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Thesis Title

Essays on the Adoption of Sustainable Innovation and Sustainable Behavior

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Thesis Abstract

Meeting fundamental human needs while reducing ecological footprint requires an accelerated transition towards sustainability. Despite increased popularity of *sustainability* or *sustainable development* term, the achievement of its overarching goals seems difficult in light of a continuous increase in over-consumption, climate change, environmental degradation, and societies' pursuit of indefinite economic growth. The transition towards sustainability hence is a multi-dimensional complex challenge that requires a significant improvement in existing knowledge of all diverse fields of management. Among others a crucial role is ascribed to Innovation Management, since both technological and business innovation are the necessary omens for the evolution of an economy towards more sustainable configurations.

To undertake this research, I take one of the fundamental aspects of innovation management: innovation diffusion. Innovation diffusion, a much-studied field which emerged around the turn of the last century, tackles key problems of diffusion barriers. It answers how an innovation is adopted by an individual entity and spread among the society. Different stakeholders and strategies (either in synergy or in alternative) play an active role to foster diffusion of eco-innovations: regulatory push/ pull, technology push, and demand pull (Rennings, 2000). However, there is a consensus that citizens or consumers involvement is mandatory for any sustainable initiative to succeed. Hence, my overall research project deals with different perspectives of the general issues of consumer's innovation adoption. There is a lot of ongoing debate on the subject; few research questions still remain uncovered:

1. How does an individual adopt and choose an innovation and is there a process of adoption? If the process exists, does a (potential) adopter perceive different attributes of an innovation during various stages in the process? Literature on consumer adoption supports

that the innovation-decision is a process; however it does not provide an empirical investigation of the phenomena.

2. If technological attributes are relevant for different stages, what would happen if those attributes are changed? Would such change affect the choice and create value? Literature on business model supports that a firm's value proposition is a way to create value for (potential) customers; however, it does not address whether a change in the value proposition also changes the customer perception and choice of a sustainable innovation?

3. What are the determinants of behavioral change towards more sustainable alternatives? To what degree, psychological and behavioral factors predict change in intention and actual behavior- the two broad stages of adoption? Literature on consumer behavior sufficiently addresses these questions, however results are still fragmented and inconclusive.

To fill these voids, three different research studies were conducted. The empirical setting of the three studies mainly deals with sustainable mobility innovations and behaviors. Below, I present the abstract of each of the three studies covered in subsequent three chapters.

Study 1:

Existing research on innovation adoption is divided into two main streams: organizational innovation adoption and individual (consumer) innovation adoption. Proponents of both perspectives approach the topic in a variety of ways. Contrary to the organizational adoption, research on the consumer adoption investigates the determinants of adoption/non-adoption without considering the innovation-decision as a process. Particularly, for high involvement innovations that require efforts in terms of cost, money, and resources to switch to a new routine and behavior, innovation adoption as a multi-stage process is most relevant. In line with Rogers' (2003) multi-stage individual adoption process, the first study of my thesis aims

to first explore the existence of distinct stages of innovation adoption and then identify the different determinants of each stage of adoption.

To address both research questions, the exploratory factor analysis (EFA) and structural equation modeling (SEM) technique were used. Data was collected from individuals using two different online surveys on smartwatch and alternative engine cars (AECs). Data from the first survey was used to extract factors using EFA. The results confirmed the existence of five distinct stages: knowledge, persuasion, decision, implementation, and confirmation. Based on these results, data from the second online survey was used to identify the predictors of each stage. Different determinants in terms of perceived innovation characteristics of AECs were analyzed using a structural model. In line with temporal distance theories and loss aversion theory, the findings show that perceived benefits of an innovation explain variation in persuasion stage, while perceived losses impact implementation stage. Decision and confirmation stages on the other hand are less explained. The study contributes by confirming the existence of distinct stages and developing a framework which not only determines the direction but also the strength of the relationships between different determinants and adoption stages.

Study 2:

To address the slow diffusion of sustainable innovations, the second study takes a business model perspective. Value proposition, an integral and central component of a business model, creates a link between customers and a firm and is a firm's promise to deliver values to its customers. Particularly for sustainable innovations, value proposition innovation (VPI) is salient since it is generally assumed that these technologies create value, yet customers fail to appreciate this value. The second study of the thesis addresses two research questions: what

is the mechanism to innovate a firm value proposition and what is the relationship between a VPI and attractiveness of new sustainable technologies?

To do so, Vehicle-to-Grid (V2G) technology was selected as a research setting and a mixed-method approach was applied, using focus groups and survey data. First, two focus group meetings with lead and non-lead users- (potential) Electric Vehicles (EV) owners in the Netherlands were arranged to understand customer values and to explore possible configurations of V2G. Second, online expert surveys from Dutch car enthusiasts were conducted to cluster groups of EV and non-EV adopters and to test each group's attractiveness of different configurations. The findings show that the change in a value proposition increases the attractiveness of the technology by (re)configuring different bundle of attributes according to values expressed by different customers' segments. This study contributes by providing a mechanism of VPI and explicating its importance in accelerating the diffusion of technologies which suffer from lock-in.

Study 3:

Unsustainable mobility is a relevant concern for developed countries as well as for emerging economies, with detrimental impacts from the standpoint of environmental degradation, health-related issues and social inclusion. Private mobility has probably the biggest share of the impact on environment and as for the social costs, so that active steps to decrease private car use and to switch to alternative paradigms are required. A successful shift to sustainable travel modes does not solely depend on regulatory and technology push, as it should rather focus on changing individual behaviors as well. Hence, it is vital to understand the key drivers of such travel mode choices. Although there is a vast literature on the topic, the results are still inconsistent and inconclusive. The third study of the thesis aims to systematically

analyze and synthesize the findings in the literature by examining the predictive capability of psychological and behavioral correlates of both, actual behavior and behavioral intention.

To achieve this goal, a meta-analysis was conducted followed by a moderator analysis of 58 primary studies examining drivers of intention and behavior as to explain the heterogeneity in the results. The results of the meta-analysis reveal that i) besides intention, habits and past behavior are strong predictors of both behavior ii) psychological determinants are related more to intention than behavior and iii) environmental variables are able to predict intention to use car or other travel modes, while have less explanatory power in predicting actual behaviors. The prevalence of environmental variables and habit-related correlates in explaining intentions and behaviors, respectively, represent the base of the so-called intention-behavior gap. The moderator analysis confirms that behaviors' operationalization and measurement in primary studies causes heterogeneity in outcomes the most, above trip purpose, sample type, and year of the study; while location does not appear as a relevant moderator. These results have theoretical as well as practical implications.

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Chapter 1

Consumer Innovation Adoption Stages and Determinants

1.1. Introduction

The diffusion of innovation (DOI) as a field of research has gained as much importance, if not more, as the innovation creation itself. Early studies on DOI highlight the importance of understanding the nature of this phenomenon, whose empirical manifestations show subsequent decisional stages (Rogers, 1962, 1983), in contrast with the discontinuous concurrence of events of the Schumpeterian perspective (Robertson, 1967).

Researchers from various disciplines adopt different perspectives. Economists tend to conceive innovation as an outcome while organizational sociologists mainly adopt a process perspective (Gopalakrishnan & Damanpour, 1997). Management studies consider both viewpoints with a focus on the adoption process conditions and emerging patterns, both in organization and in consumer behavior literature (Kimberly & Evanisko, 1981; Meyer & Goes, 1988; Van de Ven & Rogers, 1988).

Rogers' (1983, 1995, 2003) theory on DOI supports that innovation-decision is a multi-stage process through which a decision making unit passes through a number of selective steps. Such process occurs both in individuals and organizations adoption choices. Understanding the process perspective is relevant as the adoption of new technologies often require resources and efforts to shift towards a new behavior. Different actors in a society e.g. policy makers, industry players, local authorities make and implement strategies to make the shift successful. Hence it is of paramount importance for such stakeholders to analyze how a decision making unit passes through the adoption process and what are the factors that

ensures smooth transition from one phase to another in the process. The dynamics that play role during each phase may be different due to a distinct nature of each phase and identification of such success factors behind every step in the process can foster diffusion. Rogers' seminal contributions have deeply influenced the research in this field. He claims that the 'process' nature of innovation should be investigated through a research based on a type of data gathering and analysis that seeks to determine the ordered sequence of a set of events. In contrast, the majority of diffusion studies mainly focus on variance type investigation; innovation adoption as a process consisting of sequence of stages is, indeed, ignored (Frambach & Schillewaert, 2002; Rogers, 2003).

Empirical studies, on large bases, investigate determinants of adoption/non-adoption decision; ignoring other pre and post adoption phases in the decision process. For example, Frambach, Barkema, Nooteboom, & Wedel (1998) analyze determinants of adoption of an innovation by quantifying it as a binary variable (i.e., adoption or non-adoption decision). Very little is known about the factors that affect other phases (Frambach & Schillewaert, 2002; Arts, Frambach, & Bijmolt, 2011). There are few recent exceptions in consumer innovation adoption, however they either focus relatively on the broad categorization of phases or a subset of the whole process (e.g., Alexander, Lynch, & Wang, 2008; Arts et al., 2011; Manning, Bearden, & Madden, 2005; Wood & Moreau, 2006). On the other hand, relatively higher number of studies have empirically tested the phenomena in organizational innovation adoption with an interactive process perspective (e.g., Chong & Chan, 2012; Damanpour & Schneider, 2006; Kim & Garrison, 2010; Matta, Koonce, & Jeyaraj, 2012). Although the topic is considered relevant (Frambach & Schillewaert, 2002; Hameed, Counsell, & Swift, 2012), to the best of my knowledge the empirical validation of a multi-staged innovation-decision in consumer adoption process is still to be provided.

This article finds its motivation in this gap. Adoption is the premise for innovation diffusion and the research in this field commonly assumes that an individual evaluates a new idea and decides whether or not to incorporate the idea into ongoing practice through an interrelated series of actions and choices. As highlighted above, presently this assumption do not relies on empirical validation. What is more, adoption of the innovation which suffers from lock-in and is in early stages of diffusion curve require more time, effort, and cost to switch to new behavior compared to established alternatives. Adoption of such innovations is likely to occur in distinct steps, hence provides a relevant setting to validate the assumption. This leads to two overarching research questions: whether distinct innovation adoption stages exist and whether different determinants affect different stages?

The study relies on Rogers (2003) framework of individual innovation adoption to test stage assumption and on temporal distance theories (Trope & Liberman, 2003; Wright & Weitz, 1977) to test varying effects of perceived innovation characteristics on each stage. Two surveys were conducted in order to collect the responses from (potential) adopters. The existence of stages is explored through principal factor analysis (PCA) using data collected from the first online survey on smartwatch technology (N_1=110) while the determinants of each stage are identified through a Structural Equation Modeling (SEM) approach using data gathered from the second survey on alternative engine cars (AECs) (N_2= 246). The peculiar kind of innovations has been chosen since both requires high consumer involvement and efforts and are in early phases of diffusion; thus the possible separation among stages is more evident with respect to a situation where the choices have assumed a routine connotation. The second survey, in particular, benefitted from a series of contributions (e.g., Jansson, 2011; Jansson, Marell, & Nordlund, 2010; Jansson, Marell, & Nordlund 2011; Ozaki & Sevastyanova, 2011; Petschnig, Heidenreich, & Spieth, 2014; Rezvani, Jansson, & Bodin;

2015) that also analyze high involvement consumer behaviors related to adoption of hybrid electric vehicles (HEVs) and electric vehicles (EVs).

The findings confirm the existence of five distinct stages –knowledge, persuasion, decision, implementation, and confirmation stage in both empirical settings in line with Rogers' framework. The findings further reveal that each stage is explained by different set of perceived innovation characteristics- persuasion is affected by perceived benefits of an innovation, while implementation is explained by perceived costs and proximal factors. Decision and confirmation are explained by only few attributes.

The contribution to the present knowledge stands both in the proposed model and in the implications stemming from the results of the empirical research. First, the paper contributes by empirically validating and confirming the existence of five unique stages in case of high involvement innovations. Such contribution differs from prior studies in the field to the extent they look at adoption decision as a dichotomous variable (adoption or rejection i.e., 1 or 0) rather than focusing on each stage of the process. In addition, prior adoption literature utilizes 2-stage (e.g., Arts et al., 2011) or 3-stage models (e.g., Chong & Chan, 2012; Damanpour & Schneider, 2006; Kim & Garrison, 2010) while this study utilizes the five stages of adoption process as suggested by Rogers (2003). Secondly, the findings extend the results of earlier studies by identifying a clear dynamic role of antecedents of stages, but with respect to five stages. Furthermore, the empirical analysis developed to test the model of determinants here suggested, identifies both the direction and the strength of the relationships between determinants and stages. Finally, to the best of author's knowledge, the existing literature provides weak operationalization of the five stages, with few exceptions from different fields (Celik, Sahin, & Aydin, 2014; Gilly & Zeithmal, 1985; Li & Lindner, 2007). The current study validates the stage questions partly adapted and partly constructed for both surveys.

The remainder of the paper is structured as follows: section two lays the foundation by introducing DOI theory and consumer innovation-decision process and presents the framework of the study and hypothesis. The third section covers sample details, data collection, and measures and operationalization of variables. Fourth section is devoted for factor analysis and SEM results. Finally, fifth section discusses the results, limitations and contributions.

1.2. Literature review and theoretical framework

Existing empirical work on consumer innovation adoption considers it as an outcome and determines it in terms of adoption or non-adoption (e.g. Jansson, 2011; Jansson et al., 2011; Lassar, Manolis, & Lassar, 2015). This perspective affects the way innovation adoption and related issues are interpreted. In particular, a crucial problem regards innovations that suffer from lock-in due to established/ dominant products available in the market are hard to diffuse quickly. This is because consumers using conventional products have to break their existing routine in order to switch to a new innovation. For example, the substitution of conventional brown products with green innovations requires a process of change in existing behavior. Roger's (2003) work on DOI clarifies this point by conceptualizing innovation adoption as a multi-stage process. However, existing literature did not investigate multi-step process of adoption empirically. This study fills the gap by first exploring consumer innovation adoption as a process based on different stages and secondly identifying different predictors of each stage further confirming the existence of stages for new products. Below, I review the existing literature after briefly shedding light on DOI and its emergence.

1.2.1. Background of the diffusion of innovation theory

Diffusion is a social process which is characterized by seven elements: *acceptance*, over *time*, of some specific *item*- an idea or practice, by *adopting units*, linked to specific *channels* of

communication, to a *social structure*, and to a given system of values or *culture* (Katz, Levin, & Hamilton, 1963). The diffusion of innovation is generally acknowledged as the main mechanism of technical and social change; its importance emerged around the turn of twentieth century by the work of Gabriel Tarde, a French lawyer, judge, and sociologist, who wrote the book, "The Laws of Imitation" in 1903. Although he did not use the word 'diffusion' directly in his work, he opened the way for further studies identifying the role of opinion leader and of social status in the diffusion process. He also postulated the S-shape curve of the rate of adoption (Tarde, 1903). Later, during the 1930s and the 1940s, sociologist and anthropologists started conducting empirical studies on diffusion of cultural traits, for example Pemberton (1936, 1937, 1938) analyzed postage stamps diffusion and Bowers (1937) studied diffusion of consumer innovations. Ryan & Gross (1943) studied the diffusion of hybrid corn seed. These contributions, as many others, commonly look at the diffusion as a cultural fact that follows successive, distinctive phases. Starting from these and other pioneering studies, the theory of diffusion was gradually modified and its principles were adopted by other social sciences. DOI then progressed overtime and Rogers' (1962) most widely cited theory played a vital role in popularizing and spreading the field. Presently the diffusion research is spread among various academic disciplines like anthropology, agriculture, sociology, economics, geography, political science, marketing, communication, management etc.; infact the diffusion paradigm has provided an interdisciplinary common ground.

This paper is grounded in the classical DOI theory introduced by Rogers (1962, 2003), whose seminal work lays the foundation of today's research on innovation adoption and diffusion. In his book "Diffusion of Innovations", Rogers (1983) defines innovation as "*an idea, practice, or object perceived as new by an individual or other unit of adoption*" (p. 35), and defines diffusion process as "*the process by which an innovation is communicated through certain*

channels over time among the members of a social system" (p. 5). The diffusion process follows the S-shaped curve. The S-shaped slope of the curve represents the rate of adoption or diffusion. Some new innovations, which diffuse quickly, form a steeper S-shaped curve, while others form a gradual curve. The S-shaped curve is formed in relation with different adopter categories: innovators, early adopters, early majority, late majority, and laggards (Rogers, 1995, 2003). Initially, the S-curve starts progressing slowly as the innovators start adopting the new innovation. Due to early adopters the curve then raises faster (reaches "take-off") and reaches at its steepest as early majority and late majority start adopting the innovation. Lastly, the curve moves slower and levels-offs at the top as laggards adopt the innovation slowly and the cumulative number of adopters are exhausted.

Although strictly related, innovation diffusion and innovation adoption are two different concepts. Innovation diffusion refers to the accumulated level of users of an innovation in the market; whereas, innovation adoption refers to the decision process in which a decision making entity- an individual or an organization makes use of an innovation (Rogers, 1995). The decision process reflects the existence of distinct stages ranging from the first knowledge of the innovation to the confirmation of innovation use. During 1960s and 1970s, a number of other studies of innovation adoption (e.g., Robertson, 1974; Ostlund, 1974) and diffusion (e.g., Bass, 1969; Mahajan, Muller, & Bass, 1991) were conducted, but the adoption process of a decision making unit and the way it is influenced lie at the heart of the diffusion paradigm.

1.2.2. Innovation adoption: A multi-stage perspective

The adoption of an innovation is a *process* that results in the introduction and use of a product, process, or practice that is new to the adopter (Kimberly & Evanisko, 1981). The adoption process is defined as the "mental and behavioral sequences through which the

consumer progresses and which may result in acceptance and continued use of a product or brand" (Robertson, 1974, p. 271). Being a process, the innovation adoption occurs through a sequence of actions and choices. Rogers (2003) defines innovation-decision process as the process through which an individual passes from first knowledge to an innovation (knowledge stage), to forming an attitude towards the innovation (persuasion stage), to a decision to adopt or reject (adoption decision stage), to implementation of the new idea (implementation stage), and to confirmation of this decision (confirmation stage). This behavior is based on dealing with the uncertainty which is inherent in deciding about a new alternative. Therefore, *perceived newness* of the innovation and the *uncertainty* attached with this newness are distinctive facets of innovation decision-making as compared to other types of decision-making (Rogers, 1983).

The evidence of the validity and existence of these stages comes initially from an Iowa study by Beal and Rogers (1960) and Beal, Rogers, and Bohlen (1957). The studies of agriculture innovations provide two important insights. First, most farmers recognized that they moved through the series of stages as they passed through knowledge-awareness and adoption decision of two agricultural innovations and were exposed to different communication channels at different functions. Secondly, none of the farmers adopted the innovation immediately after being aware of new ideas and they took different time period to pass through different stages. Hence, the channel and time differentiation at different functions of innovation decision confirmed that innovation adoption behavior is a process that has distinct phases which occurs over time. Similarly, other early studies also support the evidence of existence of innovation process stages like Copp, Sill, and Brown (1958), Coleman, Katz, and Menzel (1966), Kohl (1966), and Rahim (1961).

Besides individual innovation decision process, Rogers (2003) also contributes in organizational innovation literature by identifying similar five stages of innovation process in organizations. The stages are agenda setting, matching, redefining/ restructuring, clarifying, and routinizing. Organizational decision-making particularly focuses on collective or authority innovation decision. However, the main concern in this study is consumer or individual decision-making that focuses on optional innovation decisions. Optional decision to adopt or reject is made by an individual who is independent of the decisions or choices of other members in the system.

Beside Rogers' innovation-decision process, others also provided stage-based process of innovation adoption. The summary of multi-stage models by prior studies is presented in table 1.1 below. Each stage in the process is characterized by a specific set of actions, events, and decisions. All the stages of individual or organizational adoption have been widely categorized into three phases: initiation, adoption-decision, and implementation (Damanpour & Schneider, 2006; Frambach & Schillewaert, 2002; Pierce & Delbecq, 1977; Tornatzky & Fleischer, 1990; Zmud, 1982). Initiation is based on information gathering, conceptualization, and planning to adopt an innovation while implementation refers to all actions, events, and decisions for putting an innovation into use. The actual decision to adopt the innovation falls in between initiation and implementation. These three phases are commonly referred as pre-adoption, adoption, and post-adoption. Later stages in adoption process depend on earlier stages and cannot be undertaken unless earlier stages have been settled (Rogers, 1983, 2003).

Table 1.1. Examples of multi-stage adoption models

Stages of Adoption		Studies
Intention, behavior	2-stage process	Ajzen (1991), Fishbein & Ajzen, (1975)
Evaluation, adoption, integration	3-stage process	Grover & Goslar (1993), Kim & Garrison (2010)
Awareness, selection, adoption, implementation, routinization	5-stage process	Hage & Aiken (1970)
Awareness, consideration, intention, adoption decision, continued use	5-stage process	Frambach & Schillewaert (2002)
Knowledge, persuasion, decision, implementation, confirmation	5-stage process	Rogers (2003)
Knowledge, awareness, attitudes formation, decision, initial implementation, sustained implementation	6-stage process	Zaltman, Duncan, & Holbek (1973)
Initiation, adoption, adaptation, acceptance, routinization, and infusion	6-stage process	Cooper & Zmud (1990)

1.2.3. Hypotheses development and the research model

Given the limited literature on antecedents of Rogers' five adoption stages namely knowledge, persuasion, decision, implementation, and confirmation stage; the theoretical framework and research hypotheses have been developed partially from available consumer adoption studies on relatively less number of stages (e.g. Alexander et al., 2008; Arts et al., 2011; Castaño, Sujan, Kacker, & Sujan, 2008; Meuter, Bitner, Ostrom, & Brown, 2005; Wood & Moreau, 2006) and organization innovation adoption literature (e.g. Chong & Chan, 2012; Damanpour & Schneider, 2006; Frambach & Schillewaert, 2002; Hameed et al., 2012; Kim & Garrison, 2010).

The literature highlights different categories of predictors of adoption. Given the overall framework and the exploratory nature of the present work, this study focuses on a subset of relationships referring to the most fundamental aspect- perceived characteristics of an innovation, which are found to be a major driver of innovation adoption (Arts et al., 2011; Frambach, 1993; Frambach et al., 1998; Frambach & Schillewaert, 2002; Gatigno &

Robertson, 1985; Rogers, 2003; Tornatzky & Klien, 1982; Vowles, Thirkell, & Sinha, 2011). Arts et al. (2011) conduct a meta-analysis of 77 studies from 1970 –2007 on consumer innovation adoption to identify how drivers of adoption differ across two broad stages: intention and behavior. The study confirms that different stages have different predictors in terms of innovation attributes. The research framework of this study hence is built on the assumption that perceived attributes of an innovation vary across distinct stages of innovation-decision. This assumption, if proven, will further confirm the stage existence hypothesis and it will provide the premise to the analysis of the relationships between different determinants and stages. The constructs describing the stages and perceived innovation characteristics are the following.

Knowledge Stage: A potential adopter learns about the existence of an innovation and gains some understanding of its way of functioning during the first stage. The knowledge stage is not included in the structural model of this study, since the awareness of the innovation's existence is a pre-requisite for the evaluation of determinants of subsequent stages.

Persuasion Stage: This stage helps form an attitude towards the innovation. During this stage, the potential consumer takes interest and actively seeks information about the innovation. The attitude is formed based on the knowledge they developed in the previous stage and on continued exposure. Whereas the mental activity at the knowledge stage was mainly cognitive (or knowing), the main type of thinking at the persuasion function is affective (or feeling).

Decision Stage: During this stage, the potential consumer takes the concept of change and is involved in certain activities e.g. trying out an innovation on a probationary basis, comparing its pros and cons etc. Such activities help a potential adopter to make the choice to adopt or

reject the innovation. The adoption decision infact precedes the actual choice or acquisition of an innovation.

Implementation Stage: Until the implementation stage, the innovation-decision process has been strictly a mental exercise. But implementation involves overt behavior change, as the new idea is actually put into practice by employing the innovation to a varying degree. Rogers (1983) adds that this stage may continue for a long period but ends up when the innovation loses its distinction and becomes a routine.

Confirmation Stage: The consumer finalizes his decision to continue using the adopted innovation. Confirmation is the stage of reinforcement for the adoption decision which has already been taken. Consumers reconsider the innovation based on their level of satisfaction or dissatisfaction. He may reverse the decision to continue if received conflicting messages about the innovation. Hence, a consumer continuously seeks to avoid the state of cognitive dissonance.

Perceived Innovation Characteristics: Innovation characteristics refer to the *attributes* consumers use to evaluate an innovation (Arts et al., 2011). Innovation adoption literature generally utilizes six most common innovation characteristics. Rogers (2003) suggests five attributes namely relative advantage, compatibility, trialability, complexity, and observability to evaluate an innovation. Hoeffler (2003), Midgley and Dowling (1978), and Ostlund (1974) add perceived uncertainty or risk to the list. Moore and Benbasat (1991) developed an instrument to measure perceived characteristics of IT innovation. They identify eight characteristics useful to study diffusion of innovations namely voluntariness, image, relative advantage, compatibility, ease of use, trialability, result demonstrability, and visibility.

As explained above, different attributes are tested in this study to identify determinants of stages. These are perceived relative advantage, compatibility, complexity of use, trialability,

risk, ecology, and image. The definitions of each perceived characteristics are provided in table 1.2.

Table 1.2. Perceived innovation characteristics

Variable	Definition	Operationalization Source
Relative Advantage	The extent to which an innovation is perceived as being better than the existing product it supersedes.	Moore & Benbasat (1991), Jansson (2011), Petschnig et al. (2014)
Compatibility	The extent to which an innovation is perceived as consistent with the past experiences, existing values, life style, and needs.	Jansson (2011), Petschnig et al. (2014)
Complexity	The extent to which an innovation is perceived as relatively difficult to understand and use. Ease-of-use is taken as an alternative in different studies.	Moore & Benbasat, (1991), Jansson (2011), Petschnig et al. (2014)
Trialability	The degree to which an innovation is perceived to be easily experimented on a limited/ probationary basis.	Moore & Benbasat (1991), Jansson (2011)
Risk	The degree to which individuals perceive uncertainty about the functional, social, and/or financial consequences of purchasing and using an innovation.	Jansson (2011), Petschnig et al. (2014)
Ecology	The extent to which an innovation is perceived as environmental friendly and harmless to the environment.	Petschnig et al. (2014)
Image	The extent to which the use of an innovation is perceived by the individual to enhance his/her image or status in the social system or community.	Moore & Benbasat, (1991); Petschnig et al. (2014)

Existing studies usually do not distinguish between the impacts of innovation attributes on different stages of adoption (Arts et al., 2011). The innovation-decision process is essentially an information seeking and processing activity in which an individual is motivated to reduce uncertainty about an innovation (Rogers, 2003). This means that each stage in the process deals with a certain level of uncertainty. To reduce the uncertainty and deal with the perceived newness of the innovation, individuals consistently seek information and knowledge of innovation during each stage. This knowledge requirement is higher and different in the early stages due to relatively higher uncertainty and newness than in the later

stages. This represents that consumers may use different criteria to evaluate the innovation across various stages of decision-making (Alexander et al., 2008; Castaño et al., 2008). At different stages, use purposes and situations are perceived differently and therefore, consumers may weigh product attributes differently (Arts et al., 2011).

Similar argument is used by temporal distance theories (Trope & Liberman, 2003; Wright & Weitz, 1977). The theories explain how consumers adopt a new product and guide how innovation characteristics can impact temporally distinct decisions. They explain that adopters evaluate product characteristics differently, depending on whether the purchase behavior is closer or further in time. For example, construal level theory (CLT) suggests that the behaviors that are more distant in time, as reflected by *adoption intentions*, are more likely to be affected by relatively abstract or general attributes. Behaviors that are closer in time, as reflected by *adoption behavior*, are more likely to be affected by concrete, specific, and context-dependent attributes (Trope and Liberman, 2003). The above arguments clarify that different innovation attributes are relevant for different stages in the process. Hence, my first hypothesis is:

> H_a: Different stages in the innovation adoption process are influenced by different perceived innovation characteristics.

Secondly, in order to evaluate which attributes are more relevant for each phase, innovation attributes are here categorized into perceived benefits, proximity, and costs. Relative advantage, compatibility, ecology, and image represent the direct benefits which make the innovation desirable for the potential adopter. Trialability provides close proximity to a product before purchase and helps to assess the direct benefits of an innovation. In contrast, risk and complexity represent the expected losses or costs which may decrease the adopter's motivation to adopt.

Potential adopters are likely to give high weights to perceived benefits of an innovation when they are farther from actual adoption (Arts et al., 2011, Wright & Weitz, 1977). This is because when potential adopters intend to buy an innovation, they form their attitude based on abstract or higher level features. In terms of innovation decision as a goal-directed process, this reflects relatively abstract *'why'* aspect of an innovation (Trope & Liberman, 2003; Vallacher &Wegner, 1987). The *'why'* aspect shows the desirability of a particular behavior. The desire increases when a potential buyer perceives the outcome of innovation as beneficial. Hence, the desirability in terms of improved performance and psychological gains are more important than the feasibility of choosing an option (Lynch & Zauberman, 2006). Based on this perspective, Castaño et al. (2008) suggest and find that managing uncertainties about potential outcomes like performance and symbolic benefits is important for distant future adoption decisions. The organization innovation adoption literature favors the same argument. In their study on CRM adoption; Ko, Kim, Kim, and Woo (2008) advocate that the decision makers perceive advantages of an innovation during persuasion phase and the benefits affect the decision phase positively. Findings of Chong and Chan (2012) study on RFID adoption confirm that perceived advantages are significantly relevant for pre-adoption and adoption stages. Hence this study hypothesizes:

> H_b: Perceived relative advantage, compatibility, ecology, and image of an innovation significantly affect persuasion.
>
> H_c: Perceived relative advantage, compatibility, ecology, and image of an innovation strongly affect decision.

In contrast, individuals are likely to assign high weights to the losses of an innovation when they are at behavior stage (Arts et al., 2011; Wright & Weitz, 1977). The notion is in line with loss aversion or prospect theory (Kahneman & Tversky, 1979), which proposes that an

individual focuses on potential losses than potential gains when faces a decision of behavioral change. In the present setting, implementation is the overt behavior in line with the construct conceptualized in theory of reasoned action (TRA, Fishbein & Ajzen, 1975). As individuals adopt the new behavior and put the new solution to practice, more concrete and lower level considerations explain their actions. In terms of innovation decision as a goal-directed process, this reflects relatively context-specific *'how'* details of an innovation (Trope & Liberman, 2003; Vallacher &Wegner, 1987). The *'how'* aspect shows the feasibility in terms of time, effort, and cost of conducting a new behavior or action. While analyzing time horizon effects on new product evaluation, Wright and Weitz (1977) find that negative aspects of choice options are weighted more by the individuals as the time to finally decide comes very close. Increasing time proximity shifts consumers attention from abstract to concrete mental models (Trope & Liberman, 2003), where costs matter more than benefits and feasibility matters more than desirability (Lynch & Zauberman, 2006). Based on this perspective, Castaño et al. (2008) find that managing uncertainties of potential switching costs like time, effort, affective, financial, and other risks is important for imminent future adoption decisions. This suggests that firm's promise to reduce perceived learning difficulty, time, and cost of using an innovation is effective during actual use rather than early stages where it only creates unrealistic expectations (Wood & Moreau, 2006). Similarly, organization adoption literature supports the argument for example, Chong and Chan (2012) find that perceived losses like complexity and cost of RFID effect on post-adoption is stronger than pre-adoption stages. Based on the above arguments and loss aversion and temporal distant perspectives, here I hypothesize that perceived losses of an innovation are more relevant for post adoption stages in the decision process.

H_d: Perceived risk and complexity of using an innovation significantly affect implementation.

H_e: Perceived risk and complexity of using an innovation significantly affect confirmation.

Trialability provides an opportunity to a potential adopter to closely observe the advantages and disadvantages of an innovation, enables him to see how it works within a limited time period, and helps him to analyze the required degree of change in existing behavior in order to switch to new behavior. Perceived trialability increases an individual's readiness to accept the change in such a way that he understands his role and feels confident to use a new innovation (Meuter et al. 2005). Hence, it is most relevant for overt behavior stage (Arts et al., 2011) which is closely associated with implementation. On the basis of this argument, the study hypothesizes that perceived ease of trialability is relevant for implementation stage.

H_f: Perceived trialability of an innovation strongly affects implementation.

The hypothesized relationships are shown in the research model in figure 1.1.

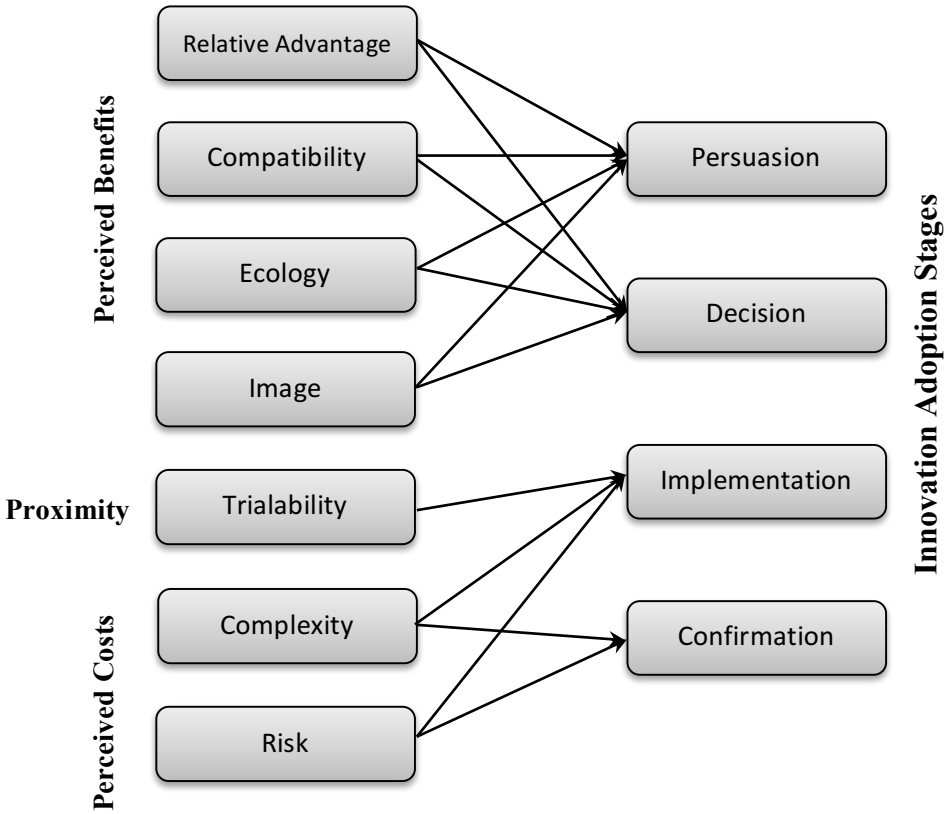

Figure 1.1. The research model

1.3. Methodology

1.3.1. Research design

The aim of this research is twofold: to identify and verify multi-stage process nature of high involvement innovation adoption and to identify various predictors of each identified stage. For this, I collected data about innovations which face lock-in and slowly diffuse due to the presence of alternative dominant technologies in the marketplace, hence makes existence of distinct stages more likely. The research questions were investigated through two different questionnaire-based online surveys. To identify distinct stages of adoption, data collected during the first survey were analyzed through exploratory factor analysis (EFA) technique while to identify different determinants of stages, data collected during the second survey were analyzed through structural equation modeling (SEM) approach. The first survey was administered for smartwatch innovation while the second survey was administered for alternative engine cars (AECs). The basic reason to select different innovations is to validate and confirm the existence of distinct stages for different innovations. Moreover, the two innovations share common issues. First, both are in early adoption stage of a diffusion curve and faces lock-in to cross the chasm and penetrate in the mass market. Second, though smartwatch and AECs are in early stage of diffusion still both are visible in the markets which means that products are known to the people, hence are possible to survey. Finally, use of both technologies require a shift to new behavior by breaking existing routines. It is highly likely for potential adopters of such products to invest their efforts before purchasing and during change of existing behavior. For example, substituting a conventional watch with a smartwatch or an existing conventional car with a green car requires building a new routine, hence requires efforts in terms of cost, time, and resources.

Since major focus of my work and the final survey is on sustainable vehicles, I reviewed empirical studies on their adoption to identify most suitable perceived characteristics of such

vehicles. The review of existing literature provides a list of functional, economical, and social attributes like range, acceleration, top speed, purchase price, fuel/ energy efficiency, maintenance/ operating cost, resale price, charging infrastructure availability, ease of driving/ use/ maintenance, charging time, environmental impact, safety, health risk, physical risk, financial risk, security, safety, comfort, design/ style, social image, visibility, policy incentives etc. (table 1.3). I categorize all such dimensions into broad characteristics. For this, I adopt Jansson (2011) and Petschnig et al. (2014) classification of innovation attributes because *(1)* their frameworks are based on Rogers' theory of adoption and *(2)* they study sustainable vehicles in general. Hence, the existing list of Roger's innovation characteristics was extended by adding new dimensions related to alternative cars. The attributes included in this study are perceived relative advantage, compatibility, complexity, trialability, risk, ecology, and image.

1.3.2. Measures and operationalization

I adapted the existing scales to measure perceived characteristics of AECs. The details are given in table 1.2 in previous section. The items were adapted from Jansson (2011), Moore and Benbasat (1991), and Petschnig et al. (2014). Similarly, I partly adapted existing scales to measure innovation adoption stages. Since the existing literature on individual adoption lack operational definitions and measurement scales of different stages; I adapted the existing scales from organizational and other literature which includes work by Celik et al. (2014), Chong and Chan (2012), Gilly and Zeithaml (1985), Kim and Garrison (2010), and Li and Lindner (2007). Few items were newly constructed and were validated before inclusion in the final survey. All the items were measured on five point Likert scale ranging from 1 = 'strongly disagree' to 5= 'strongly agree' to reflect respondents' degree of agreement or disagreement with a series of statements.

Table 1.3. Summary of perceived characteristics of sustainable vehicles

Studies	Ewing & Sarigollu (1998, 2000)	Brownstone et al. (2000)	Tzeng et al. (2005)	Lane & Potter (2007)	Eggers & Eggers (2011)	Hidrue et al. (2011)	Jansson (2011)	Egbue & Long (2012)	Ziegler (2012)	Schuitema et al. (2013)	Petschnig et al. (2014)	Peters & Dütschke (2014)
Vehicle Characteristics	Clean-Fuel vehicles	AFV	AFV	BEV	EV	EV	AFV	PHEV BEV	AFV	PHEV BEV	AFV	EV
Relative Advantage [1]	X	X	X	X	X	X	X	X	X	X	X	X
Ecology	X	X	X	X	X	X		X	X	X	X	X
Ease of use[2]		X	X	X	X		X		X		X	
Compatibility							X			X	X	X
Risk [3]				X			X	X			X	
Trialability							X				X	X
Observability							X			X	X	
Image				X						X	X	
Design/ style		X									X	

Note: AFV = Alternative Fuel Vehicle, BEV= Battery Electric Vehicle, EV= Electric Vehicle, PHEV= Plug-in Hybrid Electric Vehicle

[1] Relative advantage also includes profitability in terms of price, cost etc. and performance in terms of speed, acceleration, range, energy efficiency, range etc.
[2] Ease of use includes ease to drive, charging/ fueling, maintenance etc.
[3] Risk includes all types of risks e.g. physical, financial, health, security, emotional, social, safety etc.

1.3.3. Content Validity

Since the scale items for adoption stages were partly adapted from the existing literature, I analyzed whether items were representative of the adapted construct. For this, content validity of the innovation adoption scale was performed employing a quantitative approach. In order to validate contents, the following steps were followed. Based on existing literature and existing scales, a total of 27 items for five stages were identified and selected for validation process. A content validity questionnaire was then generated that comprised definitions of the constructs and associated items on a three-point scale, where 1 = 'clearly representative of the construct', 2='somewhat representative of the construct', and 3= 'not representative of the construct'. The questionnaire along with a covering letter indicating the purpose and instructions were sent to academic experts via email. Responses from 6 experts were then gathered and item-level content validity index (I-CVI) was calculated. Based on experts' rating of each item's relevance to a particular construct, I deleted two irrelevant items: "I will adopt the innovation the next time I need it" and "I have been using the innovation for quite some time". The I-CVI for both items was less than the threshold value of 0.78 (Lynn, 1986). Few other items were refined and/or reworded as suggested by experts. Finally, 25 items were retained for inclusion in the first survey and for factor analysis which further confirmed convergent and discriminant validity.

1.3.4. First survey- sample and data collection

The unit of analysis is the individual level. Using Qualtrics software, an online survey was developed to have quantitative responses for the content validated 25 items. The questionnaire has two sections. The first part is based on socio-demographic questions while the second part has the whole set of validated questions of smartwatch innovation adoption. Smartwatch is a wearable smartphone technology. Compared to a regular watch, it has

additional features like game playing, portable media playing, physical fitness tracking, supporting mobile apps using mobile operating system etc. However, such technology is relatively less attractive among consumers of conventional watches and faces slow diffusion rate. For data collection, I used snowball non-probability sampling technique. I contacted acquaintances, colleagues, and friends with a request to fill the online survey and to send the survey link to their acquaintances. Moreover, the questionnaire was spread on social networks. Follow up strategies were adopted to get timely and maximum responses. This resulted in 138 responses. However, 110 usable set of responses were included in the analysis. It is not possible to know the exact response rate as the survey was conducted through the internet. In order to have variation in the variables of interest, I recruited a heterogeneous sample of respondents with different gender, age, income, and education. The sample statistics of final sample are shown in table 1.4. Majority of the respondents are non-owners of smartwatch, male, highly educated, and under age 35. Sample is partially based on European and Asian residents.

Table 1.4. Sample statistics (N1 = 110)

Socio-demographics		**Frequency** ***(%age)***
Gender	Male	85 (77.3%)
	Female	25 (22.7%)
Education Groups	Primary	0 (0%)
	Intermediate	1 (0.9%)
	Secondary	3 (2.7%)
	University	106 (96.4%)
Continent of Residence	Europe	45 (40.9%)
	USA	3 (2.7%)
	Asia	59 (53.6%)
	Africa	1 (0.9%)
	Australia	2 (1.8%)
Age	25 and below	27 (24.5%)
	26-35	57 (51.8%)
	36-45	21 (19.1%)
	46 and above	5 (4.5%)
Smartwatch Owners	Owners	30 (27.3%)
	Non-owners	80 (72.7)

1.3.5. Second survey- sample and data collection

To test the different determinants of adoption stages a survey instrument was developed based on existing literature. The data for the second online survey were collected from car users. A similar approach was used by Petschnig et al. (2014) and Jansson (2011) to analyze consumer adoption of alternative fuel vehicles. In this research the empirical setting has been defined as Alternative Engine Cars (AEC). AECs power their engines through additional sources of energy besides petroleum like CNG, electricity, hydrogen, ethanol etc. Typical examples of AECs are hybrid, electric, and hydrogen fuel cell cars. The alternative engine

innovation is selected for the analysis because such vehicles *(1)* are in the early phase of diffusion or S-shaped diffusion curve *and (2)* require high consumer involvement behavior and consumers are more likely to pass through distinct stages of adoption. Existing studies by Jansson (2011), Jansson et al. (2010), Jansson et al. (2011), Ozaki and Sevastyanova (2011), Petschnig et al. (2014), and Rezvani et al. (2015) also analyze high involvement consumer behaviors related to adoption of hybrid and electric vehicles. However, none addressed the adoption in terms of multi-stage process.

The survey questionnaire has 4 sections. The first section asks questions about five distinct stages of adoption process as identified during EFA discussed in the next results section. The second section asks questions about seven perceived characteristics of AECs as elaborated earlier. Finally, the third section is based on socio-demographic questions. Following Chong and Chan (2012), Jansson (2011), Kim and Garrison (2010), and Petschnig et al. (2014) the questions of independent and dependent variables were measured on 5-point likert scale. The 5-point Likert scale checks the level of agreement, ranging from 1 = 'strongly disagree' to 5 = 'strongly agree'.

Using snowball sampling technique I received 263 online responses from traditional or alternative car users and 246 set of data were actually used for analysis. In order to have variation in the variables of interest, a heterogeneous sample of respondents was recruited. The sample statistics of final sample are shown in table 1.5. As in case of the previous survey respondents, individuals are majorly male, highly educated, and under 35 years age. Half of the respondents live in large towns having more than one million residents. More than half of individuals own traditional cars while only one tenth of the sample own AECs.

Table 1.5. Sample statistics (N2 = 246)

Socio-demographics		**Frequency (%age)**
Gender	Male	214 (86.99%)
	Female	32 (13.01%)
Education Groups	Primary	1 (0.41%)
	Intermediate	2 (0.81%)
	Secondary	6 (2.44%)
	University	230 (93.5%)
	Other	7 (2.84%)
Residence	Very large town	124 (50.41%)
	Large town	48 (19.51%)
	Middle town	49 (19.92%)
	Small town	17 (6.91%)
	Rural area/ country side	8 (3.25%)
Age	25 and below	62 (25.2%)
	26-35	128 (52.03%)
	36-45	42 (17.07%)
	46 and above	14 (5.7%)
Income	Less than $15,001	74 (30.1%)
	$15,001-$35,000	38 (15.4%)
	$35,001-$55,000	23 (9.3%)
	$55,001-$80,000	12 (4.9%)
	More than $80,000	9 (3.7%)
	No response	90 (36.6%)
Existing car type	Traditional	142 (57.7%)
	Bi-fuel	63 (25.6%)
	Alternative	25 (10.2%)
	Other	16 (6.5%)

1.4. Results

1.4.1. Analysis of adoption stages

To identify distinct adoption stages, I run factor analysis in SPSS using two extraction methods- Principal Component Analysis (PCA) and Principal Axis Factor (PAF). To confirm the validity and reliability, I further run confirmation factory analysis (CFA) and reliability analysis. The details of each analysis are given below.

Although PCA is the most popular, conventional, and default method to extract factors, PAF is often considered a preferable approach (Osborne & Costello, 2009). Osborne and Costello (2009) and Widaman (1990, 1993) suggest that PCA, though a popular and default extraction method, is not a reliable method of factor analysis. The aim of the factor analysis is to reveal latent constructs that allow manifest variables to covary. In order to reveal the underlying factor structure, the shared variance is separated from its unique variance and error variance during the analysis, and only shared variance is reflected in the solution. PCA disregards the underlying structure caused by latent variables and components are extracted using all the variance of manifest variables (Ford, MacCallum, & Tait, 1986). This means that PCA fails to partition shared and unique variance and analyze all the variance. Factor analysis only reveals shared variance and avoids the inflation of estimates of variance accounted for. On the other hand, proponents of PCA disagree that there is much difference between factor analysis and component analysis and preferred PCA (Arrindell & van der Ende, 1985; Schoenmann, 1990; Velicer & Jackson, 1990). Keeping in mind pros and cons of both approaches, this study considered results from both analyses. Following steps were performed to extract distinct factors using PCA and PAF.

1. To identify the number of distinct stages, the eigenvalues and scree plot were checked. The scree test examines the graph of eigenvalues and reveals a bend or break point

in the data where the curve flattens out. As expected, the eigenvalues (greater than 1.00) and scree plot (data points above the break) revealed 5 distinct constructs with different number of items loading on it. Further, 5 distinct constructs explained 59.2% cumulative variance[4].

2. The Kaiser-Meyer-Olkin Measure of Sampling Adequacy value of 0.804, greater than the threshold value 0.60, confirms that the sample (N_1 = 110) is adequate to run the factor analysis. Similarly, the significant p-value of Barlet's test of sphericity confirms that factor extraction is useful.

3. In the next step, I entered Direct Oblimin rotation method which simplifies and clarifies the data structure. The oblique rotation assumes that the factors are correlated as there is generally some correlation among the variables in real life, hence renders more accurate solutions (Osborne & Costello, 2009). This technique resulted in a pattern matrix which shows the items loadings (table 1.6 and 1.7). As suggested by Osborne and Costello (2005), I deleted the items with items loadings lesser than 0.30 and which cross load on more than one factor with loading greater than 0.30. This criterion resulted in the exclusion of 7 out of 25 content validated items. Once deleted, I calculated correlations between factors for each stage to confirm the distinctness of each factor or stage (table 1.8 and 1.9).

Comparing the analysis shown in table 1.6 and 1.7 confirms that both techniques PAF and PCA revealed similar findings with an exception. Both showed clear factor structure and extracted 5 different constructs. These factors are in line with the adoption stages conceptualized by Rogers (2003), hence referred as knowledge, persuasion, decision, implementation, and confirmation. This confirms the existence of stages of high involvement innovation adoption as hypothesized.

[4] To confirm that five distinct factors (extracted) is not the result of over-extraction or under-extraction, I run multiple factor analyses by manually setting the number of factors to four, five, and six. However, the cleanest factor structure with item loadings greater than 0.25 and only few cross-loadings was achieved with 5 factor solution.

Table 1.6. Results of principal component analysis (N1 = 110)

	Extracted Factors				
Item codes and details	**KNOW**	**PERS**	**DEC**	**IMP**	**CONF**
KNOW1- I know about the innovation	.838	.141	-.018	-.084	.032
KNOW2- I am aware of the innovation	.786	-.121	.067	-.117	.142
KNOW3- I have seen the innovation	.727	-.051	-.086	.115	-.022
KNOW4- I have some knowledge of how it works	.724	-.014	.006	.281	-.084
KNOW5- I have heard about the innovation	.720	.285	.143	-.146	-.126
PERS1- I like to have further information about it	.022	.803	.148	.137	-.137
PERS2- I believe the innovation is appropriate *	.038	.706	-.071	.035	.343
PERS3- I think the innovation is beneficial *	.154	.641	-.066	.075	.322
PERS4- I have a positive impression of the innovation	.024	.631	-.022	-.099	.130
PERS5- I think it is better than the alternative	.245	.526	.151	-.170	.285
DEC1- Before buying, I would compare it with the alternative	-2.16E-005	-.051	.846	-.099	.058
DEC2- Before buying, I would try the innovation	.147	-.005	.733	.134	-.005
DEC3- Before buying, I would have sufficient knowledge about its advantages and disadvantages	-.064	-.093	.704	-.199	.149
DEC4- Before buying, I am going to evaluate the innovation	.015	.214	.703	.033	-.196
DEC5- I would make all the arrangements to buy it*	-.159	.370	.398	.494	-.020
IMP1-I am currently using the innovation	.023	.038	-.153	.850	.048
IMP2-I use the innovation on a regular basis	.066	.017	-.151	.741	.239
IMP3-I know how to maintain the innovation *	.251	-.161	-.064	.541	.391
IMP4-I know how to use the innovation *	.245	-.228	.028	.535	.482
CONF1-I find the innovation useful	.099	-.140	.128	.090	.825
CONF2-I receive positive feedback for using the innovation	.036	.163	-.013	-.029	.804
CONF3-I would suggest others to use the innovation*	-.010	.303	-.095	-.132	.754
CONF4-I am satisfied with the its performance*	-.124	-.016	.146	.359	.732
CONF5-I will continue its use	.029	.129	-.011	.024	.713
CONF6-I plan to continue its use in the future	-.046	.165	-.030	.294	.637

* Item deleted due to cross-loading

Note: KNOW= knowledge, PERS = persuasion, DEC= decision, IMP= implementation, CONF= confirmation

Table 1.7. Results of principal axis factoring (N1 = 110)

	Extracted Factors				
Item codes and details	**KNOW**	**PERS**	**DEC**	**IMP**	**CONF**
KNOW1- I know about the innovation	.833	.126	-.024	-.086	.018
KNOW2- I am aware of the innovation technology	.718	-.087	.045	-.080	.113
KNOW5- I have heard about the innovation	.671	.235	.147	-.141	-.107
KNOW4- I have some knowledge of how it works	.652	-.018	.012	.227	-.046
KNOW3- I have seen the innovation	.630	-.024	-.080	.113	-.014
PERS2- I believe the innovation is appropriate	.030	.742	-.084	.059	.257
PERS1- I like to have further information about it	.022	.718	.172	.108	-.132
PERS3- I think the innovation is beneficial for me	.146	.664	-.075	.095	.242
PERS5- I think it is better than the alternative	.233	.494	.140	-.136	.230
PERS4- I have a positive impression of the innovation	.038	.482	.035	-.089	.138
DEC1- Before buying, I would compare it with the alternative	-.004	-.078	.813	-.105	.065
DEC4- Before buying, I am going to evaluate the innovation	.016	.165	.653	.010	-.175
DEC2- Before buying, I would try the innovation	.131	-.020	.650	.079	.023
DEC3- Before buying, I would have sufficient knowledge about its advantages and disadvantages	-.051	-.010	.547	-.130	.054
DEC5- I would make all the arrangements to buy it*	-.126	.274	.371	.339	.058
IMP1-I am currently using the innovation	.016	.085	-.131	.854	-.016
IMP2-I use the innovation on a regular basis	.060	.033	-.123	.716	.210
IMP4-I know how to use the innovation *	.247	-.226	.040	.517	.466
IMP3-I know how to maintain the innovation *	.243	-.132	-.056	.515	.358
CONF1-I find the innovation useful	.105	-.125	.111	.080	.789
CONF2-I receive positive feedback for using the innovation	.039	.165	-.025	-.047	.779
CONF3-I would suggest others to use the innovation*	-.004	.289	-.100	-.148	.730
CONF4-I am satisfied with the its performance*	-.130	-.019	.156	.329	.724
CONF5-I will continue its use	.039	.152	-.018	.052	.620
CONF6-I plan to continue its use in the future	-.037	.176	-.026	.276	.585

* Item deleted due to cross-loading
Note: KNOW= knowledge, PERS = persuasion, DEC= decision, IMP= implementation, CONF= confirmation

The only exception in the analysis is that PCA suggested the deletion of seven items while PAF suggested the deletion of five cross loaded items. All other items were converging to

different constructs with loadings greater than 0.30 reflecting convergent validity. Considering the theoretical and empirical perspective, seven items were deleted from further analysis in order to achieve uncorrelated factor structure as shown in table 1.8 and 1.9. The low correlation coefficients between different stages shown in both tables confirm the distinct nature of identified stages.[5] However, PAF shows a relatively higher correlation between implementation and confirmation- which are subsequent post adoption stages, thus signaling a possibility of emergence of one unique stage instead of two in other settings.

Table 1.8. Factor correlation matrix based on PCA results[6]

Factors	KNOW	PERS	DEC	IMP	CONF
KNOW	1	-.160	-.087	-.098	-.253
PERS	-.160	1	.226	-.030	.214
DEC	-.087	.226	1	-.147	.042
IMP	-.098	-.030	-.147	1	.226
CONF	-.253	.214	.042	.226	1

Note: KNOW= knowledge, PERS = persuasion, DEC= decision, IMP= implementation, CONF= confirmation

Table 1.9. Factor correlation matrix based on PAF results

Factors	KNOW	PERS	DEC	IMP	CONF
KNOW	1	-.197	-.104	-.129	-.304
PERS	-.197	1	.342	-.053	.286
DEC	-.104	.342	1	-.189	.050
IMP	-.129	-.053	-.189	1	.336
CONF	-.304	.286	.05	.336	1

Note: KNOW= knowledge, PERS = persuasion, DEC= decision, IMP= implementation, CONF= confirmation

[5] High correlation of a group of items within a single construct and low correlation among different constructs confirm construct validity. Discriminant validity is apparent by the examination of the cross-loadings, which are not substantial in magnitude compared to the loadings.

[6] Table 1.8 and 1.9 are the results of SPSS while running PCA and PAF. The negative signs should be ignored and weights should be considered while interpreting the association between different factors.

In order to confirm the validity of constructs or stages identified during EFA and subsequently used in the second survey, confirmatory factor analysis (CFA) was applied[7]. The results are shown in figure 1.2. Findings show that all items except one item of persuasion "I like to have further information" exceed the stringent threshold value of 0.72 with p-value < 0.05. This shows that except one, all others were loading appropriately on relevant latent construct. Goodness of fit measures confirmed the uni-dimensionality in the factors. Goodness Of Fit Index (GFI), Adjusted Goodness Of Fit Index (AGFI), and Comparative Fit Index (CFI) are greater than the threshold value of 0.90 and Root Mean Square Error Of Approximation (RMSEA) is below 0.05 (Hair, Black, Babin, Anderson, & Tatham, 2006).

Additionally, to confirm the internal consistency among items, Cronbach's alpha values were calculated and results are reflected in table 1.10. A higher coefficient of reliability shows that all items of each latent construct measure the same content universe. As shown in the table below, all alpha coefficients exceed the cut-off value of 0.70 (Nunnally & Bernstein, 1978; 1994), thus confirms the internal consistency of group of items within a construct. The table also reflects the mean values of each variable. Mean of implementation stage is 1.93 which indicates that respondents on average do not use AECs. Similarly the mean values of confirmation, trialability, and risk are closer to 3.00 which indicates that the majority of respondents are neutral about using the innovation in future, the ability of the innovation to be experimented or tried, and the uncertainty related to the innovation adoption. Bivariate Pearson correlations (r) were calculated and included in table 1.10 to show early signs of

[7] The data from the second survey was not used to replicate EFA due to several reasons: *(i)* majority of respondents are non-adopters (70% and 90%non-adopters of smartwatch and alternative engine cars respectively), which shows that they were are not in the post implementation stages which may affect the association of last stages differently in different contextual settings, *(ii)* two innovations used in the surveys are at different stages of diffusion and the level of involvement and efforts required for the two innovations is different which reflects the likelihood of different degree of correlation and interaction between different stages , and *(iii)* items were adapted from already existing weak operationalization of constructs as mentioned earlier, which might have an effect on our results.

strong associations between the constructs. An unexpected result is a strong association between implementation and confirmation stage (r =0.73, p <0.01) corroborating the early signal provided by the factor correlation matrix (table 1.9). Very high correlation is also observed between relative advantage and compatibility (r = 0.70) and between complexity and risk (r = 0.60). The possible reason is that innovation attributes are interdependent to some extent (Holak & Lehman, 1990).

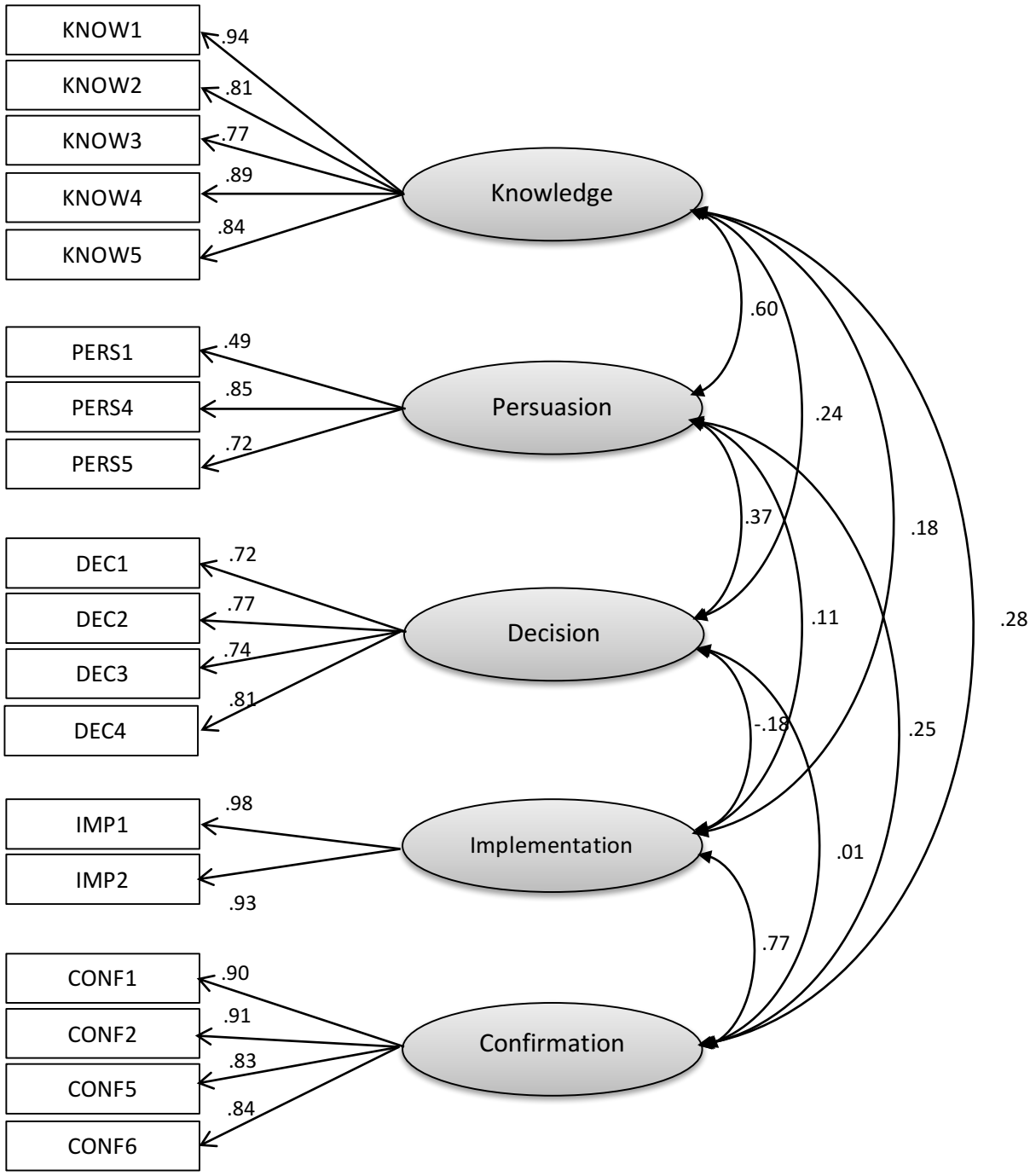

Figure 1.2. Results of CFA (N2=246)

Table 1.10. Cronbach's alpha, mean, and bivariate Pearson correlation matrix

Constructs	**Cron α**	**Mean (SD)**	**Bivariate correlations (r)**											
			KNOW	PERS	DEC	IMP	CONF	RA	COMPAT	COMPLEX	TRIAL	RISK	ECO	IMAG
KNOW	0.92	3.71(1.002)	1											
PERS	0.76	4.00 (0.796)	.50***	1										
DEC	0.84	4.29 (0.673)	.24***	.23***	1									
IMP	0.94	1.93 (1.349)	.17***	.13**	-.15**	1								
CONF	0.92	3.25 (0.666)	.26***	.22***	.01	.73***	1							
RA	0.83	3.60 (0.689	.29***	.50***	.15**	.19***	.28***	1						
COMPAT	0.83	3.71 (0.679	.41***	.53***	.16**	.28***	.42***	.70***	1					
COMPLEX	0.74	3.38 (0.729)	.16**	.001	.15**	-.05	.02	-.02	-.05	1				
TRIAL	0.84	2.93 (0.823)	.16**	.09	-.15**	.26***	.25***	.26***	.27***	.07	1			
RISK	0.75	2.88 (0.702)	.02	-.16**	-.08	.12*	.11*	-.09	-.12*	.60***	.21***	1		
ECO	0.81	3.87 (0.694)	.33***	.45***	.19***	.006	.21***	.40***	.42***	.04	.01	-.15**	1	
IMAG	0.84	3.42 (0.742)	.16**	.34***	.08	.19***	.23***	.40***	.46***	.01	.27***	.02	.23***	1

Note: *** = p-value significant at 0.01 level, **= p-value significant at 0.05 level, *= p-value significant at 0.10 level

Cron α = cronbach's alpha, SD= standard deviation, KNOW = knowledge, PERS= persuasion, DEC= decision, IMP = implementation, CONF= confirmation, RA= relative advantage, COMPAT= compatibility, COMPLEX= complexity, TRIAL= trialabity, RISK= risk, ECO = ecology, IMAG= image

1.4.2. Results of the model

The structural equation modeling is applied to examine the hypotheses proposed in the second section as this method examines both the directions and strengths of the relationships of the latent variables. In addition it has the potential to analyze a larger number of constructs and their interrelations simultaneously and to control for measurement error (Mackenzie, 2001; Steenkamp & Baumgartner, 2000). For the estimation of the model, I used AMOS *ver* 18.0. Before running the SEM analysis, some of the basic assumptions were tested. There was no multicollinearity among variables as VIF was less than the stringent cut-off threshold of 3.00 and tolerance level> 0.01. Similarly, the assumption of homoscedasticity was not violated. Power test showed that the required sample size to run SEM was 200 which is less than the study's sample size of 246 observations. Finally, scale reliability and validity were confirmed as discussed above. I assessed path coefficients and significance values using Maximum Likelihood estimation technique in SEM and the results are shown in table 1.11 and figure 1.3 below. The standardized regression weight shown in the table not only indicates the direction but also the magnitude of the proposed relationship while p-value confirms the significance of the relationship.

As hypothesized, findings show that persuasion stage is positively affected by all perceived benefits of AECs like relative advantage, compatibility, ecology, image as expected. Hence hypothesis H_b is supported. This is consistent with temporal distance theories (Trope & Liberman, 2003; Wright & Weitz, 1977) suggesting that perceived performance benefits are important for distant future adoption decisions to encourage non-adopters to adopt (Castaño et al., 2008). Among all the significant AEC benefits, compatibility is the strongest predictor of persuasion ($\boldsymbol{\beta}$ = 0.29, p< 0.01). Ecology is the second critical factor explaining the second stage of AEC adoption ($\boldsymbol{\beta}$ = 0.28, p<0.01). Image, on the other hand, is the weakest factor significant at 10% significance level ($\boldsymbol{\beta}$ = 0.10).

Table 1.11. Results of the structural model

Hypotheses		Standardized regression weights (**β**)	p-value	Decision
Relative advantage → Persuasion	H_b	0.21	.000	Accepted
Compatibility → Persuasion	H_b	0.29	.000	
Ecology → Persuasion	H_b	0.28	.000	
Image → Persuasion	H_b	0.10	.090	
Relative advantage → Decision	H_c	0.03	.635	Rejected
Compatibility → Decision	H_c	0.08	.183	
Ecology → Decision	H_c	0.15	.021	
Image → Decision	H_c	0.00	.991	
Complexity → Implementation	H_d	-0.18	.003	Accepted
Risk → Implementation	H_d	0.18	.003	
Complexity → Confirmation	H_e	-0.07	.242	Partially
Risk → Confirmation	H_e	0.15	.013	Accepted
Trialability → Implementation	H_f	0.23	.000	Accepted

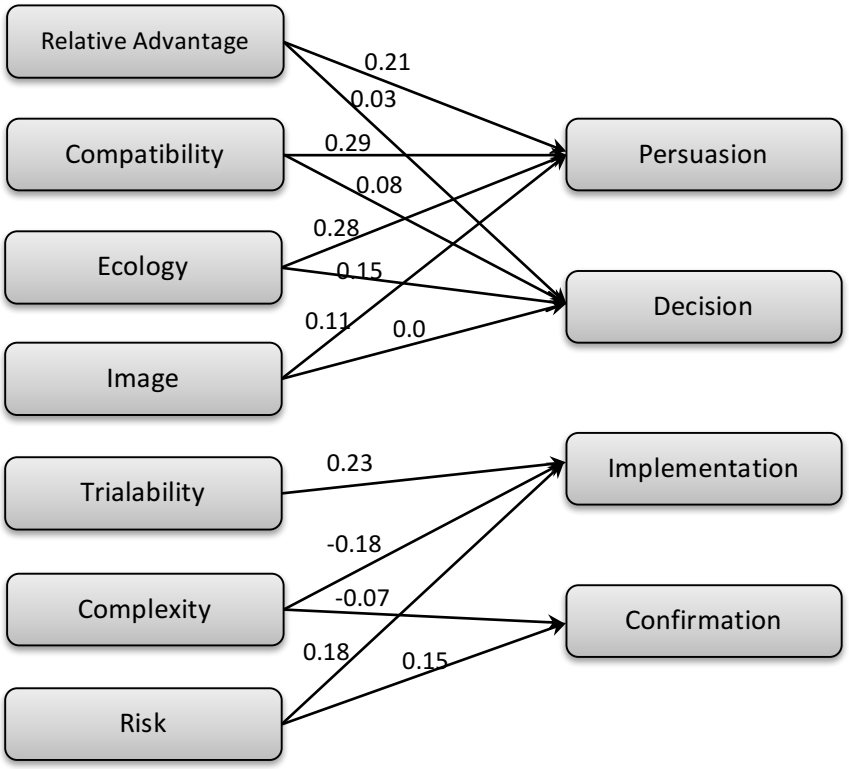

Figure 1.3. Results of the structural model

On the other hand, none except perceived ecology of using an AEC significantly explains variation in decision stage (**β** = 0.15, p <0.05). This leads to the rejection of hypothesis H_c which proposes that all perceived benefits predict decision phase.

As hypothesized, potential losses of using an AEC strongly affects implementation at 1% significance level. Perceived complexity of use and risk associated with AEC, both brings 18% change in individual's overt behavior of using a green car (**β**= -0.18 and 0.18 respectively), indicating equal importance of both predictors. These results confirm the assumptions of temporal distance theories and loss aversion theory (Kahneman & Tversky, 1979) that perceived costs, losses, and uncertainties of innovation's actual use are important for imminent future adoptions decision (Arts et al., 2011; Castaño et al., 2008). More specifically, the finding suggests that perceived learning difficulty, time, and cost are effective during actual use rather than early stages (Chong & Chan, 2012; Wood & Moreau, 2006). However, the results show a positive relation between risk and implementation. This is due to participants neutral response about the potential riskiness of using AECs in terms of financial, functional, health-related, and social uncertainty (mean score = 2.88, table 1.10) and their disagreement with AEC current use (mean score = 1.93, table 1.10). In terms of proximal benefits, perceived trialability also significantly predicts implementation stage (**β** = 0.23, p <0.01). Both results confirm hypotheses H_d and H_f. In terms of degree of change, trialability of green cars is the strongest determinant of overt behavior compared to the other two.

Unexpectedly, complexity of using a sustainable car does not explain significant change in reaching to confirmation stage (**β** = -0.07, p >0.10). However, low risk of using a sustainable car explains significant variation in confirming the adoption decision (**β** = 0.15, p < 0.05). This result facilitates partial acceptance of hypothesis H_e. Finally, the overall results support first hypothesis, H_a which suggests that different attributes of innovation affect different stages. The results shown in table 1.11

reveal that pre-adoption, adoption, and post-adoption stages have different predictors further confirming the existence of stages in case of AEC technology.

1.5. Discussion and conclusion

1.5.1. Discussion

The present paper addresses the first research question by exploring distinct nature of innovation adoption process. It empirically confirms the stage hypothesis by identifying 5 stages in case of high involvement innovations which require efforts to break existing routines and switch to new innovations which are in the early stage of diffusion. To do so, data on smartwatch innovation was collected from individuals. Exploratory factor analysis extracted solution of 5 different factors referred as knowledge, persuasion, decision, implementation and confirmation. The factors are unique and show little or no association with each other. However, the PCA and PAF used to extract factors show relatively highest association between the last two stages (r = .25 and .30 respectively, table 1.8 and 1.9). Such results provided an early signal that the two stages have a significant relation and are collinear. To further confirm the results and to validate the stage existence in another similar setting, data were collected on AEC adoption from car users. The data were analyzed through CFA, which also confirms the existence of stages. However, this time the results indicated that there is strong association between implementation and confirmation of sustainable cars (covariance = 0.77, figure 1.2 and r =0.73, table 1.10). This leads to the conclusion that the two extracted post adoption stages may not be distinct and may be considered as a single stage. This is further confirmed by the goodness of fit indices of the SEM which did not exceed the threshold values (GFI and AGFI < 0.90 and RMSEA > 0.05)[8]. Though the study supports the existence of different stages of adoption in case of innovations which require

[8] Modification indices shown by the SEM suggests to covary the last two stages, confirming that the two constructs are not unique. The model was retested after merging both constructs which showed goodness of fit (chi-square/df < 5.00, p-value > 0.05, GFI and AGFI > 0.90, CFI > 0.95, RMSEA < 0.05) between observed model and theoretical model.

efforts to switch to new behavior, the results should be used cautiously as the last two subsequent stages show high collinearity. However, the findings of the structural model reveal different predictors of both stages, signaling a separation.

The study also successfully addresses the second research question by identifying and confirming dynamic effects of innovation characteristics on consumer innovation adoption process further verifying the stage existence. Knowledge stage is taken away from the structural model as individuals at this stage know only about the innovation's existence and do not form a positive or negative impression hence are less likely to use various criteria for innovation's evaluation. The results suggest that individuals use different evaluative criterions during the multi-stage adoption process and different perceived attributes affect stages differently (Alexander et al., 2008; Arts et al., 2011; Castaño et al., 2008; Wood & Moreau, 2006). I found that perceived benefits of an innovation are relevant for persuasion in line with the CLT argument (Trope & Liberman, 2003). Similarly, perceived losses of an innovation are relevant for implementation stage in line with prospect theory (Kahneman & Tversky, 1979). However, the assumptions of both theories are not fully supported in case of decision and confirmation stage. Infact, the study is unable to find numerous determinants of both stages. This is in part inconsistent with the stage hypothesis confirmed from both surveys. Perceived ecology explains variation in buying decision of a sustainable car and complexity of use explains variation in confirming the future use of an adopted car while all other expected relations could not be confirmed. A possible explanation is that many other predictors that were not included in the research model due to explorative nature of this study (for example observability, profitability, car cost, car design) could be additional possible candidates. In this respect, Moore and Benbasat (1991) classification of innovation characteristics can serve as a starting point. The present study combines financial, social, health/ safety, and functional risks under a single latent construct. Testing the impact of each separately (Petschnig et al., 2014) may affect stages in different ways (Castaño et al., 2008). Castaño and colleagues show that

uncertainty about potential benefits is more relevant for distant future decisions while uncertainty about switching and learning costs is more pertinent for near future decisions. Others add (potential) adopter characteristics and find relevance with adoption (Arts et al., 2011; Gatignon & Robertson, 1985; Manning et al., 1995; Tornatzky & Klein, 1982). The other possible explanation is that many relationships between exogenous and endogenous constructs were not hypothesized during the literature review which may reveal significant results, if added. For example, complexity-decision link, ecology-decision link, compatibility-confirmation link etc. show significant correlations (r = 0.15, 0.19, and 0.42 respectively, table 1.10). The present work is an exploratory study which confirms the basic assumption of stages' existence. Hence, it should be considered as a first step and used to extend the existing framework by including other relevant innovation attributes or relationships.

1.5.2. Conclusion

Existing literature on consumer innovation adoption does not provide empirical validation of distinct stages of innovation decision process neither typically differentiates between the impact of perceived innovation characteristics on distinct stages despite the evidence that individuals use different product evaluation criteria in different stages (see for example, Arts et al., 2011; Gardial, Clemons, Woodruff, Schumann, & Burns, 1994; Karahanna, Straub, & Chervany, 1999; Wilton & Pessemier, 1981). The results of this empirical research contribute to the existing knowledge which stands both in the theoretical framework and in the implications.

The present study contributes by exploring five distinct stages in line with Rogers' (2003) framework of innovation-decision process and identifying dynamic effects of perceived innovation attributes on each adoption stage. The SEM technique helped not only to test the model but also to explicate the strongest and weakest determinant of each stage by identifying the strengths of all relationships. This has implications as it helps practitioners to understand the most/least weighted abstract and/or concrete

benefits that encourage potential adopters in their smooth transition to the next stage. The existing literature on consumer adoption provides weak operationalization of the five stages, with few exceptions (Celik et al., 2014; Li & Lindner, 2007; Gilly and Zeithmal, 1985). The study also contributes by providing a valid and reliable scale for stages.

The findings of the study are also helpful for policy makers and practitioners to foster the diffusion of technologies which are locked-in due to the dominance of existing technologies in the mass markets. Since the information needs vary across stages, different messages and communication channels can be used at different stages to improve (potential) adopters' perception. For example, in distant future adoption case, managers should use communication strategies that engage individuals in an outcome simulation which reduces performance uncertainties and encourage positive feelings while in near future adoption case, managers should use strategies that engage them in a process simulation which reduces switching cost and assuage fatigue and anxiety (Castaño et al., 2008). In particular, ads and mass media messages which increase product awareness can help people at the knowledge stage pass to the next level, peer and subjective opinion can help people at the persuasion stage to form positive impression and pass to the next stage, while technical assistance by change agents or sales representatives can help people reduce operational complexity at the implementation stage to pass to the final stage (Rogers, 2003).

What's more, consumer's evaluation and adoption of a new product results in emotional responses that should be considered during the development of product launch strategies (Wood and Moreau, 2006). In this regards, designing a compelling value proposition (Anderson, Narus, & van Rossum, 2006) by combining required functional and/or hedonic attributes is a suitable strategy to encourage non-adopters pass through the adoption phases. The subsequent chapter sheds light on this perspective to foster diffusion of sustainable technologies.

The main results of the study offer new insights for future research to enrich the much-studied consumer innovation adoption literature. The results of the study should be verified in other similar settings to address both the limitations discussed in the previous section. The findings show that persuasion and implementation have numerous predictors but decision and confirmation are relatively less explained. In this respect, correlation results provide opportunities to test more determinants. In the case of sustainable cars, the last two stages seem similar but are not explained by the same set of variables still favoring the distinction. Besides, another limitation of the present study is that majority of the respondents in both surveys were non-adopters as obvious from sample statistics. Participants in the two surveys were mainly in pre-adoption or adoption phases. Although the empirical setting was chosen for practical reasons, findings especially for post adoption phases may change in the study with sample of only adopters. The high association among several innovation attributes signals possible interdependencies and testing such interlinks can be another avenue for future research.

Chapter 2

Value Proposition Innovation: The Case of Vehicle-to-Grid Technology

2.1. Introduction

In the bourgeoning literature of business model, business model innovation (hereafter BMI) seems the panacea for competitive advantage. BMI is a new dimension of innovation which has more strategic advantages than traditional dimensions like process and product innovation (Chesbrough, 2007).

Recent studies have identified BMI as an important source of competitiveness, particularly for sustainable innovations (Boons & Lüdeke-Freund, 2013; Schaltegger, Lüdeke-Freund, & Hansen, 2012). “Firms need different business models to transform the specific characteristics of sustainable technologies into new ways to create economic value” and to “create new sources of value for customers in addition to their positive impact for the environment” (Bohnsack, Pinkse, & Kolk, 2014, p. 284). BMI aims to change the core logic and key elements of a firm (Bucherer, Eisert, & Gassmann, 2012), on the two key dimensions of a business model on which innovation can occur namely 'value creation' and 'value capture' (Amit & Zott, 2001; Baden-Fuller & Morgan, 2010; Casadesus-Masanell & Ricart, 2010; Chesbrough, 2007; Demil & Lecoq, 2010; Teece, 2010; Zott, Amit, & Massa, 2011). So far, innovation for value creation and value capture has been lumped together as BMI and innovation of individual elements has to the knowledge of the author not been the focus of academic studies. Yet, a separation is necessary, considering that innovation can occur in different areas of the business model (Bohnsack et al., 2014), e.g. sometimes only the value network is innovated and sometimes only the value proposition. This has important managerial and theoretical implications.

Hence, I take a more fine-grained approach and focus on value creation which is often attributed to the link to the customer (Baden-Fuller & Haefliger, 2013). I submit that particularly the customer perspective is important for sustainable innovations since it is generally assumed that these technologies create value, yet customers fail to appreciate this value. The link between the customer and the business model is the *value proposition*- the most integral and central component in a business model.

Although the value proposition concept is largely used in the literature, in depth research on the topic is scarce (Frow & Payne, 2011). Value proposition is a firm's promise of value to its customers, combining benefits and price (Lanning & Michaels, 1988). In a word, the value proposition describes "the way a firm differentiates itself from its competitors and is the reason why customers buy from a certain firm and not from another" (Osterwalder & Pigneur, 2004, p. 70). Value is created only when the product or service is consumed (Gummesson, 1998, p. 247; Gummesson, 2008, p. 15). A firm can only offer a value proposition, it's the customer who evaluates and possibly accepts, thus creating value (Vargo & Lusch, 2004, p.11). An innovation in itself does not necessarily provide a higher value (Lindic & da Silva, 2011) even if it is technically superior to existing offers (Bower & Christensen, 1995). Clearly then, the value proposition has a key role in the diffusion of sustainable technologies which are often perceived inferior compared to conventional technologies.

Despite its importance, there is remarkably little research focusing exclusively on the innovation of a value proposition. Mostly, it is discussed within the BMI concept and hence lacks a clear conceptualization. Few exceptions are Payne and Frow (2014 a, b) who contribute in the marketing field by detailing the development of new value propositions for specific best exemplar organizations. The authors, however, fail to provide a general framework and suggest that "there is a need…for the

development of a conceptual framework that integrates different perspectives, contributions and insights from the value and strategy literatures" (Payne & Frow, 2014a, p. 256).

To fill this void, this research tends to answer what are the mechanisms of innovating a value proposition and what is the relationship between VPI and attractiveness of new sustainable technologies which otherwise are hard to diffuse? Based on Baden-Fuller and Haefliger's (2013) framework, the research distinguishes between BMI and VPI and illustrates that the two concepts are distinct which are often treated jointly by the academic literature within the realm of BMI.

Following the conceptualization part, I illustrate my approach at the case of a novel sustainable technology, namely vehicle-to-grid (V2G) technology. V2G – a charging technology that allows to charge and discharge the battery of an electric car and therefore enables storage of renewable energy, balancing the grid, and trading of electricity – exactly fits the notion of sustainable innovation since it targets a specific customer niche but has the potential for electric car industry and provides a sound basis to validate assumptions of this research (Helms, Loock, & Bohnsack, 2016). To address both research questions, I adopt a mixed-method approach building on focus groups and survey data. Through focus groups, different value propositions for V2G were configured, which were subsequently used in the expert surveys. I used the quantitative data from the online expert surveys to cluster EV and non-EV users. I then analyzed the reactions of user groups to different configurations of V2G value proposition.

The results suggest that VPI is a process of (re)configuring attributes according to the expectations and needs of target customers. Since early adopters and late adopters differ in their characteristics, firms should narrow their focus on single value discipline to target a particular segment and (re)bundle attributes accordingly. The findings show that early adopters or experienced users were attracted to value propositions focused on hedonic attributes while late adopters or inexperienced group preferred

value propositions focused on utilitarian attributes. Based on the results, I submit a method of value proposition innovation to enhance innovation attractiveness which has implications for managers and discuss the contribution to the current debate on sustainable technologies and BMI.

Before moving to the empirical results, I first review the literature on BMI and differentiate between innovation for value capture and value creation. Subsequently I show how the data was collected using qualitative and quantitative methods. The fifth section presents and discusses results of the study. Final section discusses the implications and contributions, indicates caveats, and provides future directions.

2.2. Theoretical background and conceptual framework

2.2.1. Business model innovation types

2.2.1.1. Business model

The term ‘business model’ was predominantly coined in practice during the 1990s, but only gradually has been adopted and researched by the scientific community (Morris, Schindehutte, Richardson, & Allen, 2006). Over time, the concept has evolved continuously from being simply a term that refers to ‘the logic of the firm’ or a ‘way of doing business’ to a conceptual tool including different building blocks (e.g., Osterwalder, Pigneur & Tucci, 2005). The literature lacks a clear and precise definition of business model (Magretta, 2002; Teece, 2010). This is because the concept has largely progressed in divergent 'silos' as per the research interests of scholars from different streams like e-business, strategy, and innovation and technology management (Zott et al., 2011). However, there is a consensus that business models are about how firms 'create' and 'capture' value (Amit & Zott, 2001; Baden-Fuller & Morgan, 2010; Casadesus-Masanell & Ricart, 2010; Chesbrough, 2007; Demil & Lecoq, 2010; Rauter, Jonker, & Baumgartner, 2015; Teece, 2010; Zott et al., 2011). A plethora of frameworks have emerged around these two core dimensions (e.g. Bohnsack et al., 2014; Chesbrough and Rosenbloom, 2002;

Johnson, Christensen, & Kagermann, 2008; Morris, Schindehutte, & Allen, 2005; Osterwalder et al., 2005).

Around the two dimensions Baden-Fuller and Haefliger (2013) and Baden-Fuller & Mangematin (2013) suggest a typological classification of a business model that presents four elements namely customer identification, customer engagement, value delivery and linkages, and monetization. Customer identification helps to answer who are the customers i.e. who pays for the product and who uses the product? Customer engagement requires understanding the needs and expectations of key customer segments and then developing a value proposition for each segment. Value chain and linkages build a link between the other three elements and provides the mechanism to deliver a firm's product to its different customer groups. Such value linkages create a governance system and an architecture of information flows between different players in a firm's value chain (Amit & Zott, 2001; Casadesus-Masanell & Ricart, 2010). Monetization is not all about pricing; it includes models and systems that determine methods of collecting revenues and timings of payments. Clearly then, the four elements relate to the two dimensions of a business model; value creation is attributed to the link to the customer and value capture to the delivery of the value and its monetization (Baden-Fuller & Haefliger, 2013). Specifically, they reflect different integrated building blocks proposed by the existing literature in order to describe how a business model is composed or configured (Abdelkafi, Makhotin, & Posselt, 2013; Amit & Zott, 2001; Boons & Lüdeke-Freund, 2013; Casadesus-Masanell & Ricart, 2010; Chesbrough & Rosenbloom, 2002; Johnson et al., 2008; Morris et al., 2005; Osterwalder et al., 2005; Osterwalder & Pigneur, 2010; Zott & Amit, 2010). Among all building blocks, most commonly studied are customer value proposition, value network/ supply chain, and financial model. However, in a large number of contributions, value proposition which creates customer value and is a link between a firm's business model and customers plays the most integral and central role in any enterprise business model

(Abdelkafi et al., 2013; Chesbrough & Rosenbloom, 2010; Johnson et al., 2008; Morris et al., 2005; Osterwalder & Pigneur, 2002; Voelpel, Leibold, & Tekie, 2004). Value networks and financial models, on the other hand, facilitate value capture. The value proposition explains what the product offering is and how it can be used by the target customers while value network explains the role of different stakeholders like suppliers, third parties, and customers in capturing value from the product commercialization (Chesbrough & Rosenbloom, 2002).

Having this distinction, innovation can occur on both dimensions: value creation and capture, separately or together. Thus, BMI creates "new ways to create and capture value for its stakeholders" (Casadesus-Masanell & Zhu, 2013, p. 464). However, so far, innovation in this realm has been treated all as BMI, despite an obvious separation in practice. Bohnsack et al. (2014) hint at the fact that a separation is necessary in order to better understand the role of BMI in the case of sustainable technologies. In studying BMI of electric vehicles (EVs), they state that "while the firms in our study did not make radical changes to the value proposition, most adjustments occurred in the value network and the revenue/cost model" (p. 299). To that end, I suggest to distinguish between innovation of business model and innovation of its individual dimensions.

2.2.1.2. Business model innovation

During the last decade, BMI at the nexus between business model literature and innovation literature has gained much attention. There are two prevailing themes in the literature- business model as a 'vehicle *for* innovation' and 'subject *of* innovation' (Zott et al., 2011). First, the business model is a 'market device' (Callon, Millo, & Muniesa, 2007; Doganova & Eyquem-Renault, 2009) that brings innovative ideas and products to the market, hence mediates between technology and economic value creation (Chesbrough & Rosenbloom, 2002). Indeed, research has shown that the design of business models can often make the difference between innovations that are successfully commercialized versus

those that stay on the shelf (Chesbrough & Rosenbloom, 2002; Teece, 2010). Second, business model is a subject of innovation in and of itself: it is a new dimension of innovation (Mitchell & Coles, 2003). That is to say that business model innovation complements traditional dimensions like process, product, and organizational innovations (Zott et al., 2011), infact provides more strategic advantages than others (Chesbrough, 2007; Zott & Amit, 2010). This study focuses on the role of BMI as a subject of innovation.

BMI is *"a process that deliberately changes the core elements of a firm and its business logic"* (Bucherer et al.,2012, p. 184). It is the *"discovery of a fundamentally different business model in an existing business"* (Markides, 2006, p. 20). BMI for sustainability refers to a subset of general BMI, specifically to innovations that *"create significant positive and/or significantly reduced negative impacts for the environment and/or society, through changes in the way the organisation and its value-network create, deliver and capture value (i.e. create economic value) or change their value propositions"* (Bocken, Short, Rana, & Evans, 2014, p. 44). Sustainable business models define firm's purpose, business logic, and performance measurement based on triple bottom line approach (cf. Elkington, 1997) and go beyond creating economic value by including other forms of values targeted for a wide range of stakeholders like environment and society (Bocken, Short, Padmakshi, & Evans, 2013; Rauter et al., 2015; Stubbs & Cocklin, 2008), thereby creating the business case for sustainability (Schaltegger et al., 2012).

BMI has been argued to come in two broad forms; business model design referring to entirely new business models such as for start-ups and business model reconfiguration/redesign referring to change of an existing business models (Bocken et al., 2014). The business model reconfiguration is distinguished from new business model since it is an activity in which managers reconfigure or acquire new organizational resources to integrate sustainability in an existing business model. Other BMI

classifications are based on the degree of change. For example, Mitchell & Coles (2003) propose four classes- improvement, catch-up, replacement, and actual innovation while Schaltegger et al. (2012) distinguish between four BMI stages - adjustment, adoption, improvement, and redesign.

In line with Baden-Fuller and Haefliger (2013), I suggest that BMI refers to the innovation of the value creation and value capture while VPI refers to the innovation of the customer identification and engagement. In other words, innovating a business model does not require all building blocks to be changed simultaneously, although changing a single element of a business model may impact the overall business model (Johnson et al., 2008; Spieth & Schneider, 2016). This is because of the fit between all elements of the business model which creates a coherent story that makes sense to wide range of stakeholders. Hence, managers view a business model as a boundary spanning interdependent activity system and change its content, structure, or governance to innovate firm's business model (Zott & Amit, 2010). This is also depicted in figure 2.1 below. The figure shows that three types of BMI emerge next to the box which resembles the status quo. The figure shows that innovation on one dimension refers to value network (or financial model) innovation or VPI respectively (box 2 and 3) while innovation on both dimensions, simultaneously or consecutively, constitutes BMI (box 4). A change in a value proposition occurs at instrumental/ operational level while a change in a business model occurs at strategic management level (Breuer & Lüdeke-Freund, 2015).

Since BMI has recently received increased academic and management attention (Schneider & Spieth, 2013; Spieth, Schneckenberg, & Ricart, 2014), while VPI on the other hand did not receive explicit attention (Payne & Frow, 2014a). This is surprising since it has been found that the superior value proposition is a way to achieve competitive advantage. A peculiar characteristic of the business model innovation is that it enhances different performance dimensions over the dimensions emphasized by

existing business models of competitors (Markides, 2006). This adaptation changes the configuration and composition of the existing value proposition which is discussed below.

Key Dimensions	Sustained Value Capture	Innovated Value Capture
Sustained Value Creation	1 Status Quo (Sustained Business Model) *Example: Internal Combustion Engines with reduced emissions*	2 Value network and/or financial model innovation (change in value delivery and key roles of stakeholders; change in revenue/cost model) *Example: In-house bakery in supermarkets, Ryanair*
Innovated Value Creation	3 Value proposition innovation (change in value creation by reconceiving the product/service offering) *Example: Cirque du soleil*	4 Business model innovation (change in value creation, delivery and monetization) *Examples: Airbnb, Car2Go, Self-storage*

Figure 2.1. Matrix of innovation in key elements of a business model

2.2.2. Value proposition innovation

2.2.2.1. Value proposition and its innovation

The value proposition is a firm's promise (Lanning & Michaels, 1988) to deliver a bundle of benefits (Osterwalder & Pigneur, 2010) and values to its customers such as quality, price, performance, and convenience (Treacy & Wiersema, 1993).

The delivery of a superior value proposition may provide a competitive advantage to a firm (Lanning & Michaels, 1988; Payne & Frow, 2014a). It provides the firm a way to differentiate from its rivals and the customer a reason to buy from a certain firm (Osterwalder & Pigneur, 2004). In fact, the value proposition is central to "the creation of a unique and valuable position" (Porter, 1996, p.68) for which customers are willing to pay a premium price that exceeds the cost of differentiation. Value proposition is then a way to make explicit a business strategy. The essence of strategy is choosing to perform

activities differently from competitors so as to provide a unique value proposition (Kaplan & Norton, 2001).

Value propositions can also create 'blue oceans' (Kim & Mauborgne, 2005) in which firms venture outside their present paradigms to find new value both for the firm and customers by breaking traditional value/cost trade-off and thereby opening up an uncontested market space. This makes the value proposition actually the most integral and central element in any enterprise business model and therefore crucial to understand its innovation (Chesbrough & Rosenbloom, 2002; Johnson et al., 2008; Morris et al., 2005; Osterwalder & Pigneur, 2010; Voelpel et al., 2004).

A firm can only make its value proposition; it's the customer who determines value and participates in its creation through coproduction (Vargo & Lusch, 2004). Hence, the relation between value proposition and value creation stands in the achievement of customer needs through combining different performance attributes or performance dimensions in a value proposition. An innovation of the value proposition simply refers to a change of the value proposition. As BMI refers to business model design or business model redesign (Bocken et al., 2014), VPI on the similar basis is then defined as the *combination* or *recombination* of attributes for customer value.

VPI is a process consisting of a sequence of stages (Sheehan & Bruni-Bossio, 2015) which starts with (I) the identification and understanding of key dimensions of target customer value; (II) hierarchical evaluation and combination of these value dimensions to develop a value proposition; and (III) finally the evaluation of the competitiveness of value proposition which is based on the suitability of the company resources and competencies required for delivering the proposition to gain competitive advantage (Rintamäki, Kuusela, & Mitronen, 2007). Once a value proposition is designed other steps are taken to ensure its success like its market testing, launch of the solution, and review of its performance and knowledge gained from its implementation (Payne & Frow, 2014a). Hence, value

proposition configuration is a process that initiates with the identification of target customers, sensing of customer needs and competitor's offerings; followed by the development of value proposition based on the identification of relevant value dimensions. Finally the value proposition is tested and evaluated in the market based on its ability to solve customer problems, meet their needs, and exceed customer value more than the competitive offering(s). Moreover, the steps in the process may not be linear or may be iterative due to the refinement of value proposition prototype through testing and customer feedbacks, essentially a trial and error learning approach (cf. Sosna et al., 2010). In the end, VPI is meant to lead to a value proposition that resonates with the customer.

2.2.2.2. Value proposition innovation and innovation adoption

To answer the second research question: how a change in value proposition can increase innovation attractiveness, it is important to acknowledge the differences between customers (Reinhardt & Gurtner, 2015). Literature on innovation diffusion (Rogers, 2003) and consumer innovativeness (Bartels & Reinders, 2011; Goldsmith & Hofacker, 1991; Hirschman, 1980; Midgley & Dowling, 1978; Roehrich, 2004) help identifying and engaging different groups of customers, called adopters. The innovativeness of adopters influences diffusion. Innovativeness is an individual's tendency to adopt new product or service more quickly than others (Midgley & Dowling, 1978). The diffusion curve depicts how innovation adoption passes through different groups such as innovators, early adopters, early majority, late majority, and laggards (Rogers, 2003). Innovators are technologists and well-informed risk takers willing to try an unproven innovation. Early adopters are educated opinion leaders who envision the future applications of the innovation and willing to be the first to reap benefits to achieve competitive advantage. Early majority users are pragmatists and need to be confident before adoption by relying on the feedback from existing users. Late majority are conservative buyers who only adopt the product

once it is established in the market. Finally, laggards are skeptic customers who do not trust novel technologies and only adopt when forced (Moore, 1991).

Literature suggests that rate of innovation diffusion across these segments is not the same and forms an S-shape curve (Rogers, 2003). In the start, the curve is flat when the innovation is adopted by innovators and early adopters for testing. If the innovation is a success, early majority and late majority enters the market and the diffusion rate takes a steep increase. The curve again flattens out when laggards adopt the product. Innovators and early adopters form 16% of the total market. These adopters differ in terms of their socio-economic and psychological characteristics, requirements, and market entry time. This means that different customers may form different preferences and satisfy different needs from the same product. Moore's (1991) technology acceptance lifecycle identifies gaps between different adopter groups but the largest gap - the *chasm* is formed between early adopters and early majority users. Crossing this chasm is a crucial point in the adoption process where some innovations enjoy a successful take-off while others suffer decay in sales.

Early adopters are true lead users and market visionaries. So the firms closely work with the members of this niche to develop and refine the innovation (Moore, 1991). The concept initially embraced by early adopters becomes the core of the product that will be adopted by early majority. Late adopters form the mainstream market, are pragmatists who need assurance that the adoption of the product will offer them economic value. They require firms to provide a whole solution that offers more benefits compared to their existing best alternative. Firms need to work effectively with the pragmatists to successfully offer them the economic value (Moore, 1991). In other words, early adopters encourage novel concepts that offer *scarcity* while mainstream market customers need *social proof*. Clearly then, different customer groups are attracted to different value propositions of the same product. For instance, for electric cars, Tesla's Model S targets an affluent tech-oriented consumer, promising fun in

driving, while Nissan's Leaf offers an affordable car for the environmentally conscious consumer. This might suggest that in the introduction phase of technological innovation, firms should focus on social attributes in the value proposition (to attract early adopters) and subsequently stress more functional elements (to attract late adopters) in order to accelerate the diffusion through the *chasm* to the tipping point. This can be done by reconfiguring a value proposition.

For accelerated diffusion, the performance dimensions of an innovation should match the needs of specific customer segments. That is to say, customers across different segments differ in their characteristics; for instance some are price conscious while others are quality conscious, some are experienced while others are inexperienced. These differences require firms to match their offerings with what customers value by (re)combining a particular set of attributes. In other words, value proposition changes the whole value bundle to satisfy specific needs rather than changing a single performance attribute. Below I elucidate how a customer value bundles are created.

2.2.2.3. Customer value

In order to create an attractive value proposition, the bundle of attributes needs to be carefully configured to create customer value. Thus, identifying what do consumers value is a precondition to design a differentiated proposition (Rintamäki & Kirves, 2016). Value is created when a consumer's valuation of benefits using a product/ service is increased (Priem, 2007). Customer value is defined as "the consumer's overall assessment of the utility of a product based on perceptions of what is received and what is given" (Zeithaml ,1988, p. 14). While this definition reflects the first route to understand a customer value: tradeoff between benefits and costs; there is another route: identifying the outcomes of buying in terms of key value dimensions of customer value (Rintamäki & Kirves, 2016). We follow the second route because "modeling the key dimensions enables profiling customer perceptions of value for comparison of them to the intended value creation" (Rintamäki & Kirves, 2016, in press).

The term value in the value proposition literature is mostly described as "customer value" or "perceived value" (Rintamäki et al., 2007; Sweeney & Soutar, 2001; Zeithaml, 1988). Sweeney and Soutar (2001), Christenen (2010), and Rintamäki et al. (2007) identify different value dimensions. These value dimensions are in line with different components indicated by Maslow's (1943, 1954) hierarchy of need model and Sheth, Newman, & Gross's (1991b) theory of consumption values.

Table 12.1 Value dimensions

Attributes / customer value	**Economic**	**Functional**	**Emotional**	**Social/ symbolic**
General attributes V2G	Saving money	Charging car	Fun to trade electricity	Sustainable
Product Focus	Price	Solution/ convenience	Customer experience	Meaning
(Re)combination Tactic	Improve existing price or combine functional attributes to offer convenience and fair price	Improve existing solutions or combine hedonic/psychic attributes	Improve existing affective experience or combine social and functional attributes	Improve existing social meaning or combine different attributes
Type of customer cluster	Late adopters/ Pragmatists			Early adopters/ Visionaries

Economic value is defined as the perceived utility derived from the offering due to reduction of its perceived costs. Functional value is defined as the perceived utility derived from the offering due to its perceived quality, convenience, and performance. Few studies refer economic and functional values, the two primary drivers of consumer choice, jointly as functional values (cf. Sheth et al., 1991a,b) because they consider economic benefits as part of functional benefits. While others emphasize the importance of studying price and performance separately as two functional sub-factors (cf. Sweeney & Soutar, 2001). Emotional value is defined as the utility derived from the offering due to the feelings or

affective states attached with the offering. Finally, symbolic/ social value is defined as the perceived utility derived from the offering's ability to enhance self-concept and self- expression in a social circle. These value dimensions are further explained in table 2.1.

Following the hierarchy of needs, these value dimensions which form the value proposition can be viewed on a continuum, namely from utilitarian to hedonic dimensions (Rintamäki et al., 2007). Economic and financial are more utilitarian while social, symbolic, and emotional values are more hedonistic. Figure 2.2 shows value dimension continuum. The utilitarian dimensions can be regarded as pre-requisites and allow product acceptance by bringing customers to the market for the first time. However, when the product becomes more attractive, it is increasingly bought and moves from left to right on the continuum stimulating more hedonic attributes. Berry, Carbone, & Haeckel (2002) state that "it's no doubt clear that providing the right clues about functionality is essential - if a product is perceived as shoddy, people won't buy it, period" (p.86). But restricting a customer value only to price vs. functionality reduces the value of firm's offerings; hence it is important to synergize emotional components of experiences with functional cues (Berry et al., 2002). Offerings with utilitarian focus are simpler in nature and do not require deep customer understanding while the offering with the social emotional focus are complex in nature and require deeper customer understanding (Khalifa, 2004). This suggests that attracting inexperienced customers requires value proposition with concrete and objective value dimensions, yet experienced customers in the market require more emotional and social attributes.

Concluding above, I submit that (re)configuration of value proposition is a process including two steps. First, identifying and engaging the target customer groups (Baden-Fuller and Haefliger, 2010) and second the (re)combination of attributes. While recombining attributes in a value proposition, firms

face important decisions of what attributes should the main value consist of? In the following section I test the conceptual framework based on the V2G technology.

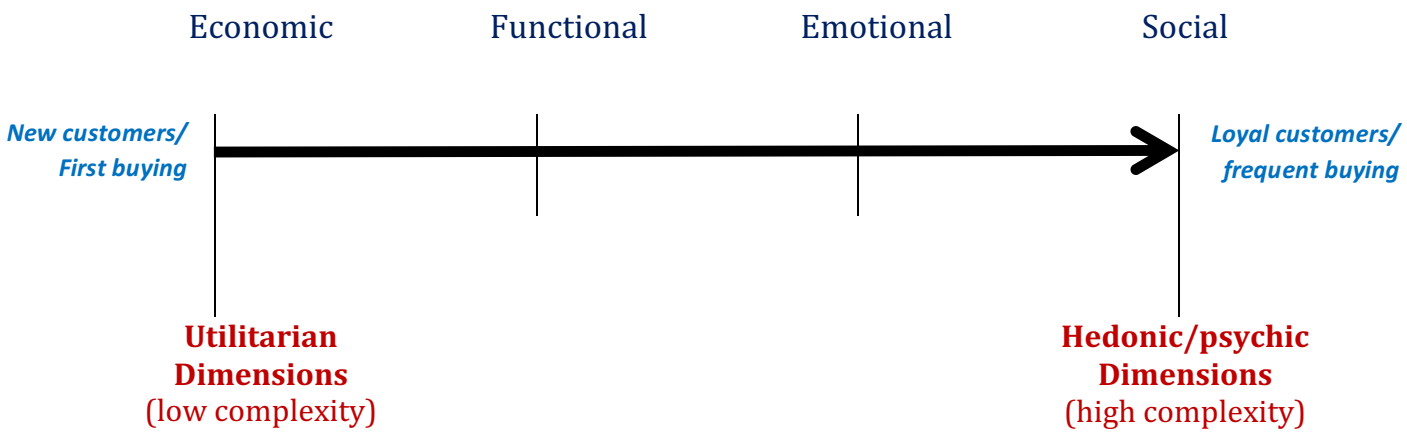

Figure 2.2. Value dimension continuum

2.3. Research design

Based on the literature review, I find that value proposition broadly answers what (combination of) values are delivered and to whom. Hence, gaining insight of customer value and customer segments is essential to innovate a value proposition. Following the conceptualization of VPI mechanism in previous section, I address the research question: does the (re)combination of attributes enhance the attractiveness of a sustainable innovation? I explore this in a study on a new EV charging technology, called vehicle-to-grid (V2G) technology, which fits the notion of sustainable technology. I adopted a mixed-method approach and collected data in two steps: focus groups and online expert surveys. The focus groups facilitated the understanding of important customer values and design of V2G value propositions while online expert surveys helped to cluster group of individuals who share similar preferences for different value propositions and to test reconfiguration strategies.

2.3.1. Research setting: vehicle-to-grid (V2G) technology

V2G technology refers to a charging system which allows EV owners to not only charge the battery but also to discharge and in doing so make money through selling electricity and balancing the electric grid. This technology provides storage for renewable energy and allows using resources more efficiently as compared to alternative charging strategies.

The normal way to charge batteries, an existing best alternative of V2G, creates an increased load on the electricity grid as EVs are aggregated in sizeable numbers and often charge at the same time. The basic concept of V2G technology is cars can be charged smarter, namely the timing of charging can be allocated to different times and EVs can also feedback (excess) energy to the grid when there is peak of demand for electricity. Hence, the fundamental idea behind V2G is to use EVs as a source of energy generation and power reservoir of the grid (Guille & Gross, 2009; Parsons, Hidrue, Kempton, & Gardner, 2014). A setup of a V2G charging system is illustrated in Figure 2.3 below.

Thus, this technology allows efficient use of electricity resources, balances the energy fluctuations, provides control and flexibility to the driver, and enables the driver to trade electricity during peak hours. This creates value not only for suppliers but also for consumers. Yet capturing such value and convincing consumers to adopt V2G technology brings costs and complexities as there are some pre-conditions like a suitable infrastructure for V2G, EV ownership for conventional vehicle owners, and behavioral change to switch from normal charging to V2G charging. The value proposition of V2G is likely to be compelling for experienced EV drivers but not for inexperienced non-EV drivers. Put differently, the value proposition is likely to be different for each of the customer segments. This makes V2G an ideal case for testing value proposition reconfiguration.

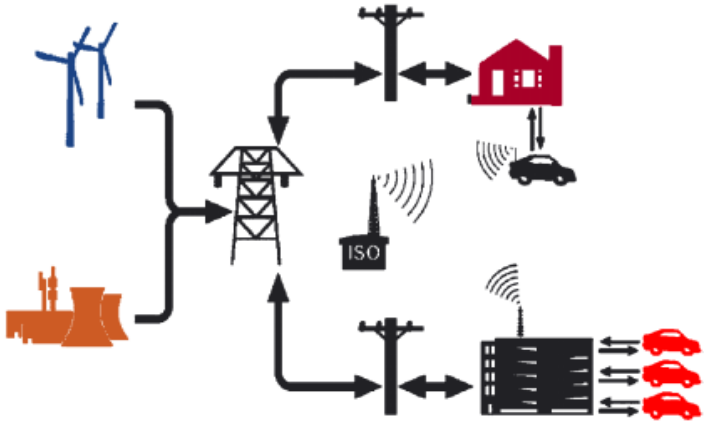

Figure 2.3. Illustrative schematic of V2G by Kempton and Tomić (2005)

2.3.2. Data collection process

Following the conceptual framework, two focus group meetings were conducted in the Netherlands with lead users and non-lead users (von Hippel, 1986) in June 2015. These were EV owners and non-EV owners. Lead users expect high benefits from a new technology and are ahead on important trends in the marketplace (von Hippel, 1986). The purpose of focus group meetings was to identify the most important attributes and explore three possible value propositions namely, the Electricity Bank (EBank), the Electricity Club (EClub), and the Green Electricity Club (Green EClub). Secondly, an online expert survey was conducted amongst Dutch sustainable car enthusiasts (n=54) from November to December 2015. Prior the survey, a pre-test was conducted among 28 Dutch EV and non-EV drivers. In the expert survey I included the technology itself and then different configurations of value propositions (see figure 2.4 as an example), ranging from a value proposition with an economic focus to a value proposition with a social focus. The process of the data collection is shown in table 2.2 below.

Figure 2.4. Schema representing the Electricity Bank value proposition

Table 2.2. Data collection methods

Steps	Data Collection		Objective	Respondents
1	Qualitative Data	1st Focus group	To establish the important attributes and explore possible configurations for V2G value propositions.	EV owners (n = 4)
2	Qualitative Data	2nd Focus group	To finalize the important attributes and possible configurations for V2G value propositions based on the output from step 1.	3 potential EV owners and 1 EV owner (n = 4)
3	Quantitative Data	Online Expert Survey	To observe preferences and attractiveness of each value proposition configuration finalized during step 1 and 2.	EV and non-EV users (n = 54)

2.3.2.1. Sampling for online expert survey

Using Qualtrics software, an online expert survey was designed to have quantitative responses from Dutch car enthusiasts. For this, snowball non-probability sampling technique was applied. Acquaintances, colleagues, and friends were contacted with a request to fill the online survey and to forward the survey link to their acquaintances. Follow up strategies were adopted to get timely and maximum responses. This resulted in 200 responses. However, after deleting the incomplete responses, I was left with 54 usable set of data. It is not possible to know exact response rate as the expert survey was conducted through internet. In order to have variation in the variables of interest, a heterogeneous sample of respondents was recruited with different gender, age, income, and education. The sample statistics is shown in table 2.3. The sample had 61% EV users, 89% males, 57% high monthly income holders (greater than € 4001), and 50% university degree holders.

Table 2.3. Sample statistics of an online expert survey (n= 54)

Socio-demographics		Frequency *(%age)*
Gender	Male	48 *(88.9)*
	Female	6 *(11.1)*
Vehicle Users	EV users	33 *(61.1)*
	Non-EV users	21 *(38.9)*
Monthly Income	€ 3,000 and less	8 *(14.8)*
	€ 3001-4000	15 *(27.8)*
	€ 4001-5000	14 *(25.9)*
	€ 5001 and above	17 *(31.5)*
Age	18-34	11 *(20.4)*
	35-44	13 *(24.1)*
	45-54	19 *(35.2)*
	55 and above	11 *(20.4)*
Education Groups	Lower vocation education	1 *(1.9)*
	Secondary vocational education	5 *(9.3)*
	Higher professional education	21 *(38.9)*
	University Education	27 *(50.0)*

2.3.2.2. Focus Groups

The objective to conduct focus group sessions was to establish a list of important attributes and to explore different configurations to design a superior value proposition for V2G technology. The two focus group meetings were held in Amsterdam, the Netherlands. Each focus group session included four Dutch members. The participants of the first session were EV owners. Whereas, majority of the group members of the second session did not own EVs (3 out of 4) but had plans to buy/ lease one in the future and were related to the industry. So, in both the sessions, the participants were knowledgeable. Each session was split in two parts. The first part was devoted to stimulate general awareness of V2G concept. The group members were given a detailed presentation on V2G technology. The second part included discussion on possible value proposition configurations of V2G technology and what they value in terms of economic, functional, hedonic, and social performance attributes. Details are summarized in table 2.4 below.

Table 2.4. V2G value proposition configurations and attributes

	Electricity Bank	**Electricity Club**	**Green Electricity Club**
Functional Attributes	Emergency button (low flexibility)	Each time flexibility (medium)	Each time flexible (high) + relocation
Economic Attributes	Fixed monetary reward	Variable credits / free charging	Variable points/ comparison/ free km
Emotional Attributes	n/a	n/a	Social comparison
Social Attributes	n/a	Membership	Part of club
Focus	Economic focus	Social focus (club)	Functional focus (relocation), emotional focus (comparison)
Needs fulfilled	Utilitarian	Hedonic	Utilitarian + Hedonic - gamification

2.3.2.3. Online expert survey and measures

The final part of data collection was completed through online expert survey from Dutch EV and non-EV users. The final versions of the different configurations: EBank, EClub, and Green EClub were included in the survey. The respondents were shown the configurations one by one and asked to rate the attractiveness of each.

The survey comprised of two parts: first part of the questionnaire was based on introduction and charging strategies information blocks while the second part consisted of questions divided in four sections: drivers' general profile, their general attitude and psychographics, value proposition configurations, and socio-economic characteristics.

In general attitude and psychographics section, questions were included to measure individual's environmental friendliness, sharing and interaction propensity, and their innovativeness. All the items were measured on 5-point Likert scale ranging from 1 = 'strongly disagree' to 5 =' strongly agree'. The items of consumer innovativeness were adopted from Goldsmith and Hofacker (1991). The items for other customer values like environmental friendliness and sharing and interaction propensity were constructed based on V2G setting and experts' suggestions. The new scales were face and content validated. To confirm the validity, I consulted with subject experts the items' scales, their wording, representativeness and relevance. In addition, a pilot online test was conducted from 28 individuals.

The configuration section measures the attractiveness for the three configurations of the V2G value proposition. For conventional vehicle drivers/users, the section starts with a scenario in which they were asked to imagine that they lease an EV and pay € 200 per month. Then all of the respondents were shown different configurations one by one. An example is shown in figure 2.4 above. They were then asked to indicate the attractiveness of each configuration on a 5 point rating scale (1 = very

unappealing to 5 = very attractive). I did not randomize the different propositions as I assume the sequence of configurations.

2.4. Results and discussion

In the following I report the findings of this study. Based on the focus group meetings, 3 value proposition configurations were tested in an online expert survey. The quantitative data from the online expert surveys was analyzed to test the assumption that different customer segments react differently to the reconfiguration of attributes. In order to do so, I conducted an exploratory cluster analysis based on factorized consumer values. For this, I first run principal component analysis (PCA) and then hierarchical cluster analysis based on the socio-demographic variables and extracted factors from PCA using SPSS. Similar approach is adopted by Hinkeldein, Schoenduwe, Graff, and Hoffmann (2015) for market segmentation. In their study, they identify different user groups to make sustainable mobility services attractive. After the formation of clusters, I compared the attractiveness of each value proposition across these clusters to reveal which values appeal to which customer segment and to reveal a pattern of change in group's attractiveness towards different configurations.

2.4.1. Results of principal component analysis (PCA)

I run PCA for all the items recorded on five point Likert scale (1 = strongly disagree, 2 = disagree, 3 = neither agree nor disagree, 4= agree, and 5 = strongly agree) using direct oblimin rotation method. The results are shown in table 2.5 below.

Four factors extracted from the component analysis referred as innovativeness, sharing, social media interaction, and environmental friendliness. Six items load on innovativeness with all factor loadings greater than the recommended threshold value of 0.4 (Costello & Osborne, 2005; Osborne & Costello, 2009). Similarly, three factors load on sharing, two on social media interaction, and four on

environmental friendliness. These four factors were further used in the cluster analysis to identify different customer groups.

2.4.2. Results of the cluster analysis

I conducted a hierarchical cluster analysis using Ward's method to group respondents. Cluster analysis is a technique to segment different members or objects in in a way that the members are homogeneous within the same group but are heterogeneous across different groups. The analysis was based on the input of factorized psychographics and socio-demographic variables (EV or non-EV use, age, income, and education) resulted in four different clusters having different attitudes and preferences. These clusters were named as the *holistic-sceptic*, the *innovators*, the *environmentalists*, and the *young educated* group. To check heterogeneity across different clusters, I run one-way between groups ANOVA. The ANOVA test shows that all the clusters are heterogeneous at 5% significance level in majority of cases except social media interaction. Sharing propensity however is significant at 1% level. This reveals that there is a significant difference in the four clusters based on all socio-demographic and psychographic characteristics. These clusters are shown in figure 2.5 below. Differences among the clusters across factorized constructs are shown in table 2.6.

Cluster 1 is referred as *holistic-sceptic*. They are non-EV users who score relatively highest on sharing propensity and environmental friendliness while relatively low on social media interaction and innovativeness. Cluster 2 is referred as *innovators.* These are EV users with relatively highest score on innovativeness factor. This is the highest income group with monthly salary greater than €5000. Cluster 3 is the group of *environmentalists*. They are EV users who have a very positive attitude only towards the environment and they score very low on all other factors like innovativeness, sharing, and social media interaction. Individuals in this group belong to relatively high age group. Finally, cluster 4 is a group of *young educated* members. They are non-EV users and belong to lowest age group. Majority of

the individuals are 18-34 years old but are highly educated. They are indifferent individuals who are neutral towards environmental friendliness, innovativeness, sharing, and social media interaction.

Table 2.5. Factor loadings and standardized factors

Factors and Items	Factor Loadings			
	1	2	3	4
(1) Innovativeness				
I am first to buy new products among my friends	.908			
I know the names of new products before others know	.832			
Compared with friends, I have new products	.807			
If I hear about a new product in the market, I am interested in buying	.807			
I am the last one among friends to know the name of latest products [a]	.645			
Even if I have not heard, I will buy the new product	.491			
(2) Sharing				
I make extensive use of new sharing concepts		.783		
I think the growing number of sharing concepts is an important development		.745		
I would not mind to participate in a car sharing concept		.719		
(3) Environmental Friendliness				
Waste separation gives me good feeling			.764	
If I drive car, I will do my best to drive economically/ efficiently			.728	
I always check that all lights are off while leaving home			.692	
I think it's important that my energy provider delivers green energy [b]			.398	
(4) Social Media Interaction				
I use social media to follow others' lives				.856
I like to keep people informed of highlights via social media				.745

[a] *Item was reverse coded for analysis*

[b] *Item retained with caution as loading is approximately 0.4*

Table 2.6. Cluster comparisons

	Cluster 1 Holistic-sceptic (n = 14)	Cluster 2 Innovators (n = 15)	Cluster 3 Environmentalists (n = 18)	Cluster 4 Young Educated (n=7)	ANOVA* F-Statistics *(p-value)*
Innovativeness	Moderate	High	Low	Moderate	2.724**
Sharing propensity	High	Moderate	Low	Low	2.511*
Environmentalism	High	High	High	Moderate	5.721***
Social media interaction	Low	Low	Low	Moderate	0.997 n.s.
Monthly income	Moderate	High	Moderate to low	Very Low	18.361***
Education	High	High	Moderate	Very High	3.284**
Age	Middle	Middle	High	Low	10.343***
Vehicle use	Non-EV users	EV users	EV users	Non-EV users	
Type of adopter	Late Adopters	Early Adopters	Early Adopters	Late Adopters	
Preferred VP	EBank	EClub	EClub	Indifferent	
Characteristic of VP	Economic	Social	Social		

*** p<0.01, ** p<0.05, * p<0.1, n.s. non-significant

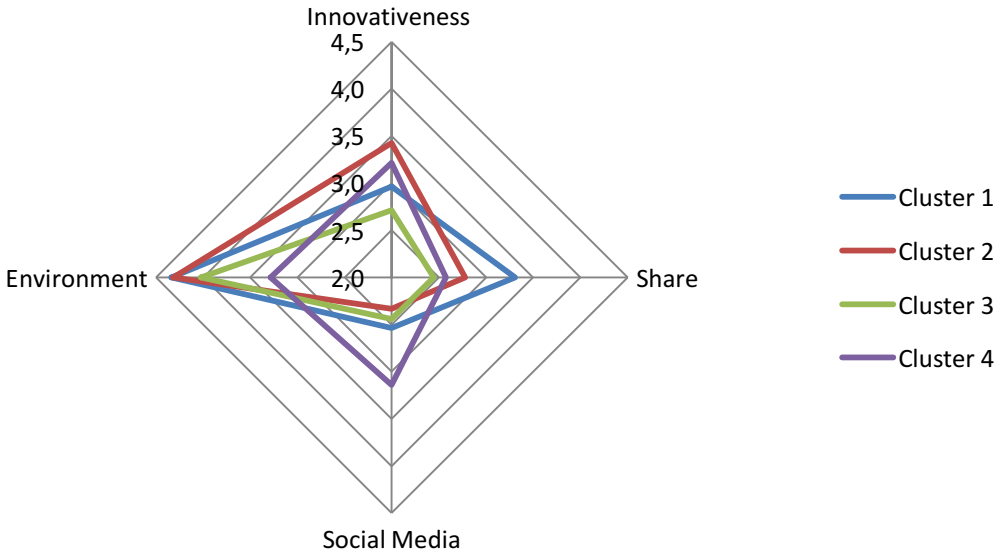

Figure 2.5. Four customer clusters based on factorized customer psychographics

2.4.3. Customer clusters and attractiveness of V2G value proposition

Next I explored how differently configured value propositions influence the customer attractiveness of a technology. Each cluster of car enthusiasts was compared with their attractiveness scores of each VP configuration. The comparison helped in tracking the 'reconfiguration journey' of each cluster. Figure

2.6 shows the journey visually. The x-axis shows the mean scores of attractiveness (where 3.00 is the neutral score) and y-axis shows the three configurations. The figure explains each cluster's pattern of movement from first to third configuration. The EBank was attractive for holistic-sceptic non-EV users while unattractive for young educated non-EV user group. The EClub was attractive for EV users only. The Green EClub on the other hand shows mixed results.

2.4.3.1. Reconfiguration patterns

This section explicates how the different groups of car users evolve in terms of VP attractiveness. During the survey, the different configurations of V2G value proposition were shown in a natural sequence to understand how respondents changed their perception about the technology from the basic configuration offering financial benefits to the advanced configuration offering hedonic benefits (left to right in figure 2.6).

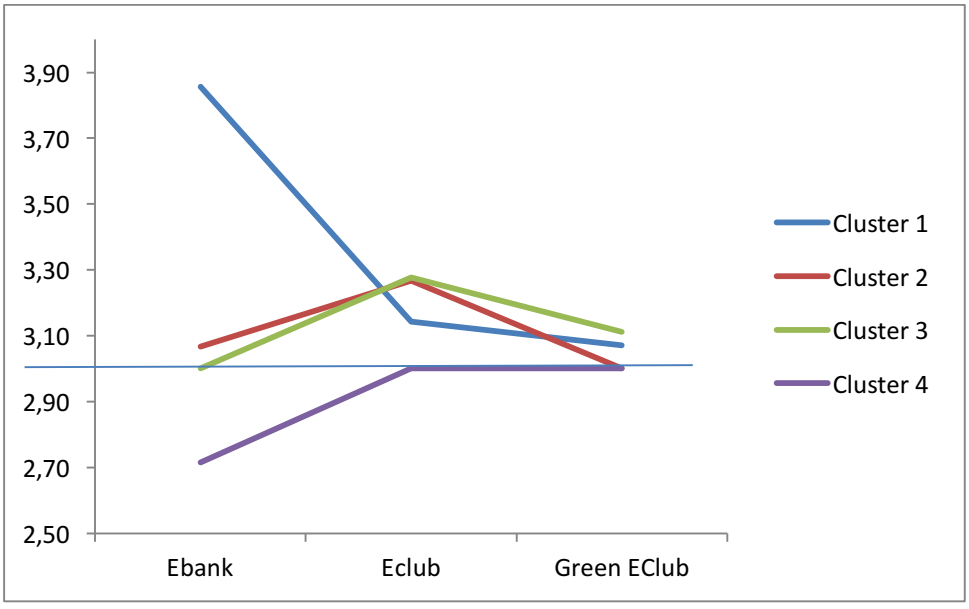

Figure 2.6. Visual representation of attractiveness of value proposition configurations by customer segments

The analysis revealed that the young-educated non-EV users (cluster 4) who were less environmental friendly felt the EBank unattractive (mean value less than 3.0). As they were shown the next configurations their attractiveness score increased relatively and did not change for the last configuration. This shows that they were generally indifferent among the EClub and Green EClub. Overall the mean scores showed that the individuals were almost neutral about all configurations. They were highly educated; however their income level was quite low. This pointed out that the group members might be in the start of their professional careers and reluctant to buy an EV at this stage which is expensive compared to a conventional car. Therefore, inexperienced young people with very low wages were indifferent. Therefore, inexperienced young people with very low wages were indifferent (Priem, 2007).

On the other hand, holistic-sceptic group with sharing and sustainable environmental values (cluster 1) liked EBank which emphasized economical attributes rather than functional and social. However, as the group was shown the next value proposition the curve showed a steep downward slope which indicates they did not like EClub compared to EBank. The slope of the curve did not change significantly for the last configuration, Green EClub. These results are inline with focus group discussion. A non-EV owner in a focus group meeting said, *"It [E-club] is hard to understand ... such rewards cannot really be measured and virtual incentives are not beneficial"*. This implied that the non-EV users with relatively better monthly income levels were ready to adopt an EV with the basic V2G configuration that offered utilitarian benefits in terms of fixed rewards. This suggests that the value proposition with economic focus is more attractive for late adopters or non-experienced users. In turn, for such a value proposition, firms need to pursue operational excellence (Treacy and Wiersema, 1993) by focusing and leveraging its *exploitation* value creation capabilities (cf. Zacharias, Nijssen, & Stock, 2016).

On the contrary, the economic attribute was not appealing for EV drivers groups. The EV users-experienced groups or early adopters did not find EBank very attractive. The mean neutral score of attractiveness showed that fixed rewards were not interesting for such groups. These results from online survey are also inline with the feedback from focus groups. An EV owner in a meeting said, *"The problem with offering too much reward is that people would remain connected and would block charging stations"*. In continuation, another EV owner said, *"It [E-Bank] would be very interesting for charge station owners"*. The EV drivers, who either had high innovative values with very high income (cluster 2) or had high environmental values with relatively low income (cluster 3) preferred configurations which were based on functional and social attributes. The attractiveness curve for both groups initially showed an upward shift for the EClub and then a slight downward shift for Green EClub.

More specifically, the EV drivers who valued innovativeness (cluster 2) more than any other group were middle aged people with professional education and high income professions. This means that that they were relatively stable in their careers and were ready to invest in latest sustainable technologies. Their innovativeness values reflected that they always try to be the first to buy any innovation in their social circle. Hence, they preferred social attributes and show high attractiveness for EClub. The other experienced or early adopter cluster with relatively low innovativeness and high environmental values belonged to old age group receiving moderate income (cluster 3). They too preferred the social value dimensions. The trajectory showed an upward shift in favor of EClub but downward trend for other configurations. This is inline with my earlier argument that early adopter or experienced segment value *scarcity*; hence preferred hedonic attributes over utilitarian attributes. Similar interests were shown by EV owners during focus group meetings. A focus group member said,

"Being part of the community sounds great. It's nice to see comparison and ranking [in the community]".

Concluding all above, the trend analysis first confirms the assumption that early market and mainstream market segments form different preferences towards an offering. Moreover, different clusters and attractiveness scores revealed different trajectories. A group of non-EV users were highly attracted to the first basic value proposition but the attractiveness trend suddenly dropped for the other two advanced configurations. This implied that as the focus shifted from economic to functional/ social values, this group of individuals lost their interest in the offering. A similar analysis of EV user clusters revealed that individuals were not attracted to the first configuration. In the second stage, as the configuration focus shifted from utilitarian to hedonic/ psychic attributes, the attractiveness score showed an increasing trend. These results support the proposition that for inexperienced customers, more objective and utilitarian value dimensions are salient, however as the experience grows, these dimensions are less important (Rintamäki et al., 2007) and hedonic attributes should be added (Carbon, 2004). In other words, mass market customer groups, particularly pragmatists require suppliers to offer them economic value through their offering (Slater & Narver, 1998).

As a final note, the attractiveness scores for the Green EClub show that neither of the clusters finds it very attractive. The reason is that Green EClub lacks a focus and emphasizes too many customer values i.e. functional, emotional, and social. This makes the value proposition blur (cf. Anderson, Narus, van Rossum, 2006) and unclear to the customer (Loock, 2012). A focus group member said, *"It [Green EClub] is an ideal system which is very hard to roll out"*. Literature suggests that to create a superior customer value, a business should narrow down the focus by excelling in only one value discipline and meeting standards in some of the other value disciplines (Treacy & Wiersema, 1993; Zacharias et al., 2016). This means that a firm should concentrate on a few key attributes rather than adding too many

benefits in the proposition statement. Such a value proposition is referred as a 'resonating focus value proposition' (Anderson et al., 2006) which concentrates on just one or two points of difference (PoDs), despite the fact that there may be more. PoDs refer to the "elements that make the supplier's offering either superior of inferior to the next best alternative" (Anderson et al., 2006, p.94).

2.5. Conclusion

The current study offers a mechanism for VPI and shows its relation with the attractiveness of technologies, particularly sustainable technologies. The study contributes in the literature in several ways. It distinguishes BMI and VPI and provides a framework to innovate a value proposition. In BMI, innovation occurs on its key dimensions –value creation and/or value capture (Baden-Fuller & Haefliger, 2013); while VPI is the innovation of the value creation for customers. The overall results of the study conclude that VPI is the combination/ recombination of attribute bundles which improves technology attractiveness given that customer values and expectations are well understood. A firm cannot design a value proposition to target *any* customer. The superior value proposition is highly customer segment dependent (Lanning & Michaels, 1988). One should clearly distinguish the expectations of early market and mainstream market customers in order to smoothly cross the *chasm* (Moore, 1991). Looking at the customer segments and their changing preferences, managers can adapt their existing value propositions. Hence, VPI is a way to meet different needs from the same product. A superior value proposition can provide customer-based advantage. Such advantage can be achieved when a particular segment prefers the firm's offering over competitor's offering (Srivastava, Fahey, & Christensen, 2001).

The study highlights it is important that the new value bundle should be configured according to a particular value discipline in order to lead the market (Treacy and Wiersema, 1993) and to achieve competitive advantage (Porter, 1996). Broadening the focus by adding too many performance attributes

is never a good idea. The tactic to configure a superior value proposition is to add only few PoDs (Anderson et al., 2006). If the existing offering has points of inferiorities, the tactic then is to shift the focus towards high performing attributes (Markides, 2006). The example of Green EClub- a *blurred* proposition justifies the point that firm managers should never lose the focus.

To provide a framework of VPI and to validate the assumptions, mixed-method approach based on qualitative and quantitative techniques was applied to collect data. For such an exploratory study with new empirical setting, such technique is appropriate as it offers fruitful insights by providing robust findings. The analysis based on clustered groups and attractiveness scores show different trajectories and trends. Understanding this trend offers managerial insights: *what* to reconfigure and for *whom* to configure. The study offers another interesting result: managers can even attract non-adopters or non-customers by changing their existing value proposition. For example, non-EV users were attracted to V2G when offered a new value proposition based on concrete financial benefits like low price, fixed rewards, discounts etc. However, retaining existing adopters to continue the use of adopted innovation requires a different strategy: utilitarian benefits are no more of their interest; managers should add ingredients that enhance fun, emotions, sharing, and social proof. This clearly has managerial as well as policy implications.

2.5.1. Implications and future research

The idea of reconfiguring product attributes is not new, however has not been formalized in the academic literature of sustainable innovation and business models. Hence, this study contributes in the academic literature by conceptualizing VPI and answering how VPI enhances attractiveness of sustainable innovations. In particular, it contributes in the literature of business models for sustainable technologies (Bohnsack et al., 2014; Boons & Lüdeke-Freund, 2013; Schaltegger et al., 2012). The value proposition reconfiguration concept used in this study is in line with Schaltegger et al.'s (2012)

'business model adoption' classification of BMI which requires firms to match their value propositions with competitive offering and to reconfigure different elements of their value proposition in order to remain competitive.

The study broadly has implications for all technologies and specifically for new sustainable technologies which suffer from lock-in due to the presence of existing best alternative in the market. It offers a new mechanism to increase the adoption rate and successfully cross the *chasm* between early adopters and early majority segments. For example, at the beginning of adoption, firms should communicate social element and afterwards stress functional element in the value proposition for mainstream customers. In particular, current research setting confirms that the V2G technology may help to make EVs more attractive and democratize sustainable technologies given that a compelling value proposition is designed.

One of the caveats of the study is generalizability of results for other sustainable technologies. An attempt has been made to validate the framework using V2G technology. I invite future researchers to investigate all assumptions in other high involvement sustainable contexts. Moreover, the recency and primacy effect might have affected the expert survey, though is the limitation of the study, it helped me explain the progression of attractiveness of clustered groups. In the present setting, these effects augmented study's results instead of biasing them. Last, the results of the study are based on a simulated situation. This is because the V2G is new-to-the world technology and there are insufficient real examples of its VPI. This study does not shed light on firm side of value proposition and invites future researchers to expand the framework by conceptualizing the role of other blocks of a firm's business model and its resources and capabilities in innovating a value proposition.

Chapter 3

Psychological and behavioral determinants of travel mode choice: A meta-analysis

3.1. Introduction

One of the major unresolved issues in consumer innovation adoption and consumer behavior literature is the understanding of travel mode choice. Despite sufficient literature, there is little consensus on the key drivers of behavioral change. Inconsistent understanding of the phenomena hinders transition towards sustainable mobility. The motivation to conduct this study hence is to systematically synthesize and analyze the existing knowledge on the dynamics of sustainable or unsustainable mobility behavior. The study aims to answer what are the determinants of behavioral change towards sustainable travel alternatives?

There is wide consensus over the un-sustainability of current mobility patterns, and the need to shift towards new paradigms (Collins & Chambers, 2005; Gardner & Stern, 2008; Stern, 2011). The transport sector is indeed responsible for problems ranging from air pollution and climate change (Oskamp, 2000) to health related issues (Peters, von Klot, Heier, Trentinaglia, Hörmann, Wichmann, et al., 2004), and even to social exclusion/accessibility (Geurs & van Wee, 2004).

Transportation currently accounts for around 14% of greenhouse gas (GHG) emissions on global scale (IPCC, 2014). In the EU 28, transport in 2013 accounted for 22.2% of GHG emissions, up from 14.9% in 1990 (Eurostat tables[9]). Moreover, unlike other industrial sectors, transport did not reduce emissions; although after the peak of 2007, the trend started to change due to increasing oil prices and diminishing activity by freight vehicles as a consequence of the economic downturn. Similarly in the

[9] Eurostat, European Environment Agency, European Topic Centre on Air and Climate Change http://ec.europa.eu/eurostat/statistics-explained/index.php/Greenhouse_gas_emission_statistics

US, transport accounted for 26% of GHG emissions in 2014, with a sensible increase since 1990 (EPA, 2016). Until recently, the environmental impacts of transportation have been an issue affecting western countries. However, emerging economies are experiencing a steady increase so that the contribution to emissions deriving from transport sector is bound to rise over the next years. China represents a striking example (Gambhir, Lawrence, Tong, & Martinez-Botas, 2015): vehicle sales rose from 2.1 million in 2000 to 23.5 million in 2014 (CAAM, 2015), with private vehicles and freight respectively responsible for 5% and 8% of GHG emissions, and on the increase (Hao, Geng, Li, & Guo, 2015; Hao, Liu, Zhao, Li, & Hang, 2015). India has still low figures as regards private cars (with on the other hand many two-wheeler vehicles), yet it is projected to become the third world's largest automobile market, with a rapid growth especially in the segment of small vehicles (Altenburg, Schamp, & Chaudhary, 2015).

The shift towards sustainable mobility represents a complex issue where various solutions and pathways (either in synergy or in alternative) can be envisaged, encompassing an active role played by different actors and stakeholders. For instance, the automotive industry can propose new or improved technologies capable of curbing the environmental impacts of mobility (e.g., new vehicles such as electric vehicles or the improvement of the efficiency of conventional engines). Local authorities can adopt plans for sustainable mobility in urban areas (like so called SUMPs, Sustainable Urban Mobility Plans) focusing on new infrastructures, improved public transportation or even congestion charges. Policy makers at national and international level can implement standards and regulations to drive the change by means of a top-down approach (e.g., the Fuel Quality Directive, European Commission, 2009). However, citizens represent the key-actor whose involvement is necessary for any sustainable mobility strategy to succeed (Donald, Cooper, & Conchie, 2014): private mobility is a crucial contributor of CO_2 and other pollutants' emissions with detrimental

impacts especially in urban areas (Dulal & Akbar, 2013). People are different who adopt different behaviors and form different preferences in a given situation. Their daily travel mode choice is affected by several behavioral and contextual factors. Understanding these dynamics behind each individual's action is relevant for the successful shift towards sustainable travel behavior at micro level and for the realization of sustainable mobility strategies at macro level. In particular, psychological drivers of behavioral change proved to be more effective than infrastructural changes in addressing the issue (Hunecke, Haustein, Böhler, & Grischkat, 2010). Indeed, there is growing awareness that transport policies aiming at reducing car use can be accomplished by focusing on the psychological constructs of commuters (Möser & Bamberg, 2008). It is hence necessary to understand the relevance of different drivers capable of spurring the adoption of sustainable mobility patterns. The present study focuses on the psychological and behavioral determinants of travel mode choice. The existing literature is not conclusive and different studies reach inconsistent results on the main predictors of (sustainable) mobility. The fragmentation and heterogeneity in the existing findings blur the actual picture and hinder our understanding of important factors should be targeted for a behavioral change. The aim of the present study, therefore, is to systematically synthesize existing research on the determinants of travel mode choice and the psychological and behavioral correlates of car vs. non-car use.

I perform a meta-analysis to synthesize existing quantitative literature on the topic. To the knowledge of the author, only one comprehensive meta-analysis on travel modes has been carried out, based on a 2006 database (Gardner & Abraham, 2008) and representing the starting-point of the present research. Indeed, this study provides a contribution to the ongoing debate by i) including recent and current research, ii) broadening the scope of analysis as to encompass further predictors and new perspectives

of analysis (which will be described in the methods section) and iii) investigating possible explanations of the variability across studies, by means of heterogeneity analysis.

The remaining paper is structured in different sections: the second section sheds light on different theoretical models underpinning travel mode choice. The third section discusses the methodological aspects: data collection, sample statistics, and meta-analysis strategy. Fourth section discusses the results of meta-analysis and heterogeneity analysis. Final section presents the concluding remarks, highlights the implications of the results of the meta-analysis, and proposes preliminary ideas for future research.

3.2. Theoretical models

Different theoretical frameworks have been applied to investigate travel mode choice, with different degrees of complexity and predictive capability, the most popular of which is represented by the Theory of Planned Behavior (TPB, Ajzen, 1991). TPB is broad in scope and is not born out of environmental research; however, it is very useful to investigate sustainability related domains, including mobility. The theory holds that intentions are the closest antecedents of behavior and have, in turn, three main predictors: attitudes, subjective norms and perceived behavioral control (PBC). Attitudes represent the personal desirability of a behavior, or the feeling of being more or less favorable towards performing the activity. As regards mobility, I might have a positive attitude towards, say, commuting by means of public transportation because I believe that it is nice to contribute to environmental protection through my daily activities. Subjective norms refer to the social pressure we experience: do people who are relevant to me expect that I adopt a specific behavior? That is, for instance: do I feel pressure from my peers and relevant ones to commute by means of environment-friendly transport modes? PBC has been added to the original framework of

the Theory of Reasoned Action (TRA, Fishbein & Ajzen, 1975) as a third predictor of behavioral intentions (and thus behaviors): it accounts for the perceptions of how difficult or easy it is to perform a behavior, representing the answer to speculations that behaviors are not completely under volitional control as originally suggested by TRA. In my example, I might hold positive attitudes and feel social pressure towards sustainable means of commuting, yet I might feel that such behavior is too difficult to adopt, thus leading to an attitude-behavior gap (Kollmuss & Agyeman, 2002; Lane & Potter, 2007).

TPB has been adopted by a number of studies analyzing the determinants of travel mode (Harland, Staats, & Wilke, 1999; Klöckner & Matthies, 2009; Lois, Moriano, & Rondinella, 2015; Noblet, Thøgersen, & Teisl, 2014; Nordfjærn, Şimşekoğlu, & Rundmo, 2014; Polk, 2013). Further variables have been included to integrate the original framework, as to increase the explanatory power of the model: for instance, habits (Bamberg & Schmidt, 2003; Donald et al., 2014; Verplanken, Aarts, van Knippenberg, & Moonen, 1998), role beliefs (Bamberg & Schmidt, 2003), personal norms (Manstead & Parker, 1995; Parker, Manstead, & Stradling, 1995), and descriptive norms (Donald et al., 2014; Heath & Gifford, 2002). While the predictive capability of TPB proved to be good (Armitage & Conner, 2001; Sutton, 1998), the relative importance of the constructs as antecedents of travel mode choice varies across studies (Gardner & Abraham, 2008).

A second stream of research on transport mode focuses on "feelings of moral obligation to perform or refrain from specific actions" (Schwartz & Howard, 1981, p. 191). Such constructs, which have been suggested as a relevant driver of pro-environmental behaviors, have been labeled as personal norms, moral norms or other equivalent formulations (Conner & Armitage, 1998). According to Norm-Activation-Theory or Model (NAM, Schwartz, 1977), personal norms get *activated* by variables such as awareness of the adverse consequences of not adopting the virtuous behavior (awareness of consequences) or the ascription of responsibility reflecting feelings of being accountable for such

negative outcome (ascription of responsibility).

Moral obligations represent the basis of other psychological theories on consumer behavior such as Value-Belief-Norm (VBN) theory (Stern, 2000; Stern, Dietz, Abel, Guagnano, & Kalof, 1999), which integrates the work of Schwartz on values (Schwartz, 1992), NAM and the New Ecological Paradigm (NEP, Dunlap & Van Liere, 1978). In the words of Schwartz (1944), values are a "desirable transsituational goals, varying in importance, that serve as guiding principles in the life of a person or other social entity" (p. 21). NEP, on the other hand, focuses on beliefs in the limit of growth and the need to preserve natural balance endangered by reckless development of human activities; it represents a widely adopted measure of pro-environmental orientation (Dunlap, van Liere, Mertig, & Jones, 2000). VBN suggests focusing on a chain of variables, from general pro-environmental values and concern to specific beliefs on the consequences of certain activities, and the responsibility of individuals to avoid such detrimental consequences: sustainable personal norms for pro-environmental behavior should be activated, guiding individuals towards greener behavioral patterns.

A third stream of research on pro-environmental behaviors is represented by habits (here analyzed outside of TPB-based frameworks), which assume particular relevance for mobility since behaviors are performed in stable contexts and decisional settings (Aarts & Dijksterhuis, 2000; Verplanken, Aarts, van Knippenberg, & van Knippenberg, 1994). According to the Theory of Interpersonal Behaviour (Triandis, 1977), when individuals frequently perform a given behavior in response to a specific goal (like commuting to work, university, or shopping) behavioral intentions no longer act as the main predictor of behavior itself. Habits hence represent an independent determinant of behavior (Bamberg & Schmidt, 2003), moderating the intention-behavior relationship (Verplanken et al., 1998). Whereas habit has been sometimes used as a synonym of (or at least as a construct very close to) past behavior (Triandis, 1980), consistently with recent literature, Iconsider the former as a more

complex construct: habits represent goal-oriented scripts that are based on repeated behaviors and carried out in stable contexts (Ouellette & Wood, 1998; Verplanken & Aarts, 1999). This study, hence, focuses on past behaviors and habits as distinct predictors of given travel mode choices.

Albeit planned behavior, values, and habits represent the three principal streams of research on travel modes; there are other variables that have been investigated in literature and need to be taken into consideration. For instance, not only subjective (sometimes referred to as injunctive or social) and personal (moral) norms but also descriptive norms can represent relevant predictors of intentions and behaviors. Descriptive norms represent typical and normal behaviors, *what people do* in a given situation (Cialdini, Kallgren, & Reno, 1991; Cialdini, Reno, & Kallgren, 1990): the perception of how people behave represents a motivation to do the same, providing "evidence as to what will likely be effective and adaptive action" (Cialdini et al., 1990, p. 1015). Personal norms might be activated by problem awareness and by environmental values (Nordlund & Garvill, 2003), which can also be considered as predictors of pro-environmental behaviors including mobility. Another example is represented by the Technology Acceptance Model (TAM, Davis, 1989), precursor of TRA and TPB, which suggests that perceived usefulness and perceived ease of use explain attitudes, which in turn explain behavioral intentions and actual behaviors.

3.3. Methods

3.3.1. Data collection and data extraction

The aim of this article is to synthesize empirical evidence on the determinants of travel mode choice, as regards both private car and environment-friendly alternatives: I label them as *car* and *non-car* (*green*), respectively. Green transport modes include public transport, bicycles, walking and reduction in (intention/ willingness to reduce) car use, and carpooling. To conduct a synthesis, I searched

primary studies focusing on behavior and/ or intention of different transport modes, as both actual behavior and behavioral intentions are relevant constructs to analyze mobility trends.

Relevant studies were searched using the internet search machine Google Scholar and the Web of Science, EBSCOhost, Scopus, and ScienceDirect databases. The keywords used for search were: travel mode choice, travel behavior, travel intention, car (public transport/ bus/ bicycle/ walk) use, travel mode determinants, plus their synonyms and/or combinations. To refine the search, I integrated the string by adding keywords based on underlying theories and their determinants[10]. After this preliminary search, 185 titles were selected as potential candidates for inclusion. Abstracts and methodology sections were then checked to identify whether studies were in line the goals of the research. I read the 73 studies left after this second screening, and manually added 13 more articles adopting an ancestry approach.

The 86 studies obtained were then checked for bivariate Pearson correlations and data collection methods: only primary studies having correlation matrices and at least one relevant independent and dependent variable were included in the initial dataset[11]. These criteria lead to the exclusion of 25 studies. 10 more studies have been deleted after a case-by-case discussion with an external expert in the field; studies have been dropped either because *i)* they did not focus on travel mode choice but on the adoption of innovative technologies such as electric vehicles (Busse, El Khatib, Brandt, Kranz, & Kolbe, 2013; Lai, Liu, Sun, Zhang, & Xu, 2015; Moons & de Pelsmacker, 2012; Sang & Bekhet, 2015), *ii)* they addressed active transportation for leisure time or health-related issues, so that car was not an alternative (Lee & Shepley, 2012; Rhodes, Courneya, Blanchard, & Plotnikoff, 2007), *iii)* they

[10] For example, perceived behavioral control, attitude, (subjective/ descriptive/ injunctive/ social/ personal/moral) norm, habit, past use, environmental values, social values, awareness of consequences, ascription of responsibility, problem awareness, perceived usefulness, perceived ease-of-use, reasoned action, and planned behavior.

[11] In case of experimental studies, only pre-treatment/ pre-intervention correlations were included in the database (for example, Heath and Gifford, 2002; Bamberg et al., 2003; Garvill et al., 2003; Eriksson et al., 2008).

focused on non mobility-specific, general pro-environmental behaviors (Kaiser & Gutschier, 2003), *iv)* their sample included a very specific group (Murtagh, Rowe, Elliott, McMinn, & Nelson, 2012), or *v)* Pearson product moment correlations between variables were provided for different groups in the study sample (Klöckner & Matthies, 2004; Thøgersen, 2006b). After deletion of such studies, the final database was based on 51 articles; 7 studies out of which provided two datasets each with independent samples (e.g. Bamberg, Hunecke, & Blöbaum, 2007; de Groot & Steg, 2007; Eriksson, Garvill, & Nordlund, 2006; Gardner, 2009; Gärling, Fujii, & Boe, 2001; Kaiser, Ranney, Hartig, & Bowler, 1999; Lo, van Breukelen, Peters, & Kok, 2016) resulting in 58 sample studies (N=58).

3.3.2. Study characteristics

Sample characteristics are shown in table 3.1. With respect to the frameworks, existing literature mostly applied TPB as 29 out of 51 articles in the database used the model either in its original formulation (n=5) or with extensions (n=24). TPB is extended generally by adding habits (n=8) and NAM (n=8).In total, 18 articles used habits in their frameworks, 14 used NAM, while only 5 used VBN. On the other hand, very few studies did not mention any theory (n=3).

Table 3.1. Characteristics of the sample studies

Primary Studies	Theory applied	Outcome variable(s)	Sample size	Country
Abrahamse et al. (2009)	NAM, TPB	Frequency of car trips, intention to reduce car use	241	Canada
Baldassare and Katz (1992)	N/A	Frequency of reduced driving	641	USA
Bamberg et al. (2003)	TPB, habit	Bus use; intention to use bus	1874	Germany
Bamberg et al.(2007)*	NAM, TPB	PT use; intention to use PT	796, 437	Germany
Carrus et al. (2008)	MGB	Intention to use PT	180	Italy
Chen & Chao (2011)	TPB, TAM, Habit	Intention to use PT	442	Taiwan
Cools et al. (2011)	TDM, NAM, VBN	Willingness to reduce negative effects of car use	300	Belgium
de Bruijn et al. (2005)	TPB	Frequency of bicycle use; intention to use bicycle	3859	Netherlands
de Bruijn et al. (2009)	TPB	Average cycling time; intention to use bicycle	317	Netherlands
De Groot & Steg (2007)*	TPB(extended)	Intention to use transferium	68, 150	Netherlands
De Groot et al. (2008)	NAM	Intention to reduce car use	489	5 EU Countries
Donald et al. (2014)	TPB (extended)	Car and PT use; intention to use car and PT	827	UK
Eriksson & Forward (2011)	TPB	Intention to use car and other modes	620	Sweden
Eriksson et al. (2006)*	TDM, VBN	Willingness to reduce car use	462, 460	Sweden
Eriksson et al. (2008)	VBN, Habit	Frequency of car trips	71	Sweden

Forward (2014)	TPB, TTM, habit	Willingness to bike	414	Sweden
Friedrichsmeier et al. (2013)	Habit	% of car use; intention to use car	1048	Germany
Fuji (2006)	TPB (extended)	Intention to reduce car use	341	Japan
Gardner(2009)*	Habit, motivation	% of car & bicycle trips; intention to use car & bicycle	107,102	UK, Netherlands
Gardner & Abraham (2010)	TPB	Proportion of car to non-car use; intention to use car	190	UK
Gärling et al. (2001)*	N/A	Car use frequency; car preference (hypothetical scenario)	60, 48	Sweden
Garvill et al. (2003)	Attitude, Habit	Car use frequency	115	Sweden
Harland et al. (1999)	TPB, NAM	Intention to use other modes than car	305	Netherlands
Haustein & Hunecke (2007)	TPB (extended)	% of actual use; intention to use other modes	1545	Germany
Haustein et al. (2009)	TPB, NAM	% of car use; intention to use PT	2612	Germany
Heath & Gifford (2002)	TPB, NAM	Percentage of bus use; intention to use bus	175	Canada
Hsiao & Yang (2010)	TPB (extended)	Willingness to take high speed rail	300	Taiwan
Joireman et al. (1997)	Interdependence theory	Preference of car vs. other modes (hypothetical scenario)	102	Netherlands
Kaiser et al. (1999)*	Rational choice, NAM	Intention for pro-environment travel behavior	436, 488	Switzerland, USA
Klöckner & Matthies (2009)	NAM, TPB, habit	Ratio of car trips to all trips	430	Germany
Lo et al. (2016)*	TPB, PN, habit	Frequency of car use; intention to use car	452, 386	Netherlands
Lois et al. (2015)	TPB, TTM	Intention for cycle commuting	595	Spain
Loukopoulas & Gärling(2005)	N/A	Driving frequency; walking frequency	155	Sweden
Mann & Abraham (2012)	TPB (extended)	Car and PT use; intention to use car and PT	229	UK
Nilsson & Kuller (2000)	Attitude	Distance driven by car during the previous year	421	Sweden
Noblet et al. (2014)	TPB (extended)	Attempts to drive less and use of alternative modes	1340	USA
Nordlund & Garvill (2002)	NAM	Pro-environmental travel behavior	1414	Sweden
Nordlund & Garvill (2003)	NAM, VBN	Willingness to reduce car use	1467	Sweden
Nordlund & Westin (2013)	TPB, VBN, NAM	Intention to use train	1238	Sweden
Onwezen et al. (2013)	NAM, TPB	Frequency of bike and PT use	617	Netherlands
Passafaro et al. (2014)	MGB	Desire to use bicycle	387	Italy
Polk (2003)	TPB, habit	Regular car use, willingness to reduce car use	1180	Sweden
Staats et al. (2004)	TPB, habit	Intention to use travel modes other than car	150	Netherlands
Steg (2004, 2005)	TPB, TNC	Percentage of car trips	113	Netherlands
Steg & Sievers (2000)	Cultural theory	Annual distance driven by car; proportion of car vs. other modes	269	Netherlands
Tanner (1999)	ITB	Frequency of car use	153	Switzerland
Thøgersen (2006a)	NAM, SDT, CMDT	Frequency of PT use	810	Denmark
van Vugt et al. (1995)	Interdependence theory	Preference of car vs. other modes (hypothetical scenario)	56	Netherlands
Verplanken et al. (1994)	Attitude, Habit	Frequency of car use	199	Netherlands
Verplanken et al. (1998)	TPB, Habit	Ratio of car use to other modes; intention to use car	200	Netherlands
Yang-Wallentin et al. (2004)	TPB	Percentage of PT use; intention to use PT	912	Germany

* Authors conducted two independent studies
Note: CMDT= Cognitive moral development theory (Kohlberg, 1984), ITB = Ipsative theory of behavior (Frey, 1988), NAM = Norm activation model (Schwartz, 1977; Schwartz & Howard, 1981), SDT = Self-determination theory (Deci & Ryan, 1985), TAM = Technology acceptance model (Davis, 1989), TDM = Travel demand management measures, TNC= Theory of normative conduct (Cialdini et al.,1991; Cialdini et al., 1990), TPB = Theory of planned behavior (Ajzen, 1985, 1991), VBN = Value-belief-norm (Stern et al., 1999; Stern, 2000), MGB= Model of goal-directed behavior (Perugini & Bagozzi, 2001), N/A = not available

Existing literature measures travel behavior in two ways: actual and typical (Garnder & Abraham, 2008). *Actual behaviors* are measured with reference to a specific time-frame (e.g. "how many times

did you drive a car over the past week?"), while *typical behaviors* are measured with no such reference (e.g. "how often do you drive a car?"). According to this taxonomy, 13 studies used typical measures and 22 studies used actual measures to record travel behavior. Similarly, for intention towards car or non-car use, the measures were distributed into actual and typical intentions: 23 studies included typical measures to observe intention while 17 studies considered intention over a certain time period in future. Hence, studies generally observe behavior with actual measures while intention with typical behaviors.

In terms of travel trips, statistics show that 42 out of 58 sample studies measured travel behavior (intention) for *general trips*, 12 studies observed behavior for *work trips*, and remaining 4 studies observed other trips like *shopping* or *work unrelated trips*. Sample studies are diverse in terms of their unit of analysis: 36 studies collected data from *general population*, 8 from *students*, and 8 from *employees*. In terms of location, 48 studies were conducted in *Europe* with majority of studies in Netherlands (n= 14), Sweden (n=14), and Germany (n=8); while 5 studies were conducted in *North America* (USA and Canada) and remaining 3 in *Far East* (Taiwan & Japan). Summarizing, majority of the studies were conducted in Europe, collected data from general population and measured travel model behavior (intention) for general trips.

3.3.3. Meta-analytic strategy

As regards the meta-analytic strategy, 13 determinants of behavior and 13 determinants of intention from the selected studies were extracted[12]. Based on the operational definitions of constructs, the

[12] These determinants are attitude, injunctive (subjective/social) norm, descriptive norm, personal moral norm, perceived behavioral control, habit, past use, problem awareness, awareness of consequences, ascription of responsibility, environmental concern, environmental values, perceived usefulness (only when intention is dependent variable), and intention (only when behavior is the dependent variable). Personal and moral norms are merged as studies included in the analysis often use them interchangeably (Gardner & Abraham, 2008).

determinants of travel mode choice were treated separately for car and non-car. Hence, four outcome (dependent) variables for the meta-analysis were obtained: car use behavior, non-car use behavior, car use intention and non-car use intention. Of all the predictors for behavior and intention, few had to be dropped as they appeared in one single study of the dataset (perceived ease of use and personal values).

For studies including more than one behavioral measure from the same sample but reporting separate bivariate correlations for each measure (e.g., Noblet, Thøgersen, & Teisl, 2014, Steg & Sievers, 2000), the weighted average correlation of the behaviors within the study was used as a unit of analysis; this is done to follow the independence assumption underlying the validity of meta-analytic procedures.

I applied effect size analysis based upon the correlation coefficients extracted from sample studies, pooling the effects from primary studies to assess the true overall effect size of each independent variable on the selected dependent variables (Field, 2005). Following Hedges and Olkin (1985) approach, Fischer's Z score transformation was applied to calculate weighted average correlation (for the specific formulas and a thorough description of the methodology, see Hedges and Olkin (1985) and Hedges and Vevea (1998)). During the transformation, first the correlation coefficients extracted from the primary studies are transformed into z score; the transformed *r-to-z* scores are then used to calculate averages in which each effect size is assigned a weight based upon the sample size of a primary study with standard error and sample variance being calculated during the process; finally the resulting weighted average is retransformed to *r* (Hedges & Olkin 1985).

The significance of the overall effect size was measured by the Z-test and the precision of pooled effect size was estimated by the 95% confidence intervals. The heterogeneity of results in the sample studies was tested through *I-square,* which describes the percentage of variation across studies that is

due to the true differences in effect sizes rather than chance (Higgins, Thompson, Deeks, & Altman, 2003).

There are two different models to calculate effect sizes namely fixed-effects and random-effects models. There is no clear consensus among researchers on the adequacy of both models for the effect size calculation (Field, 2005): while the former assumes a fixed weight for a specific study (effect size is weighted by the inverse of within-study variance), the latter assumes that effect size varies randomly across studies (effect size is weighted by the inverse of within-study and between-study variance). Consistently with most research in social sciences and following the argument of Hedges and Vevea (1998) about the inability of fixed effect methodology results to be generalized, random effect methodology was applied.

In order to check for the robustness of findings against publication bias, the Rosenthal's (1984) *fail-safe N* was calculated, which represents the number of missing studies averaging a Z-value of zero that should be added to yield a statistically insignificant overall effect size. That is, the larger the number, the more robust the findings: the ad-hoc rule refers to the one by Rosenthal for deciding whether the estimated number is small (true) or large (false) based on the recommended tolerance level of 5k + 10.

3.4. Results and discussion

3.4.1. Effect size analysis

Meta-analysis results are presented in Tables 3.2 to 3.5, illustrating the correlates of four outcome variables: behaviors and behavioral intentions as regards both private car use (car) and alternative, environment-friendly transport modes (green).

Table 3.2. Effect size analyses of correlates of car use

Variables	K	Sample	r̂	Z-value	95% C.I.		I^2	Failsafe N
ATT (car)	15	4290	0.406	6.012***	0.282	0.516	96.642	False
ATT (green)	7	3283	-0.358	-3.739***	-0.516	-0.176	96.673	False
INJ. N. (car)	10	2866	0.229	3.598***	0.117	0.335	88.771	False
INJ. N (green)	3	3681	-0.153	-3.250***	-0.243	-0.061	71.444	False
DES. N. (car)	6	2199	0.255	1.766*	-0.029	0.500	97.681	False
PER. N. (car)	3	1655	0.362	15.419***	0.319	0.403	0.000	False
PER. N. (green)	7	4222	-0.262	-4.120***	-0.376	-0.140	87.424	False
PBC (car use)	7	2399	0.27	2.832***	0.085	0.437	95.183	False
PBC (green)	4	1092	-0.429	-2.714**	-0.659	-0.127	96.623	False
AWAR. CONS.	2	671	-0.130	-1.076 n.s.	-0.352	0.107	88.865	True
PROB. AWAR.	8	5545	-0.17	-4.237***	-0.250	-0.094	82.76	False
ASC. RESP.	3	644	-0.144	-1.037n.s.	-0.397	0.129	91.632	True
ENV. CONC.	4	2621	-0.195	-2.975***	-0.316	-0.067	89.850	False
HABIT (car)	17	8098	0.416	5.967***	0.289	0.529	97.111	False
Past car use	6	1699	0.686	5.150***	0.478	0.821	96.683	False
INT. (car)	8	3441	0.825	6.286***	0.668	0.912	99.084	False
INT. (green)	2	3300	-0.511	-2.251**	-0.784	-0.073	98.197	False

*** p<0.01, ** p<0.05, * p<0.1, n.s. non-significant

K= number of outcomes from sample studies; r̂ = overall effect size; C.I. = confidence interval; I^2 = I-squared.
ATT= attitudes; INJ. N.= injunctive norms; DES. N.= descriptive norms; PER. N.= personal norms; PBC= perceived behavioral control; AWAR. CONS.= awareness of consequences; PROB. AWAR.= problem awareness; ASC. RESP.= ascription of responsibility; ENV. CONC:= environmental concern; INT.= intention

Table 3.3. Effect size analyses of correlates of non-car use

Variables	K	Sample	r̂	Z-value	95% C.I.		I^2	Failsafe N
ATT (green)	12	13282	0.313	8.689***	0.245	0.377	93.812	False
INJ. N. (green)	12	12737	0.234	7.773***	0.177	0.291	90.305	False
DES. N. (green)	4	2231	0.214	2.375**	0.038	0.377	93.553	False
PER. N. (green)	9	6216	0.336	6.533***	0.24	0.425	93.983	False
PBC (green)	12	12649	0.376	7.643***	0.286	0.460	96.687	False
AWAR. CONS.	3	1571	0.125	1.729*	-0.017	0.263	87.827	False

PROB. AWAR.	5	2698	0.196	3.127***	0.074	0.312	88.112	False
ASC. RESP.	4	1746	0.223	4.051***	0.122	0.339	82.018	False
ENV. CONC.	3	936	0.139	4.563***	0.079	0.197	59.635	False
HABIT (green)	2	929	0.683	2.005**	0.019	0.929	98.367	False
Past non-car use	3	2205	0.846	5.741***	0.674	0.931	97.493	False
ENV. VAL.	4	4417	0.140	1.456 n.s.	-0.049	0.319	97.298	False
INT (green)	12	11411	0.617	7.308***	0.484	0.723	98.977	False

*** p<0.01, ** p<0.05, * p<0.1, n.s. non-significant

K= number of outcomes from sample studies; r̂ = overall effect size; C.I. = confidence interval; I^2 = I-squared.
ATT= attitudes; INJ. N.= injunctive norms; DES. N.= descriptive norms; PER. N.= personal norms; PBC= perceived behavioral control; AWAR. CONS.= awareness of consequences; PROB. AWAR.= problem awareness; ASC. RESP.= ascription of responsibility; ENV. CONC:= environmental concern; ENV. VAL.= environmental values; INT.= intention.

Table 3.4. Effect size analyses of correlates of intention to use car

Variables	K	Sample	r̂	Z-value	95% CI		I^2	Failsafe N
ATT (Car)	7	2906	0.563	5.916***	0.402	0.690	96.832	False
ATT (green)	4	1483	-0.530	-4.021***	-0.705	-0.294	96.743	False
INJ. N. (car)	7	2906	0.424	7.749***	0.326	0.513	89.066	False
DES. N. (car)	6	2706	0.272	1.968**	0.001	0.506	98.048	False
PER. N. (car)	3	1665	0.394	16.953***	0.353	0.434	0.000	False
PER. N. (green)	2	421	-0.512	-11.520***	-0.580	-0.438	0.000	False
PBC (car)	7	2906	0.322	3.088***	0.121	0.498	96.867	False
PBC (green)	2	421	-0.452	-4.077***	-0.617	-0.247	82.950	False
ENV. CONC.	3	1103	-0.259	-8.434***	-0.315	-0.201	0.000	False
HABIT (car)	7	4068	0.472	7.195***	0.357	0.573	94.612	False
Past car use	4	1584	0.739	3.471***	0.391	0.902	98.762	False

*** p<0.01, ** p<0.05, * p<0.1, n.s. non-significant

K= number of outcomes from sample studies; r̂ = overall effect size; C.I. = confidence interval; I^2 = I-squared.
ATT= attitudes; INJ. N.= injunctive norms; DES. N.= descriptive norms; PER. N.= personal norms; PBC= perceived behavioral control; AWAR. CONS.= awareness of consequences; PROB. AWAR.= problem awareness; ASC. RESP.= ascription of responsibility; ENV. CONC:= environmental concern; ENV. VAL.= environmental values; INT.= intention.

Table 3.5. Effect size analyses of correlates of intention to use non-car.

Variables	K	Sample	r̂	Z-value	95% CI		I^2	Failsafe N
ATT (car)	4	4204	-0.240	-2.796***	-0.393	-0.073	96.572	False
ATT (green)	23	17824	0.467	11.086***	0.394	0.534	97.064	False
INJ. N. (car)	2	391	0.255	1.936*	-0.003	0.481	84.828	True

INJ. N. (green)	20	16770	0.410	12.819***	0.353	0.464	94.061	False
DES. N. (green)	7	3272	0.347	5.280***	0.224	0.459	93.095	False
PER. N. (green)	13	8968	0.508	9.925***	0.421	0.585	95.996	False
PBC (green)	23	15355	0.526	9.579***	0.434	0.607	98.083	False
AWAR. CONS.	4	1684	0.236	3.213***	0.094	0.369	89.019	False
PROB. AWAR.	14	13213	0.315	10.307***	0.258	0.370	91.603	False
ASC. RESP.	7	2614	0.344	7.014***	0.253	0.429	84.746	False
ENV. CONC.	14	5518	0.225	7.756***	0.170	0.280	72.609	False
HABIT (car)	3	3818	-0.096	-0.180 $^{n.s.}$	-0.815	0.739	99.817	False
HABIT (green)	4	1438	0.554	3.454***	0.264	0.752	97.144	False
Past non-car use	6	3077	0.731	8.891***	0.620	0.813	95.686	False
ENV. VAL.	9	7547	0.153	4.407***	0.086	0.220	88.016	False
P. USE. (green)	2	671	0.421	11.580***	0.357	0.482	0.000	False

*** p<0.01, ** p<0.05, * p<0.1, n.s. non-significant

K= number of outcomes from sample studies; r̂ = overall effect size; C.I. = confidence interval; I^2 = I-squared.
ATT= attitudes; INJ. N.= injunctive norms; DES. N.= descriptive norms; PER. N.= personal norms; PBC= perceived behavioral control; AWAR. CONS.= awareness of consequences; PROB. AWAR.= problem awareness; ASC. RESP.= ascription of responsibility; ENV. CONC.= environmental concern; ENV. VAL.= environmental values; P. USE.= perceived usefulness.

The first piece of information emerging from the analysis is represented by the *combined* effect size ***r̂***, which according to rules of thumb in literature (Cohen, 1992) is considered large, medium and small at the .50, .30 and .10 marks, respectively.

Consistently with the TPB framework, according to which intentions are the main antecedents of behaviors and have in turn attitudes, norms and PBC as predictors, the meta-analysis confirms that indeed intentions[13] represent the main predictor of travel mode choice. In literature, intentions and actual behaviors are sometimes collapsed in one single, overarching construct. Notwithstanding the overlapping and correlations between the two, however, this study strongly suggests disentangling them: it is indeed of paramount importance to analyze in details the intention-behavior gap (Sheeran,

[13] when analyzed as predictors, and not as outcome - dependent variables.

2002), and which drivers and predictors vary significantly in relevance according to a focus on either intentions or actual behaviors.

Besides intentions, habits and past use represent the main predictors, showing the highest correlations both with intentions and actual behaviors. Results corroborate speculations that especially in a domain characterized by stable context and settings such as commuting to work or to shopping (Aarts & Dijksterhuis, 2000), there is a strong path dependency that heavily affects our mobility-related choices (Aarts, Verplanken, & Knippenberg, 1998). This has relevant implications for policies aiming at disrupting old, long-established behavioral patterns as to promote a shift towards innovative and more sustainable routines. According to the Habit Discontinuity Hypothesis (Verplanken & Wood, 2006), when the context changes disrupting our habits a window opens, so that behaviors are more likely to be considered deliberately and alternatives rationally evaluated. As a consequence, "interventions may be more effective when these are delivered in association with a disruption of a stable context" (Verplanken, Walker, Davis, & Jurasek, 2008, p. 126): for instance, when we move to a new neighborhood, change job or face other events that modify our travel routines.

Past use shows inflated correlations with behavior ($\hat{r} = 0.85$, table 3.3). The reason being that behavior construct is usually operationalized by 'single retrospective self-reports of frequency of behavior over some period of time in the past' (Verplanken et al. 1998, pp. 122). This operationalization is infact similar to the measurement of past use, a common measure of habit.

Also the three planned behavior constructs (attitudes, norms, and PBC) proved to have a good predictive capability and, consistently with prior research (Gardner & Abraham, 2008; Bamberg & Möser, 2007), they all appear to be closer to intentions than behaviors. Moreover, while attitudes and PBC seem the main predictors within this framework as regards both intentions and behaviors (Gardner & Abraham, 2008), injunctive-subjective norms emerge as good predictors of behavioral intentions,

only. This result contradicts Sheppard, Hartwick, and Warshaw (1988), according to whom subjective norms are indeed a weak predictor of intentions, as well. The weak predictive power is due to the fact that norm was previously measured by a less reliable single item. Subjective norms, when measured by multi-items, show strong association with intention (Armitage & Conner, 2001).

All environmental variables directly connected with sustainability issues (environmental values, concern, etc.) seem to play a marginal role as regards the capability of predicting *actual* travel mode choices, while they emerge as significant predictors of *intentions* to choose an eco-friendly alternative. Heath and Gifford (2002) report similar associations between environmental constructs and behavioral outcomes indicating a mediating role of intention. This is consistent with prior literature (Kennedy, Beckley, McFarlane, & Nadeau, 2009) suggesting that many individuals fail to *walk the talk*: no matter how strong their environmental beliefs and awareness, they will fail to act accordingly to such pro-environmental profile. This is clearly problematic for policy makers and other actors aiming at modifying behavioral patterns of citizens, as initiatives aimed at increasing the awareness and the environmentalism of a community might fail at the end to lead to a concrete, effective behavioral shift. Further insights on the determinants of behavioral intentions and actual behaviors are needed, for instance, to understand which type of instrument (e.g., financial vs. non-financial appeal and inducements) prove to be more effective (Bolderdijk, Steg, Geller, Lehman, & Postmes, 2013; Lanzini & Thøgersen, 2014).

Robustness of results is supported by publication bias analysis, which suggests that in almost all cases such bias is absent: the only exceptions refer to awareness of consequences and ascription of responsibility as correlates of car use (Fail-safe N=5 and 4, respectively), and injunctive norms towards car use as correlates of intentions to use alternative transport modes (Fail-safe N=16).

3.4.2. Heterogeneity analysis

A crucial element to highlight is represented by the great heterogeneity of results, as suggested by the I-square which in most cases is well above the 75% threshold identifying a large heterogeneity (Higgins et al., 2003). Better understanding of the reasons underpinning such variability is required to set directions for future research as well as for practical decision making purposes (Möser & Bamberg, 2008). I hence identify five study characteristics as potential moderators of the effect size distribution that could explain such heterogeneity, and I perform a moderator analysis, accordingly. The first moderator refers to the operationalization and measurement (MST) of behaviors and intentions. As mentioned earlier, *actual* behavior and intention are measured with reference to a specific time-frame, while *typical* behaviors and intention are measured with no such reference. Hence, I categorize MST into typical, actual (less than a week) and actual (more than a week). Based on the speculation that the purpose of the trip (TRIP) might affect which predictors assume a prominent role, I adopt a partition where trips have been classified, according to their specific purpose, into *working trips*, *shopping trips*, *general trips* and a residual category *other trips*. The study sample (SAMPLE) moderator is categorized into *general population*, *students*, *employees*, and *others*, as different groups might differ in terms of travel modes. Also geographical location (LOC) of the study (categorized into *Europe*, *North America* and *Far East*) and study period (YEAR) have been included as moderators in the analysis. Since each covariate is required to appear in at least 10 independent studies to be included in the analysis (Borenstein, Hedges, Higgins, & Rothstein, 2009), I combine driving and non-driving intention and behavior datasets as to ensure the inclusion of all covariates in the analysis.

Results of heterogeneity analysis are presented in Table 3.6. Only cases where at least one predictor proved to be significant are reported. The analysis shows that measurement is the prominent factor affecting heterogeneity of results. Methodological aspects of surveys such as the operationalization and

measurement of behaviors and intentions heavily affect the outcome in terms of correlation with relevant predictors. This has evident implications for policy makers. Indeed, since most Travel Demand Management (Eriksson et al., 2006) and soft transport policy (Möser & Bamberg, 2008) measures have their roots in the informational background provided by analyses of commuters' decision-making processes, it is necessary to better understand the relationship between the operationalization and measurement of constructs and the results of empirical investigations. This will prevent policy makers from shaping strategies based on an over-simplified interpretation of the information at hand.

Also trip purpose and sample type explain heterogeneity of results, though to a lesser extent compared to the measurement. As regards sample type, some groups (e.g., students) display specific features that affect their behavioral patterns and the respective predictors, albeit there is evidence that socio-demographics are not effective determinants of pro-environmental behaviors (Diamantopoulos, Schlegelmilch, Sinkovics, & Bohlen, 2003). Consistently with the results, trip purpose has been investigated in literature as a variable shaping modal choice (De Witte, Hollevoet, Dobruszkes, Hubert, & Macharis, 2013). For instance, there is evidence that while car use in prominent for business (Limtanakool, Dijst, & Schwanen, 2006; O'Fallon, Sullivan, & Hensher, 2004) or shopping (Kim & Ulfarsson, 2008) trips, alternative modes are more frequent for school (Kim & Ulfarsson, 2008) or short social (Pucher & Renne, 2003) trips.

The low moderating effect of study period is somehow surprising, as it contradicts speculations that over the past 25 years sustainability gained unprecedented relevance in shaping behavioral patterns (Akehurst, Afonso, & Gonçalves, 2012). On the other hand, policy makers can benefit from such stability, as an ever-changing context would represent a hindering factor for the setting up and the implementation of sustainable mobility strategies.

Table 3.6. Results of heterogeneity analysis

Dependent Variables (ES)	*k*	**MST**	**TRIP**	**LOC**	**YEAR**	**SAMPLE**
		Q-stats (df)	Q-stats (df)	Q-stats(df)	Q-stats (df)	Q-stats (df)
		R^2	R^2	R^2	R^2	R^2
INT-BEH	22	30.3(2)*** *63%*	9.85(2)*** *14%*	n.s.	15.0(1)*** *34%*	11.2(2)*** *25%*
ATT-BEH	37	9.98(2)*** *23%*	n.s.	n.s.	4.39 (1)** *1%*	22.01(2)*** *27%*
ATT-INT[14]	38	4.69(2)* *27%*	n.s.	n.s.	n.s.	7.87(3)** *27%*
INJ-BEH	28	13.15(2)*** *18%*	n.s.	n.s.	n.s.	n.s.
INJ-INT	29	n.s.	n.s.	n.s.	n.s.	7.96 (3)*** *0%*
DES-BEH	10	16.23(2)*** *50%*	13.2(1)*** *54%*	n.s.	n.s.	n.s.
DES-INT	13	33.0 (2)*** *62%*	4.43(1)** *14%*	n.s.	n.s.	n.s.
PER-BEH	19	n.s.	n.s.	n.s.	n.s.	6.96(2)** *15%*
PBC-BEH	26	7.67 (2)** *20%*	n.s.	n.s.	n.s.	n.s.
PBC-INT	32	6.75(2)** *0%*	n.s.	n.s.	n.s.	n.s.
ENV-BEH	10	7.48(2)*** *40%*	12.6(1)*** *63%*	n.s.	n.s.	N/A
ENV-INT	16	n.s.	n.s.	n.s.	5.62(1)** *15%*	n.s.
PAST-INT	10	10.2(2)** *12%*	n.s.	N/A	n.s.	25.0(3)*** *55%*

*** p<0.01, ** p<0.05, * p<0.1, n.s. non-significant

Note: Q-stats = chi-square distribution with n-1 degrees of freedom (df), where n is the number of predictors in the model. It tests whether atleast one of the regression coefficients in the model is different from zero; a significant Q-stats confirms the relevance of covariates to the predicted effect size. R^2 = the proportion of true variance explained by the model.
ES= effect size; BEH=behavior; INT= intention; INJ=injunctive-subjective norms; DES= descriptive norms; PER= personal norms; PBC= perceived behavioral control; PAST= past use.

Location, on the other hand, is the only mediator analysed that does not explain heterogeneity in effect sizes. This might look surprising, given the differences between the locations where primary studies were performed and the subsequent assumption that both cultural and contextual factors could affect the heterogeneity of results. However, it is worth noting that results are consistent with evidence suggesting that psychological determinants of TPB are generally homogeneous across different regions

[14] P-value< 0.05 is the decision rule for the significance of the relationships. However, only in two cases, when R^2 is high, 10% significance level is considered.

(Lo et al., 2016). With regard to location, one possible speculation that should be addressed by future research is whether other variables might have better explanatory power compared to the Country or the macro-region where the studies are performed. For instance, it might be interesting to investigate more in detail the specific features of the area where data are collected: is it a rural or a metropolitan area? Does it have an efficient network of public transportation? Is there an effective involvement of public authorities for the planning and implementation of sustainable mobility plans?

3.5. Conclusions

Increased car dependency represents a crucial challenge of our times (Blythe, 2005), given the economic, environmental and societal repercussions of private mobility (Schuitema, Steg, & Forward, 2010). Different strategies have been hence proposed to lower the ecological footprint of current travel patterns and to shape new, more sustainable mobility-related behaviors. Given the inconsistent results of literature on transport mode choice and the awareness of the need to gain better understanding of socio-cognitive factors affecting such choice (Cools, Brijs, Tormans, Moons, Janssens, & Wets, 2011; Eriksson et al., 2006), a meta-analysis has been conducted to synthesize available evidence, investigating the psychological and behavioral correlates of both private car use and alternative, environment-friendly transport modes. This paper is build on the work of Gardner and Abraham (2008), including recent studies and broadening the analysis encompassing new predictors and perspectives; moreover, a heterogeneity analysis has been run to explain the variability of results.

This work has relevant implications especially for policy makers, willing to implement sound mobility plans that require the essential contribution of individual behaviors (De Witte et al., 2013). Some general patterns clearly emerge from the analysis, such as the predominance of intentions, habits and past behavior as predictors of travel mode choice or the intention-behavior gap. However, policy

makers should be careful in interpreting such an informational background, avoiding a simplistic and superficial approach that would hinder the effectiveness of policies: for instance, the methodological heterogeneity of primary studies (e.g., the measurement and operationalization of constructs) represents a problematic aspect, as the framing of survey questions has a relevant impact on the outcome on which policy makers are supposed to base their strategies. Whereas a homogenization of methodological frameworks would be particularly complex on a practical standpoint, policy makers or other actors interpreting available information should put extra care in focusing not only on the final results of the analysis, but also on the study characteristics that led to such results. From the point of view of research, future investigations could first of all increment the number of studies analyzing scantly investigated predictors (that, given the low number of observations, could not be included in the meta-analysis). Moreover, they could as anticipated be more specific in reporting relevant aspects (both contextual and methodological) of the study, specifying for instance the features of both the area and the community where data are collected, as this might represent a factor capable of explaining part of the variability in results.

The need to gain further insights on the determinants of modal choices is urgent; albeit the intertwining effect of a wide range of variables (both subjective and contextual) makes the path long and complex, this is no good reason to give up on the task as the reward is well worth the effort.

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