likely non-adopters of the bundle first due to the high value they attach to the none option (398.04). Second, this segment attaches the lowest importance scores to the attributes green electricity certificate and the installation of the private charging station, which these respondents would actually prefer not to have included in the bundle at all. Since the installation of the private charging station is a fundamental component of the bundle offer, this segment is seen as not likely to pursue a bundle solution.

The former two segments, in contrast, are seen as likely adopters of two distinct types of bundle offers. *Tech-oriented adopters* attach substantially greater importance to the four key components of the bundle of EV and charging services – installation of the

private charging station (26.98%), price (19.21%), an app to operate the private charging station (15.39%), and access to the public charging network (12.99%). While insurance is not desired by this segment, battery assistance and a green electricity certificate are only marginally influential in terms of the choice of bundle, with respective importance scores of 8.77% and 7.66%. The part-worth utilities show that the segment would prefer a pre-paid credit card for the public charging network of the lowest value offered: 30 CHF (49.13). This may however not be due to the price sensitivity of the segment. While preferring the bundle price of 3,500 CHF (61.48), this segment is the only one that attaches positive utility to the middle-priced option of 4,000 CHF (11.50). Although the part-worth utility of the none option is positive for this segment (233.80), it is much less than the value for the sum of the individual attribute levels. Therefore, the bundle is of positive value to *Tech-oriented adopters*. They prefer a narrower set-up focusing on essential components for charging.

Convenience-oriented adopters are by far the largest segment, representing 55.9% of the sample. They are most likely to opt for the bundle, as attested to by the negative part-worth utility of the none option (-851.91). The segment prefers the most complete bundle. This is proven by the balanced importance scores the segment attaches to the individual attributes, ranging from 28.01% for installation of the private charging station to 10.60% for insurance. The part-worth utilities show that the segment would prefer the attributes of battery assistance for both Switzerland and Europe (44.36), access to the public charging network with the pre-paid credit card worth 150 CHF (40.01), a green electricity certificate for the distance of 10,000 km (39.99), and insurance of the vehicle only (31.17). The segment would prefer to have a private charging station operated by an app (38.93), and attaches the largest positive value to the lowest price of 3,500 CHF (44.36). Its strong preference for the bundle is demonstrated by the fact that it is the only segment that attaches negative part-worth utilities if either of the components is not included.

Table 5. Latent class analysis, mean of the relative importance scores of attributes (in Italics), and rescaled part-worth utilities of attribute levels of the three identified segments.

<i>Attributes</i>	<i>Segment name and size</i>		
	Tech-oriented adopters (n=67)	Convenience-oriented adopters (n=170)	Likely non-adopters (n=67)
App for private charging station	(<i>m = 15.39%</i>)	(<i>m = 11.12%</i>)	(<i>m = 22.47%</i>)
○ With app	52.86	38.93	78.64
○ Without app	-53.86	-38.93	-78.64

Standard installation	(<i>m</i> = 26.98%)	(<i>m</i> = 28.01%)	(<i>m</i> = 3.35%)
○ Yes, with installation	94.42	98.05	-11.73
○ No, without installation	-94.42	-98.05	11.73
Access to the public charging network with pre-paid credit	(<i>m</i> = 12.99%)	(<i>m</i> = 13.82%)	(<i>m</i> = 13.44%)
○ With 30 CHF pre-paid credit	49.13	8.03	17.20
○ With 100 CHF pre-paid credit	-25.08	8.75	-39.93
○ With 150 CHF pre-paid credit	17.77	40.01	54.17
○ No pre-paid credit	-41.83	-56.79	-31.44
Green electricity certificate for one year	(<i>m</i> = 7.62%)	(<i>m</i> = 11.42%)	(<i>m</i> = 9.26%)
○ 5,000 km	-24.52	-15.09	-32.89
○ 10,000 km	-10.39	39.99	-10.51
○ 20,000 km	28.81	15.07	11.48
○ No green electricity certificate	6.10	-39.97	31.92
Battery assistance for one year	(<i>m</i> = 8.77%)	(<i>m</i> = 14.03%)	(<i>m</i> = 10.36%)
○ In Switzerland	18.03	9.51	-0.88
○ In Switzerland and Europe	21.68	44.36	36.69
○ No battery assistance	-39.71	-53.87	-35.80
Price	(<i>m</i> = 19.21%)	(<i>m</i> = 10.98%)	(<i>m</i> = 23.35%)
○ 3,500 CHF	61.48	44.36	98.60
○ 4,000 CHF	11.50	-11.66	-33.74
○ 4,500 CHF	-72.98	-32.60	-64.87
Insurance for a monthly fee	(<i>m</i> = 9.04%)	(<i>m</i> = 10.60%)	(<i>m</i> = 17.77%)
○ Insurance of your vehicle for 50 CHF a month	19.19	31.17	82.35
○ Insurance of your vehicle, private charging station and data for 100 CHF a month	-41.24	11.85	-40.31
○ No insurance	22.05	-32.60	-42.03
None	233.80	-851.91	398.04

5. Discussion

5.1. Research question 1: Does bundling of EV with charging services increase the EV purchase willingness of future Swiss EV adopters?

The between-subject design experiment proved that bundles can be an effective strategy for fostering the EV purchase willingness of future EV adopters. In this, we join the literature that finds bundling of EVs with additional services to be an effective way to promote EV customer acceptance (Fojcik & Proff, 2014; Hinz et al., 2015; Priessner & Hampl, 2020; Stauch, 2021). We however expand the existing literature by an empirical investigation of the essential and most commonly applied type of bundle to date – that of an EV and charging services, which has not been empirically investigated thus far. Confirming its positive effect on the EV purchase willingness of future EV adopters in Switzerland could encourage car manufacturers and electricity providers

who offer this type of bundle to continue in this and develop related marketing strategies (BMW, 2020; Plug'nRoll, 2020a; Tesla, 2020).

Additionally, our research addresses the gap identified by Cherubini et al. (2015); Priessner and Hampl (2020) which concerns identifying the factors that determine the effectiveness of bundling of EVs with additional services. Importantly, we find that bundling of an EV with charging services significantly increases the EV purchase willingness of those consumers with a low level of pre-existing knowledge about the components necessary for operating an EV. This confirms earlier findings that bundling is especially effective for such consumers (Harlam et al., 1995; Harris & Blair, 2006; Reinders et al., 2010; Spiller & Zelner, 1997). The lack of EV-related knowledge has been stated to be one of the biggest remaining barriers to EV sales (Egbue & Long, 2012; Kester et al., 2018; Li et al., 2017; Plananska, 2020; Rezvani et al., 2015). The broader segments that currently enter the market are expected to be less technologically savvy and knowledgeable than the first EV buyers (BFS, 2021; Mathieu & Poliscanova, 2020; Rogers, 2003). Addressing this issue through product bundling might thus become even more relevant for fostering EV sales.

5.2. Research question 2: What is the bundle composition preferred by future Swiss EV adopters?

The choice experiment showed that the provision of a bundle of EV and additional services would be of value to future EV adopters. The high importance attached to all attributes offered as part of the tested bundle indicated that components other than charging services, such as insurance and battery assistance, are desirable to future Swiss EV adopters. We thus answer the call of Cherubini et al. (2015) to analyze the effect of multiple services bundled together with an EV, and confirm the conclusions of Hinz et al. (2015); Priessner and Hampl (2020); Stauch (2021) and others that the latter strategy increases EV customer acceptance.

The ideal composition of the bundle reveals the preferences of future Swiss EV adopters. First, the fact that insurance is perceived as the most important attribute, and battery assistance is preferred in its most complete form (both in Switzerland and Europe) might indicate the growing risk aversion of prospective EV adopters (Moore, 1991; Rogers, 2003). This factor might be further influenced by familiarity with the product, since any newly registered vehicle in Switzerland has to be insured (Bundesrat,

2020). Second, the price was neither the most important attribute (scoring 14.79%; ranked third in importance), nor were EVs desired only at the lowest cost. In fact, even the middle price point of 4,000 CHF delivered a positive – albeit small – part-worth utility to respondents (2.76). Accordingly, we show that future Swiss EV adopters are not as price sensitive as those consumer segments that may consider an EV purchase only later. We thus contribute to the ongoing discussion in the literature about this topic and provide further evidence that price is not the most important determinant of EV purchase willingness among EV adopters (Priessner & Hampl, 2020; Stauch, 2021). However, both the strong preference for insurance and the lower price sensitivity of future Swiss EV adopters may be a cultural characteristic, with Switzerland having among the highest GDP per capita in the world (WorldBank, 2021), and Swiss people generally being rather risk averse (Allen, 2019).

Finally, the large standard deviation of the part-worth utility attached by respondents to the none option (417.38) indicated heterogeneity within our sample. This finding is in line with other contributions that found heterogeneity of clean innovation adopters (Priessner & Hampl, 2020; Salm et al., 2016; Vuichard et al., 2020; Wüstenhagen et al., 2003) and invited their further investigation through latent class analysis.

5.3. Research question 3: What are the compositions of the bundles preferred by individual segments of future Swiss EV adopters?

The latent class analysis revealed that the sample can be divided into three distinct consumer segments which we named *Tech-oriented adopters*, *Convenience-oriented adopters*, and *Likely non-adopters*. The fact that within the Swiss future EV adopters there is still a significant proportion of customers (22.0%) for whom the bundle of EV and additional services does not represent added value confirms the findings of Priessner and Hampl (2020). The authors also found a segment of Austrian EV adopters who would most likely not opt for a bundle of EV, PV, and battery storage. Our finding also highlights that there are no “one-size fits all” solutions for fostering EV adoption. We need to understand the preferences of individual customer segments and carefully craft strategies to address their specific needs (DellaValle & Zubaryeva, 2019; Gnann et al., 2018; Mukherjee & Ryan, 2020; Plananska, 2020).

The fact that the two identified adopter segments have distinct bundle preferences further confirms claims about the heterogeneity of adopters of clean innovations

(Priessner & Hampl, 2020; Salm et al., 2016; Vuichard et al., 2020; Wüstenhagen et al., 2003). The smaller yet still a substantial group of *Tech-oriented adopters* (22.0%) would prefer the smaller bundle of EV and charging services only, similar to the bundles currently offered in practice (BMW, 2020; Plug'nRoll, 2020a; Tesla, 2020). This segment strongly prefers the inclusion of the private charging station, its installation, and access to the public charging network, and this at the lowest possible pre-paid credit of 30 CHF. The members of this segment would prefer not to have insurance included in the bundle at all, while battery assistance and a green electricity certificate are only of negligible importance to them. This finding confirms and should also encourage the providers of the essential bundle of EV and charging services that there is a distinct segment, even within future EV adopters, that would prefer this bundle type.

The by far largest segment – *Convenience-oriented adopters* (55.9% of the sample) – have even stronger preferences for a bundle, leading to a strong negative part-worth utility attached to the none option. This segment prefers a bigger bundle that includes all of the offered attributes (and attaches very high importance to all of them). Additionally, they are also the only segment that is associated with a negative part-worth utility if any of the offered attributes is lacking. This further confirms the previous findings about the desirability of bundles of EVs and additional services beyond charging (Fojcik & Proff, 2014; Hinz et al., 2015; Priessner & Hampl, 2020; Stauch, 2021); it may encourage the actors in the field to develop these types of EV-additional services bundles. With the growing convenience-orientation of forthcoming adopter groups (Janssen & Jager, 2002; Rogers, 2003; Wüstenhagen et al., 2003), we can assume that this bundle type will further grow in importance at later stages of EV diffusion.

6. Conclusions

The present research investigated the potential of bundling of EV with additional services to accelerate EV adoption among forthcoming customers. We conducted mixed-method research to answer three research questions. These were aimed at increasing understanding of whether bundles of EV and charging services can increase the EV purchase willingness of future Swiss EV adopters, and what the preferred composition of a bundle of EV and additional services should be in general, and for individual customer segments.

Our study first showed that bundles of EV and charging services can increase the EV purchase willingness of future Swiss EV adopters. This effect was, however, moderated by the level of knowledge about the components necessary for operating an EV. Concretely, the bundle was effective only in relation to consumers who had a low level of pre-existing knowledge. Accordingly, we addressed a literature gap, the lack of empirical investigation of this essential bundle type that is most commonly implemented in practice (BMW, 2020; Plug'nRoll, 2020a; Tesla, 2020). We also answered the call for an analysis of the factors based on which bundles of EV and additional services are effective (Cherubini et al., 2015; Priessner & Hampl, 2020). We also showed that bundling can be a desirable marketing strategy for the forthcoming EV adopter groups, and thus advanced the discussion in this and other journals about the factors determining the EV purchases of customers other than the first innovative EV owners (Egbue & Long, 2012; Gnann et al., 2018; Kester et al., 2018; Li et al., 2017; Mukherjee & Ryan, 2020; Rezvani et al., 2015).

The choice experiment showed that bundling of EV with additional services is in general desirable for future EV adopters. However, within the latter group we identified three customer segments with differentiated bundle preferences. While *Likely non-adopters* would not opt for such a bundle, *Tech-oriented adopters* would prefer the currently offered, narrow essential bundle containing an EV and charging services only. The largest segment (constituting more than half of the sample) was the *Convenience-oriented adopters*. These consumers would obtain the greatest utility from a larger bundle that includes an EV and additional services (next to charging also insurance, battery assistance, and a green electricity certificate). This highlights the heterogeneous preferences of the adopters of clean innovations and confirms that solutions to foster EV adoption have to be carefully geared towards individual market segments and their specific needs (Gnann et al., 2018; Plananska, 2020; Priessner & Hampl, 2020; Salm et al., 2016; Vuichard et al., 2020).

6.1. Implications for policy and practice

Our findings have important implications that lead to several recommendations for policy and practice. We show that bundling of EV with charging services can address some of the most pressing barriers to EV sales; namely, limited knowledge, and the complexity of charging (Egbue & Long, 2012; Kester et al., 2018; Li et al., 2017; Rezvani et al., 2015; Tran, Banister, Bishop, & McCulloch, 2013). We thus recommend

that policymakers promote bundling of EV with charging services in their interventions, first by financially subsidizing them. This can be done on top of, or even replace, the incentives that presently exist to motivate EV purchases. Research has shown that investments in charging are often more effective and cheaper than the provision of EV purchase price subsidies (Sierzechula, Bakker, Maat, & Van Wee, 2014; Skippon & Garwood, 2011).

Second, we recommend policymakers support EV and charging bundles administratively. They should put in place legislation that obliges all new housing developments to incorporate infrastructure conducive to the installation of charging stations. This could include either the construction of charging stations on the parking lots of shopping malls and city parking, or the development of code systems, ownership structures, and infrastructure in community garages that meet charging needs of multiple households (EM, 2019; Kester et al., 2018; Mukherjee & Ryan, 2020). Policymakers can also develop guidelines regarding the standards and oblige technical personnel to participate in related trainings (EM, 2019; Kester et al., 2018; Martínez-Lao et al., 2017).

Based on our findings, we suggest that practitioners pursue a mixed-bundling strategy (Stremersch & Tellis, 2002). First, we recommend car manufacturers and electricity providers continue offering bundles of EV and charging services since they appear to be an effective and desirable option for specific consumer segments (BMW, 2020; Plug'nRoll, 2020a; Tesla, 2020). Similarly, the continuing offering of components necessary for EV operation individually is also seen by us as desirable since particular consumers do not prefer the bundle option. Finally, we recommend that practitioners develop more complete bundles of EV and additional services. Besides charging, this should also incorporate the insurance of the EV, battery assistance, and a green electricity certificate. With the growing convenience-orientation of broader adopter groups (Moore, 1991; Rogers, 2003), the importance of this bundle type, already desirable by more than half of the sample, is expected to further grow.

6.2. Limitations and further research

Despite its notable strengths, namely being the first contribution to empirically investigate the bundle of EV and charging services and in detail analyzing the preferences of forthcoming EV adopters, the research involved some limitations that

invite for further research. First, our study measured respondents' stated preferences. Further research could investigate revealed preference data by moving closer to the purchase decision and analyzing the role of product bundling in practice. We can envision using the already existing bundles, or developing the broader bundle preferred by the *Convenience-oriented adopters*. The latter might thus allow to test in practice the effectiveness of the bundle concluded by this research as the most desirable by future Swiss EV adopters.

Second, the number of attributes and the levels thereof that could be tested in the choice experiment had to be limited. It would be informative to investigate attributes and / or levels other than those selected for the present study. One option would be to test a bundle that does not include a private charging station by default. This offer could be of interest to customers living in apartment buildings who cannot install their own private charging station. Further research could also investigate if customers who prefer different EV models have different bundle preferences. Would buyers of more economical EVs prefer less extensive bundles, or vice versa? With a growing number of EV models entering the market (McKerracher, Izadi-Najafabadi, O'Donovan, & Albanese, 2020), the specification of the car type and model will become increasingly relevant in all future studies of EV adoption.

Finally, the study was conducted with a Swiss representative sample, thus being the first research to analyze the role of bundling on EV adoption intentions in the latter country. Although the results are generalizable to other countries at similar stages of EV diffusion, it would be relevant to replicate the study in countries further along the EV adoption curve. Norway and Iceland, the frontrunners in EV adoption globally (IEA, 2020a; Kane, 2020), could be ideal examples. Additionally, it would be informative to conduct the study in countries outside of Europe to control for potential cultural determinants of bundle preferences, such as the above-mentioned stronger preference for risk mitigating components (namely, insurance) and the lower price sensitivity of Swiss customers (Allen, 2019; WorldBank, 2021).

Author contribution statement

Jana Plananska: Conceptualization, Methodology, Formal analysis, Investigation, Writing - Original Draft, Writing – Review & Editing, Visualization. **Karoline Gamma:** Conceptualization, Methodology, Formal analysis, Writing – Review & Editing, Funding acquisition.

Declaration of competing interests

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

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Appendix A. Between-subject design experiment, Experimental condition 1 – Individual components

To use an electric vehicle, it has to be regularly charged.

This can be done at home at a **private charging station**, which should be installed by technical personnel. You can also (or additionally) charge the car through access to the public charging network.

Moreover, you can download a **smartphone app** that shows you the public charging network in Switzerland and Europe, as well as the free charging stations. You can also manage and pay for the charging progress at public charging stations.

You can also decide to charge your electric car with electricity from renewable energy sources. For this, you can obtain a certificate which guarantees a renewable electricity mix for a given number of kilometers.

You can obtain these individual components after or before the purchase of an electric car from various providers. You can find the information and offers of the individual providers on the internet.



Private Ladestation für zu Hause (diverse Anbieter)



Installation privater Ladestation (diverse Installateure)



Zugang zum öffentlichen LadeNetzwerk (diverse Anbieter)



Ökostrom-Zertifikat (diverse Anbieter)



Smartphone App mit Anzeige öffentliches LadeNetzwerk (diverse Anbieter)

Appendix B. Between-subject design experiment, Experimental condition 2 – Bundle

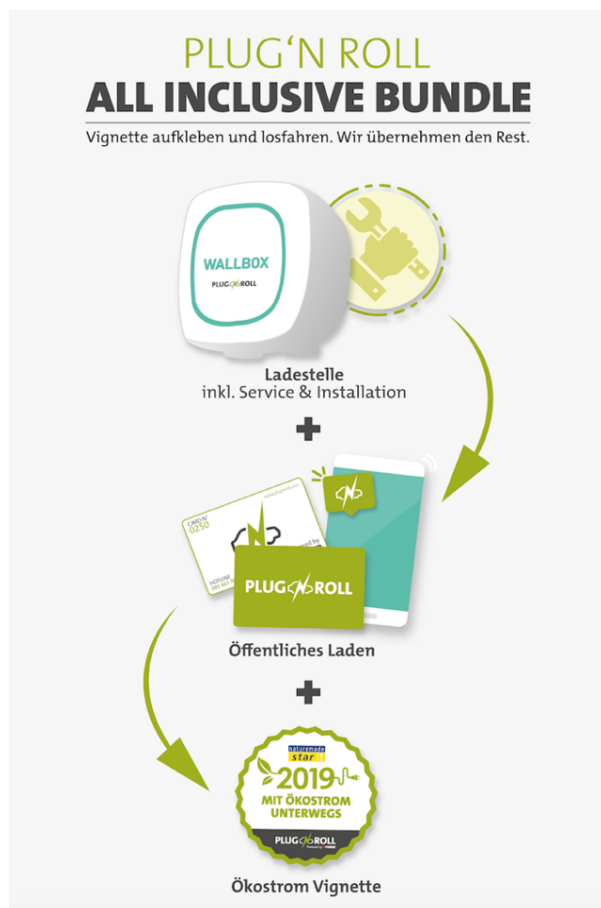
To use an electric vehicle, it has to be regularly charged.

This can be done at home at a **private charging station**, which should be installed by technical personnel. You can also (or additionally) charge the car through access to the public charging network.

Moreover, you can download a **smartphone app** that shows you the public charging network in Switzerland and Europe, as well as the free charging stations. You can also manage and pay for the charging progress at public charging stations.

You can also decide to charge your electric car with electricity from renewable energy sources. For this, you can obtain a certificate which guarantees a renewable electricity mix for a given number of kilometers.

You can order the individual components in an All-inclusive-bundle from one company directly when purchasing an electric vehicle.



Appendix C. Between-subject design experiment, Questions controlling for EV-related knowledge

Category	Question and statements	Measurement
General EV-related knowledge	How do you assess your knowledge about electric cars?	Seven-point Likert scale 1 = I have no knowledge about electric cars. 7 = I know a lot about electric cars.
Knowledge about components necessary for EV operation*	Please indicate to what extent you agree with the following statements: If I had an electric car, I would know where to find public charging stations. I know of various companies from whom I could purchase a private charging station. I know a model of a car with an electric motor that I like and that fulfils my requirements. I know enough about electric cars and the necessary technology to use them (charging etc.). I have already seen a lot of public charging stations for electric cars. I know various companies that can install a private charging station.	Seven-point Likert scale 1 = Do not agree at all 7 = Absolutely agree

*Cronbach alpha of the six-item scale for the whole sample (N = 313): .815.

Appendix D. Choice experiment, Attributes, their description and tested levels

Attribute	Attribute description	Attribute levels
App for private charging station	The private charging station Pulsar offers charging power of 11 kW. It is the perfect solution for a private installation in house and basement garages or external walls. The charging is extremely easy thanks to the integrated five-meter-long cable. The station can be locked and unlocked on request via an app; the app can also be used to program when to charge. You will get an overview about your completed and planned charging, as well as the electricity bill, via mywallbox, the personal access area.	With app Without app
Standard installation	Skilled technical personnel come to your house to professionally install the private charging station and to support you with the set-up of the station.	Yes, with installation No, without installation
Access to the public charging network with pre-paid credit	You can find public charging stations in Switzerland and Europe via the app on your smartphone. The app also shows you which stations close by are currently available. With the app you can start, manage, and control charging at public charging stations, as well as pay for your charge (upon providing your credit card details). You can alternatively manage and pay for charging at public charging stations in Switzerland and at the thousands of charging stations of our Roaming partners in the whole of Europe with the access card that you will also receive in the package.	With 30 CHF pre-paid credit With 100 CHF pre-paid credit With 150 CHF pre-paid credit No pre-paid credit

Green electricity certificate for one year	The certificate is awarded to all electric vehicle drivers who want to travel sustainably without compromise. The certificate covers the required electricity consumption with high-quality green electricity, independent of where you charge and what electricity mix you subscribe to at home. This means that the green electricity will not be delivered to you directly. The amount corresponding to your consumption will be generated from environmentally friendly renewable energy and consequently fed into the electricity network. Through this, the 'grey' electricity you use will be replaced, and you will thereby contribute to the energy transition in an important way. This certificate can be renewed every year.	5,000 km 10,000 km 20,000 km No green electricity certificate
Battery assistance for one year	With battery assistance you can travel with an electric car carefree. Should the battery unexpectedly run out, or a breakdown prevent you from continuing the journey, we will be here for you around the clock. The battery assistance can be renewed every year.	In Switzerland In Switzerland and Europe No battery assistance
Price	You can purchase the bundle for this price. Additional costs include the car and charging at the public charging network, the latter costs being deducted from the pre-paid credit.	3,500 CHF 4,000 CHF 4,500 CHF
Insurance for a monthly fee	The insurance covers the obligatory insurance of the vehicle and the liability risk of the vehicle's owner. Your private charging station as well as data can be insured in addition to the vehicle. You will thus be fully protected.	Insurance of the vehicle for 50 CHF a month Insurance of the vehicle, private charging station and data for 100 CHF a month No insurance

Paper III

Gender associations with electric vehicles as determinants of consumer adoption¹

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Abstract

Despite environmental benefits and growing technological appeal, the adoption of electric vehicles (EVs) differs across countries. One explanation is that the decision of buying a car is not only based on cost-benefit considerations. Cars are symbolically and culturally loaded products that have been traditionally associated with masculinity. This research analyzes the role of gender associations with EVs in determining their adoption, both at the country and consumer level. The first study reveals a positive relationship between femininity of national cultures and EV market share. The second study that applied an implicit association test (IAT) shows that consumers unconsciously associate EVs with femininity, especially male EV non-adopters. This points to persisting EV-feminine stereotypes as potential unconscious barriers to EV adoption, especially among certain consumer segments. By contrast, EV adopters of both genders have very similar, slight EV-feminine association. We discuss policy implications of these findings and propose avenues for further research.

Keywords

Electric vehicles, consumer adoption, culture, gender, implicit association test (IAT)

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Highlights

- Adoption of electric vehicles (EV) culturally determined.
- Positive correlation between femininity of national culture and EV market share.
- Implicit association test with German consumers reveals EV-feminine association.
- EV-feminine perception particularly strong among male EV non-adopters.
- Culturally specific and consumer targeted policy making to promote EV adoption.

1. Introduction

Representing almost one quarter of global carbon dioxide (CO₂) emissions, the transport sector is central for fulfilling energy and climate goals (IEA, 2020a; Li, Wang, & Wang, 2020). Private mobility is of particular concern since it accounts for 44.4% of the sector's emissions (IEA, 2020b). Electric vehicles (EVs) are one of the key decarbonization options. Recent analyses demonstrate that EVs have a lower carbon footprint over their lifecycle than comparable internal combustion engine (ICE) vehicles (Bauer & Cox, 2019; Hoekstra, 2019; Miotti, Supran, Kim, & Trancik, 2016). Their environmental advantage is likely to further grow with the expected greening of electricity mixes (Bundesrat, 2018; C2ES, 2019). Ongoing technological developments and a record number of EV models entering the market are further increasing the appeal of EVs to consumers (McKerracher, Izadi-Najafabadi, O'Donovan, & Albanese, 2020; Scrosati, Garche, & Tillmetz, 2015).

Sales of EVs have been growing. With 55.9% of newly sold vehicles in 2019 being electric, Norway is an undisputed frontrunner. It is followed by other Nordic countries (Ashmore, Pojani, Thoreau, Christie, & Tyler, 2018), namely Iceland (17.8%), the Netherlands (15.0%) and Sweden (11.4%) (IEA, 2020a). Despite this regional success, the global share of EVs among newly sold vehicles was only 2.6% in 2019 (IEA, 2020a). For EVs to unfold their full potential in contributing to decarbonizing the transport sector, their market diffusion has to rapidly accelerate.

A large body of literature has studied the factors influencing consumer adoption of EVs (Li, Long, Chen, & Geng, 2017; Rezvani, Jansson, & Bodin, 2015; Singh, Singh, & Vaibhav, 2020). Most of these contributions focus on socio-demographic characteristics of potential adopters and techno-economic aspects of EVs (Chen, de Rubens, Noel, Kester, & Sovacool, 2020; Hardman, Shiu, & Steinberger-Wilckens, 2016; Li et al., 2020; Muratori, Greene, Kontou, & Dong, 2020). However, cars are symbolically loaded products. Their purchases are culturally rooted and reflect a broad range of emotions and meanings such as status or identity (Noel, Sovacool, Kester, & de Rubens, 2019; Sovacool & Axsen, 2018; Steg, 2005; Urry, 2004). The analysis of cultural and symbolic meanings of EVs as determinants of adoption has only recently started growing and needs deepening (Anfinssen, Lagesen, & Ryghaug, 2019; Ashmore et al., 2018; Rezvani et al., 2015; Sovacool, Kester, Noel, & de Rubens, 2019).

One of the distinct symbolic meanings of cars is their association with gender. Many contributions show how ICE dominated car culture has been co-constructed with male identities around technology, privilege, freedom and the pleasure of driving (Ivory & Genus, 2010; Landström, 2006; Morgan, 2009). By contrast, EVs have been from their onset perceived as related to femininity, mainly due to their ease of operation, technological features portrayed as shortcomings and later for their environmental profile (Brough, Wilkie, Ma, Isaac, & Gal, 2016; Scharff, 1992; Wachs, 1987). Two recent studies expand these discussions by analyzing the views of first EV drivers, both men and women, in Norway (Anfinsen et al., 2019) and other Nordic countries (Sovacool et al., 2019). The authors confirm the presence of the stereotypical views between EVs and gender. Yet, they also observe evolving EV-gender relationship, with converging views between male and female EV drivers and new identities emerging around EV ownership and use.

Considering the need to substantially accelerate EV adoption, we need to understand what the relationship between EV-gender associations and consumers' purchase intentions is and how to utilize these findings to foster EV adoption in specific countries and at the level of consumers. Consequently, we aim to answer the following two research questions:

RQ1) How does femininity of national culture affect the EV market share at the country level?

RQ2) How does the strength of the unconscious EV-feminine association relate to consumers' EV purchase intentions?

To answer our research questions, we conducted two studies, a country-level and a consumer-level analysis, the latter employing an implicit association test (IAT). Originating in psychology (Greenwald, McGhee, & Schwartz, 1998), the method has been increasingly used to analyze the unconscious processes that influence consumer choices in a broad range of fields, including pro-environmental behavior and gender biases (Chen & Chancellor, 2019; Lewis & Lupyan, 2020; Régner, Thinus-Blanc, Netter, Schmader, & Huguet, 2019). Its application to study consumer adoption of EVs is now slowly emerging (Bennett & Vijaygopal, 2018). Second, conducting regression analysis on a global sample of 40 countries, we enrich EV adoption research by a cross-

country, cross-cultural analysis (Rezvani et al., 2015; Sovacool, 2014). We thus contribute to EV adoption literature both thematically and methodologically.

The paper is structured as follows. Section 2 reviews the relevant literature, Section 3 describes the applied research methods. Section 4 presents the data analysis and main results, while Section 5 discusses their implications. Section 6 concludes the paper by reflecting on the findings, suggesting recommendations for policymakers and industry actors and proposing avenues for further research.

2. Theoretical background

2.1. Car as a cultural artefact

Cars are not only utilitarian objects valued for their practical properties. They contain symbolic meanings, being artefacts of one's identity and culture (Skippon & Garwood, 2011; Steg, 2005; Urry, 2004). Urry (2004) famously coined the term automobility culture to describe the self-perpetuating system of actors, technological and symbolic components centered around the dominance of a privately owned fossil fuel car. He saw automobility as one of the main globalization forces that shapes national cultures worldwide (Urry, 2004).

One of the most prominent conceptualizations of national culture is represented by Hofstede's cultural dimensions theory (Hofstede, 1984; Hofstede, Hofstede, & Minkov, 2010). Analyzing employee values for multiple decades across more than 70 countries, the author concluded that any national culture can be characterized by six specific dimensions. These are power distance, individualism-collectivism, masculinity-femininity, uncertainty avoidance, long-term orientation and indulgence (Hofstede, 2001; Hofstede et al., 2010). The masculinity-femininity dimension is of particular importance for our research. National culture of countries that score high on masculinity is seen to be characterized by traits like competitiveness, assertiveness, material reward, self-centeredness, power, strength and individual achievements. By contrast, countries with low levels of masculinity are related to the opposite, feminine attributes, such as the tendency to care for others, cooperate, and a preference for modesty and quality of life over individual accomplishments (Hofstede, 1984; Hofstede et al., 2010).

Thanks to its applicability yet comprehensiveness (Kirkman, Lowe, & Gibson, 2006; Syam, Reeves, & Khan, 2011), Hofstede's cultural dimensions model has been

employed by research in many different fields ranging from business management (Ayoum & Moreo, 2008) and marketing (Soares, Farhangmehr, & Shoham, 2007) to psychology (Steenkamp, Ter Hofstede, & Wedel, 1999). Pro-environmental behavior has been analyzed by this model as well (Morren & Grinstein, 2016; Soye, 2012; Syam et al., 2011; Xu, Morgan, & Song, 2009). The studies overall conclude on the role of culture in explaining national differences in pro-environmental engagement. To illustrate, Pelau and Pop (2018) find a significant, negative relationship between a country's score on Hofstede's masculinity-femininity dimension and its share of renewable energy in the national electricity mix. In the transport sector, the studies mostly focus on cultural differences in urban travel patterns, mainly the use of public transport (Dingil, Rupi, Schweizer, Stasiskiene, & Aalipour, 2019; Syam et al., 2011). Dingil et al. (2019) find that higher femininity of national culture, i.e., lower scores on Hofstede's masculinity-femininity dimension, positively correlates with public transport use across 87 cities in 41 countries studied.

Cultural analyses of EV adoption applying Hofstede's cultural dimensions are only emerging. Ashmore et al. (2018) investigate if eco cars (EVs and hybrid cars) are perceived differently in four cultural clusters defined by two Hofstede's cultural dimensions - power distance and individualism-collectivism. The authors find that while eco cars are perceived positively in individualistic countries that score low on power distance (represented by two cultural clusters, Anglo and Nordic), eco cars have negative or at best no symbolic value in collectivist countries with high power distance score (Confucian and South Asian cultural clusters). These findings have implications for policy interventions to promote eco cars, that should be culture-sensitive, i.e., reflect the characteristics of each cultural block (Ashmore et al., 2018).

2.2. Car as a gendered product

One distinctive symbolic meaning of cars is their association with gender. While car culture has been traditionally perceived as masculine (Ivory & Genus, 2010; Morgan, 2009), EVs have been from their onset associated with femininity (Landström, 2006; Scharff, 1992; Sovacool et al., 2019). Scharff (1992) and others (Ivory & Genus, 2010; Morgan, 2009; Wachs, 1987) highlight that, at the beginning of the 20th century, EVs were an equal competitor to ICEs. Yet, due to their ease of use, limited range, silence and cleanliness, they were seen as an ideal complement to the mores and expected role of women in the Victorian society (Ivory & Genus, 2010; Scharff, 1992). The ICEs and

the car culture centered around them then positioned itself not only in contrast to EVs, but also the growing public transport system (Wachs, 1987). In contrast to the confining rail, limited range and charging capacities of EVs, ICEs offered freedom and, due to their high costs, exclusivity. Emerging from the male dominated racing culture, ICE driving was seen as competitive, dangerous and adventurous (Ivory & Genus, 2010). The fact that the elite of the beginning of the 20th century was almost exclusively represented by men and that women, in contrast to men, were confined to their households with neither time nor social approval to go touring for pleasure predisposed the newly emerging car culture to be solely male dominated and thus masculinized (Morgan, 2009; Scharff, 1992; Wachs, 1987).

The re-emergence of EVs in the 1990s further strengthened their association with femininity. Since EVs have a major potential to reduce transport's emissions and urban pollution (Lazzeroni, 2021; Miotti et al., 2016; Requia, Mohamed, Higgins, Arain, & Ferguson, 2018), they were presented as a response to the growing environmental concerns (Gärling & Thøgersen, 2001; Rezvani et al., 2015). Pro-environmental behavior has however been traditionally associated with the female gender (Hunter, Hatch, & Johnson, 2004; Luchs & Mooradian, 2012; Zelezny, Chua, & Aldrich, 2000). As care givers, women are seen to be pro-social, altruistic, compassionate and agreeable, characteristics believed to be conducive to pro-environmental action (Gilg, Barr, & Ford, 2005; Luchs & Mooradian, 2012). Literature has in fact observed lower engagement of men in green behaviors than that of women (Dietz, Kalof, & Stern, 2002; Sovacool et al., 2019; Zelezny et al., 2000). Also, EVs in the 1990s were, due to the innovative nature of the technology, rather small vehicles with a limited driving range. These technological properties predisposed EVs to be rather an additional car of the household, which have traditionally been associated with female drivers (Anfinsen et al., 2019; Wachs, 1987).

The literature analyzing the current relationship between EVs and gender is slowly emerging. Investigating the perspectives of EV drivers, both men and women, in Norway (Anfinsen et al., 2019) and other Nordic countries (Sovacool et al., 2019), the authors confirm the persistence of the stereotypical views between EV and gender. While men tend to emphasize speed, sex appeal and status, women value environmental and practical attributes of EVs such as their convenience and safety (Anfinsen et al., 2019; Sovacool et al., 2019). Yet, the authors also observe the evolution of perceptions

and symbolic meanings attached to EVs. Individuals of both genders recount stories of preference for efficient driving and convenient home charging and attach attributes that were traditionally believed to belong solely to ICEs to EVs, such as luxury, status, sex appeal, speed and performance (Anfinsen et al., 2019; Sovacool et al., 2019). Anfinsen et al. (2019) thus see EVs as hybrid constructions that enable broader participation than ICEs and the emergence of new identities around EV ownership and use.

3. Methods and data

3.1. Study I: Country-level analysis

3.1.1. Method, data collection and sample

Our first study aimed to identify how the femininity of national culture affects the EV market share at the country level (RQ1). To do so, we conducted a regression analysis that applied single and multiple linear regression models to identify the effect of Hofstede's cultural dimensions on EV market share of various countries. We additionally controlled for the effect of other factors commonly associated with EV ownership (Dargay, Gately, & Sommer, 2007; McKinsey, 2014), namely GDP per capita and car ownership per capita.

The data of the regression analysis were collected from official databases and international institutions to assure their reliability (Lavrakas, 2008; Queirós, Faria, & Almeida, 2017). Specifically, the data for EV market share were collected from the International Energy Agency (IEA) (IEA, 2020a), GDP per capita from the World Bank (WorldBank, 2021), and car ownership per capita from an official database managed by the University of Oxford (OurWorldInData, 2020). The data on Hofstede's cultural dimensions were obtained and calculated for individual countries by the Hofstede Insights analytical tool (HofstedeInsights, 2020a) that is built on the official data from Hofstede's research (Hofstede, 2001; Hofstede et al., 2010). The scales for all six cultural dimensions — power distance, individualism-collectivism, masculinity-femininity, uncertainty avoidance, long-term orientation and indulgence — range from 0 to 100; 50 is the mid-point. Scores of more than 50 indicate a relatively strong presence of the characteristic within national culture. By contrast, scores of less than 50 demonstrate its weak role, i.e., the characterization of the national culture by the opposite trait (Hofstede et al., 2010; HofstedeInsights, 2020a). To illustrate the

masculinity-femininity dimension, a country scoring more than 50 would be perceived as relatively more masculine, whereas a national culture scoring 50 and less would be relatively less masculine; i.e., increasingly characterized by the opposite, feminine attributes.

The regression analysis was conducted on a global sample of 40 countries from five continents (see Table 1). The specific countries were selected in order to represent different cultural backgrounds and socio-economic profiles. This was achieved by comparing their scores on individual Hofstede's cultural dimensions (Hofstede, 2001; Hofstede et al., 2010), GDP per capita (WorldBank, 2021) and car ownership per capita (OurWorldInData, 2020). These substantially vary across the sample, as can be seen in Appendix A.

Table 1. Sample of countries analyzed in Study I.

Continent	Country
Africa	South Africa
Asia	China, India, Japan, South Korea, Thailand
Australia and Oceania	Australia, New Zealand
Europe	Austria, Belgium, Bulgaria, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, the Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, United Kingdom
North America	Canada, Mexico, the USA
South America	Brazil, Chile

3.2. Study II: Consumer-level analysis

3.2.1. Method and sample

In Study II we aimed to examine how the EV-feminine association and its magnitude relate to consumers' EV purchase intentions (RQ2). To do so, we conducted an online survey with German consumers that combined an implicit association test (IAT) and explicit measures of stated preferences. The online survey was fielded from January 31 to February 05, 2020. The study link was distributed by a professional market research agency that recruited and reimbursed the respondents upon participation.

We recruited 441 participants representative of the German population in terms of sex and age within the delimitation of the study (adult population between 18 and 69 years). Twelve respondents were removed during the data analysis due to the excessive

speed of their answers that precluded calculating the results from the IAT. Therefore, the final sample of $N = 429$ is no longer exactly representative of the German population, as can be seen in Table 2. There are however no systematic differences between the excluded participants and the final sample (see Appendix B).

Table 2. Sample characteristics and data of the German population.

Category	Variable	Survey sample (N = 429)	German population
Sex	Female	52.4%	50.7%
	Male	47.6%	49.3%
Age*	18-29	22.1%	21.6%
	30-39	18.9%	20.6%
	40-49	19.1%	19.4%
	50-59	26.6%	25.7%
	60-69	13.3%	12.7%

Sources: Sex: Destatis (2020a); Age: Destatis (2020b).

Note: * Percentages for age refer to the German adult population aged between 18 and 69 years.

3.2.2. Study design and data analysis

The online survey was programmed in the survey-software tool Qualtrics. After a brief welcome and introduction to the study, the respondents were exposed to the IAT. Its aim was to identify if and to what extent participants unconsciously associate EVs with femininity or, alternatively, its opposite, masculinity. The IAT was followed by a number of questions related to the topic of the study. The dependent variable question, that of EV purchase intentions, was measured by a seven-point Likert-scale ranging from very unlikely to very likely, answering a question “How likely would it be for you to buy an EV?”. The question was preceded by a disclaimer informing participants to imagine that they would be about to buy a car, that the car of their preferred brand and type is available with both, electric and combustion engine and that both technologies are comparable in terms of price. This disclaimer was applied to limit the effect of these two common barriers on the measured EV purchase intentions (Egbue & Long, 2012; Rezvani et al., 2015; Singh et al., 2020).

The data collected from the online survey were analyzed by statistical software packages SPSS and R. We applied linear regression models, analysis of variance (ANOVA) and t-tests.

3.2.3. IAT method

The implicit association test (IAT) has become a popular tool to identify unconscious processes that guide consumer behavior (Carpenter et al., 2019; Greenwald et al., 2020). Originating in psychology (Greenwald & Banaji, 1995; Greenwald et al., 1998; Lane,

Banaji, Nosek, & Greenwald, 2007), its increasing use within social sciences (Bennett & Vijaygopal, 2018; Chen & Chancellor, 2019; Lewis & Lupyan, 2020; Régner et al., 2019) has reflected the need to apply deeper methods of inquiry than the self-reported measures of consciously held beliefs and attitudes. As numerous authors highlight (Greenwald & Banaji, 1995; Jacoby, Lindsay, & Toth, 1992; Lane et al., 2007; Nosek, Banaji, & Greenwald, 2002a), a majority of human behavior is determined by processes outside of one's awareness that cannot be captured by traditional explicit measures of inquiry such as surveys or interviews. Second, implicit measures are very relevant to study decisions in sensitive areas such as pro-environmental action or gender biases that tend to suffer from social desirability bias (Goerres & Prinzen, 2012; Van de Mortel, 2008). The IAT has become the most popular tool to measure implicit social cognition, mainly for its applicability yet reliability, proven to have the highest validity and psychometric qualities of the large number of indirect methods developed (Bar-Anan & Nosek, 2014; Nosek, Greenwald, & Banaji, 2007). The reliability of the test is the most commonly measured by De Houwer and De Bruycker (2007) method (Gattol, Sääksjärvi, & Carbon, 2011; Pogacar, Carpenter, Shenk, & Kouril, 2019). The scores range from 0 to 1; higher scores indicate higher IAT reliability (Pogacar et al., 2019). The IAT is considered reliable if the latter exceeds 0.7, ideally 0.8 (Nguyen, 2019).

The IAT measures the strength of a mental association between a concept and an attribute in a presence of an opposing pairing. This set-up makes the tool ideal to study situations in which consumers choose between alternatives (such as an EV vs. an ICE) (Chassot, Klöckner, & Wüstenhagen, 2015; Nosek et al., 2002a; Pogacar et al., 2019). To illustrate using an example from our study, stimuli representing either the target category *electric engine* (such as *battery, charging*) or *internal combustion engine* (*oil, gas pump*), or the attributes *feminine* (*mother, sister*) or *masculine* (*father, brother*) appear in the middle of the screen. The respondents are asked to assign them to the combination of a target category and an attribute that appear on the top-left and the top-right corner of the screen, most commonly with the keyboard keys *E* (if the respondent believes the stimulus belongs to the pairing on the top-left) or *I* (top-right assignment). The test operates under the assumption that it is easier (and thus quicker) for respondents to assign a stimulus if the pair to which it belongs is associated in their minds. By contrast, the assignment to the pair of a target category and an attribute that people do

not see as related is expected to be more complicated and thus to take longer (Carpenter et al., 2019; Greenwald et al., 1998; Nosek, Hawkins, & Frazier, 2011).

The difference in the speed at which respondents assign the stimuli to contrasting pairings is the primary output and result of the IAT, the standardized difference score (the so-called d-score) (Nosek et al., 2002a; Nosek, Banaji, & Greenwald, 2002b; Pogacar et al., 2019). It is based on a pooled standard deviation of the speeds and number of mistakes participants make while conducting the assignments (Greenwald et al., 1998). For its calculation, the answers that are too slow or too speedy are removed. Too quick answers indicate the so-called button mashing, a situation when respondents conduct the exercise without properly understanding the instructions or focusing on the task (Pogacar et al., 2019). The d-score ranges from -2 to 2. The larger the absolute value of the score, the stronger the association between the target category and the attribute, either in the hypothesized direction (positive scores) or against the hypothesis (negative scores) (Cohen, 1988). Cohen (1988) defines four thresholds of the association strength; scores of $|0| - |0.15|$ indicate no relationship, $|0.15| - |0.35|$ slight, $|0.35| - |0.65|$ moderate and scores higher than $|0.65|$ a strong relationship between the target category and the attribute.

We designed the IAT in the iatgen software (Iatgen, 2020). We chose this particular tool since it allows to develop the IAT and integrate it within online survey-software tools, namely that of Qualtrics. This compatibility was beneficial since we wanted to follow the IAT with a number of explicit measures of inquiry, mainly to control for the dependent variable of the study, EV purchase intentions. The IAT developed in iatgen software follows the original procedure of Greenwald et al. (1998). It is composed of 180 assignments divided into 7 blocks. Participants get first acquainted with the task by pairing the stimuli with either the target category or the attribute only; the data from these trial blocks (blocks 1, 2 and 5) do not feed into the d-score calculation. By contrast, the assignments in the critical blocks (blocks 3, 4, 6 and 7) in which target categories and the attributes are matched together to compatible and incompatible pairs generate data for d-score calculation. To prevent potential bias resulting from the assignment order, the participants are randomly allocated to one of the four permutations of the test (differing in the order in which the compatible and incompatible pairs appear and on which side of the screen). For the illustrations of the IAT task with the target categories and attributes of the present study, see Appendix C.

The selection of stimuli is critical for the relevance and reliability of the IAT. They have to unequivocally represent the target categories and attributes (Greenwald et al., 2020; Pogacar et al., 2019). The stimuli representing the attributes *feminine* and *masculine* followed Nosek et al. (2002b). However, we implemented two stimuli less and replaced one by the pair *woman / man*. For the stimuli representing the target categories *electric engine* and *internal combustion engine*, we analyzed the relevant literature to find the concepts most commonly associated with either technology (Cherubini, Iasevoli, & Michelini, 2015; Egbue & Long, 2012; Rezvani et al., 2015). In a second step, we conducted a pre-test with 14 participants in December 2019. We asked the respondents to list 10 associations that first come to their minds in relation to the categories *electric car* and *internal combustion engine car*. We combined the findings of these two methods, i.e., chose the attributes that were indicated by both as unequivocally representing *electric engine* and *internal combustion engine* (such as *battery* and *charging* for the former and *fuel* and *gasoline* for the latter). By contrast, we excluded the terms that were mentioned in relation to both technologies (such as *CO₂* and *power*). We thus concluded on six stimuli to represent each of the concepts tested in the IAT. For the list of target categories, attributes and stimuli selected, see Table 3.

Table 3. Set-up of the IAT: Target categories, attributes and stimuli.

Target categories	Stimuli
Electric engine	Battery, charging, charging station, electricity, lithium, plug
Internal combustion engine	Diesel, fuel, fueling, gas pump, gasoline, oil
Attributes	
Feminine	Aunt, daughter, grandmother, mother, sister, woman
Masculine	Brother, father, grandfather, man, son, uncle

4. Results

4.1. Study I: Country-level analysis

Our results show that the masculinity-femininity dimension is the most important cultural predictor of EV adoption. First, simple linear regression between individual Hofstede's cultural dimensions and EV market share of the sample of 40 countries identifies that only masculinity ($R^2 = 0.17$, $F(1,38) = 7.854$, $b = -0.155$, $SE = 0.055$, $p = 0.008$) and power distance ($R^2 = 0.10$, $F(1,38) = 4.371$, $b = -0.146$, $SE = 0.070$, $p = 0.043$) are statistically significant predictors; see Appendix D for the data of all six dimensions. Yet, in a multiple linear regression ($R^2 = 0.249$, $F(6,33) = 1.828$, $p = 0.124$),

only masculinity remains a statistically significant predictor ($b = -0.143$, $SE = 0.062$, $p = 0.028$). The effect of power distance is no longer significant ($b = -0.050$, $SE = 0.101$, $p = 0.625$); see Appendix E for data of the other variables in the model.

There is a negative correlation between a country's score on the masculinity-femininity Hofstede's cultural dimension and EV market share. In other words, countries whose national culture is relatively more feminine have higher EV market shares. This relationship is illustrated in Figure 1. As can be seen, the four countries with the highest EV market share also have the lowest masculinity-femininity scores – Norway (55.9%, 8), Iceland (17.8%, 10), the Netherlands (15.0%, 14) and Sweden (11.4%, 5) (HofstedeInsights, 2020b; IEA, 2020a).

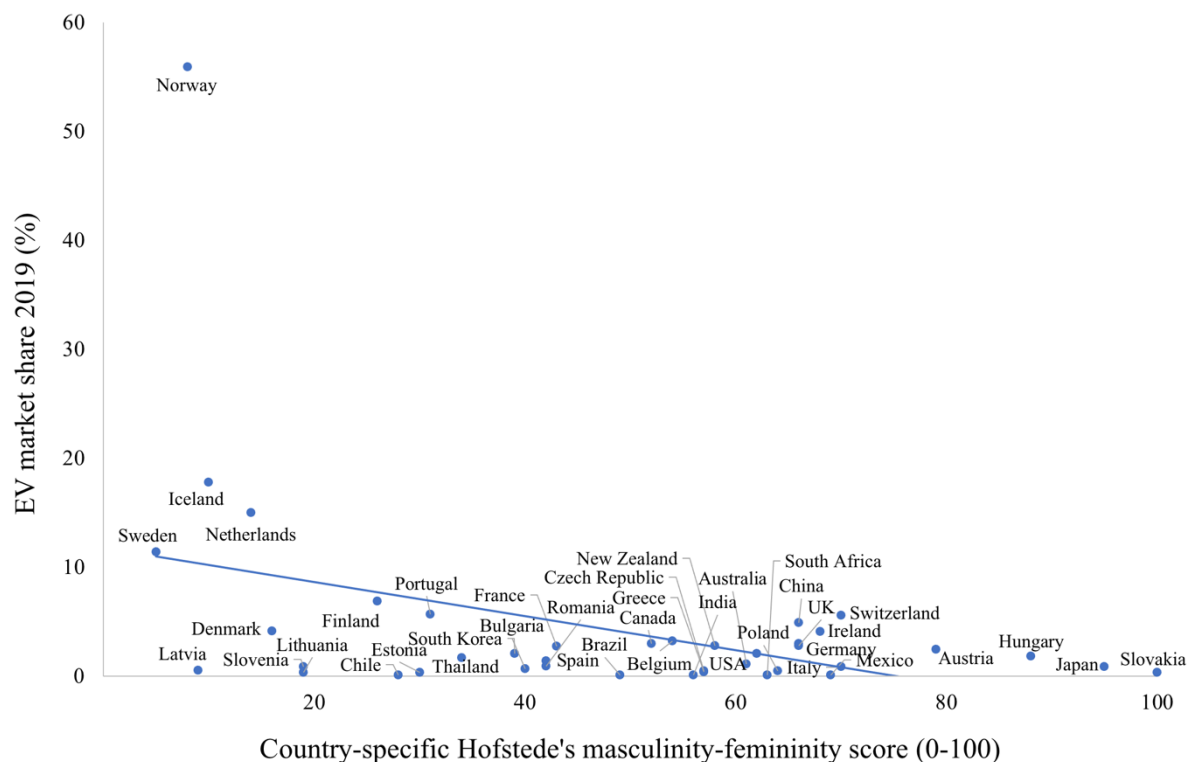


Figure 1. EV market share in 2019 (IEA, 2020a) as a function of masculinity-femininity Hofstede's cultural dimension (HofstedeInsights, 2020b).

Finally, we wanted to see if the importance of the masculinity-femininity dimension persists if we control for other common influences of EV market share (Dargay et al., 2007; McKinsey, 2014), namely GDP per capita (WorldBank, 2021) and car ownership per capita (OurWorldInData, 2020). A multiple linear regression model ($R^2 = 0.415$, $F(3,36) = 8.519$, $p < 0.001$) shows that masculinity-femininity remains a statistically significant predictor of EV market share even in this model ($b = -0.127$, $SE = 0.048$, $p = 0.012$). GDP per capita shows to be the most important predictor in the model ($b =$

0.258, $SE = 0.069$, $p = 0.001$), while the effect of car ownership per capita is not statistically significant ($b = 0.013$, $SE = 0.009$, $p = 0.134$); see Appendix F for the complete data of the models.

4.2. Study II: Consumer-level analysis

The reliability of the IAT was 0.81, which indicates a high reliability of the test (Nguyen, 2019; Pogacar et al., 2019). We can thus assume that the stimuli selection and the design of the IAT were effective, also since no participants reported incomprehension of the task or stimuli allocation in the open-ended question included at the end of the online survey. Therefore, we generated the data from the IAT to calculate the d-score and thus to see the direction and the strength of participants' unconscious association between EVs and femininity.

The IAT revealed that participants unconsciously associate EVs more strongly with feminine than with masculine stimuli. With a d-score of $M = 0.29$ ($SD = 0.44$, $t(428) = 12.69$, $p < 0.001$, Cohen's $d = 0.66$, 95% CI [0.25, 0.34]), the results suggest a slight association between EVs and femininity for the average respondent ($N = 429$) (Cohen, 1988). Yet, we find important gender differences. The association between femininity and EVs is moderately strong ($M = 0.41$) among male respondents ($N = 204$, $SD = 0.45$; $t(203) = 12.92$, $p < 0.001$, Cohen's $d = 0.90$, 95% CI [0.34, 0.47]). Women ($N = 225$) also perceive EVs as feminine, but to a much lesser degree ($M = 0.19$, $SD = 0.42$; $t(224) = 6.90$, $p < 0.001$, Cohen's $d = 0.46$, 95% CI [0.14, 0.25]). The difference in EV-gender association between men and women is statistically significant (ANOVA, $F(1,427) = 26.371$, $p < 0.001$).

Second, we assessed the d-score in relation to the explicitly measured EV purchase intentions to see if EV gender perceptions can reveal important unconscious barriers preventing EV adoption. To achieve that, we analyzed if the strength of the EV-feminine association differs between consumers who consider purchasing an EV (further referred to as "potential EV adopters") and those who do not ("EV non-adopters"), in general and in relation to specific gender.

Table 4. D-score (M) and t-test (t) overview split by EV adoption intentions and respondents' sex.

	N	M	SD	95% CI [low, high]	t	df	p	Cohen's d
Total sample	429	0.29	0.44	0.25, 0.34	12.69	428	<0.001	0.66
Men	204	0.41	0.45	0.34, 0.47	12.92	203	<0.001	0.90

Women	225	0.19	0.42	0.14, 0.25	6.90	224	<0.001	0.46
EV adopters	142	0.31	0.43	0.23, 0.38	8.49	141	<0.001	0.71
EV adopters - men	74	0.33	0.45	0.22, 0.43	6.21	73	<0.001	0.72
EV adopters - women	68	0.29	0.41	0.19, 0.38	5.78	67	<0.001	0.70
EV non-adopters	212	0.29	0.44	0.23, 0.35	9.72	211	<0.001	0.66
EV non-adopters - men	100	0.50	0.41	0.42, 0.58	12.06	99	<0.001	1.20
EV non-adopters - women	112	0.11	0.37	0.04, 0.18	3.06	111	0.003	0.29

The data first show that EV adopters of both genders hold a slight EV-feminine association that is very similar to each other and the total sample (see Table 4). Concretely, it is identical to the general sample in case of women ($N = 68$, $M = 0.29$, $SD = 0.41$; $t(67) = 5.78$, $p < 0.001$, Cohen's $d = 0.70$, 95% CI [0.19, 0.38]) and almost identical for men ($N = 74$, $M = 0.33$, $SD = 0.45$; $t(73) = 6.21$, $p < 0.001$, Cohen's $d = 0.72$, 95% CI [0.22, 0.43]). These slight differences between male and female EV adopters are therefore not statistically significant (ANOVA, $F(1,140) = 0.333$, $p = 0.565$).

Different gender dynamics however emerge between male and female EV non-adopters. While the whole group of EV non-adopters has an overall slight EV-feminine association ($N = 212$, $M = 0.29$, $SD = 0.44$; $t(211) = 9.72$, $p < 0.001$, Cohen's $d = 0.66$, 95% CI [0.23, 0.35]), male EV non-adopters perceive EVs as particularly feminine, with the highest d-score ($M = 0.50$) of all measured groups ($N = 100$, $SD = 0.41$; $t(99) = 12.06$, $p < 0.001$, Cohen's $d = 1.20$, 95% CI [0.42, 0.58]). By contrast, female EV-non adopters report very small ($M = 0.11$), based on Cohen (1988) almost non-existent, EV-feminine association ($N = 112$, $SD = 0.37$; $t(111) = 3.06$, $p = 0.003$, Cohen's $d = 0.29$, 95% CI [0.04, 0.18]). This large disparity is statistically significant (ANOVA, $F(1,210) = 53.066$, $p < 0.001$). The groups also significantly differ in comparison to EV adopters (male EV non-adopters: ANOVA, $F(1,240) = 11.760$, $p = 0.001$; female EV non-adopters: ANOVA, $F(1,252) = 15.431$, $p < 0.001$).

5. Discussion

5.1. Femininity of national culture positively correlates with EV market share

The country-level analysis identified a statistically significant relationship between the masculinity-femininity Hofstede's cultural dimension and EV market share.

Concretely, countries with lower masculinity-femininity scores, i.e., countries whose cultures are relatively more strongly characterized by femininity, have higher EV market share. With these results we are one of the first studies to show the effect of culture on EV adoption on a country level (Ashmore et al., 2018). We thus further contribute to the literature associating femininity with pro-environmental engagement (Brough et al., 2016; Dingil et al., 2019; Luchs & Mooradian, 2012).

As the first contribution to EV adoption literature, we show that masculinity-femininity is the most important cultural predictor of EV market share on a country level. We thus join Pelau and Pop (2018) who came to the same conclusion within the energy sector. We however further expand this finding and confirm the key role of femininity by controlling for additional, non-cultural, aspects commonly related to EV adoption, namely GDP per capita and car ownership per capita (Dargay et al., 2007; McKinsey, 2014). Masculinity-femininity dimension remains a statistically significant predictor even in this model, in which car ownership per capita is actually not significant. We thus further emphasize the role of culture on EV adoption and join other literature in encouraging its consideration and deeper investigation for a better understanding of EV diffusion (Anfinsen et al., 2019; Ashmore et al., 2018; Rezvani et al., 2015; Sovacool et al., 2019).

Finally, our results bring an additional evidence as to why Nordic countries globally dominate EV adoption (IEA, 2020a). The majority of contributions assign the leadership of Nordic countries, Norway in particular, to the active governmental engagement in support of EVs, namely the implementation of robust financial incentives and legislation (Kester, Noel, Z., & Sovacool, 2018; Lorentzen, Haugneland, Bu, & Hauge, 2017; Mersky, Sprei, Samaras, & Qian, 2016; Rietmann & Lieven, 2019). Alongside other emerging literature (Ashmore et al., 2018), we show that this dominance might also result from the cultural characteristics of this geographic region, most of all the relatively higher femininity of their national cultures.

5.2. Differences in unconscious EV-feminine association in regard to gender and consumers' purchase intentions

The consumer-level analysis that implemented an IAT found that respondents hold a slight unconscious association between EVs and feminine stimuli. We thus represent the first contribution to EV adoption literature that identified an unconscious association

between EVs and gender among consumers. These results further confirm the relationship between femininity and EV market share observed by the country-level analysis also at the level of individual consumers. While we provide further evidence to the literature that associates EVs with femininity (Morgan, 2009; Scharff, 1992; Wachs, 1987), we further expand the former contributions by identifying important gender differences. Concretely, the unconscious EV-feminine association is particularly strong among men. This finding seems to confirm the persistence of the traditional male dominated ICE centered car culture, especially among men, that sees EVs in their contrast and thus as feminine (Ivory & Genus, 2010; Landström, 2006).

Our analysis goes another step further and identifies how these unconscious associations between EVs and femininity relate to consumers' purchase intentions. Most importantly, we find that male EV non-adopters hold a particularly strong EV-feminine association, the strongest of all measured groups, with significant differences to EV adopters and the overall sample. This finding provides evidence that among certain consumer segments, the perceived excessive femininity of EVs relates to their undesirability (Ivory & Genus, 2010; Landström, 2006; Sovacool & Axsen, 2018). However, this stereotypical notion was not present among female EV non-adopters. In fact, female EV non-adopters expressed an almost non-existent EV-feminine association. While this could be assigned to the traditional views of women not interested and not involved in car culture and thus not assigning any particular attachments to vehicles, be them ICEs or EVs (Morgan, 2009; Wachs, 1987), we believe that the foundations of this relationship are more complex and merit further investigation.

In contrast to gender differences within the overall sample and EV non-adopters, male and female EV adopters perceive EVs as equally feminine. Our data show that their unconscious EV-feminine association is slight, almost identical to each other and to the whole sample. This finding points to the evolving EV-gender relations that have been also observed by Anfinssen et al. (2019) and Sovacool et al. (2019). Among potential EV adopters, the stereotypical gender divide of the traditional ICE male dominated car culture seems to be evolving to more inclusive electric mobility futures with convergent values and views of both men and women. However, as our research also identified, this ongoing change is still limited, with persisting EV-gender stereotypes, particularly among male EV non-adopters. Given the importance of men as

car buyers (Hardman et al., 2016; Kurani, Caperello, & TyreeHageman, 2018), this finding could point to a significant unconscious barrier that has to be better understood and addressed to foster further EV adoption.

6. Conclusion

In this paper, we investigated the role of cultural and symbolic factors of EV adoption, namely that of gender associations with EVs, both at the country and the consumer level. Through a mixed-methods research, we first analyzed how Hofstede's cultural dimensions, masculinity-femininity in particular, affect EV market share of individual countries. A second study applied an implicit association test (IAT) to examine if consumers unconsciously associate EVs with femininity and how the direction and strength of this relationship relates to their expressed EV purchase intentions.

Our research contributes to EV adoption literature both thematically and methodologically. First, it enriches the contributions on the role of culture for EV adoption (Ashmore et al., 2018; Rezvani et al., 2015) by emphasizing the latter's effect on EV market share. It also expands the growing discussion on EV-gender relationships (Anfinssen et al., 2019; Morgan, 2009; Sovacool et al., 2019; Wachs, 1987), mainly by analyzing the link between unconscious EV-feminine associations and EV purchase intentions of individual consumers. Second, our research is also methodologically relevant. It enriches the EV adoption literature by a global, cross-country, cross-cultural analysis (Rezvani et al., 2015; Sovacool, 2014) and is, together with Bennett and Vijaygopal (2018), one of the first contributions to apply implicit measures of inquiry, namely that of IAT, to study EV adoption.

The country-level analysis shows that femininity of national cultures positively correlates with their EV market share. The masculinity-femininity dimension is also the most important of all Hofstede's cultural dimensions and remains a significant predictor even if controlling for other determinants of EV adoption. This is particularly relevant among Nordic countries, such as Norway, Iceland, the Netherlands and Sweden, that have the lowest Hofstede's masculinity scores yet the highest EV market shares globally (HofstedeInsights, 2020b; IEA, 2020a). We thus become one of the first contributions to confirm the effect of culture on EV adoption on the country level (Ashmore et al., 2018). Our analysis also provides further evidence to the relationship between

femininity and other types of pro-environmental behavior observed elsewhere (Brough et al., 2016; Dingil et al., 2019; Pelau & Pop, 2018).

The consumer-level analysis finds that consumers unconsciously associate EVs with femininity, men importantly more so than women. We identify these gender differences also between male and female EV non-adopters. By contrast, EV adopters of both genders have a very similar, slight EV-feminine association. These findings further elaborate on the results of our country-level analysis and expand the accounts of EV-feminine relationship discussed elsewhere (Anfinsen et al., 2019; Morgan, 2009; Sovacool et al., 2019; Wachs, 1987) by their investigation in relation to EV purchase intentions. By showing that male EV non-adopters have the strongest EV-feminine association, we provide further evidence that traditional EV-gender stereotypes persist (Ivory & Genus, 2010; Landström, 2006; Sovacool & Axsen, 2018) and that they can, especially among specific consumer segments, unconsciously relate to low EV purchase intentions. Additionally, the almost identical EV-feminine association among male and female EV adopters expand the observations of Anfinsen et al. (2019) and Sovacool et al. (2019) about the evolving EV-gender perceptions among EV drivers that could be more conducive to electric mobility futures.

6.1. Implications for policymakers and industry actors

Our findings lead to several recommendations for policymakers and industry actors. First, showing that culture has an important role for EV adoption, we suggest refraining from direct policy transfer since interventions effective in one country might backfire in another one (Ashmore et al., 2018; Pelau & Pop, 2018). Therefore, we recommend that policy mixes and programs aiming to promote EV adoption consider cultural specificities of any given country. In view of the key role of masculinity-femininity on EV market share, we suggest policymakers adjusting their policies and activities along this particular Hofstede's cultural dimension (Hofstede et al., 2010; HofstedeInsights, 2020b). To illustrate, being already more open to EV adoption thanks to the general appreciation of pro-environmental behavior, policies in relatively more feminine country cultures can focus on highlighting the environmental and safety benefits of EVs and implement soft-policy tools to encourage EV adoption rather than needing to motivate it. By contrast, policymakers in culturally rather masculine countries might need to apply more prescriptive and intervention measures such as emission regulations and financial incentives (Ashmore et al., 2018; Pelau & Pop, 2018). The latter could

also prioritize the interventions that associate EVs with the elements of traditional ICE centered car culture and masculinity such as power and status by, for example, creating incentives for a dense network of fast chargers on highways or converting government fleets to luxury EVs (Gebauer, Vilimek, Keinath, & Carbon, 2016; Ivory & Genus, 2010; Morgan, 2009). However, we acknowledge that such policies will have to carefully navigate a fine line between creating effective incentives and reproducing old stereotypes and be mindful of cultural shifts that might occur.

As for the information and marketing campaigns implemented by both policymakers and industry actors, we recommend a careful segmentation of target groups. Our results suggest that for the large parts of the population, the perceived femininity of EVs does not constitute a barrier to adoption. Yet, for the consumer segment that is still skeptical of EVs in relation to their perceived excessive femininity, simply emphasizing environmental advantages or aspects traditionally associated with EVs will not be enough to overcome the latter's reservations. Therefore, for those specific segments of male EV non-adopters, relating the messaging to the aspects associated with the traditional masculine-centered car culture such as speed, power, technological strength and freedom may be more effective. We can also imagine promoting EVs in traditionally masculine action movies by, for example, making the heroes drive an EV (Brown, 1996; Sherwin, 2019) or using EVs in traditionally masculine sports, such as racing (FIA, 2021) and football (i.e., players of famous football clubs driving EVs) (FCBayern, 2020). The application of the latter two examples in practice might provide a fruitful ground for further research, analyzing the impact of these activities on fans' EV-gender perceptions and their EV purchase intentions.

6.2. Limitations and further research

Our research has shown a number of strengths. The study is the first one to analyze the role of culture and EV-gender associations on EV adoption at both the country and the consumer level. It is also the first research to explicitly study the relationship between unconscious EV-gender associations and purchase intentions of consumers. The research is also rich methodologically, being one of the first contributions to apply IAT to analyze the unconscious processes that influence EV adoption.

Despite that, our research encountered some limitations that invite for further research. First, the reasons for the identified EV-feminine association and the differences in its magnitude between men and women would merit further analysis. Especially interesting would be to focus on the disparities between male and female EV non-adopters, yet the very similar unconscious associations of EV adopters of both genders. Second, of particular importance would be to identify the causality between EV-gender associations and the limited EV purchase intentions of male EV non-adopters.

Second, the empirical context of the consumer-level analysis was Germany. Considering the cultural embeddedness of our work, it would be desirable to investigate consumers' EV-gender associations also in different cultural contexts. Extending the research to countries such as Norway or Iceland could reveal whether EV gender perceptions change with the increasing EV market penetration (IEA, 2020a) and whether those countries' substantially lower score on Hofstede's masculinity-femininity dimension (8 and 10, respectively, compared to 66 for Germany) (HofstedeInsights, 2020b) influences the perceived femininity of EVs. Conducting the analysis in the USA, Australia, South Africa or China could reveal if the EV-femininity association remains stable in countries with fairly similar Hofstede's masculinity-femininity score (62, 61, 63 and 66, respectively) yet differences on all other cultural dimensions (HofstedeInsights, 2020b).

Finally, we measured EV purchase intentions using stated preferences. Further research could move closer to the actual purchasing decision and analyze EV-gender associations at the point of sale. For example, it can examine customers before and after an EV test drive to investigate whether gender associations change with direct experience of the product. Further research could also survey customers for their preferred EV model, in order to investigate whether implicit gender associations differ from one brand and type of EVs to another. With an increasing number of EV models and types entering the market (McKerracher et al., 2020), it will become relevant to see if they are gendered in the same way or differently. A better understanding of these nuances and thus the dynamics between gender, EV-feminine associations and purchase intentions might help identify the processes leading to EV (non-) adoption and thus to inform more effective, culturally sensitive and carefully targeted, policies to foster further EV adoption.

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Author contribution statement

Jana Plananska: Conceptualization, Methodology, Formal analysis, Software, Investigation, Writing - Original Draft, Writing – Review & Editing, Visualization. **Rolf Wüstenhagen:** Conceptualization, Methodology, Writing – Review & Editing, Funding acquisition. **Emanuel de Bellis:** Conceptualization, Formal analysis, Writing – Review & Editing, Funding acquisition. **Andreas Herrmann:** Conceptualization, Writing – Review & Editing, Funding acquisition

Competing interests

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

Ethics

We confirm that the consumer-level analysis received ethical approval of the Ethics Committee of the University of St.Gallen. The respondents of the online survey were informed about the purpose and the set-up of the study before they agreed to participate.

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Appendix A. Sample of countries analyzed in Study I

Country	Hofstede's cultural dimensions*						GDP per capita (US\$)	Car ownership per capita
	PD	IND-COL	MA-FE	UA	LTO	INDUL		
Australia	38	90	61	51	21	71	54,907.1	730
Austria	11	55	79	70	60	63	50,277.3	562
Belgium	65	75	54	94	82	57	46,116.7	511
Brazil	69	38	49	76	44	59	8,717.2	364
Bulgaria	70	30	40	85	69	16	9,737.6	396
Canada	39	80	52	48	36	68	46,194.7	685
Chile	63	23	28	86	31	68	14,896.5	230
China	80	20	66	30	87	24	10,261.7	181
Czech Republic	57	58	57	74	70	29	23,101.8	540
Denmark	18	74	16	23	35	70	59,822.1	447
Estonia	40	60	30	60	82	16	23,659.93	563
Finland	33	63	26	59	38	57	48,685.9	629
France	68	71	43	86	63	48	40,493.9	478
Germany	35	67	66	65	83	40	46,258.9	568
Greece	60	35	57	100	45	50	19,582.5	487
Hungary	46	80	88	82	58	31	16,475.7	373
Iceland	30	60	10	50	28	67	66,944.8	711
India	77	48	56	40	51	26	2,104.2	22
Ireland	28	70	68	35	24	65	78,661.0	445
Italy	50	76	70	75	61	30	25,739.3	549
Japan	54	46	95	92	88	42	40,246.9	615
Latvia	44	70	9	63	69	13	17,836.4	369
Lithuania	42	60	19	65	82	16	19,455.5	512
Mexico	81	30	69	82	24	97	9,863.1	297
Netherlands	38	80	14	53	67	68	52,447.8	494
New Zealand	22	79	58	49	33	75	42,084.4	860
Norway	31	69	8	50	35	55	75,419.6	516
Poland	68	60	64	93	38	29	15,595.2	617
Portugal	63	27	31	99	28	33	23,145.0	514
Romania	90	30	42	90	52	20	12,919.5	332
Slovakia	100	52	100	51	77	28	19,329.1	426
Slovenia	71	27	19	88	49	48	33,189.6	649
South Africa	49	65	63	49	34	63	6,001.4	174
South Korea	60	18	39	85	100	29	31,762.0	475
Spain	57	51	42	86	48	44	29,613.7	513
Sweden	31	71	5	29	53	78	51,610.1	476
Switzerland	34	68	70	58	74	66	81,993.7	539
Thailand	64	20	34	64	32	45	7,808.2	226
UK	35	89	66	35	51	69	42,300.3	473
USA	40	91	62	46	26	68	65,280.7	838

Note: * Abbreviations of Hofstede's cultural dimensions: Power Distance (PD), Individualism-Collectivism (IND-COL), Masculinity-Femininity (MA-FE), Uncertainty Avoidance (UA), Long-Term Orientation (LTO), Indulgence (INDUL).

Sources: Hofstede's cultural dimensions: HofstedeInsights (2020b); GDP per capita: WorldBank (2021); Car ownership per capita: OurWorldInData (2020).

Appendix B. Differences in socio-demographic data between the final sample (N = 429) and the excluded respondents (N = 12) (ANOVA)

Socio-demographic data	Mean (standard deviation)		F	p
	Final sample (N = 429)	Excluded respondents (N = 12)		
Sex	1.48 (0.50)	1.58 (0.52)	0.542	0.462
Age	26.09 (13.92)	19.92 (10.01)	2.324	0.128

Appendix C. Illustrations of the IAT task

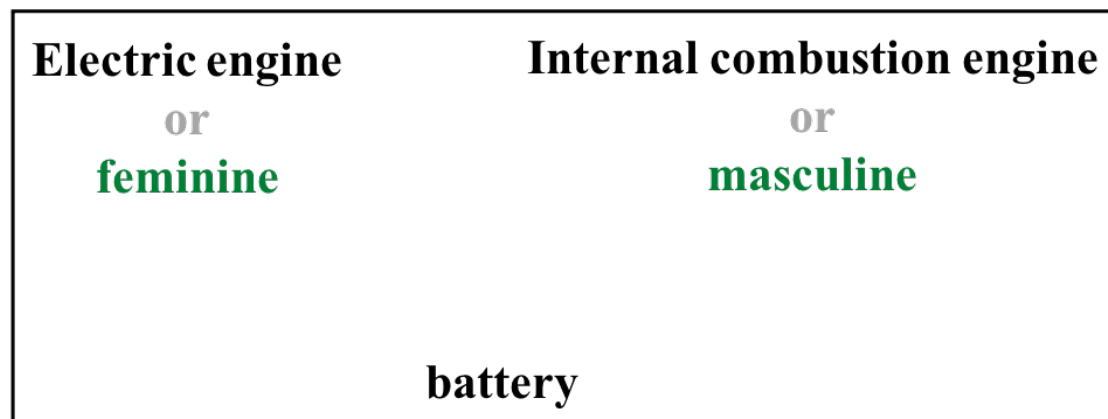


Figure C1. Compatible pair; Allocation of a stimulus representing the target category *electric engine*.

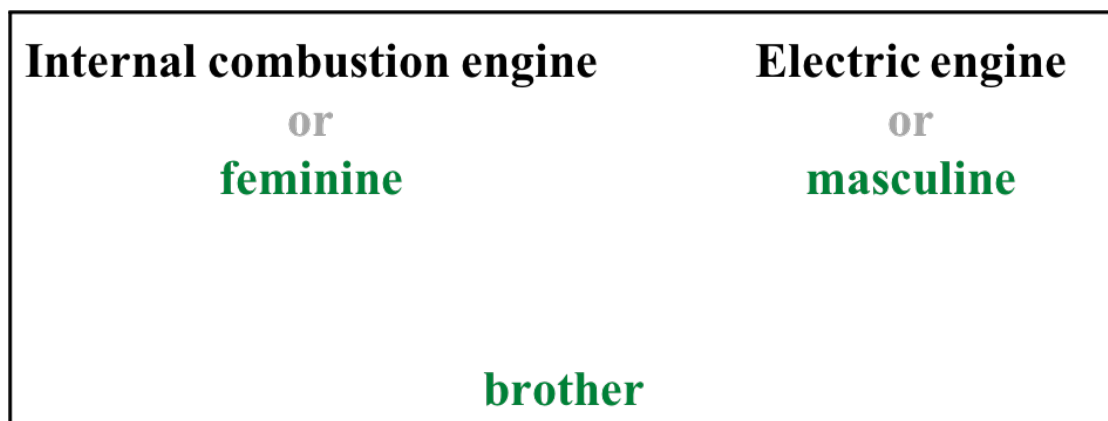


Figure C2. Incompatible pair; Allocation of a stimulus representing the attribute *masculine*.

Appendix D. Effect of Hofstede's cultural dimensions on EV market share (simple linear regression)

Predictor	R ²	F	<i>b</i>	Std. Error	t	p
Power distance	0.103	4.371	-0.146	0.070	-2.091	0.043
Individualism-Collectivism	0.032	1.259	0.077	0.068	1.122	0.269
Masculinity-Femininity	0.171	7.854	-0.155	0.055	-2.803	0.008
Uncertainty avoidance	0.065	2.651	-0.110	0.068	-1.628	0.112
Long-term orientation	0.026	1.024	-0.069	0.068	-1.012	0.318
Indulgence	0.039	1.559	0.087	0.069	1.248	0.220

Sources: Hofstede's cultural dimensions: HofstedeInsights (2020b); EV market share: IEA (2020a).

Appendix E. Effect of Hofstede's cultural dimensions on EV market share (multiple linear regression)

Predictor	<i>b</i>	Std. Error	t	p
Power distance	-0.050	0.101	-0.493	0.625
Individualism-Collectivism	0.027	0.091	0.301	0.756
Masculinity-Femininity	-0.143	0.062	-2.294	0.028
Uncertainty avoidance	-0.043	0.077	-0.564	0.577
Long-term orientation	0.000	0.081	0.006	0.995
Indulgence	0.041	0.091	0.456	0.652

Source: Hofstede's cultural dimensions: HofstedeInsights (2020b); EV market share: IEA (2020a).

Appendix F. Effect of masculinity-femininity Hofstede's cultural dimension, GDP per capita and car ownership per capita on EV market share (multiple linear regression)

Predictor	<i>b</i>	Std. Error	t	p
Masculinity-Femininity	-0.127	0.048	-2.635	0.012
GDP per capita*	0.258	0.069	3.752	0.001
Car ownership per capita	-0.013	0.009	-1.534	0.134

Sources: Hofstede's masculinity-femininity dimension: HofstedeInsights (2020b); GDP per capita: WorldBank (2021); Car ownership per capita: OurWorldInData (2020).

Note: * The unit of GDP per capita was set to 1 USD.

Curriculum Vitae

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- 08 / 2013 – **Intern – Sub-Saharan Africa Department**
10 / 2013 Ministry of Foreign Affairs of the Czech Republic
- 09 / 2012 – **Intern – Office of the Czech Ambassador**
12 / 2012 Permanent Delegation of the Czech Republic to UNESCO
- 08 / 2011 – **Intern – Cultural Section**
09 / 2011 Embassy of the Czech Republic in Washington, D.C., USA