DOCTORAL THESIS

UCAM
UNIVERSIDAD CATÓLICA
DE MURCIA

INTERNATIONAL DOCTORAL SCHOOL

Doctoral Programme in Social Science

Not yet ready for electrification?!

An empirical study of the barriers and drivers of electric vehicle adoption in Germany

Author:

Steffen Berg, M.Sc.

Supervisors:

Prof. Dr. Mercedes Carmona Martínez

Prof. Dr. Thomas Heupel

Murcia, July 2025

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AUTHORISATION OF THE THESIS SUPERVISOR FOR ITS PRESENTATION

Prof. Dr. Mercedes Carmona Martínez and Prof. Dr. Thomas Heupel, as Supervisors[1] of the Doctoral Thesis 'Not yet ready for electrification?! An empirical study of the barriers and drivers of electric vehicle adoption in Germany' by Mr Steffen Berg in the Doctorate Programme Social Science, **authorise its submission**, given that it meets the required conditions for its defence.

Which I sign, in compliance with Royal Decree 99/2011, of 28 January, amended by R.D. 576/2023, of 4 July, which regulates official doctoral studies.

In Murcia on July 21, 2025.

Prof. Dr. Mercedes Carmona Martínez Prof Dr. Thomas Heupel

[1] If the Thesis is supervised by more than one director, both of them have to be stated and signed.

ABSTRACT

This dissertation analyses the acceptance of electromobility in Germany using an extended technology acceptance model. An integrative research model was developed based on the unified theory of acceptance and use of technology (UTAUT 3) by Blut et al. (2022) and the empirically substantiated determinants from the meta-analysis by Wicki et al. (2022). This was supplemented by trust-based influencing factors (McKnight, 2009; Hilale & Chakor, 2024) as well as demographic moderators adapted to the research context according to Sovacool (2018). The empirical examination was conducted through a quantitative online survey with a final sample size of n = 485, which was compiled by a professional market research institute to ensure a representative sample. The data was analysed using structural equation modelling (PLS-SEM) in SmartPLS. The results confirm the central causal relationships of the extended model and emphasise, in particular, trust in electromobility, reliability, contextual acceptance, and other experience- and demographics-based moderators as key factors in user acceptance of electric vehicles. Finally, implications for research and practice as well as recommendations for future studies are discussed.

RESUMEN

Esta tesis analiza la aceptación de la electromovilidad en Alemania utilizando un modelo ampliado de aceptación de la tecnología. Se desarrolló un modelo de investigación integrador basado en la teoría unificada de la aceptación y el uso de la tecnología (UTAUT 3) de Blut et al. (2022) y los determinantes empíricamente corroborados del metaanálisis de Wicki et al. (2022). Este se complementó con factores de influencia basados en la confianza (McKnight, 2009; Hilale y Chakor, 2024), así como con moderadores demográficos adaptados al contexto de la investigación según Sovacool (2018). El examen empírico se llevó a cabo mediante una encuesta cuantitativa en línea con una muestra final de n = 485, que fue recopilada por un instituto profesional de investigación de mercados para

garantizar una muestra representativa. Los datos se analizaron mediante modelos de ecuaciones estructurales (PLS-SEM) en SmartPLS. Los resultados confirman las relaciones causales centrales del modelo ampliado y destacan, en particular, la confianza en la electromovilidad, la fiabilidad, la aceptación contextual y otros moderadores basados en la experiencia y la demografía como factores clave para la aceptación de los vehículos eléctricos por parte de los usuarios. Por último, se discuten las implicaciones para la investigación y la práctica, así como las recomendaciones para futuros estudios.

KEYWORDS: electromobility, technology acceptance, UTAUT, TAM, consumer behaviour, innovation and diffusion, acceptance, electric vehicles, trust in electromobility

PALABRAS CLAVE: electromovilidad, aceptación de la tecnología, UTAUT, TAM, comportamiento del consumidor, innovación y difusión, aceptación, vehículos eléctricos, confianza en la electromovilidad.

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"Small disciplines repeated with consistency every day lead
to great achievements gained slowly over time."
— John C. Maxwell (2010).

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ACRONYMS AND ABBREVIATIONS

Abbreviation	Meaning
ACEA	European Automobile Manufacturers' Association
AtET	Attitude towards environment and technology
AVE	Average variance extracted (average explained variance of a construct)
BAFA	Federal Office of Economics and Export Control (Bundesamt für Wirtschaft und Ausfuhrkontrolle)
BEV	Battery electric vehicle (Batterieelektrisches Fahrzeug)
BI	Behavioural intention
BMW	Bayerische Motoren Werke (German automobile manufacturer)
BMWK	Federal Ministry for Economic Affairs and Climate Protection (Bundesministerium für Wirtschaft und Klimaschutz)
BRD	Federal Republic of Germany (Bundesrepublik Deutschland)
BYD	Build Your Dreams (Chinese automobile manufacturer)
CA	Contextual acquaintance
Cav	Charging availability
CAM	Centre of Automotive Management
CB-SEM	Covariance-based structural equation modelling
CD	Contextual determinants
CLT	Central limit theorem
CLVS	Central limit value set
CMB	Common method bias
Co	Costs
Com	Compatibility
CR	Composite reliability (Maß für interne Konsistenz)
CT	Charging time
DR	Driving range

Abbreviation	Meaning
EE	Effort expectancy
EFA	Exploratory factor analysis
EI	Environmental impact
EMOB	Electric mobility
EmoG / EmoG	Electric Mobility Act (Elektromobilitätsgesetz der BRD)
EU	European Union
EV	Electric vehicle
Ex	Experience
EY	Ernst & Young
Fa	Familiarity
FC	Facilitating conditions
FCV	Fuel cell vehicle
GEIG	Building Electromobility Infrastructure Act (Gebäude-Elektromobilitätsinfrastruktur-Gesetz of the BRD)
GM	General Motors (American automobile manufacturer)
GW	Great Wall (Chinese automobile manufacturer)
H2 MOBILITY	Operator of hydrogen refuelling station infrastructure
Ha	Habit
HM	Hedonic motivation
HEV	Hybrid electric vehicle
IC	Individual characteristics
ICE	Internal combustion engine
ICV	Internal combustion (engine) vehicle
In	Individualism
KBA	Federal Motor Transport Authority of the BRD (Kraftfahrt-Bundesamt)
Kn	Knowledge
LoI	Length of interview (survey completion time)
LTM	Long-term memory

Abbreviation	Meaning
Ma	Masculinity
Mav	Market availability
ME	Mediator effect
MO	Moderator effect
MP	Motor power
N	Sample size
NC	National culture
NEDC	New European Driving Cycle
OEM	Original equipment manufacturer
OLS	Ordinary least squares (e.g. in "partial OLS regressions")
PCA	Principal component analysis (e.g. for Harman's single-factor test)
PE	Performance expectancy
PHEV	Plug-in hybrid electric vehicle
PI	Policy and incentives
Pin	Personal innovativeness
PLS	Partial least squares (variance-based estimation method)
PLS-SEM	Partial least squares structural equation modelling
PV	Price value
Q^2	Stone-Geisser Q^2 (predictive relevance)
R	Statistical software
R^2	Coefficient of determination (variance explained)
REEV	Range extended electric vehicle
Re	Reliability
SA	Structural assurance
Scopus	Scientific literature database
SD	Situational determinants
SEM	Structural equation modelling
SI	Social influence
S-curve	Sigmoid curve (used for the visualisation of innovation diffusion)

Abbreviation	Meaning
SOR	Stimulus-organism-response
SR	Stimulus-response
SRMR	Standardized root mean square residual
STM	Short-term memory
T	t-value (for significance testing)
TAM	Technology acceptance model
TAM 2	First extension of the TAM (Davis & Venkatesh, 2000)
TAM 3	Second extension of the TAM (Venkatesh & Bala, 2008)
TD	Technical determinants
TI	Trusting intention in electromobility
TPB	Theory of planned behaviour
TRA	Theory of reasoned action
UB	Use behaviour
ULS	Unrestricted least squares
UNFCCC	United Nations Framework Convention on Climate Change
USP	Unique selling proposition
UTAUT	Unified theory of acceptance and use of technology (Venkatesh et al., 2003)
UTAUT 2	First extension of the UTAUT for the consumer context (Venkatesh et al., 2012)
UTAUT 3	Second extension of the UTAUT, latest version (Blut et al., 2022)
VDA	Association of the Automotive Industry (Verband der Automobilindustrie)
VuMA	Consumption and media analysis (Verbrauchs- und Medienanalyse)
VW	Volkswagen (German automobile manufacturer)
Web of Science	Scientific literature database
WLTP	Worldwide harmonised light vehicles test procedure
ß	Standardized path coefficient (beta)

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I – INTRODUCTION

I INTRODUCTION

1.1 MOTIVATION

The acceptance of electric vehicles in established markets is one of the key challenges for implementing sustainable mobility strategies (K. Dudenhöffer, 2015, p. 318; Kampker et al., 2018, p. 13; Nationale Plattform Elektromobilität (NPE), 2012; Sovacool et al., 2018, p. 18; Wicki et al., 2022, p. 66). Pollution and particulate matter caused by transport are increasing year on year. The transport sector is responsible for approximately 20 per cent of global carbon dioxide emissions each year, with almost half of these emissions attributable to private motorised transport (Europäisches Parlament, 2023a, p. 3; Martin et al., 2022; Rodrigue, 2020, pp. 132–133). Passenger transport therefore has a significant impact on human health and the environment as it contributes to local noise and air pollution as well as global climate change (Creutzig et al., 2015, p. 911 ff.; Lelieveld et al., 2015, p. 367 ff.; Münzel et al., 2021, p. 2882 f.; Nieuwenhuijsen, 2018, p. 432 f.; Victor et al., 2019, p. 33 f.). As a result, an increasing number of people are concerned about their environment (Attenborough & Lagarde, 2019, p. 5; Continental AG, 2020, p. 7; Finger, 2015, p. 10). The classic combustion engines are at the centre of discussions about drive technology. The electrification of drive systems should lead to the use of more environmentally friendly technologies, offering the opportunity to reduce dependence on oil in the long term and minimise emissions (Appel, 2021; Delhaes, 2021; Karle, 2022, p. 2; Proff & Szybisty, 2018, p. 2). A reduction in emissions from motorised private transport is crucial to achieving the goals of the Paris Agreement (Rockström et al., 2017, p. 1269 f.).

This is why electric mobility (EMOB) plays a crucial role in the energy transition and sustainable mobility in many countries. Battery electric vehicles (BEVs) and fuel cell vehicles (FCVs) in particular are a key factor here (Kampker et al., 2018, p. 60 f.; Karle, 2022, p. 29 f.; Middelkoop & Koppelaar, 2017, p. 45 f.). BEVs rely on electricity that comes from local, low-emission sources wherever possible. In the area of hydrogen production, more attention should be paid to hydrogen from green sources in the future (Ajanovic & Haas, 2016, p. 1452).

Electric vehicles have now been available on the market as a series product for just over a decade (Deutsches CleanTech Institut, 2010, p. 26; K. Dudenhöffer, 2015, p. 315; Karle, 2022, p. 3). As the sales figures for electric vehicles in Germany did not account for a large proportion of total vehicle sales for a long time, the market penetration potential of this innovative drive technology was scrutinised accordingly (Kampker et al., 2018, p. 13; Schmidt, 2009, p. 27 f.).

There were many reasons for the lower registration figures, with the main criticisms levelled at electric vehicles concerning the significantly higher purchase price, insufficient range, a lack of nationwide charging infrastructure, long charging times and doubts about technical safety and reliability (Bennett & Vijaygopal, 2018, p. 501; Proff et al., 2022, p. 7).

Sales figures has only risen noticeably in the past five years (2019 to 2023). However, the question arises concerning whether this development is solely due to government support measures or whether other technical, socio-economic and psychological factors have influenced purchasing decisions (Bandelow & Kundolf, 2018, p. 172; Center of Automotive Management (CAM), 2021, 2023; Kampker et al., 2018, p. 14; Kraftfahrt-Bundesamt (KBA), 2024a).

Acceptance is understood as the willingness to use a product, which requires positive attitudes and intentions to use (Dethloff, 2004, p. 18). Acceptance is therefore a key measure for the evaluation of alternative drive technologies by potential consumers (K. Dudenhöffer, 2015, p. 76; Wicki et al., 2022, p. 66).

As Germany has missed the target of one million registered e-vehicles by 2020, **the question emerges concerning which factors specifically influence or inhibit acceptance, and how it can be increased** (Bundesministerium für Wirtschaft und Klima (BMWK), 2022; Bundesministerium für Wirtschaft und Klimaschutz der Bundesrepublik Deutschland (BMWK), 2016, 2023; Fazel, 2014, p. 1 ff.; Kraftfahrt-Bundesamt (KBA), 2020b).

Although technological, economic and ecological aspects have frequently been studied, an integrated model that also takes behavioural, trust-based and cultural factors into account remains lacking (Blut et al., 2022; Hilale & Chakor, 2024; H. McKnight et al., 2009)

This study addresses the research gap by empirically testing an extended acceptance model supplemented with trust (e.g., integrity, competence, reliability),

as well as demographic and cultural moderators. This creates a differentiated understanding of the determinants of acceptance, with practical implications for politics, business and society.

1.2 OBJECTIVE

Electromobility is considered a key technology for reducing emissions in the transport sector (Europäisches Parlament, 2023b, p. 3; Rockström et al., 2017, p. 1269 f.). Nevertheless, market success has been limited to date (Bundesministerium für Wirtschaft und Klimaschutz der Bundesrepublik Deutschland (BMWK), 2022; Kraftfahrt-Bundesamt (KBA), 2020c, p. 10). One possible reason for this is the existing uncertainties among consumers, which can be attributed to psychological, social, and cultural influencing factors (K. Dudenhöffer, 2015, p. 76; Sanguesa et al., 2021; Wicki et al., 2022).

This thesis aims to develop a theory-based structural model to explain the acceptance of electric vehicles, drawing on existing research on technology acceptance (Blut et al., 2022; F. Davis, 1989; Venkatesh & Davis, 2000). In addition to the literature-based determination of possible influencing factors (Wicki et al., 2022), which are used as the basis for determining a suitable initial model and its assignment, the extension of the initial model to include the following components is also considered:

- Trust in technology (integrity, capability, benevolence; (Hilale & Chakor, 2024; H. McKnight et al., 2009)
- Demographic and cultural moderators, such as age, gender, individualism vs. collectivism (Sovacool et al., 2018; Triandis, 2004)
- Other indirect influencing factors, such as political support, technical infrastructure or risk appetite (Kampker et al., 2018; Karle, 2022; Salamon, 2002)

As it is assumed that many consumers have already gained experience with electromobility in the past ten years or have at least formed an opinion about it, not only the intention to use but also the actual usage behaviour is analysed as a dependent variable, in contrast to previous studies (Ajzen & Fishbein, 1980, p. 188 f.; F. D. Davis, 1989; K. Dudenhöffer, 2015, p. 111; Wicki et al., 2022, p. 76).

The aim of the study is to develop an empirically verified and theoretically sound acceptance model that contributes to the further scientific development of acceptance models and explains the concrete adoption behaviour of electric vehicles in practice.

1.3 STRUCTURE OF THE THESIS

Chapter 1 begins with the introduction. In addition to the thematic categorisation of the thesis, the motivation, objectives and the overarching research question are presented. Moreover, an overview of the study's objectives and the planned thesis structure is presented.

Chapter 2 provides a theoretical foundation for the topics covered. The central theoretical principles of electromobility, consumer behaviour, innovation and diffusion theory and acceptance research are presented. The thematic framework begins with a description of the development, variety and market overview of electric vehicles, followed by an examination of consumer behaviour, whereby internal and external influencing factors as well as psychological and political determinants of decision-making behaviour are discussed. The following sub-chapters on market segmentation, innovation and diffusion as well as technological acceptance provide the theoretical frame of reference for the subsequent research model. The selection of relevant theories is theory-led and oriented towards the scientific connectivity of existing empirical studies. The current state of research on user acceptance in the field of electromobility is then analysed and the existing research gap is identified in Chapter 3.

Chapter 3 follows with a systematic derivation of the research model. Building on the UTAUT3 model (Blut et al., 2022), this model is extended to include trust-related influencing factors (Hilale & Chakor, 2024; H. McKnight et al., 2009) as well as demographic and cultural moderator variables (Sovacool et al., 2018; Triandis, 2004). The aim is to map the contextual, social, cultural and psychological influencing factors, which have been insufficiently considered to date, in a joint model and systematically investigate their effect on the intention to use. The research questions and hypotheses are formulated based on theory. The chosen deductive-quantitative approach is particularly suitable for further developing existing theoretical models and empirically validating their explanatory content.

Chapter 4 describes the methodological realisation of the empirical study. The study is conducted based on a standardised online questionnaire using LimeSurvey software. The sample (N = 450) is recruited through the market research institute Lightspeed (Kantar) and is drawn based on defined quota characteristics (age, gender, region, and driving licence ownership). The target group is people with a residence in Germany and a class B driving licence. The survey is anonymised. Validated scales are used to measure the theoretical constructs, which were subjected to a pre-test in advance to check comprehensibility, reliability and validity.

Chapter 5 describes the data analysis using structural equation modelling (PLS-SEM), which is particularly suitable for testing complex causal models with latent variables and enables analysing moderation effects. Once the model has been estimated, the hypothesis is tested and significant influencing factors are identified. This study focusses on the theoretical evaluation of the extended model.

Chapter 6 concludes with a discussion of the results. In addition to a critical reflection and a summary of the central findings, implications for research and practice are derived and an outlook on further research questions is provided.

This systematic approach can make a well-founded contribution to the further development of existing acceptance models. The study is methodologically feasible, based on current scientific standards and contributes to closing an empirically substantiated research gap in the field of user acceptance of sustainable mobility solutions. Figure 1 shows the procedure described above:

Figure 1: Structure of the Thesis

Chapter	Content
Introduction	Motivation, purpose of the study, structure of the thesis
Theoretical Background	Theoretical framework of consumer behavior, e-mobility, innovation and diffusion, acceptance theory and introduction to basic models
Theoretical Analysis	Synthesis of current research and meta-analyses, identification of the research gap, development of the research model and hypothesis formulation
Methodology	Introduction and conceptualization of the SEM approach, operationalization of constructs, study design
Results	Data collection and analysis, hypothesis testing
Conclusion	Summary of Results, Implications, Outlook

Source: Own illustration

II – THEORETICAL BACKGROUND

II THEORETICAL BACKGROUND

This chapter aims to create a comprehensive theoretical foundation for explaining consumer behaviour in the context of electromobility. For this purpose, central theories and influencing factors of consumer behaviour as well as the purchasing decision process are presented first. This is followed by a detailed introduction to the development, market structure and political framework conditions of electromobility in Germany. This is supplemented by selected studies on consumer behaviour in the e-mobility sector. Finally, concepts of innovation and diffusion, as well as various acceptance theories, are presented to develop a holistic understanding of the challenges and drivers of user acceptance of new mobility technologies. These fundamentals form the theoretical basis for the research model that will be derived in the subsequent course.

2.1 CONSUMER BEHAVIOUR

2.1.1 Theory of consumer behaviour

"How can I make myself indispensable to the customer and retain their loyalty?" The answer to this question is: "I have to "live" the customer's life, i.e. put myself in their shoes, recognise their problems, find optimal solutions and offer these to the customer as individually as possible" (Loitsch, 2021, p. 106; Nolden et al., 2012, p. 438). Consequently, the market and the interactions associated with it form the basis for marketing (Lippold, 2015a, pp. 3–4).

Understanding, influencing, and interacting with customers have traditionally formed the core of marketing. Customer orientation, which was originally a pure marketing task, has now also been integrated into other business management disciplines and transferred to various value creation functions within the company (Foscht et al., 2017, p. 3).

The concrete analysis of buyer behaviour is one of the main tasks of marketing. Marketing aims to align company activities with current and potential markets, ensuring that customers' needs are consistently met and generating

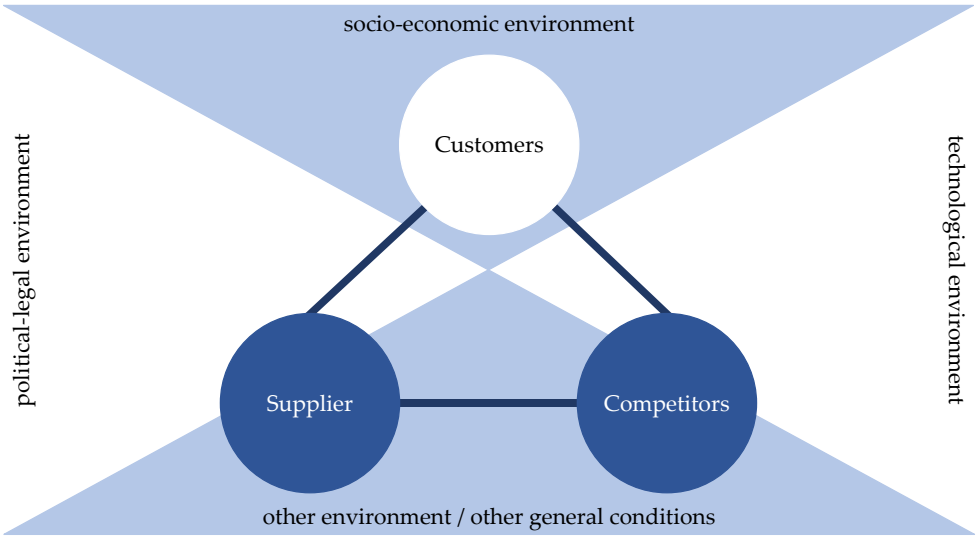
competitive advantages (Meffert et al., 2019, p. 10). Following this, the greater the competition in the relevant markets or the more successful new customer acquisition becomes, the more pronounced customer orientation becomes (Nolden et al., 2012, p. 438; Spindler, 2016, p. 45).

There is also a recognisable difference in acceptance conditions between industrial and consumer goods markets. While there is a negative attitude towards the analysis of buyer behaviour in the B2B sector, decision-makers in the B2C sector are already sensitised and utilise the analysis of consumer behaviour for their marketing activities (Foscht et al., 2017, p. 158 ff.; Kotler & Keller, 2016, p. 220). The terms buyer behaviour and consumer behaviour can be distinguished from one another. Buyer behaviour deals with the behaviour of commercial consumers when purchasing economic goods or services, whereas consumer behaviour deals with the behaviour of end consumers when purchasing and consuming economic goods or services (Foscht et al., 2017, p. 3).

This research project will focus on consumer research. The focus will be on the classic triangular relationship in marketing between customers, suppliers, and competitors, which is embedded in a political-legal, socio-economic, technological, and other environment (Lippold, 2015a, pp. 3–4). The illustration below makes it clear that competitive advantages can only arise if they:

- are recognised by the customer;
- have relevant purchasing characteristics; and
- are copy-protected and therefore cannot be taken over directly by the competition (Foscht et al., 2017, p. 4).

Figure 2: Marketing Triangle



Source: Own illustration based on (Foscht et al., 2017, p. 4)

Consumer behaviour is influenced by various factors that have different effects on the purchase decision, including:

- Cultural factors
- Social factors
- Personal factors
- Psychological processes/factors

A company's marketing measures must be tailored to the influencing factors that affect the respective target group to direct the consumer's focus to its own products (Rutschmann, 2019, p. 180).

Recommendations from customer 1 to potential customer 2 are particularly important, with this behaviour being referred to as "customers recruiting customers". It is essential to emphasise that the recommendations are directly target group-oriented, as they are only made to individuals with a corresponding need for products and services. This approach can be used for market novelties. However, it must be emphasised that the manufacturer can also convince the consumer to buy by offering special incentives. It is also important to emphasise that consumers consider using and purchasing the product voluntarily. First

movers[1] initially advertise new products on a trial basis and wait for an initial résumé before investing in large-scale marketing campaigns.

The perspective of this research project is essentially characterised by target group-oriented customer orientation. This includes understanding the factors that lead to consumer acceptance as well as market segmentation. This allows marketing activities and processes to be created and aligned to the target group (Foscht et al., 2017, p. 3).

The frame of reference for analysing consumers can be divided into different categories. The problem of the underlying research perspective determines the respective application. In this context, four perspectives can be presented (Moser, 1990, p. 84 f.).

Perspective 1: Categories of goods

Initial differentiation is possible using different subcategories. In the first step, a distinction can be made between free goods (e.g., sunlight, rain) and economic goods (e.g., tap water, cars). In the second step, economic goods can be divided into nominal goods (e.g. money, equity), real goods (e.g. tangible goods, merchandise) and intangible goods (e.g. services, patents, licences). In addition, a distinction can be made between consumer goods and productive or industrial goods in a further level of classification (O'Shaughnessy & others, 1987, p. 143; Proff & Szybisty, 2018, p. 115).

The underlying consumer behaviour can also differentiate consumer goods:

- Convenience goods: consumer goods for everyday needs.
- Shopping goods: consumer goods that are purchased after comparing possible substitutes (e.g. household appliances).
- Speciality goods: consumer goods that have unique characteristics and whose purchase involves a heavy budget burden and is therefore

[1] First movers are pioneering companies that introduce a new product to the market. At the time of the market launch, there is no technically comparable product on the market. First movers can also be a group of consumers who are the first to adapt a new technology, who are called "innovators" (Wisbert & Knappe, 2021, p. 134).

preceded by intensive research to obtain information (e.g. cars) (Meffert et al., 2015, p. 101).

Perspective 2: Degree of cognitive control

The purchase decision types allow for a second differentiation based on the degree of cognitive control, i.e., mental control. Here, the decision-making process is considered as a whole, and only the degree of cognitive development for decision-making characterises the purchase decision type. A distinction can be made between purchase decision types with stronger cognitive control (extensive and limited purchase decisions) and those with less cognitive control (habitualised and impulsive purchase decisions) (Kroeber-Riel & Gröppel-Klein, 2019, p. 458 ff.). Table 2 below illustrates the differences and provides a general overview of the findings.

Table 1: Purchase decision types in the purchase decision process

Purchase decision type	Description including example
Extensive purchase	Here, all available information is considered, analysed and evaluated in detail, e.g. purchasing a house.
Limited purchase	If not all information is available for a purchase decision, heuristics and rules of thumb are used, e.g. purchasing a car from a German OEM.
Impulsive purchase	Influenced by external stimuli, the purchase is completed as quickly as possible, often as an impulsive reaction to external circumstances, e.g. buying an ice cream on a warm summer day.
Habitualised purchase	Purchasing decisions that are subject to regularity and thus represent a routine for the consumer. However, these can also be consumption habits, persuasion purchases or consumption for self-image, e.g. repeated purchase of a BMW 3 series car.

Source: Own illustration based on (Felser, 2015, pp. 156–160)

Perspective 3: Psychological determinants

Behaviour-oriented consumer research is the analysis of psychological determinants (explanatory constructs). It is considered the dominant approach in consumer research (Weinberg, 1981, p. 16 ff.). Different, non-observable mental states and processes are used as a basis for explanation. This is intended to make the consumer's psyche transparent (Foscht et al., 2017, p. 20).

The SR and SOR models are based on behaviourism, a branch of behavioural research. The SR model is based on the research paradigm that a specific stimulus (S = stimulus) interacts with an organism and elicits a response (R = response). Initially, only the input and output variables were considered, and the processes within the organism (O) were not investigated further, treated as a "black box". The SOR model includes the variable "organism" in the analysis (Gerrig, 2016, p. 210 f.).

Recent research into behaviourism (neobehaviourism) examines the mental processes in the organism, based on two classes of variables:

- Observable variables
- Intervening variables

The observable variables are the stimuli that act on the organism and the response that it produces. The intervening variables attempt to describe and concretise the processes within the organism/ within the black box. Theoretical constructs from intervening variables are used to explain this:

- Activating processes (emotions, motivation and attitude)
- Cognitive processes (perception, learning and memory)

The observable and intervening variables are linked in the SOR model so that they can be associated with observable stimuli and/or reactions for measurement. The measurement is carried out using indicators, e.g. verbal utterances (Kroeber-Riel & Gröppel-Klein, 2019, p. 35 f.).

Perspective 4: Phases

Phase approaches do not examine the psychological processes in the buyer's organism, but rather look at consumer behaviour in a temporally differentiated manner according to the purchase phase approach. Similar to total models, phase models aim to determine a comprehensive explanation of variance, assuming extensive purchasing behaviour (Stauss & Seidel, 2014, p. 6). Purchase phase

approaches are also crucial in B2B marketing, as the procurement decision-making processes for industrial and capital goods are often lengthy and complex (Meffert et al., 2019, pp. 132–135). Three main phases can be recognised: the pre-purchase phase, the purchase phase and the post-purchase phase. In terms of the buying cycle, a post-purchase phase can lead back to a pre-purchase phase (Zentes et al., 2002, p. 423). The buying cycle considers whether a product fulfils the customer's expectations and needs throughout the entire purchasing process (Kuß & Tomczak, 2012, p. 171 f.). One of the most popular buying phase models, Kotler's five-stage buying process, is presented in detail in Chapter 2.1.4 (Kotler & Keller, 2016, p. 195).

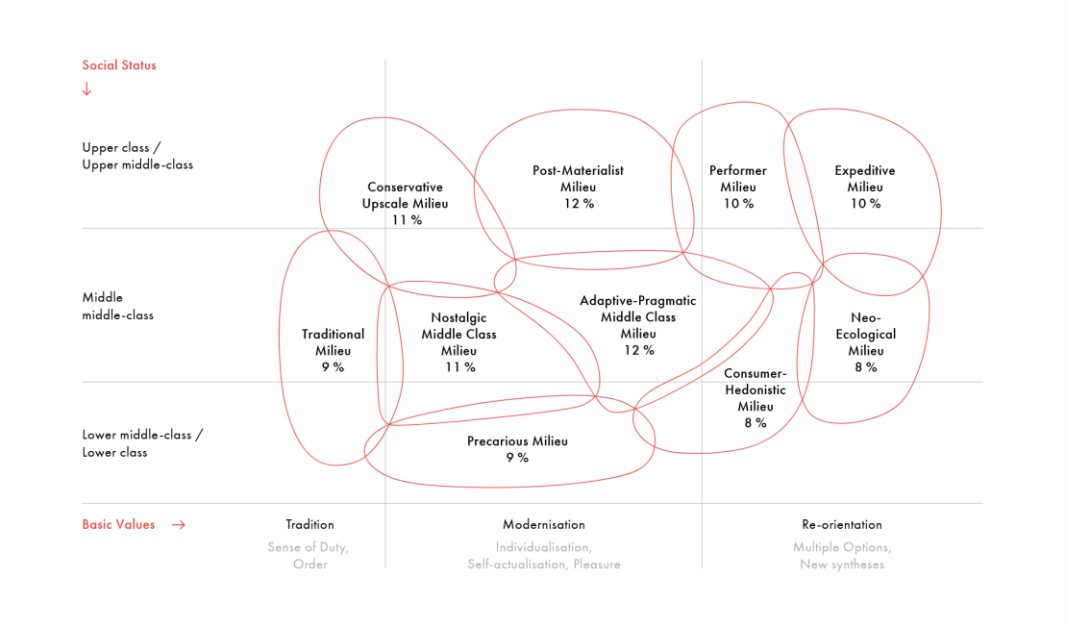
2.1.2 Psychological processes and consumer characteristics that influence purchasing behaviour

Based on the explanations in Chapter 2.1.1, it can be summarised that consumer behaviour is understood as the study of individuals, groups or organisations, for example. The aim of this is to understand the needs and wishes of consumers and respond to them to retain them as customers (Solomon, 2019, p. 8 ff.). An increased understanding of consumer behaviour can even have a positive influence on the economic development of a country or an industry. This in turn can lead to better competitiveness on international markets (Egan, 2020, p. 55).

An important aspect in the analysis of consumer behaviour is based on an understanding of the social situation and value orientation of consumers within society. The results and findings of the sinus-milieus, which can aid in target group segmentation, are often utilised in this context (Calmbach et al., 2024). These study findings categorise German society in terms of people's social backgrounds, values, lifestyles, and attitudes, among other factors (Calmbach & Hecht, 2024). In the individual sinus-milieus, people with similar values and a comparable social situation are grouped into a group of like-minded people. The transitions between the milieus are fluid and are referred to as the blurring of everyday reality. In principle, the following applies to sinus-milieus: the higher a milieu is positioned in terms of social status, the more educated it is, and the further to the right the milieus are categorised, the more modern the basic socio-cultural orientation is (Calmbach et al., 2024). The sinus-milieus were last updated in 2021, and Figure 3

shows the sinus-milieus in Germany and is intended to reflect the above as an example:

Figure 3: Sinus-Milieus in Germany



Source: (Calmbach & Hecht, 2024)

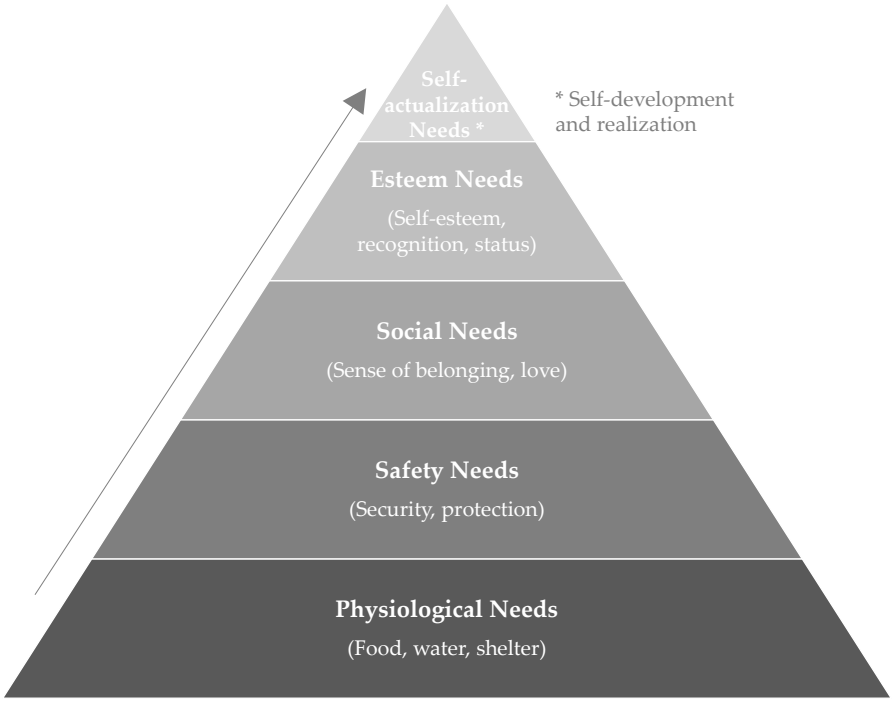
By understanding the attitudes of the population, marketing campaigns can be tailored to the respective clusters by targeting specific groups (B. Barth et al., 2018, pp. 1–18; Calmbach & Hecht, 2024).

To build such a database, it is first necessary to understand how consumer behaviour is influenced by psychological factors, including motivation, perception, emotions, education, and memory (Kotler & Keller, 2016, p. 187; Rutschmann, 2019, p. 2).

According to Maslow's pyramid of needs (see Figure 4), people need motivation to fulfil certain needs. The individual levels of the pyramid represent different types of needs. They all build on each other and are read from bottom to top (Hamm, 2019, p. 122 ff.). The first stage is physiological needs. These are absolute basic needs without which the body cannot survive. Hunger, thirst and sleep fall into this category. The need for security builds on the physiological needs mentioned above. People seek protection and security. This includes not only

physical protection but also mental and financial security. This security can be reinforced through order and structure. The need for security is followed by social needs on the third level. These include friendships, integration into a social community and communication and interaction with other people. Individual needs are situated at the fourth level of Maslow's hierarchy of needs. Each person sets different priorities and therefore prioritises them differently. For one individual, this may be the idea of power, and for their neighbour, the appreciation of others. Self-realisation is at the top of the pyramid. Only when all previous needs have been satisfied can a person realise themselves. Self-realisation can be understood here as the development of one's own personality and abilities (Kotler & Bliemel, 2005, p. 355 ff.; Krings, 2020, p. 61 ff.; Ondracek, 2020, p. 41 ff.).

Figure 4: Maslow's Hierarchy of Needs



Source: Own illustration based on (Maslow, 1943, p. 370 ff.)

However, Maslow's pyramid of needs has also been criticised. For example, it is said that a person seeks social contact despite hunger and does not always have just one need. Nevertheless, Maslow's pyramid is a basic framework for

differentiating and defining the various layers of needs and individual demands in the initial phase of the pre-purchase process (Träger, 2021, p. 137).

Despite criticism of Maslow's hierarchy of needs, the needs are considered in the order described in this paper. It is also implied that a need becomes a motivation if it is urgently necessary for the individual to fulfil the need (Kotler & Keller, 2016, p. 188).

The actions of a motivated person are mainly influenced by perception. For marketing activities, this means that the perceived reality is more important than the actual reality, as it determines consumer behaviour. This the case is because perception is the process by which consumers select, sort and interpret information between offers (Kiley, 2006, p. 58). This in turn can be attributed to the fact that every consumer perceives the environment differently despite the same stimuli. This different perception is based on the following three perceptual processes:

- The process of selective attention is designed to capture the customer's attention and differentiate itself from the multitude of different advertising messages that reach consumers every day.
- In the process of selective distortion, information is presented to the consumer in a way that supports their existing beliefs, thereby building product or brand loyalty.
- In the process of selective retention, the consumer perceives information that emanates from a communication about a product as positive if it aligns with their own attitudes and knowledge. In addition, a positive association with the brand and the product is internalised. To achieve this, communication often relies on the repetition of the advertising message[2] relied on (Kotler & Keller, 2016, pp. 190–191).

Purchase intentions and preferences are not completely reliable predictors of the actual purchase because a consumer can reconsider their purchase decision,

[2] Such a repetition of the advertising message is called the Mere-Exposure-Effect and works with certain repetition skills to promote buying (G. C. Moore & Benbasat, 1991, p. 203).

modify it, or avoid a final purchase decision due to one or more perceived risks, leading to a level of uncertainty. This in turn influences the decision based on the amount to be spent and the individual's self-confidence. The decision can also be not to make the purchase or postpone it (Campbell & Goodstein, 2001, p. 439 ff.). When uncertainty arises, consumers tend to seek further information, buy local brands or use additional safeguards (e.g. when buying a vehicle, look for additional guarantees;(Dowling & Staelin, 1994, p. 119 ff.). The perceived risks include, according to (Kotler & Keller, 2016, p. 200):

- Functional risks
- Physical risks
- Financial risks
- Social risks
- Psychological risks
- Temporal risks

In addition to motivation and perception, actions play an essential role because when we act, we learn. This means that learning influences our behaviour, and experiences are formed from learning. Through learning and external influences from the environment, consumers can develop beliefs that in turn influence their purchasing behaviour. Learning therefore shows how people's behaviour changes based on experience and the information they receive. For example, if a consumer has had a negative experience with a certain product and associates the product with this discomfort, they will no longer buy this product. If, on the other hand, they are satisfied with the product, they are more likely to repurchase it. This means that customers can have different beliefs and attitudes towards the same products and brands based on their individual experience (Kotler & Keller, 2016, pp. 191–192).

This also means that the brand image and the product image are made up of these beliefs and attitudes, and influence the purchasing behaviour of consumers. Both short-term memory (STM) and long-term memory (LTM) play an important role here. The idea is that memories stored in the long term can be compared with situations in daily life. The long-term memory is used as a starting point for new experiences. Marketers can change consumers' beliefs and attitudes by changing

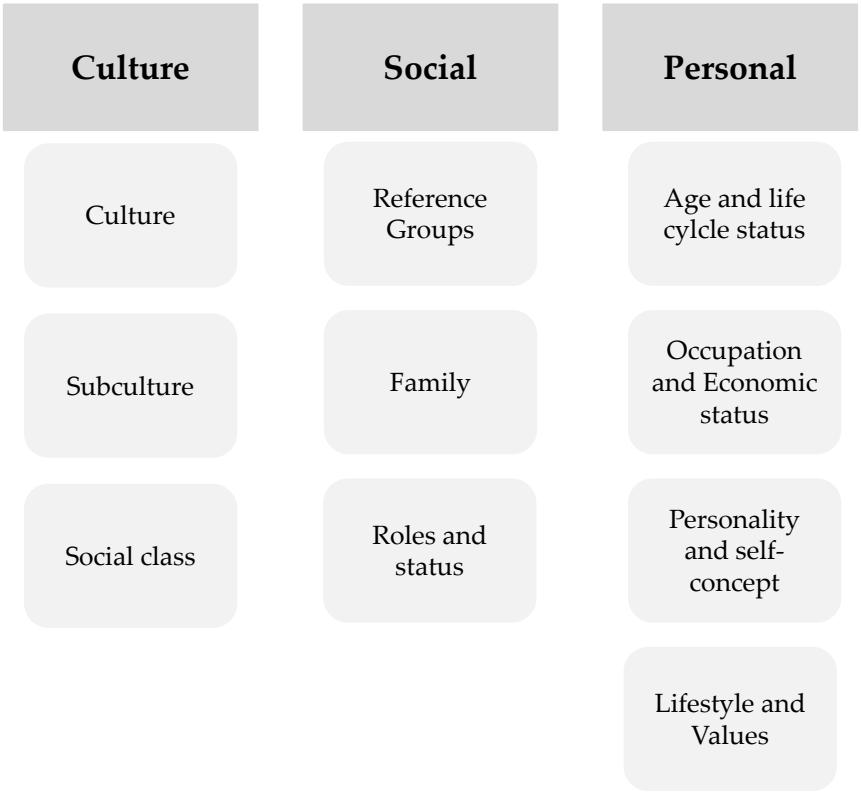
the marketing strategy or adjusting the positioning of the brand (Kaplan, 2010, p. 56 ff.; Kotler & Keller, 2016, pp. 193–194; Lamons, 2005, p. 46 ff.; Sullivan, 2009, p. 10).

2.1.3 Factors that influence consumer behaviour

In addition to the psychological factors and processes described above, consumer behaviour is also influenced by cultural, social and personal factors (Kotler & Keller, 2016, p. 179).

Figure 5 shows the key factors influencing consumer behaviour, which are explained in more detail in the following three chapters:

Figure 5: Factors influencing the buying behaviour of consumers



Source: Own illustration based on (Kotler & Keller, 2016, pp. 179–187)

Cultural factors

Among the three factors mentioned above, cultural factors have the most significant influence on the needs and (consumer) behaviour of an individual. The generic term "culture" can be broken down and differentiated into culture, subculture and social class.

The behaviour of a person who belongs to a certain group is significantly influenced by the culture associated with this group. At this point, the family and other key institutions play a decisive role, particularly as the child grows up. It is important to note that cultural factors differ from country to country, for example. Marketers must therefore carefully understand and evaluate how new products can be advertised and sold on the market in relation to the individual country (Schiffman et al., 2010, p. 364 ff.).

It is helpful to know that the formation of a person's basic values and preferences, as well as the emergence of behaviour, is inevitably influenced by the groups surrounding them. In a broader sense, this means that every culture comprises small subcultures that offer their members opportunities for identification and social functions. Subcultures include nationalities, religions, racial groups and geographical regions. If one of these subcultures offers sufficient potential, special marketing measures are tailored to it (Kotler & Keller, 2016, p. 180).

The vast majority of human societies are characterised by social stratification or social classes, which in their selective perception consist of homogeneous and permanent classifications. Each of these social classes is characterised by a (social) hierarchical structure whose members pursue the same values, interests and behaviour. Social class is therefore significant for predicting consumer behaviour. Influencing factors can include income, occupation, family background, and educstion level. Members of the social class show very different preferences in many areas, e.g. leisure activities, clothing and cars, which are related to this thesis (Coleman, 1983, p. 265 ff.).

Social factors

In addition to cultural factors, social factors also have a significant influence on consumer behaviour, including reference groups and cliques, family, social role and status.

This means that all groups that have a direct or indirect influence on a consumer's attitude or behaviour are referred to as reference groups. Reference groups that have a direct influence are also referred to as membership groups. Family, friends, neighbours and work colleagues can be counted among the direct influences or primary reference groups. Secondary reference groups, on the other hand, include those with whom the individual consumer has a more formal and less regular relationship. Reference groups can influence behaviour in at least three ways: first, they can show the individual new behaviours and lifestyles; second, they can influence the individual's attitudes and self-image; and finally, they can use (social) pressure to insist that the individual adapts to the group. This can lead to only specific products and brands being favoured for consumption. In this context, it should also be noted that people are also influenced by groups with which they do not identify. On the one hand, this means that the individual strives towards specific groups and their membership, and on the other hand, rejects membership in groups with which they have no connection or do not wish to have a connection (Kotler & Keller, 2016, p. 181).

With a strong group influence on the individual, marketers must identify the opinion leaders of the respective group and find suitable ways and means to reach and persuade them in the most appropriate manner (Schiffman et al., 2010, p. 318 ff.). Especially against the background of innovative technologies, it is necessary to involve opinion leaders in public relations activities at an early stage, as consumers pay particular attention to their advice in the purchasing decision process (Homburg, 2017, p. 54, 830).

As the most influential main reference group, the decisions of family members with regard to brands and products have a non-negligible influence on the purchasing behaviour of consumers (E. S. Moore et al., 2002, p. 17 ff.). Consumers who have already developed brand preferences at a young age, influenced by their family, may also choose the same brands in the future. Even if the consumer has no further interactions with their family, the manifested influences from the family remain. For example, this leads to 40% of children taking out car insurance with the same company as their parents (Palan & Wilkes, 1997, pp. 162–168). As the role model and understanding of roles within a family or household are also changing, marketers need to adapt accordingly. After all, it is

not always the woman who goes grocery shopping, and nowadays both spouses/partners usually make extensive and/or limited purchasing decisions together (Felser, 2015, p. 156 ff.; Melnyk et al., 2009, p. 83; Rick et al., 2010, p. 164 f.). The influence of children on the consumer behaviour of parents should also not be neglected, as children pay close attention to which brands and products their friends wear or use and mirror or anticipate this behaviour (Homburg, 2017, p. 53).

As mentioned in the previous chapter, role and status can also influence the purchasing behaviour of individual consumers. A person's role and status determine their position in the respective group. The role is defined by the activities or actions of the person that are expected of this person by the reference group. The role assumed corresponds to the status within the group. The choice of product to some extent corresponds to the role one plays and the actual or desired position in society (Kotler & Keller, 2016, p. 183).

Personal factors

In addition, consumers' product choices are influenced by personal factors such as age and life cycle, occupation and economic status, lifestyle, as well as the consumer's personality and self-concept (Kotler & Keller, 2016, p. 183).

Consumers' consumption preferences change over the course of their lives, influenced by age and life status. This can be observed in relation to the respective living situations of households, with the proportion of traditional households consisting of a father, mother, and two children becoming increasingly smaller (Homburg, 2017, p. 260). Furthermore, the transition to individual life phases such as birth, marriage, relocation and retirement also play an important role in measuring the influence on the change in consumer behaviour (Du & Kamakura, 2006, p. 121 ff.).

Occupation and economic situation also have an influence on consumer behaviour. The level of income has an impact on consumers' price perception. Compared to the purchase of luxury goods, low-income groups are more interested in buying products that they need to fulfil their basic needs. Similarly, people's attitudes towards products and brands, especially luxury goods, significantly differ in times of economic prosperity compared to during an economic recession. In times of recession, suppliers can diversify or reposition their products, for example,

by redesigning or repricing them to continue offering their customers added value (Clifford, 2011; Kotler & Keller, 2016, p. 185).

In addition, each person's personality influences their purchasing behaviour. Personality is understood as a series of characteristic human psychological traits that lead to relatively consistent and lasting, as well as predictable reactions to environmental stimuli (Kassarjian & Sheffet, 1981, p. 160 ff.). Just like people, brands also try to create a personality. This so-called brand personality attempts to assign as many human traits as possible to a specific brand. This allows several different consumer groups to be addressed, as consumers generally choose the brand that most closely matches their own personality. Five different dimensions of personality can be distinguished, namely sincerity, excitement, competence, sophistication and robustness (Aaker, 1997, p. 347). Consumers also often choose brands that match their actual self-concept, even though this match may be based on the consumer's ideal self-concept or even on the self-concepts of others (Aaker et al., 2001, p. 492 ff.).

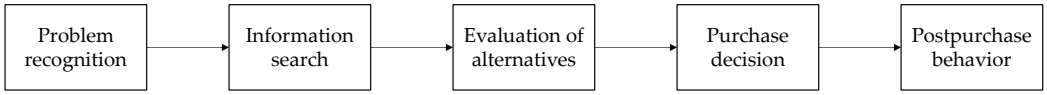
The customer's lifestyle is another important factor that influences consumer buying behaviour. This refers to people's attitudes towards activities, interests and opinions in their lives. Suppliers therefore try to identify similarities between their products and the lifestyles of consumers. Consumers can thus be divided into those have too little money and those who have too little time (Daswani, 2012; Jargon, 2011; Kotler & Keller, 2016, p. 186). Values also play an important role in purchasing decisions. These values lie deep within the consumer's self and reflect their desires and decisions over a long period. Influencing and changing these values should also have a lasting effect on consumer behaviour and attitudes (Homburg, 2017, p. 1090 ff.; Kotler & Keller, 2016, p. 187).

2.1.4 Purchase decision process

As described above, basic psychological processes play a crucial role in consumers' purchasing decisions (Kotler & Keller, 2016, p. 194). It is therefore also important for companies to understand the purchasing decision process as fully as possible. Ideally using predefined guiding questions to gain an understanding of the different experiences of consumers about knowing, finding, using and disposing of products (Belch & Belch, 2003, p. 29).

One of the best-known purchasing decision processes is the five-stage purchasing decision process, as outlined by Kotler and Keller (2016), representing the typical five phases that a consumer goes through while considering the purchase of a product. The five phases are the perception of need, the search for information, the evaluation of the available alternatives, the purchase decision and the post-purchase behaviour (Kotler & Keller, 2016, p. 195). The following illustration shows Kotler's buying process, which is presented in detail and greater depth below:

Figure 6: Five-stage model of the consumer buying process



Source: Own illustration based on (Kotler & Keller, 2016, p. 195)

In the needs perception or problem identification phase, the consumer realises that their needs are not currently being optimally satisfied and that they are suffering a deficiency. As a result, the desire for a benefit or product that eliminates this deficiency is established. This desire is referred to as a need, which is triggered by both internal and external influences. Assuming an external influence, marketing already plays a significant role in this early phase, as customers did not even know that the product from a company existed, which now makes them feel a want = need to consume this product (Kilian & Mirski, 2016, p. 34 ff.; Kotler et al., 2015, p. 214).

The information search phase is characterised by more or less intensive research activities on the part of the prospective customer, as they seek to find the best possible solution for themselves. Additionally, an in-depth analysis of the product and the subject area in which it will be used is conducted. Four different sources of information can be identified:

- Personal sources of information (family, friends, neighbours or acquaintances)
- Commercial sources of information (advertising, e-mail advertising, exhibitions, packaging or sellers)

- Public sources of information (mass media, social media, product test foundation)
- Testimonials (from other users, mostly accessible via the internet)

Furthermore, friends, acquaintances, the internet, and salespeople can be asked for advice or further information. It also happens that friends and acquaintances provide information without a specific enquiry when they learn of the prospective customer's needs, which is then classed as word-of-mouth advertising[3]. In this phase, it is also important that the product's unique selling proposition (USP)[4] is specifically emphasised and advertised by marketing (Kotler et al., 2015, p. 214; Kotler & Keller, 2016, p. 196; Rusnjak & Schallmo, 2018, p. 144 ff.).

The phase of evaluating the alternatives follows the information search phase. Depending on the type of buyer and personal individual preferences, the alternatives on offer are evaluated differently. In this phase, the results of comparative tests and further information are also used or referred to. In addition, instruments more familiar from the business-to-business (B2B) sector, such as utility analysis, can be used to determine the best possible alternative (Kotler & Keller, 2016, pp. 197–198; Noll, 2003, p. 35).

After evaluating the alternatives, a purchase intention is derived, and the purchase decision phase follows. In the course of deriving the purchase intention, the consumer makes at least five further decisions: From which brand, from which seller, what quantity, at what time and with which payment method will the corresponding product be purchased. In addition to the personal purchase intention, the final purchase decision is influenced by the attitude of others towards the consumer's purchase intention, as well as by unexpected situational factors

[3] Mouth-to-mouth propaganda or word-of-mouth, in the context of marketing, is oral communication from a communicator to a recipient that is perceived by the recipient as non-commercial in nature in relation to a brand, product or service (Buttle, 1998, p. 243).

[4] USP stands for unique selling proposition. This is an objectively unique value proposition that is seen by the target person as either unique or superior to alternatives (Rusnjak & Schallmo, 2018, p. 113).

shortly before the purchase decision is made (Kotler et al., 2015, p. 218; Kotler & Keller, 2016, pp. 198–199; Meffert et al., 2019, p. 17).

Post-purchase behaviour is the last of the five phases of the buying process according to Kotler. In this phase, the buyer evaluates the product and determines whether it meets their expectations and assumptions. This results in either satisfaction or rejection of the product. In both cases, it must be expected that the consumer will share their judgement with other people in their environment (Kotler & Keller, 2016, pp. 200–201).

It is worth noting that during the purchasing decision process, various internal needs and external factors influencing the consumer must be considered to respond to them in the most effective way (Spindler, 2016, p. 45). It is also worth noting that the buying process begins long before the actual purchase takes place and has lasting consequences long after the purchase has been made (Gupta & Mela, 2008, pp. 102–109). It is therefore essential that marketing and its measures in all phases have a significant impact on the purchasing decision, which should not be underestimated, and that a holistic planning approach is adopted (Grant, 2011, pp. 96–103). It is also worth noting that consumers do not necessarily progress through each of the phases described above, but may skip individual phases or catch up on them later if necessary. This five-stage approach is particularly relevant for purchases involving high-involvement or extensive products or products that are new to the consumer (Kotler & Keller, 2016, p. 195).

As has become clear from the previous chapter, the basis for the purchase of a product is a positive purchase decision. By purchasing the product, the consumer expects to receive a benefit that satisfies their needs. In this context, reference can be made, for example, to "normative decision theory", which states that the consumer will always decide in favour of the product that will provide them with the maximum benefit. To this end, the available alternatives can be evaluated and weighted with a probability of occurrence. This is intended to determine the best-rated alternative and simplify the selection of the item to be purchased (Betsch et al., 2011, p. 67 ff.).

A purchase decision largely depends on the product and the (background) knowledge of the consumer (Moser, 1990, p. 84 f.). Advertising can influence the consumer's purchasing decision (Bergler et al., 1992, p. 104 ff.). Moral reasons in

favour of or against a product can also be decisive (O'Shaughnessy & others, 1987, p. 1987). In addition to the psychological processes and consumer characteristics described above, the purchase decision is also influenced by various purchase decision criteria, such as the product itself and the consumer's environment and surroundings. For example, when buying a car, criteria such as brand, quality and price can take centre stage (Proff & Szybisty, 2018, p. 115 ff.). For products newly established or launched on the market, additional or product-specific purchase criteria may apply (Binsack, 2003, p. 7 ff.).

It should be emphasised at this point that not only can product-related criteria be taken into account when making a purchase decision, but that consumer-related criteria should also always be considered. Product-related criteria reflect the relevant factors of the product alternatives. The individual influencing factors of the consumer interact with this (Diez, 2015, p. 28 ff.).

In addition to evaluating product- and consumer-related criteria, prospect theory can also significantly influence the purchase decision. At this point, prospect theory is related to the expected utility concept presented above (Foscht et al., 2017, p. 239). This mental accounting follows the following three principles:

- The alternatives that present themselves are not measured against the final state of gain or loss, but are measured and subsequently evaluated based on the change from the current reference point.
- Consumers perceive losses to be worse than gains in relation to the reference point. At the same time, consumers behave in a risk-seeking manner when it comes to losses and in a risk-averse manner when it comes to gains.
- Objective probabilities of occurrence of possible environmental conditions are overvalued for losses and undervalued for gains (Kotler & Keller, 2016, p. 205).

2.1.5 Political factors that influence consumer behaviour

Academics have been researching government policy measures since the 1970s. Although there are various definitions and characteristics of political measures, most of them are based on the assumption that governments formulate

measures to implement their own policies and thereby influence the behaviour of citizens and companies (Bemelmans-Videc et al., 1998, p. 23 ff.; Howlett, 1991, p. 1 ff.). The policy measures initiated can also be described as neutral instruments, which in turn can be characterised either directly or indirectly (Pollert et al., 2016, p. 83 f.). In principle, a government has a wide range of political measures at its disposal to implement its policies as effectively and efficiently as possible (Salamon, 2002, p. 65). A government's options are limited by the predetermined framework, which is based on established governance models and political regime logics (Gunningham et al., 1998, p. 210 ff.; Jordan et al., 2005, p. 477 ff.; Lascoumes & Galès, 2007, p. 3 f.).

In most cases, political measures are described in their ideal form. In reality, however, hybrid versions or a mix of different instruments are often used (Kagan & Axelrad, 1997, p. 180 ff.). Five different instruments can be distinguished, which are regularly used by the government (Yeh, 2007, pp. 5867–5868):

1. Legislative/regulatory instruments
2. Economic/fiscal policy instruments
3. Agreement-based/cooperative instruments
4. Economic/tax measures
5. Knowledge-enhancing instruments

The knowledge-enhancing instruments could be categorised as the classic information and communication instruments of a government. However, the approach being pursued in the field of electromobility is to exchange information through targeted communication between the stakeholders (for example between researchers, OEMs and consumers), thus expanding the level of knowledge of all and ultimately promoting the innovation (Adelle & Jordan, 2014, p. 375 f.; Vedung, 1998, pp. 21–59).

The policy instruments are presented in detail below:

Legislative/regulatory measures

Legislative or regulatory measures refer to the use of laws and regulations. The main focus here is on defining and establishing binding requirements, monitoring their fulfilment and imposing sanctions in the event of non-compliance.

The requirements can be divided into prohibitive and prescriptive measures.[5] Over time, the use of hard regulations and legal requirements has changed into a looser due diligence system that emphasises entrepreneurial diligence and following process rules (Salamon, 2002, p. 29 ff.).

There are many reasons for choosing such measures. First of all, these regulations are highly binding. This means that the government is not dependent on the voluntary cooperation or compliance with laws or regulations of the participants. The laws and regulations apply equally to all participants, which in turn protects the participants from arbitrary government action. Additionally, government actions can be anticipated, as they serve to ensure compliance with laws and regulations. However, disadvantages can also be recognised. First, the compliance costs must be borne by the affected stakeholders. This externalisation of costs leads to the government generating high enforcement costs in the event of a high violation rate, which are then passed on to those responsible. Second, laws and regulations as a rigid basis are not suitable for reacting to complex dynamic situations. As a result of these negative aspects, it is often difficult to win over stakeholders for the realisation of political goals (Bouwma et al., 2015, p. 20; Perrels, 2001, p. 2).

Cooperative / agreement-based measures

Agreement-based or cooperative measures involve the government and other stakeholders voluntarily deciding to act in a certain way. These measures can also be called deregulation measures. Such deregulation can be achieved by creating a new market or by granting freedom to institutions and/or companies within a negotiated framework (Howlett, 1991, pp. 13–16).

As the measures are voluntary, the government and the stakeholders concerned can rely on the application of the measures being utilised. However, this is also a problem, as stakeholders who have not been involved in this voluntary agreement are very unlikely to comply with these voluntary measures. This can be

[5] A prohibitive measure is, for example, the rationing of a good and prescriptive measure are, for example, performance standards or benchmarks (Salamon, 2002, p. 20).

explained by the fact that non-compliance with the regulations is not penalised by sanctions. Of course, voluntary measures can be formalised retrospectively so that fines can be levied, for example. However, such a change is time-consuming and labour-intensive, resulting in high transaction costs. In addition, such a change generates potential for conflict due to unclear allocation of tasks and responsibilities, which in turn inhibits the change potential of such cooperative measures (van Gossum et al., 2010, p. 251).

Economic and fiscal policy measures

In this type of measure, the government influences market mechanisms, such as loans, taxes, and subsidies. While most of these measures, compliance with the measures or adherence to them offers added value to the actors concerned, so that the behaviour of most actors can be predicted (van Gossum et al., 2010, p. 257). The advantage of these measures is that they can be used to correct or prevent market failure. This is particularly possible for goods for which no market (yet) exists. In principle, economic and fiscal policy measures offer the potential to create an efficient market. However, these measures cannot prevent market failure through regulation. This can be argued via the costs associated with subsidies. Additionally, loans and taxes require coordinated planning before they are allocated or levied (Howlett, 1991, p. 3).

Information and communication measures

Information is used to try to influence market players on certain topics in order to bring about a change in behaviour. This type of measure is unilateral and comes from the government. The measures can be aimed at a broad audience using public service media or, for example, educational programmes aimed at a specific target group (van Gossum et al., 2010, p. 258).

The major disadvantage of such measures is that they only indirectly lead to compliance with the regulations, as the public or individuals may decide to ignore them. Furthermore, this means that groups of people who are not yet affected by these measures may not be reached in the future in this way. However, more interactive communication measures by governments have been observed recently. These include dialogue forums, interactive seminars or government invitations to the population to share their opinions and views on prepared (digital) platforms (Adelle & Jordan, 2014, p. 386; Gunningham et al., 1998, pp. 226–229).

Knowledge and innovation-based measures

Knowledge and innovation-based measures are comparable to information and communication measures, but are more strongly focused on actors participating in measures to expand their knowledge. This means that the knowledge gained is not just information, but allows the actors to act with/according to this knowledge. It is therefore a matter of implicit and explicit knowledge. Examples of such measures are the development of communities of practice, living labs or creative workshops (Adelle & Jordan, 2014, pp. 381–382; Salamon, 2002, p. 30).

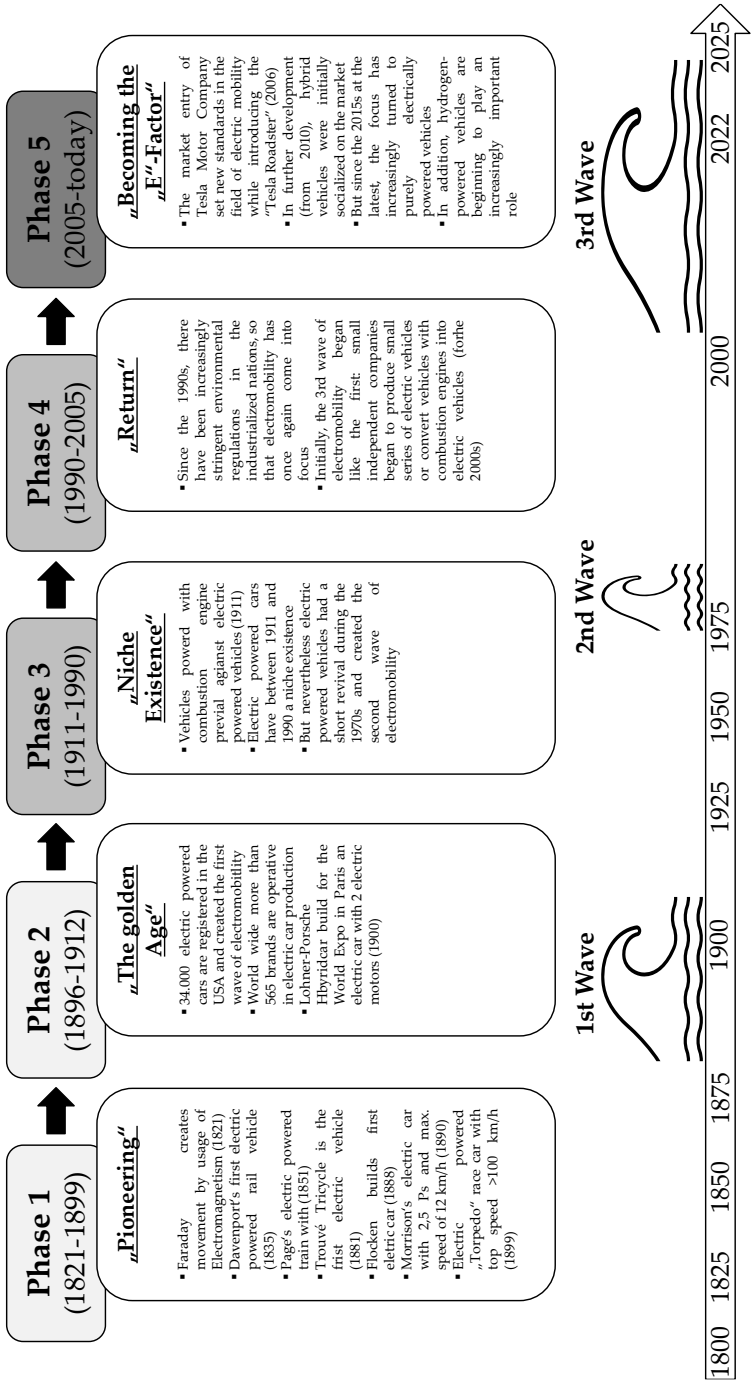
The advantage of these methods is that the actors involved are able to deal with complex and changing situations. The opportunity to get actively involved in the situation also makes it easier to process new findings and refine skills. In addition, the active experience promotes innovative exchange, making these measures the most promising for adapting innovations. However, it can be disadvantageous if only small groups can participate in these measures, as the limited number of test subjects or an insufficient target group also hinders the exchange regarding innovations. In the case of small groups, it is also necessary for the parties involved to work together and recognise each other's achievements. Innovation proclamation is a labour-intensive process: if the measures do not convince stakeholders, the benefits can quickly be reversed, generating higher transaction costs than if the government had used agreement-based measures (Bouwma et al., 2015, p. 21).

2.2 ELECTROMOBILITY

2.2.1 History of electromobility

Electromobility has a history spanning more than 200 years and has undergone several stages of utilisation (Karle, 2022, p. 6). The history can be divided into several phases, and this analysis will focus on the last phase and its current significance for the consumer society. The following diagram illustrates the individual phases of electromobility and the categorisation of the phases into the three waves of electromobility marketing (Dudenhöffer, 2015, p. 11):

Figure 7: History of Electromobility



Source: Own illustration

The first phase and also the first wave of commercialisation of electromobility began in England in 1821. There, the British scientist and inventor Michael Faraday developed a current-carrying conductor that rotated on its own axis under the influence of a permanent magnet. This discovery by Faraday formed the foundation on which the further development of electric motors was based (German CleanTech Institute, 2010, p. 10).

In the 1830s that followed, the first vehicles could already be powered by electric motors. The developments and pioneering achievements in this first phase were based on the idea of powering electric vehicles more efficiently and designing vehicles suitable for everyday use to compete with the emerging vehicles with internal combustion engines (Karle, 2022, p. 6). The sustainability aspect, which has now taken centre stage, did not play a role at that time (German CleanTech Institute, 2010, p. 10).

In 1835, for example, an electrically powered rail vehicle can be traced back to the Briton Thomas Davenport. At the same time, battery development was also being driven forward. John Frederic Daniell and William Grove are regarded as notable representatives here. The two elements named after their discoverers, "Daniell element" and "Grove element", are regarded as the initial development of the fuel cell (Abele & Mener, 1995, p. 10). The next milestone was achieved by Charles Grafton Page in 1851 with the construction of the first electric locomotive. This vehicle was powered by two 20 hp electric motors but had a short range due to its heavy weight (Deutsches CleanTech Institut, 2010, p. 14). With the development of Nikola Tesla (namesake of Tesla Motors Incorporated) in 1878, alternating current could be used instead of direct current for energy transmission. Thanks to this innovation, more powerful electric motors could be built from then on, because AC motors have a higher efficiency, a higher power density and a simpler mechanical design compared to DC motors (Abele & Mener, 1997, p. 21 ff.).

In the 1880s, further progress was made in the field of electrically powered vehicles. In 1881, the Frenchman Gustave Trouvé developed the first electric vehicle with a rechargeable battery. Today, this vehicle is regarded as the first modern prototype of a purely electric vehicle. The prototype (Trouvé Tricycle) had a speed of 12 km/h and was built on the platform of a tricycle (Westbrook et al., 2001, p. 9). Furthermore, in 1888, just two years after Gottlieb Daimler developed

the motorised carriage, Andreas Flocken was the first to develop a four-wheeled electric car (Bergmann, 2021, p. 17; Linz & Schrader, 2008). The electrically powered carriage built by the American William Morrison in 1890 also managed a speed of between 10 and 12 kilometres per hour. This vehicle was powered by a 2.5 hp electric motor, which in turn was supplied by eight batteries (German CleanTech Institute, 2010, p. 15). One of the last pioneering achievements in the field of electromobility is the racing car developed by the Belgian Camille Jentzky in 1899, which travelled at over 100 km/h. It was also the first road vehicle to exceed the 100 km/h mark. It was also the first road vehicle to exceed the 100 km/h mark (Kampker et al., 2018, p. 4; Kuther, 2017). One of the drivers during the first wave of electromobility was the cultural image of the technology as a symbol of the future, which excited society and potential consumers. However, the use of testimonials and the emergence of a large-scale industry also promoted its position in the subsequent second phase of electromobility (Möser, 2011, p. 23). Electric cars were presented as elegant, clean and safe. As a result, electric vehicles were marketed at a higher price and the main target group was women (Möser, 2011, p. 26 f.). In 1900, Ferdinand Porsche presented the Lohner-Porsche-Elektromobil at the World Exhibition in Paris. This vehicle was not only equipped with two 2.5 hp electric motors but also with a Daimler combustion engine, making it a landmark in history as the first hybrid vehicle (Deutsches CleanTech Institut, 2010, p. 14 ff.).

In the following 20 years, the three possible drive concepts (steam vs. electric vs. combustion engine) fought a fierce neck-and-neck race in which the combustion engine prevailed at the beginning of the 1920s - also known as the "combustion paradigm" (Kuhn, 1970, p. 62 ff.). Around 1900, there were even briefly more steam and electric vehicles in the USA than vehicles with internal combustion engines (Möser, 2011, p. 26 f.). During this golden age of electric vehicles, more than 34,000 vehicles were produced by twenty manufacturers in 1912 alone. There were more than 565 different brands worldwide that produced electric vehicles (Kampker et al., 2018, p. 4-5; Georgano, 1996, p. 2 ff.).

The number of electric vehicles produced declined with the advent of assembly line production, for example, at the Ford Motor Company in 1913, which began producing internal combustion engines. One of the reasons for this was that petrol was cheap and combustion engines could be better and, above all, more cost-

effectively adapted to user requirements, particularly in terms of range, comfort and performance. A nationwide supply via the expanding petrol station network also paved the way for the long-term adoption of combustion technology. Furthermore, electric vehicles had to contend with a loss of prestige, as they were said to be less adventurous and were more likely to be driven by people who were not very enthusiastic about cars (German CleanTech Institute, 2010, p. 16; Möser, 2011, p. 24 ff.).

As electric vehicles were no longer competitive due to these technical and socio-cultural factors (Mom, 1997, 274 ff.), they went into a niche existence from the mid-1910s. During this third phase of electromobility, electric vehicles were primarily used in select special projects or in specific niches where a quieter vehicle was required. Here, there was supply and demand; for example, as a milk float in the United Kingdom, a vehicle for emptying letterboxes in Berlin or golf carts on golf courses. There was a second major, but unsuccessful, wave of marketing for electric vehicles during the oil crises of 1973 and 1979 (Biermann & Scholz-Starke, 2010, p. 14 ff.). However, these also flopped, as did the Volkswagen (VW) CitySTROMer produced from 1992 to 1995 and the 1117 Electric Vehicle manufactured by General Motors GM. The main reasons for this were the lack of range and insufficient battery performance or the battery technology used, as neither of these criteria were able to fulfil consumer demand (German CleanTech Institute, 2010; Karle, 2022, p. 7). In addition to the unsuccessful revivals mentioned above, the fuel cell has been regarded as the new hope for electromobility since the 1990s. Here, for example, reference can be made to the developments of this alternative drive technology by manufacturers such as BMW, Daimler Chrysler, Toyota, and Ford (Weider et al., 2004, pp. 19–22).

In the early 21st century, the Tesla Motor Company introduced the latest generation of electric cars. This innovative type of production-ready electric vehicle utilises lithium-ion batteries (see Tesla Roadster, for example) and achieves ranges of several hundred kilometres, representing the latest phase in the development of electromobility. The advantages of lithium-ion batteries include high storage density, the absence of a memory effect, and minimal self-discharge. The disadvantages, on the other hand, include a high price and the current scarcity of lithium. With the resurgence of the oldest drive technology, Tesla took on a

pioneering role, which existing car manufacturers followed and, in some cases, still follow. This heralded the third wave of electromobility commercialisation (German CleanTech Institute, 2010, p. 17; Karle, 2022, p. 7).

2.2.2 Variants and market overview

This chapter describes the different types of electric vehicles. The focus here is on electric cars, as these are the centre of attention in the further investigation.

In the "Act on Prioritising the Use of Electrically Powered Vehicles (Electric Mobility Act - EmoG)", the Federal Government of the Federal Republic of Germany defines the following vehicles under the term "electric mobility" (Gesetz Zur Bevorrechtigung Der Verwendung Elektrisch Betriebener Fahrzeuge (Elektromobilitätsgesetz - EmoG), 2021, pp. 1–2). In this context, it should be mentioned that similar or identical definitions are already known in the relevant literature (Deutsches CleanTech Institut, 2010, p. 25; DEW21, 2019; Emadi et al., 2008, p. 2237 ff.; M. Held, 2019; Töschke, 2015, pp. 2–9):

Vehicles that are powered exclusively by (battery) electricity. These purely BEVs are charged exclusively by an external power source and driven by an electric motor. These vehicles are called BEVs.

Vehicles that are predominantly electrically powered, but which, due to range anxiety[6] are additionally equipped with a so-called range extender function. This is typically a small combustion engine that charges the battery and powers the electric motor as needed. These vehicles are known as range-extended electric vehicles (REEVs).

Vehicles in which the drive is realised both electrically and by means of a conventional combustion engine. The degree of electrification depends on the hybridisation. These vehicles are called hybrid electric vehicles (HEVs).

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[6] Range anxiety describes the fear of a lack of range of the electric vehicle used. Particularly at the beginning of the third wave until the late 2010s, the range of electric vehicles was significantly more limited than that of conventional combustion engines. Range anxiety was also exacerbated by a lack of comprehensive charging station coverage (Töschke, 2015).

Plug-in hybrid vehicles essentially follow the above definition of hybrid vehicles, but they also have the option of charging their battery from an external power source. These vehicles are known as plug-in hybrid electric vehicles (PHEVs).

Vehicles that use hydrogen as a fuel. The hydrogen is converted into electrical energy in a fuel cell. The electricity generated powers the vehicle through an electric motor. These vehicles are known as FCVs.

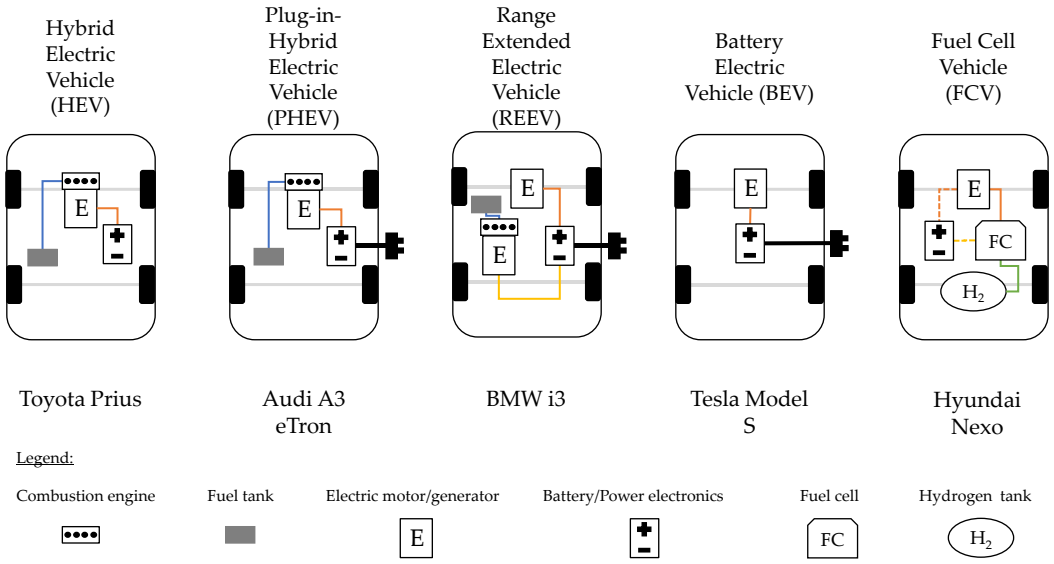
The main common feature of the electric vehicles listed above is the electric motor. The electric motor also offers an important distinguishing feature compared to vehicles with a conventional combustion engine. The electric motor achieves 100% efficiency. This is a relevant advantage over petrol and diesel engines, as these only achieve an efficiency of 35%-45% (Dhinakaran et al., 2021, pp. 103–104; M. Held, 2019).

The basic component of the electric motor is the electrical converter. This converts electrical energy into mechanical energy. The working principle of an electrical transducer is as follows: When a magnetic field exerts force on a current-carrying conductor of a coil, movement is created. This property is utilised by both the DC motor and the three-phase AC motor, which are operated with the type of current required in each case. Several electric motors can be used to drive electric vehicles (Deutsches CleanTech Institut, 2010, p. 18 ff.; Karle, 2022, pp. 19–23).

Returning to the discrepancy in efficiency between electric motors and combustion engines, it is essential to note that electric cars have fewer mechanical parts installed in their drivetrains. This results in significantly less power loss due to mechanical frictional resistance. Another positive aspect is that this results in lower maintenance and repair costs. Additionally, there are no pollutant emissions and minimal noise emissions. Furthermore, electric motors are superior to combustion engines in terms of acceleration and transmission ratio. In addition, even at the lowest level of electrification, electrical energy can be recovered during braking using the recuperation process (Karle, 2022, pp. 23-26; Wallentowitz et al., 2010, p. 45).

The following illustration clearly shows the electric vehicle variants already mentioned:

Figure 8: Overview of variants of electric vehicles



Source: Own illustration based on (K. Dudenhöffer, 2015, p. 13; Shocking Solutions, 2009; Töschke, 2015, pp. 2–10)

As shown in Figure 8, there are three variants of electric vehicles that are recharged using an external power supply (Dhinakaran et al., 2021, p. 109). It should be emphasised here that BEVs are considered the purest form of electric drive, as their electric motor is powered exclusively by the energy previously supplied externally. The Tesla Model M, for example, has a range of 305-425 km[7] where the ranges of BEVs are now comparable with those of combustion engines - the range is compared with one tank of petrol / one charging cycle. BEVs have neither a fuel tank nor an internal combustion engine. The vehicle is only powered by an electric motor, which in turn is supplied with electricity by lithium-ion

[7] The range quantified here primarily depends on the selected equipment of the vehicle. The ADAC has meanwhile tested two versions of the Model 3: first, the Model 3 AWD Long Range version, which is extremely powerful and useful for ranges of well over 500 kilometres; and second, the Model 3 Standard Range Plus version, the long-awaited basic model for 42,900 euros (Rudschies & Wieler, 2019, pp. 18–20).

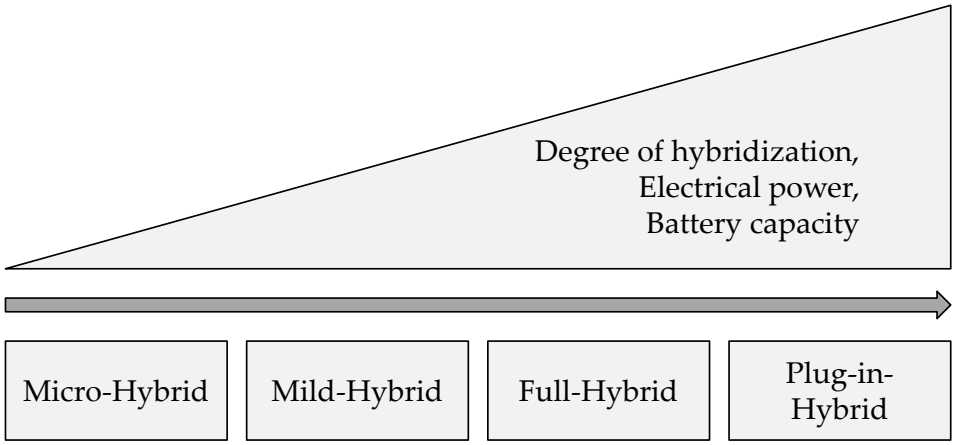
batteries (K. Dudenhöffer, 2015, p. 14; Faraz et al., 2021, pp. 137–144; Larminie & Lowry, 2012, p. 51; Rudschies & Wieler, 2019, pp. 18–20).

Hybrid vehicles are regarded as the precursor to pure electric vehicles, paving the way for the development of high-performance electric vehicles. Various degrees of hybridisation and different operating principles can be identified in hybrid vehicles (Wallentowitz et al., 2010, p. 54).

The lowest level of hybridisation is the micro-hybrid. This first level of hybridisation usually offers the option of using an automatic start-stop system. In contrast, the mild hybrid takes on significantly more functions and provides support during the acceleration process, for example. The full hybrid is used on an equal footing with the combustion engine to drive the vehicle. However, the battery cannot be charged from an external power source. This is only possible with the latest and highest level of hybridisation in plug-in hybrids. In order to make hybrid vehicles more energy-efficient, ever larger batteries have been installed in the vehicles. However, as these cannot be charged within the vehicle in a meaningful way, an external charging option was eventually provided by means of a plug (German CleanTech Institute, 2010, p. 22; Doppelbauer, 2020, p. 270; Töschke, 2015, pp. 2-4). Due to this peculiarity, the plug-in hybrid vehicles are listed separately in the overview (see Figure 9).

Figure 9 shows the various degrees of hybridisation with increasing electric motor output:

Figure 9: Different degrees of hybridisation with increasing electrical power of the electric motor



Source: Own illustration based on (Karle, 2022, p. 21)

In addition to the subdivision into the degree of hybridisation, hybrid vehicles can also be differentiated according to the three currently predominant operating principles. The three operating principles are the serial, parallel or power-split mixed hybrid drive.

The parallel drive is considered the simplest form of hybridisation. Here, both the combustion engine and the electric motor drive the drive axle. This means that both engines can be smaller, which results in a weight and installation space advantage. However, this also means that two complete drivetrains must be installed in the vehicle, which in turn leads to the installation of additional mechanical components, including those in the clutch and gearbox areas. For this reason, parallel hybrid drives are particularly suitable for larger and heavier vehicles (Dudenhöffer, 2015, p. 14; Singh et al., 2021, p. 56).

On the other hand, there is the serial drive, in which only the electric motor drives the vehicle. The electric motor is powered by a generator, which itself is mainly driven by an internal combustion engine. The aforementioned is probably the most important distinguishing feature between all three operating principles - the serial hybrid drive is not connected to the drive axle of the vehicle and therefore causes less noise and pollutant emissions. The variant of the serial drive is also known as a range-extended electric vehicle, as shown in Figure 2. Due to the larger drive battery required for this, the weight also increases, which is noticeable in the

vehicle's top speed (Singh et al., 2021, pp. 53-59; Töschke, 2015, pp. 5-6; Wallentowitz & Reif, 2011, p. 87 ff.)

The power-split or axle-split hybrid variant is likely the most complex type of hybrid drive from a technical standpoint. In most cases, the driver can choose for themselves whether they want an electric and/or combustion-assisted drive. There are also vehicles in which the vehicle itself decides which form of drive should be used (German CleanTech Institute, 2010, p. 23; Faraz et al., 2021, p. 152).

All three hybrid drives have the following characteristics, which vary in intensity depending on the type of drive:

- Boosting (here the electric motor supports the starting process)
- Purely electric driving
- Start-stop functions
- Brake energy recovery (recuperation)
- Energy recovery by raising the load point of the combustion engine (Karle, 2022, p. 23)

Finally, FCVs need to be introduced. FCVs are often seen as the long-term goal of electromobility. FCVs generate electrical energy from the chemical reaction of oxygen with hydrogen. The energy released is either temporarily stored in a battery or fed directly to the electric motor. Water is released into the environment as a chemical by-product (Kampker et al., 2018, p. 60; Töschke, 2015, p. 13; Wallentowitz et al., 2010, p. 84). In addition to the advantages of hydrogen technology, which are characterised by a short charging time (approx. 3 min.) and a long range per tank filling (500-700 km), the compact storage of hydrogen in the vehicle and the cost-intensive production and storage of hydrogen are currently a recognised disadvantage (Karle, 2022, p. 29). It is conceivable that there could also be REEVs that use a fuel cell instead of an internal combustion engine to provide additional range over long distances (German CleanTech Institute, 2010, p. 26; Rosen, 2018, p. 10 ff.; Töschke, 2015, p. 13). As of 31 December 2022, there are 163 filling stations for hydrogen vehicles in Germany (H2 MOBILITY Deutschland, 2022b). In addition to Toyota, Mercedes-Benz and Hyundai are also pioneers in the provision of vehicle technology. However, other well-known OEMs such as BMW, petrol station infrastructure operators such as H2 Mobility Deutschland and

suppliers such as ZF are also planning to use hydrogen as an additional pillar in the mobility transition (Ecomento, 2022; H2 MOBILITY Deutschland, 2022b, p. 18; Sallee, 2011, p. 189 ff.; Thim & Lenz, 2022). The entry-level prices for this green drive technology are currently around 70,000 euros (Baumann & Hebermehl, 2018; Gohler et al., 2018).

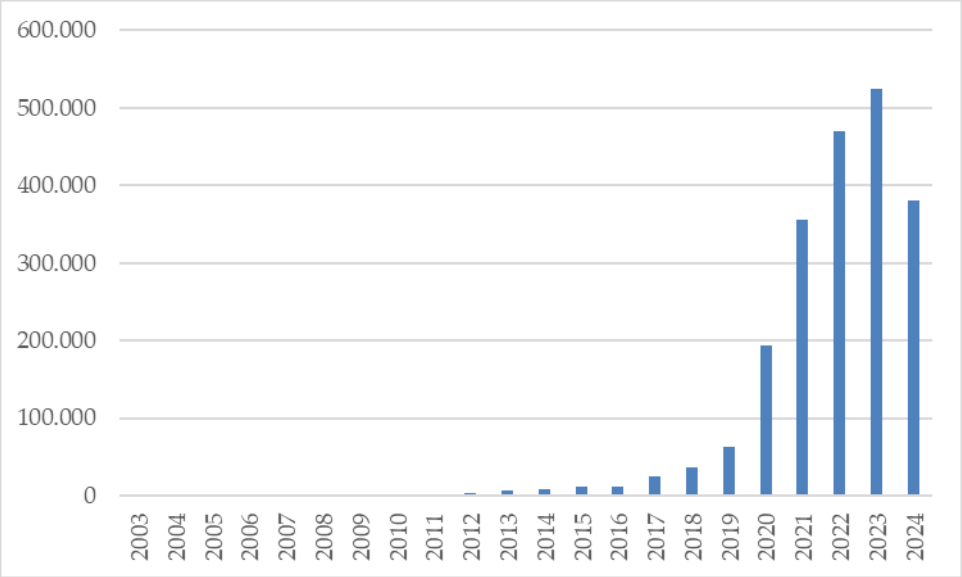
2.2.3 Registration development and sales trends

In addition to the probable growth potential in the overall passenger car market, forecasts are made for future market developments in the field of electromobility. Based on these forecasts, a mix of drive concepts will be used in the future (Gary Silberg et al., 2021, p. 5; McKinsey&Company, 2011, p. 5-8). It is generally assumed that this drive mix will consist of the following variants: pure electric vehicles (BEV), range extenders (REEV), HEVs, and FCVs. Hybrid vehicles can also be further subdivided into hybrid and plug-in hybrid vehicles (Kampker et al., 2018, p. 24; DEW21, 2019; Emadi et al., 2008, p. 2237; Töschke, 2015, p. 2-9; German CleanTech Institute, 2010, p. 25). The new VW CEO Oliver Blume also favours a significantly more diverse drive mix (Viehmann, 2023).

As shown in Figure 10, only a few purely electrically powered vehicles were registered in Germany up to 2010. It should be emphasised that the majority of these registered electric vehicles were not produced by well-known OEMs, but by niche suppliers. At this time, OEMs were only occasionally involved with this alternative drive technology and continued to focus on the further development of combustion engines. In 2000, at the start of the third wave of electromobility, FORD began testing two electric versions of the Ford Ka. Mercedes also presented an electrified version of the A-class. Other OEMs, such as Kia, Hyundai, Renault, and Volkswagen, followed with their own studies and concepts from the 2000s onwards. Last but not least, the market entry of new car manufacturers such as Tesla, Build Your Dreams (BYD), or Great Wall (GW) and the associated accelerated development of purely BEVs ensured that the long-established vehicle manufacturers became increasingly involved with this drive technology and developed their own series vehicles. Smart made the Smart Fortwo electric drive ready for series production and offered it on the market from 2010. In the same

year, Tesla also sold 23 Tesla Roadsters (K. Dudenhöffer, 2015; Kampker et al., 2018; Kraftfahrt-Bundesamt (KBA), 2023a; Middelkoop & Koppelaar, 2017).

Figure 10: Number of new registrations of BEVs in Germany from 2003 to 2024



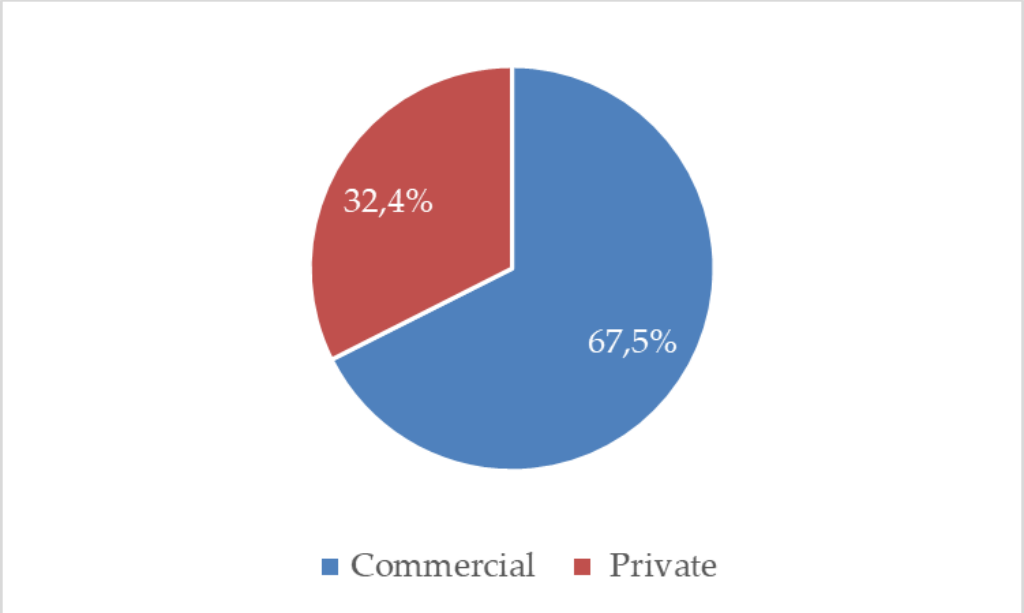
Source: Own illustration based on (Kraftfahrt-Bundesamt (KBA), 2025a)

It can be seen that strong absolute growth has occurred in the past three years, from 2020 to 2022, in particular. In contrast, disproportionately high growth rates were achieved from the mid-2010s to the late 2010s, in particular. However, it must also be said that the registration figures for BEVs in 2024 were again in sharp decline. The registration figures available for January 2025, on the other hand, suggest a slight increase in the number of BEV registrations in 2025 compared to the previous year. In January 2025, 34,498 new BEVs were registered; scaled up to the full year 2025, this would mean a total number of 413,976 newly registered BEVs, or a growth of just under 9% compared to 2024 (Kraftfahrt-Bundesamt (KBA), 2025a).

Figure 11 shows the distribution of new car registrations, clearly emphasising that around two-thirds of new registrations are accounted for by commercial owners and only around one-third come from private owners. This representation not only applies generally to the total number of new registrations in 2024, but also continues in the area of vehicles with alternative drive systems, although the ratio

here is approximately 2:1 in favour of commercial owners (Kraftfahrt-Bundesamt (KBA), 2024c, 2025c).

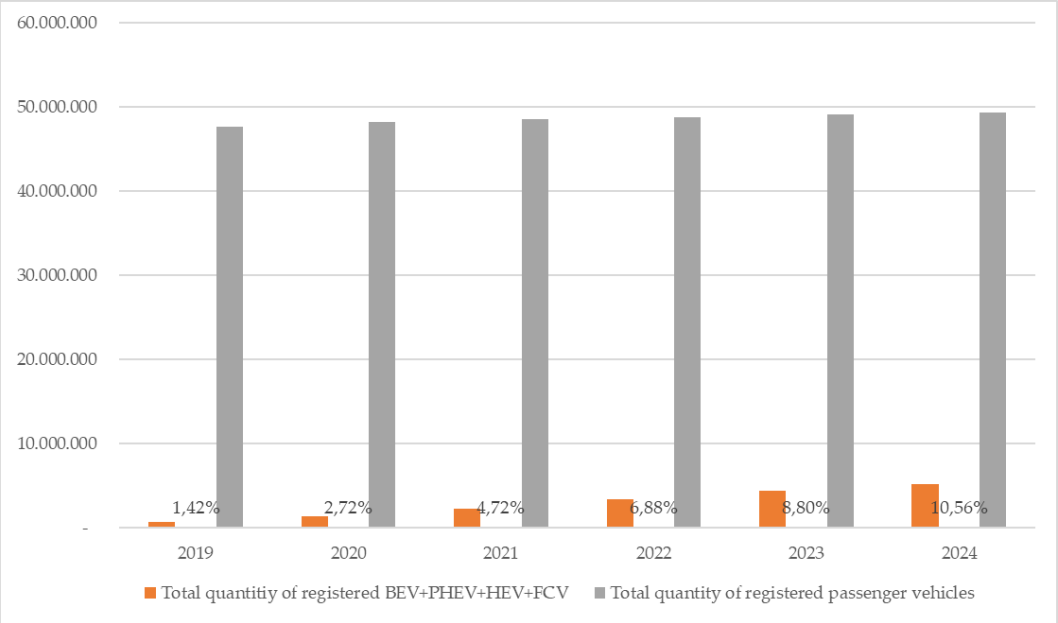
Figure 11: Distribution of new passenger car registrations in Germany by owner in 2024



Source: Own illustration based on (Kraftfahrt-Bundesamt (KBA), 2025c)

Figure 12 illustrates the ratio of the total number of passenger cars to the total number of registered passenger cars with an electrified drive system for the years 2019 to 2024, inclusive, in Germany. The share of electrically powered vehicles in the total vehicle population has risen in the past six years from 1.42% (2019) to 10.56% in 2024 (Kraftfahrt-Bundesamt (KBA), 2020a, 2021a, 2022a, 2023c, 2024b, 2025b). It can also be inferred from the figure that if growth remains constant, the proportion of electric vehicles in the total vehicle population in Germany will be approximately 20% by 2030. That is around 10.5 million vehicles with an electrified drive. This, in turn, means that the German government's target of 15 million vehicles with electrified drive systems by 2030 will not be met (Bundesverband Erneuerbare Energie, 2024; Deutscher Bundestag, 2024).

Figure 12: Total quantity of registered passenger cars and total quantity of registered passenger cars with electric drive in Germany 2019-2024



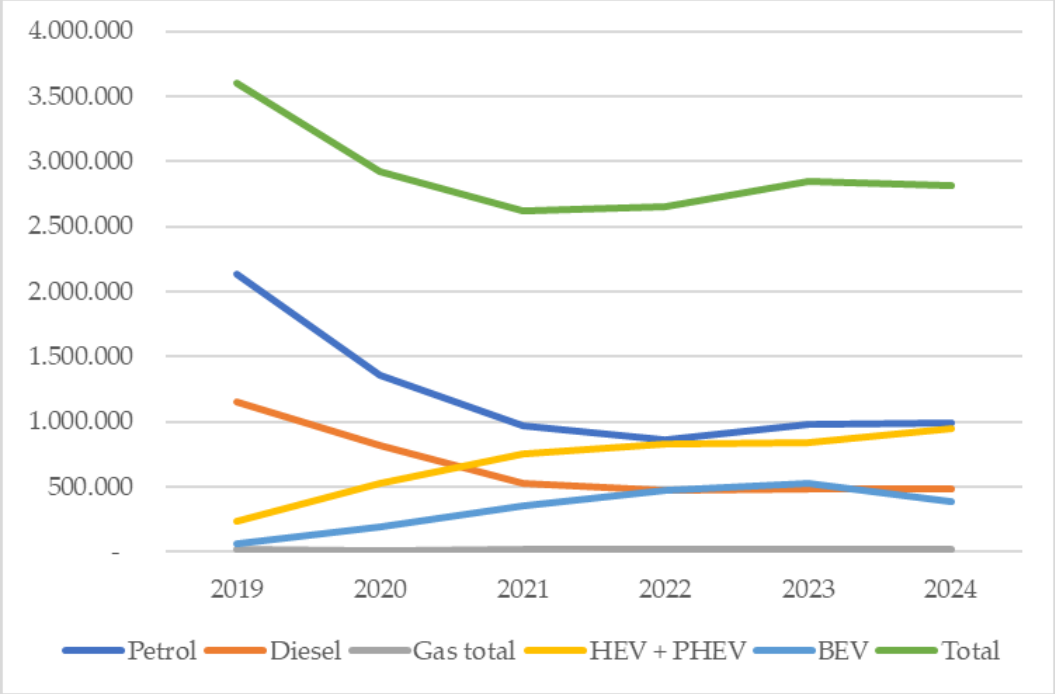
Source: Own illustration[8] based on (Kraftfahrt-Bundesamt (KBA), 2020a, 2021a, 2022a, 2023c, 2024b, 2025b)

As already indicated in the previous section, there has been a shift in the types of drive systems registered in recent years. Figure 13 shows that, in 2019, around 90% of registered vehicles were powered exclusively by a combustion engine. By contrast, in 2023 and 2024, only just under half of newly registered vehicles were based on a classic drive system with an internal combustion engine. It is also clear that the number of hybrid vehicle registrations has risen sharply. In 2019, only around 6.5% of newly registered vehicles were hybrid vehicles. In 2024, just over a third were registered with this type of hybrid drive. A similar upward trend can also be observed in BEVs: in 2019, the share of newly registered BEVs was just under 2%. In 2024, this number of new registrations increased approximately eightfold to 13.5%. It can also be observed that the ratio of newly registered hybrid vehicles to BEVs in 2024 is approximately 3:1. However, this distribution shifted in 2022 and 2023, with one newly registered BEV for every two

[8] For further insights please see Appendix 1-6.

newly registered hybrid vehicles. Finally, however, the green trend line also shows that new vehicle registrations have declined from around 3.6 million newly registered vehicles and recovered slightly in 2023 and 2024, with around 2.8 million new vehicles still being registered in Germany (Kraftfahrt-Bundesamt (KBA), 2019, 2020c, 2021c, 2022c, 2023e, 2024c).

Figure 13: Share of passenger vehicle registrations by different drive systems from 2019 to 2024

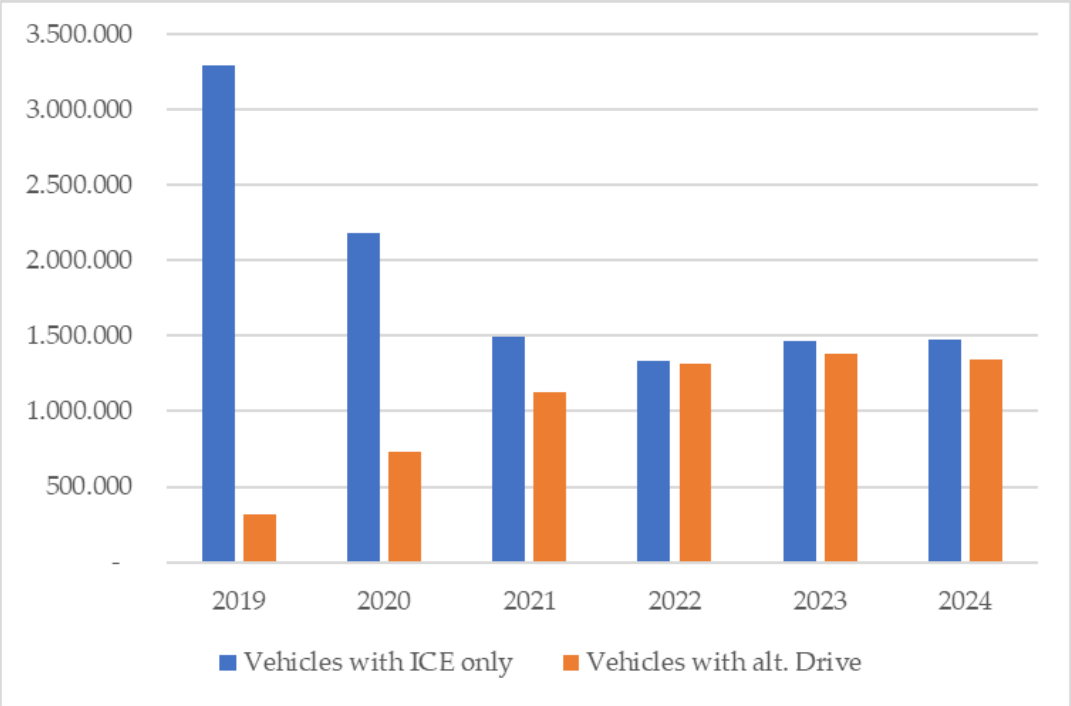


Source: Own illustration[9] based on (Kraftfahrt-Bundesamt (KBA), 2019, 2020c, 2021c, 2022c, 2023e, 2024c)

In addition to the generally declining registration figures in Germany, Figure 14 also shows that new registrations of vehicles with a purely combustion engine are falling sharply and that registrations of vehicles with an alternative drive system are on the rise. This is also clear from a comparison with Figure 13, which shows that the hybridisation of drive systems is particularly popular (Kraftfahrt-Bundesamt (KBA), 2019, 2020c, 2021c, 2022c, 2023e, 2024c).

[9] For further insights please see Appendix 7.

Figure 14: Share of passenger vehicle registrations by different overall comparison between vehicles with ICE and vehicles with alternative drive systems



Source: Own illustration[10] based on (Kraftfahrt-Bundesamt (KBA), 2019, 2020c, 2021c, 2022c, 2023e, 2024c)

2.2.4 Focus of this study in relation to electromobility

In the course of this work, not only purely BEVs were considered, but also the aforementioned plug-in hybrid, hybrid, and FCVs. The aforementioned vehicle types are summarised in this thesis under the term electromobility (EMOB), and the research focus is on vehicles for personal individual transport (passenger cars). For ease of reading, the EMOB vehicles will be referred to as electric vehicles (EV) in the remainder of the thesis. Vehicles with fuel cell drive (FCV) consistently appear in the statistics of the Federal Motor Transport Authority (KBA), but their share of the total vehicle population is relatively low (Kraftfahrt-Bundesamt (KBA), 2022b). Although BEVs and FCVs are both EVs, it is important to note that they

[10] For further insights please see Appendix 7.

differ from each other in a number of key respects, which will briefly explain the research focus of this thesis below:

- FCVs can be refuelled with hydrogen at a filling station, and the refuelling process takes only a few minutes. In contrast, EVs have a much longer charging process, but can be charged at any location with a power source (Doppelbauer, 2020, pp. 175–177; Karle, 2022, pp. 211–212; Randelhoff Martin, 2020; Rudschies & Wieler, 2019, pp. 10–15).
- Due to a limited hydrogen refuelling station network, hydrogen vehicles are considered a niche solution, whereas EVs are trying to establish themselves as a mass market solution through a steadily expanding charging network (Enride, 2023; H2 MOBILITY Deutschland, 2022a; Karle, 2022, p. 211; Rudschies & Wieler, 2019, pp. 10–15).
- The costs for the energy required, i.e. electricity and hydrogen, also differ greatly. In addition, falling battery prices will make EVs cheaper, which will allow them to stand out from FCVs in terms of price (Enride, 2023; H2 MOBILITY Deutschland, 2022b, pp. 18–21; Kaindl, 2019; Rosen, 2018, p. 11).
- In addition, EVs are often associated solely with BEVs, rather than FCVs, which creates a distinct awareness in the minds of consumers (Jonuschat et al., 2012).

Accordingly, FCVs are excluded from further analysis, even though they are, by definition, EVs.

2.2.5 Multifaceted challenges for the further development of electromobility in Germany

The automobile has a rich history of over 125 years in Germany. This history was largely written through the construction and sale of vehicles with combustion engines. However, due to changing structural conditions, the historiography is at a turning point (Möser, 2002, p. 273 ff.). The challenges of change encompass

ecological, customer-related, technological, and legal/political drivers.[11] drivers (Wallentowitz et al., 2009, p. 46).

Cars are regarded as one of the most defining elements of German society and have often been seen as the leading sector of the German economy. Germany not only owes its status as a world leader in exports to the German automotive industry, but also its enduring reputation as a car nation globally. Of course, this also had an impact in Germany, and the automotive industry made a significant contribution to Germany's prosperity (Grieger, 2019; Kampker et al., 2018, p. 5 ff.).

Today, the automotive industry is undergoing profound change. In addition to the demand for a turnaround in transportation and agreed-upon climate targets, the car remains the primary means of transport for many commuters, holidaymakers, and residents of non-urban regions in Germany. Many Germans also see the car as a status symbol, an expression of personality or the embodiment of individual freedom (K. Dudenhöffer, 2015, p. 154; Grieger, 2019).

Looking to the future, it is not only hard facts based on the economy or living conditions that are required for a reorientation of consumers, but also a new emotional conditioning and an answer to the question of what significance the automobile currently has in society and will have in the future (Möser, 2017, p. 136 ff.; Welzer, 2011, pp. 34–36). Despite rising incomes and increasing traffic volumes, demotorisation can be observed in large cities in particular. This process has been known in Japan since the 1990s as "Kuruma Banare" (Fournier et al., 2012, p. 61). For younger people in particular, owning a car is becoming less important and often no longer serves as a status symbol (Winterhoff et al., 2009, p. 4 ff.). The change in the importance of the car in German society is also being reinforced by steadily rising life expectancy and low birth rates. In an industrialised nation like Germany in particular, an ageing population can be observed (Wallentowitz et al., 2009, p. 17).

As a result, it can be assumed that conflicts over the necessity and use of a car for personal individual transport will increase, as individual mobility has become

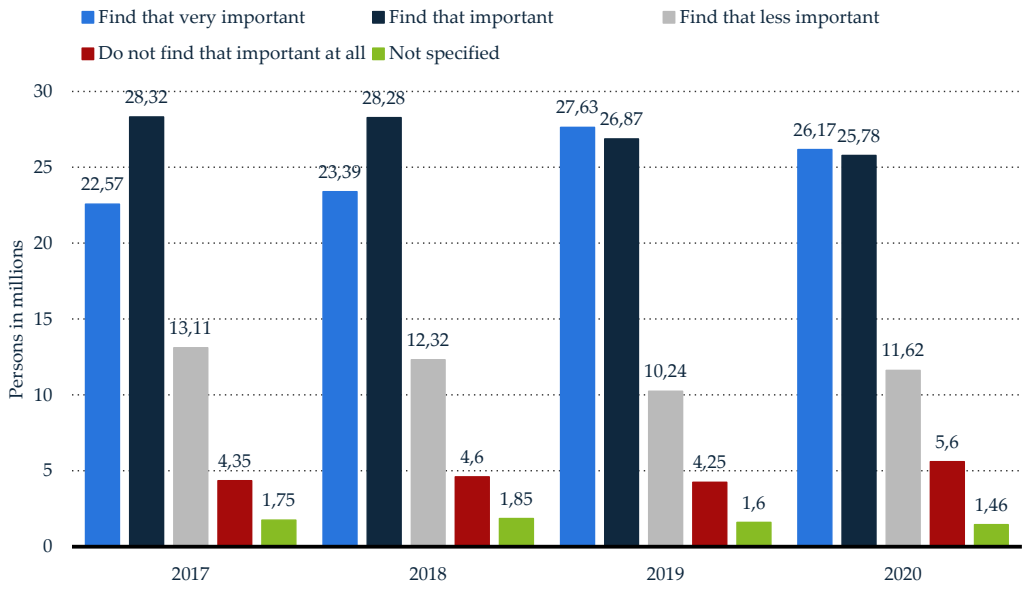
[11] Will be in depth reviewed and evaluated in Chapter 3.

more popular due to local public transport and newly established mobility services such as car-sharing (Kalmbach et al., 2011, p. 13 ff.; Rammler, 2017, p. 15 ff.).

This effect is also intensified because the household income available each month can be spent on a variety of competing products, such as housing or smartphones. The willingness to pay for the purchase and maintenance of one's own vehicle decreases accordingly (Winterhoff et al., 2009, p. 9). Additionally, the cost of housing in major German cities has risen sharply in recent years, with a 5.5% increase from January 2020 to August 2023 alone. Munich leads rents with rents per square metre of more than 20 euros. The fact that more than half (57.9%) of all Germans live in rented flats also plays a role in this analysis (Statistisches Bundesamt, 2023a). The cause of urbanisation is no longer just rural exodus, but also urbanisation resulting from the expansion of suburban settlements (Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung, 2023).

In addition to the situation described above, which provides a holistic overview of the automobile in German society, the customer is still a major driver of change (Wallentowitz et al., 2009, p. 14). One of these changes can also be seen in Figure 15. It has become evident that environmental friendliness has emerged as a significant purchasing criterion for the German population in recent years.

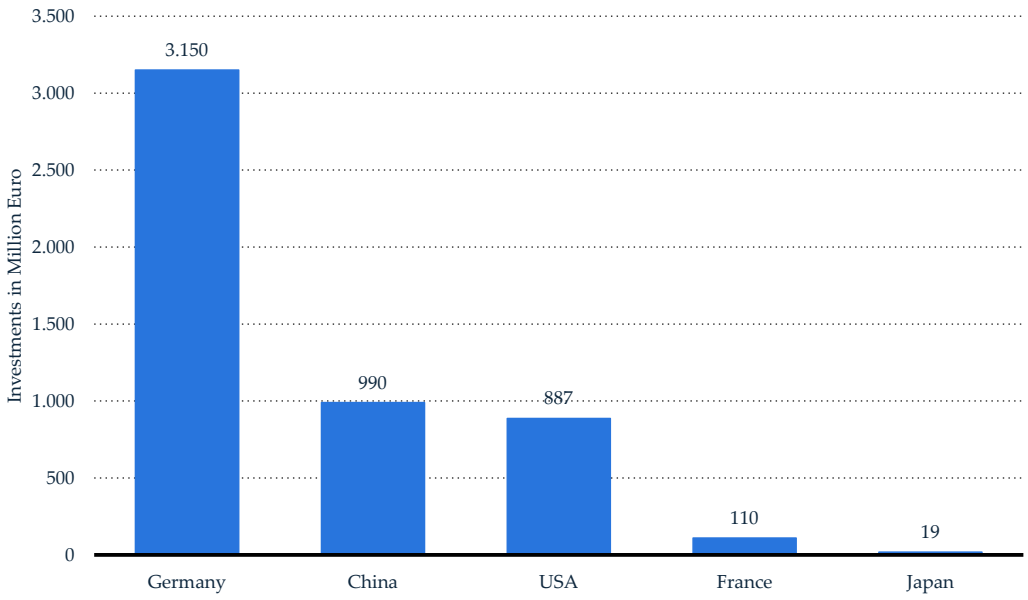
Figure 15: Population in Germany according to the importance of environmental friendliness as a criterion when buying a car from 2017 to 2020



Source: (Verbrauchs- und Medienanalyse (VuMA), 2021)

Car manufacturers responded to this megatrend, heeding the calls of their customers and investing billions in electromobility from the mid-2010s onwards. This not only allowed new models and platforms to be launched on the market in a very short period, but also enabled them to start the race to catch up with Chinese competitors (Ernst & Young (EY), 2018, p. 10). As Figure 16 shows, OEMs have invested heavily in electromobility, particularly in Germany.

Figure 16: Amount of investments by the world's sixteen largest automotive groups in electromobility in selected target countries in the period of 2016 and 2017



Source: (Handelsblatt, 2018)

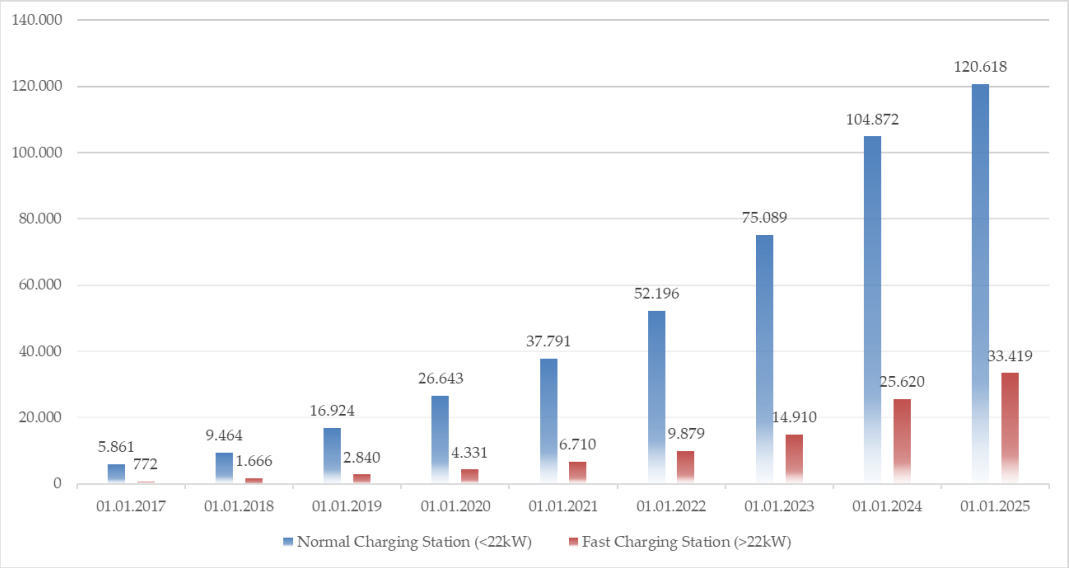
In the coming years, approximately 220 billion euros will also be invested in research and development to further expand electromobility by 2026 (Verband der Automobilindustrie (VDA), 2022, p. 3).

The investments made are also reflected in new registrations of EVs (PHEV, FCV and BEV). While around 2 million new EVs were registered globally in 2018 and 2019, the number of new registrations climbed to more than 3 million in 2020. In 2021, more than 6.5 million new cars were sold worldwide. With around 15,000 units sold, FCVs play a relatively minor role in this analysis. For 2021, this means that one in nine globally registered vehicles will have an electrified drive system, with BEVs accounting for the largest share, at around 70%. It can be stated that the transformation towards electromobility is in full swing, and growth in the various markets is heterogeneous. In addition to the prosperity of a market, incentives and legal requirements, in particular, play a significant role in market penetration (Ernst & Young (EY), 2023b; Verband der Automobilindustrie (VDA), 2022, p. 65). In addition to the number of registrations, the number of charging points has also risen enormously in recent years, meaning that demand can currently be said to be

exceeded. Figure 17 illustrates the rapid expansion of the charging infrastructure in Germany. There are currently around 150,000 charging points in Germany. As of December 2024, these are divided into just over 120,000 normal charging points and around 33,000 fast-charging points[12] (Bundesnetzagentur, 2024). In addition to the absolute number of public charging points, the expansion of fast-charging points is particularly important for the further development of electromobility. In a nationwide comparison, this currently means a rather uneven distribution of available fast-charging stations per EV. Thuringia, for example, has the fewest electric cars per fast-charging point at 61.9. In Saarland, on the other hand, there are 210.1 EVs per fast-charging point. Additionally, Germany has a total of 841,000 charging points, which have been subsidised by the federal government (Statista Research Department, 2023; Verband der Automobilindustrie (VDA), 2023). In addition to the strong growth in the area of charging points to date, the EU Parliament decided in March 2023 that the member states must significantly expand the number of charging stations by 2026. This should ensure that a public charging station is available at least every 60 kilometres on main roads (Frisch, 2023).

[12] To be considered as a fast charging point, a charging station must have a capacity of more than 22 kilowatts, according to the Federal Network Agency of the Federal Republic of Germany.

Figure 17: Number of public charging points in Germany from January 2017 to December 2024



Source: Own illustration based on (Bundesnetzagentur, 2024)

However, the further expansion of the charging station infrastructure alone is not enough to drive forward the mobility transition. Rather, given an increasingly competitive market, a holistic view and market understanding is required from all parties involved to ensure a sustainable expansion of electromobility (F. Dudenhöffer, 2021, p. 9). In addition to declining subsidies or the complete cancellation of subsidies for EVs by the German government, the development of electricity prices is a not insignificant factor that could have a negative impact on the attractiveness of EVs in the coming years (Autobild, 2023; Kroher & Paulsen, 2023). From a macroeconomic perspective, the persistently high electricity prices and the associated trend in Europe are because electricity, unlike oil, cannot be transported internationally and is therefore not traded internationally. This means that the current high electricity prices are dependent on regional production costs, which are at a high level due to the war in Ukraine and the German government's energy policy (F. Dudenhöffer & Wisbert, 2023, p. 70).

In addition, manufacturers are faced with rising raw material prices. This development was already evident at the end of the coronavirus pandemic in the context of the semiconductor crisis and is expected to occur in the medium term,

particularly in the area of battery production (Roman Tyborski, 2022). Due to an insufficient supply of semiconductors, manufacturers primarily built high-margin vehicles, which, on the one hand, supported the aforementioned investments in electromobility, but on the other hand, also led to significantly longer delivery times for mid-range models (Ernst & Young (EY), 2023a).

As the battery accounts for up to 40% of the production costs of a BEV, it cannot be denied that a 10% increase in costs will increase sales prices by at least 4%. The price increases are multi-dimensional: On the one hand, they are caused by significantly higher raw material costs for battery materials (such as lithium hydroxide, nickel, cobalt, manganese or phosphorus). On the other hand, as mentioned above, battery production costs have risen due to increased energy costs, a complex drying process in electrode production and the fact that European cell production is only just beginning (F. Dudenhöffer & Wisbert, 2023, p. 70; Kötter, 2022). To become less dependent on Asian raw material supplies in the medium and long term, it is essential for manufacturers to conduct research (Karle, 2022, p. 82 ff.).

In addition to a tense production cost situation in Europe, European manufacturers have to compete for customers' favour both on their home markets and even more so on the Chinese market. If price reductions are given, this not only damages the margin but also the brand's prestige. However, such measures can also secure market share (Ernst & Young (EY), 2023a). In summary, it is crucial to address any competitive disadvantages compared to Chinese manufacturers and maintain a strong market position, as Asian manufacturers are increasingly expanding into domestic markets (Hubik & Tyborski, 2023; Proff & Szybisty, 2018, pp. 28–30).

However, the post-corona reality is also that manufacturers are confronted with economic weakness, falling demand, price pressure, and overcapacity after the reduction in orders following the chip shortages (Ernst & Young (EY), 2023b).

However, in order to fulfil the goal of climate-neutral mobility in 2050, to which the German automotive industry has committed itself, an understanding of consumers, their expectations and needs is required in addition to further investment (Kampker et al., 2018, p. 15 ff.; Verband der Automobilindustrie (VDA), 2022, pp. 1–3).

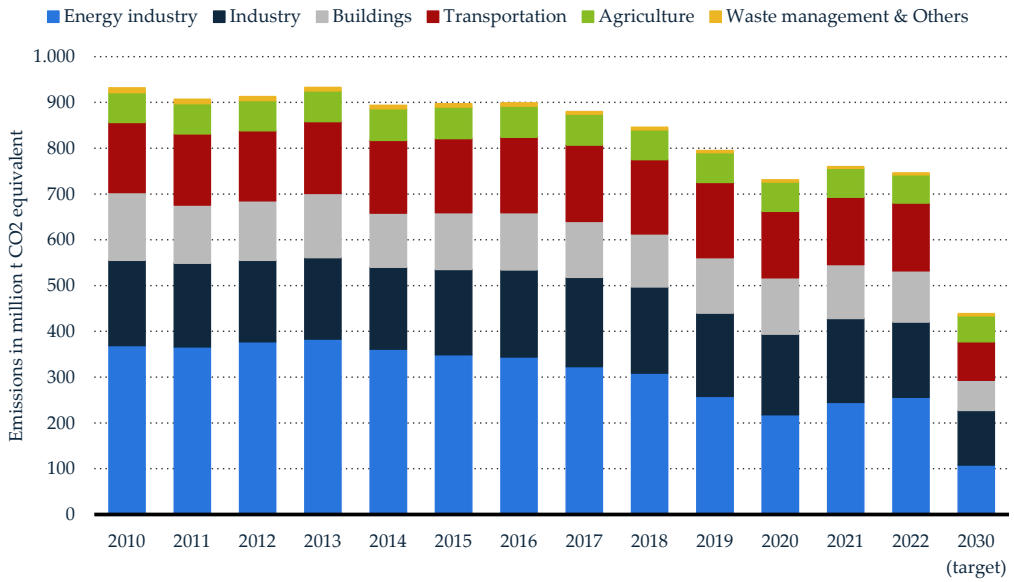
2.2.6 Environmental policy development in Germany

Climate and environmental protection are considered to be one of the most important reasons for the shift from combustion engines to electromobility. This change was triggered by the agreement of the member states of the European Union in 1996 to use the "two-degree target" to combat climate change as a guideline for climate policy. The aim is to limit global warming to a maximum of 2 degrees compared to the average pre-industrial level. Achieving this goal requires a reduction or limitation of carbon dioxide emissions. Alongside other greenhouse gases, carbon dioxide is[13] the main driver of global warming (Schwedes & Keichel, 2021, pp. 9; 56 ff.).

Figure 18 illustrates the areas where climate-damaging emissions are generated. It can be seen that in 2022 around 20% of total emissions in Germany were caused by transport. However, it can also be said that emissions have decreased by around 20% between 2010 and 2022. However, the percentage of emissions from transport has increased from 16% to 20% in the same period. This increase can be attributed to the sharp rise in freight transport, motorised private transport, and the still high level of diesel-powered vehicle use. In addition to the transport sector (34%), industry (22%), and buildings (15%), including private households, were among the largest sources of pollutant emissions in 2022 (Allekotte et al., 2023, p. 62; Umweltbundesamt, 2023a).

[13] Greenhouse gases include carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, sulphur hexafluoride and perfluorocarbons. Greenhouse gases are found in the atmosphere. They limit the escape of heat radiated from the Earth into space, causing the Earth's temperature to rise. By converting emissions of greenhouse gases other than carbon dioxide (CO2) into CO2 equivalents according to their global warming potential, the unit of measurement CO2 equivalent allows the balances of different greenhouse gases to be compared (Umweltbundesamt, 2023b).

Figure 18: Development of greenhouse gas emissions in Germany by sector of the Climate Protection Act from 2010 to 2022



Source: (Umweltbundesamt, 2023b)

Additionally, it can be noted that road transport is considered particularly important in reducing CO2 emissions. This is due to the fact that road transport was responsible for around 98% of greenhouse gas emissions in Germany in 2022 (Bundesministerium für Digitales und Verkehr, 2022, p. 211 ff.; Umweltbundesamt, 2023b). The share of road transport caused by passenger transport amounted to 62.5% of all greenhouse gas emissions in the transport sector (Bundesministerium für Digitales und Verkehr, 2022, p. 211 ff.; Hartz et al., 2022, p. 76; Umweltbundesamt, 2023c).

With regard to the present research focus on personal individual transport, it should be added that 60.6% of CO2 emissions from road transport at European level in 2022 are attributable to passenger cars (cars) (Europäisches Parlament, 2023a; Statistisches Bundesamt, 2023b). During the same period, the share of car traffic in total road traffic in Germany was 60.13%. Compared to Germany's total CO2 emissions, this also means that 11.65% of CO2 emissions in 2022 are attributable to car traffic (Eurostat Datenbank, 2023; Umweltbundesamt, 2023b). Table 2 shows the calculation of CO2 emissions caused by car traffic in Germany.

Table 2: CO2 emissions by passenger cars in Germany in 2022

	Year 2022	Share of the specific line compared to the next level above	Share of passenger vehicles per dedicated level
Greenhouse Gas Emissions in Germany	746 Mio. to	-	11,65%
Share of transportation over all	148 Mio. to	19,83%	58,71%
Share of Road transportation	144,5 Mio. to	97,76%	60,13%
Share of passenger vehicles only*[14]	86,89 Mio. to.	60,13%	-

Source: Own illustration based on (Eurostat Datenbank, 2023; Umweltbundesamt, 2023b)

Based on the above figures, it is clear why both German and European legislations are endeavouring to counter the enormous impact of car traffic on the environment with suitable instruments. In addition to international environmental agreements, these targeted instruments include the concrete definition of maximum permitted emissions. The Kyoto Protocol signed in 1997 and the pioneering United Nations Framework Convention on Climate Change (UNFCCC) signed in 1992 stand out in particular. Additionally, the European Automobile Manufacturers' Association (ACEA) has committed itself to responding promptly to political developments. This voluntary commitment in 1998 provided for a reduction in average CO2 emissions from 185g CO2/km to 140g CO2/km over the next 10 years. This value was regarded as a milestone in order to achieve the European Commission's target of 120g CO2/km in 2012 (Rodt et al., 2010, p. 48 f.;

[14] The share for passenger vehicles is based on 2021 figures because figures for 2022 were not available during the creation of this table (October 9th, 2023).

United Nations, 1997). However, the target set by car manufacturers could not be achieved despite falling emission values and efficiency improvements. In 2008, the emission values of newly registered vehicles were 157g CO2/km. As a result of missing the target, the European Commission decided to create new regulations in 2009. These provided for Europe-wide CO2 limits of 130 g CO2/km for new cars. This limit had to be reached by 2015 at the latest. Furthermore, individual CO2 limits were defined for each manufacturer. The dependent variable in this analysis was the average weight of new cars. Furthermore, a so-called "phasing-in" approach was used, with the aim of not directly overburdening manufacturers with the maximum target, but rather to allow a gradual approach to the target. Specifically, the phasing-in provided for only 65% of its new cars to be included in the average calculation of CO2 limits in 2012. In 2013, this figure rose to 75% and in 2014 to 80%. It was only in 2015 that total vehicle sales were factored into the overall calculation of annual average vehicle emissions. In addition, particularly environmentally friendly vehicles with emissions below 50g CO2/km could be credited to the manufacturers several times as supercredits (Puls, 2013, pp. 8–9). The target of 130g CO2/km was achieved by all newly registered passenger cars in 2015, 2016 and 2017. As of 2019, the CO2 limits will no longer be measured according to the New European Driving Cycle (NEDC), but rather according to the globally harmonised WLTP standard (Worldwide Harmonised Light Vehicle Test Procedure). In Germany, this led to a distortion and a significant exceedance of the specified limits (157g CO2/km), particularly in 2019. However, from 2021, even stricter CO2 limit regulations for new cars apply, with a limit of 95g CO2/km. Compliance with these limits was also not achieved in 2021 or 2022 (Kraftfahrt-Bundesamt (KBA), 2023b; Puls, 2018, pp. 5–8; Rat der Europäischen Union, 2023).

2.2.7 State subsidies in Germany

The German government set ambitious targets for itself in 2009. The aim was to have one million electrified vehicles on German roads by 2020. To achieve this ambitious goal, the German government has initiated the three-stage "National Electromobility Development Plan" to promote electromobility. The aim was not only to create incentives for research in the field of electromobility due to the uncertain market situation, but also to subsidise the investment costs for the

automotive industry (Schwedes, 2018, pp. 205–206). The three-stage plan was intended to promote electromobility in Germany until 2020 and consisted of the market preparation phase (2009-2011), the market ramp-up phase (2011-2016) and the volume market phase (2016-2020) (Kampker et al., 2018, p. 26).

The main task of the market preparation phase was primarily characterised by the research and development of rechargeable batteries and testing in field trials and small-scale production. Further studies during the market ramp-up phase should define norms and standards. Additionally, the charging infrastructure was to be expanded, and new generations of batteries were to be researched and continuously developed. The focus of the volume market phase was on research into new energy storage methods and the development of associated business models (Kampker et al., 2018, p. 27).

In addition to the above-mentioned, largely cooperative measures for research and development and the automotive industry (Howlett, 1991, pp. 13–16), the development plan also provided for the use of fiscal policy and innovation-based measures (van Gossum et al., 2010, p. 257). In the case of fiscal policy measures, it was initially envisaged that, as an indirect measure, tax exemption would be guaranteed for buyers of an electrified vehicle in the first five years after purchase. To promote dialogue with the public, the federal government established four so-called showcase regions, which were funded with 180 million euros. The aim was to demonstrate the innovative elements that electromobility offers at the interface between the energy system, vehicle and transport system (Kampker et al., 2018, p. 27). In total, the German government funded the research and development of electromobility in Germany with around 2.2 billion euros until 2017 (Bundesministerium für Wirtschaft und Klimaschutz der Bundesrepublik Deutschland (BMWK), 2022).

The Electric Mobility Act was also passed in 2015 as a legislative basis, which was initially limited until 31 December 2026 and was intended to comprehensively promote electric mobility (§8 (1) Gesetz Zur Bevorrechtigung Der Verwendung Elektrisch Betriebener Fahrzeuge (Elektromobilitätsgesetz - EmoG), 2021). Incentives for driving electric cars have also been created. These include special parking spaces at charging stations, reduced or no parking fees, driving in bus lanes and the removal of access restrictions (§3 Gesetz Zur Bevorrechtigung Der

Verwendung Elektrisch Betriebener Fahrzeuge (Elektromobilitätsgesetz - EmoG), 2021; Bundesministerium für Wirtschaft und Klimaschutz der Bundesrepublik Deutschland (BMWK), 2022).

As the current registration trend for EVs (as shown in Chapter 2.3) indicates, the target of 1 million electrified vehicles on German roads by 2020 could not be achieved. As shown in Appendix 1, only 676,507 electrified vehicles were registered by 2020, corresponding to a rate of 1.42% of the total vehicle population (Kraftfahrt-Bundesamt (KBA), 2020a, 2020b).

In addition to the above indirect measures to promote the purchase of EVs, the German government introduced a direct premium subsidy at the beginning of 2016 (Bundesministerium für Wirtschaft und Klimaschutz der Bundesrepublik Deutschland (BMWK), 2016). As it turned out, this did not initially lead to a significant increase in consumer demand for EVs. For this reason, the purchase premium was initially doubled in 2021 and extended in principle until the end of 2025 (Die Bundesregierung, 2021).

As there has been a significant increase in new registrations of EVs in the years after 2020, the previous overall funding for electric mobility was reformed into gradually degressive funding as part of the amendment to the Environmental Bonus Directive with effect from 1 January 2023 (Bundesministerium für Wirtschaft und Klima (BMWK), 2022; Die Bundesregierung, 2023a). At the end of 2022, Germany had 3.35 million electrically powered vehicles. This corresponds to a share of 6.88% of the total vehicle population (Kraftfahrt-Bundesamt (KBA), 2023c, 2023d). This means that, since 1 January 2023, only BEVs and FCVs have been eligible for funding, as these have a positive climate protection effect (Bundesamt für Wirtschaft und Ausfuhrkontrolle (BAFA), 2023).

From 1 January 2023 to 17 December 2023, newly registered BEVs and FCVs were subsidised under the following conditions (Bundesministerium für Wirtschaft und Klima (BMWK), 2022):

- Vehicles with a base list price of up to EUR 40,000 are subsidised with an innovation premium of EUR 4,500.
- Vehicles above a base list price of EUR 40,000 up to EUR 65,000 are subsidised with an innovation premium of EUR 3,000.

- From 1 September 2023, only private owners will be eligible for a subsidy.
- The minimum holding period for purchasing a subsidised vehicle is 12 months.

With the resolution for the 2024 federal budget, the federal government has decided to immediately discontinue the subsidy premium for newly registered EVs, effective from 17 December 2023, in order to achieve the necessary savings to avoid new debt (Die Bundesregierung, 2023b). This also applies to EVs already ordered by customers that have not yet been delivered and registered by 17 December 2023 (Die Bundesregierung, 2023c). Due to the sudden discontinuation of the scrapping premium, many manufacturers found themselves in a situation where they had to absorb the scrapping premium previously paid by the state in both 2023 and 2024 in order to prevent any cancellations and to be able to sell vehicles that had already been produced. The respective structure varies from manufacturer to manufacturer (Harloff & Baumann, 2023). However, at this point in time, at the end of December 2023, it is unclear how this will fundamentally affect OEM pricing in 2024. Some experts fear a dramatic slump in sales figures and lasting damage to the penetration of electromobility in Germany (dpa, 2023; tagesschau, 2023). Other experts, on the other hand, believe that the premature cancellation of the state subsidy will bring the familiar market mechanisms of supply and demand to the fore and that manufacturers will (have to) enter into a price war to maintain and secure market share (Car Maniac, 2023).

Despite the abolition of the direct subsidy premium, the German government has approved additional funding for the expansion of electric charging stations. An additional 200 million euros will therefore be available for the expansion of fast-charging stations and 100 million euros for normal charging infrastructure (Bundesministerium für Wirtschaft und Klimaschutz der Bundesrepublik Deutschland (BMWK), 2022; Heimes, Kampker, Offermanns, et al., 2024, p. 39 ff.; Karle, 2022, pp. 214–215). In addition to the aforementioned direct funding measures, it was also decided to ensure uniform charging and payment standards (Verordnung Über Technische Mindestanforderungen an Den Sicheren Und Interoperablen Aufbau Und Betrieb von Öffentlich Zugänglichen Ladepunkten Für Elektromobile, 2016; Erste Verordnung Zur Änderung Der Ladesäulenverordnung,

2017)which strengthens legal and investment security (Gesetz Zum Aufbau Einer Gebäudeintegrierten Lade- Und Leitungsinfrastruktur Für Die Elektromobilität (Gebäude-Elektromobilitätsinfrastruktur-Gesetz - GEIG), 2021) as well as tax incentives for electric mobility (Bundesministerium für Wirtschaft und Klimaschutz der Bundesrepublik Deutschland (BMWK), 2022). These measures indicate a positive trend in future compliance with clean air standards, particularly in major German cities. It is not yet clear how the suspended subsidy for commercial owners and the reduced subsidy for private owners will affect the sales figures for EVs. However, the target has been clearly formulated by the European Commission: from 2035, no more cars should be registered in the EU that cause CO2 emissions (Puls, 2018, pp. 8–10; Rat der Europäischen Union, 2023).

2.3 INNOVATION AND DIFFUSION

2.3.1 Technologies and innovations

Technology can be defined as devices, instruments and knowledge that are linked between input and output variables (process technology) and/or produce new products and services (product technology) (Tushman & Anderson, 1986, p. 440). Depending on their nature, technologies can be described as either tangible or intangible. In addition, technology usually has a (tangible) hardware component as well as an (intangible) software component (Rogers, 2003, p. 138). Technologies are regarded as the basis for new innovations.

The term innovation is complex and cannot be precisely categorised. Among other things, the Duden dictionary suggests the terms Neuerung, Erneuerung, Neueinführung or Neuheit as synonyms (Disselkamp, 2012, p. 17). The word innovation is derived from the Latin word "innovatio", which means "to create something new", which also describes the basic prerequisite for innovation (Hauschildt et al., 2016, p. 5).

To summarise, contrary to common usage, an innovation is an invention that has been successfully introduced to the market as a new product, service or process (Rogers, 2003, p. 138). According to Müller-Prothmann & Dörr, the components of an innovation can be summarised in the following formula:

Innovation = idea + invention + diffusion

An innovation is always based on an idea. If this idea evolves into an invention and the invention establishes itself on the market, this is known as diffusion (Dörr & Müller-Prothmann, 2020, p. 7). As the previous chapters have made clear, a trend towards electromobility is clearly recognisable and the market supply, as well as the number of registrations, is steadily increasing (Karle, 2022, p. 212).

For this reason, this thesis is limited to EV product innovations and the associated acceptance research. Services or processes and their prediction of acceptance are not the subject of this dissertation.

An innovation can, for example, be an idea or an object that is perceived as new (Rogers, 2003, p. 11; Zaltman et al., 1973, p. 10). Accordingly, it is not necessarily technical change, but rather awareness, the subjective dimension, that is decisive (Pohl, 1996, p. 18; Rogers & Shoemaker, 1971, p. 19). Consequently, an innovation does not necessarily have to be a new product; it can also be the development of a new market, for example. Innovations combine factors in a new way (Möller, 2017, p. 70; Schumpeter, 2008, p. 95). A distinction can be made between product innovation, process innovation, market innovation, structural or organisational innovation and social innovation (Hauschildt et al., 2016, p. 6; Pleschak & Sabisch, 1996, p. 20 f.; Steinberg et al., 2016, p. 3; 18 ff. Wahren, 2004).

An invention is the preliminary stage of an innovation and can occur either by chance or by design. The newly created knowledge can accompany and support research through its initial realisation (Brockhoff, 1999, p. 43).

The innovation that follows the invention is the economic factor that ties in with the research (Hauschildt et al., 2016, p. 24 ff.). It can be stated that the focus is on the economic optimisation of the knowledge gained, resulting in the development of an innovation for a market or an innovative market for a product (Vahs & Burmester, 2005, p. 43). Technical innovations are often considered difficult to communicate and cannot usually be tested before purchase, so that their benefits only become recognisable afterwards (Pohl, 1996, p. 18 ff.).

Innovation management distinguishes between two types of innovation: "technology-push" and "market-pull" innovations (Utterback, 1971, p. 75 ff.). In "technology-push" innovations, the technology is an autonomous factor, and it has the disadvantage that the new technology reacts passively and mechanically to

prevailing market conditions (Dosi, 1982, p. 149). On the other hand, there are the "market-pull" innovations, which are drawn into the market by the demanders (Mowery & Rosenberg, 1993, p. 104).

A crucial factor in the successful market launch of an innovation is its degree of novelty or innovation. This comes in different forms. On the one hand, there is radical innovation and on the other, incremental innovation (Seibert, 1998, p. 108 f.). Radical innovation is the introduction of something technologically completely new to the market, but which, for example, stimulates competitors to establish follow-up innovations (incremental innovations) on the market (Gerpott, 2005, p. 43 f.).

EVs are a radical innovation for the automotive industry, whose potential and demand are difficult to predict (O'Connor & McDermott, 2004, p. 11). In the following chapter, the status of the diffusion of the innovation object of EVs in Germany is determined and categorised in the product life cycle.

2.3.2 Diffusion of EVs in Germany

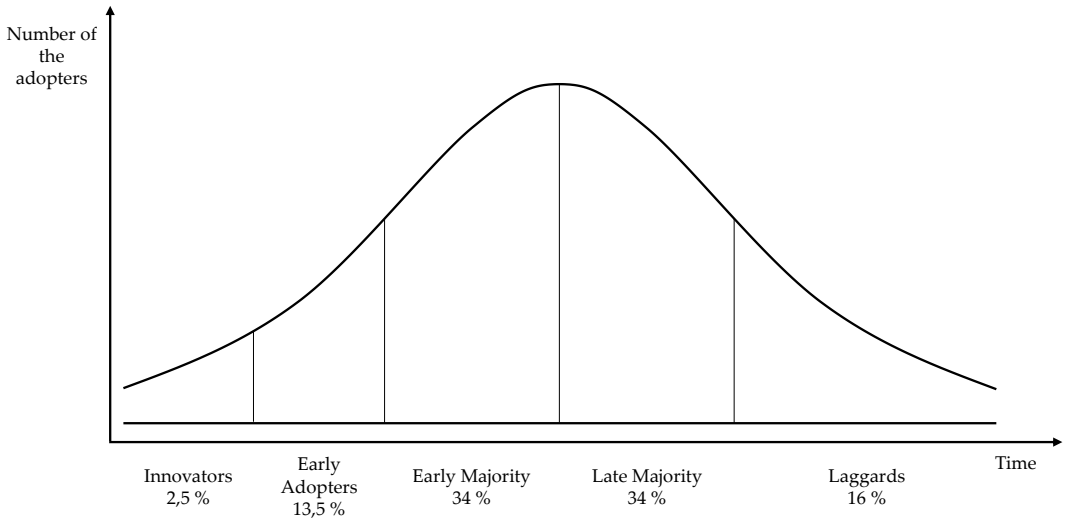
Diffusion and adoption research has taken on a decisive role in the field of electromobility. Adoption research examines how, when, and why consumers adopt innovative products. The market spread of an innovation over time is also referred to as diffusion (Rogers, 2003, pp. 5–25). The following applies: the more people within a social system adopt an innovation, the greater the pressure on other people in this social system to also adopt or reject it (K. Dudenhöffer, 2015, p. 96).

Karnowski's product life cycle model categorises consumers into five groups: innovators, early adopters, early majority, late majority, and laggards. The current diffusion status of a product can be calculated by comparing the sub-category of a specific product category on the market with the current overall market for the product category. In concrete terms, this means for the electromobility market: the number of registered EVs is compared with the total number of registered cars (Fazel, 2014, p. 88).

The product life cycle is usually represented graphically as the frequency of the S-curve (Karnowski, 2017, p. 20-23). Figure 19 shows the product life cycle according to Karnowski and divides the adopters into the following groups:

Innovators (2.5% of the company), early adopters (13.5%), early majority (34%), late majority (34%) and latecomers (16%):

Figure 19: Product life cycle according to Karnowski



Source: Own illustration based on (Karnowski, 2017, p. 21)

Innovators are the first consumers to adopt an innovation. Innovators register technical innovations on the market and want to be the first to use them (Fichman, 1992, p. 2). The characterising traits of an innovator can be described as risk-taking, tolerant of uncertainty, adventurous and open-minded (Shih & Venkatesh, 2004, p. 62). Furthermore, an innovator is characterised by a high level of education and above-average financial resources (Dillon & Morris, 1996a, p. 7). However, an innovator is not firmly integrated into a local social environment, but has a social network on a global level. Innovators are therefore not opinion leaders, but pioneers of new innovations (Gordon & Nelke, 2017, pp. 1–9; Schmidt, 2009, pp. 27–28).

In contrast to innovators, early adopters are characterised by the fact that they are firmly integrated into a social environment and it is important to them that they are seen using the innovation and that the innovation is recognised as such (Dattée & Weil, 2007, p. 595; Rogers, 2003, p. 248 f.). Due to their social environment and position in the social structure, which early adopters occupy, companies focus their

marketing and sales efforts on cooperation with them to establish their product innovations on the market (Wind & Mahajan, 1987, p. 47).

The early adopters are followed by the early majority. These are characterised by the fact that they are initially sceptical about innovations and wait to see how and whether an innovation actually catches on in society. The early majority is socially well integrated, but does not claim to be opinion leaders (Schmidt, 2009, pp. 28–29). Nevertheless, from a marketing perspective, the early majority represents an important link to the late majority (Fazel, 2014, p. 90)

The late majority tend to have a negative attitude towards innovation and change. A switch to a new technology is usually only made when this is no longer avoidable for economic reasons or when the pressure from the social environment is very great (Dutton et al., 1987, p. 233; Rogers, 2003, pp. 282–299). It is essential for the late majority to minimise uncertainties as much as possible before adopting the new technology (Dattée & Weil, 2007, p. 596).

The latecomers are the last adopters of an innovation within a social system. This is partly due to how they absorb information and gain knowledge about innovations, but also to the limited availability of financial resources (Rogers, 2003, p. 250). As a result, a bad investment in an innovation is not sustainable for this group and before a purchase is made, it must be ensured that no bad investment is made or that products are used that are established on the market in the long term (Dattée & Weil, 2007, p. 596; Schmidt, 2009, pp. 27–28). It is possible that latecomers invest in an innovation while innovators are already investing in the follow-up innovation (Rogers, 2003, p. 250).

Based on the above, it can be seen that the proportion of electrically powered vehicles at the end of 2024 was 10.69%[15] (compared to the total vehicle stock). This means that the adoption of electromobility can now be categorised as an early adopter.

[15] For further insights please see Appendix 1 - 6.

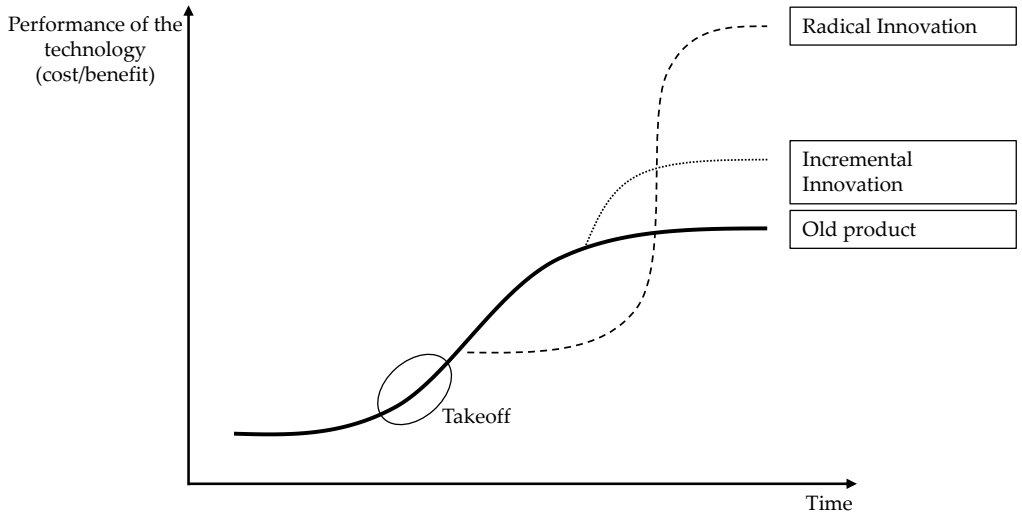
2.3.3 Diffusion effect

The speed at which the market adapts the innovation is known as the adaptation rate or diffusion rate. These can be influenced by marketing expenditure (Rogers & Shoemaker, 1971, p. 157). Furthermore, the rate of adaptation increases more quickly when there is a high level of competition (Gatignon & Robertson, 1985, p. 850). A regulatory government (e.g. in China) can also have a positive effect on adaptation (Zhu et al., 2006, p. 1557 ff.). It is also advisable to be a pioneer of innovation in the market (Schütte & Ciarlante, 1998, p. 69).

Innovation research is concerned with the reasons for the success or failure of innovations. Building on innovation research, diffusion research and marketing theory, it is possible to develop marketing concepts for innovations. In doing so, the perspective of companies is taken (K. Dudenhöffer, 2015, p. 90).

Figure 20 shows the S-curve of adaptation over time. The diffusion effect increases cumulatively over time, the greater the degree of pressure on an individual to adapt or reject an innovation. Individual adaptation or rejection is determined by increasing knowledge and the adaptation or rejection of the social system. The difference between radical and incremental innovation can also be illustrated (Rogers & Shoemaker, 1971, p. 161).

Figure 20: S-curve



Source: Own illustration based on (Utterback & Suárez, 1993, p. 5)

As soon as the so-called critical mass has been reached or the innovation has been adopted by a sufficient number of consumers, the "takeoff" occurs, and the innovation diffusion continues through its own momentum (K. Dudenhöffer, 2015, p. 96). As the types of adoption explained above and the categorisations presented follow an ideal-typical course of innovation research, they should not be clearly distinguished from one another. Transitions from one group to another are often fluid (Fazel, 2014, p. 91). Due to the close networking within a social system, the critical mass in the typical innovation process is reached during the early adopter phase (Karnowski, 2017, pp. 19–20; Schmidt, 2009, pp. 27–28). The early adopters are also considered successful implementers of innovations (Rogers, 2003, p. 281).

The total market potential for passenger cars in Germany is around 47-50 million vehicles. Based on an ideal-typical diffusion process for EVs, the critical mass is reached at around 8-12% of the maximum possible market potential (Rogers, 2003, p. 134; Shih & Venkatesh, 2004, p. 59; Wind & Mahajan, 1987, p. 47). This means that the critical mass will be reached at four to six million registered EVs (Kraftfahrt-Bundesamt (KBA), 2020a, 2021b, 2022b, 2023d, 2023a). Based on the above registration figures, it can be inferred that electromobility is currently transitioning from a niche market into a socially acceptable mass market (Fichman, 1992, p. 3; Rogers, 2003, pp. 282–299). However, it remains to be seen what effect the federal government's suspension of direct purchase incentives and subsidies will have on consumers' willingness to buy and on the diffusion of EVs. If the switching costs are too high to switch from a vehicle with a combustion engine to one with an electric drive, the diffusion could come to a standstill. This persistence of consumers or the market is also referred to as "status quo bias" (Jager & Janssen, 2002, p. 285; H.-W. Kim & Kankanhalli, 2009, p. 569 ff.)

2.3.4 Disruptive innovation and its success factors for the introduction of new technologies and their significance for electromobility

In an ideal-typical diffusion process, knowledge dissemination in the social systems is ensured when the critical mass is reached (Rogers, 2003, p. 343 ff.). So-called exogenous (external) and endogenous (internal) factors influence the diffusion process of a product on the market (Schmidt, 2009, pp. 19–20). The internal influencing factors have a direct effect on the consumer's decision to adopt.

The endogenous influencing factors can also be divided into product-related and adopter-related influencing factors. Product-related factors relate to the characteristics of the innovations themselves. On the other hand, there are the adopter-related influencing factors, which originate from the social characteristics and attitudes of the consumer's social system and influence their purchase decision (Schmidt, 2009, pp. 91–92).

Exogenous influencing factors refer to the external framework conditions that have an indirect influence on the diffusion of innovation. These indirect influences can be divided into environment-related, supplier-related and competition-related influencing factors. Environmental influencing factors describe how diffusion is influenced by the social system, the political and legal environment, as well as economic and technological development (Schmidt, 2009, p. 44). The behaviour of market participants is characterised by the decisions of suppliers and their impact on competition (Schleer, 2014, p. 48). It is not always possible to categorise the influencing factors clearly, so that overlaps can also occur (Kiendl, 2007, p. 24).

Rogers and Shoemaker (1971, p. 155 ff.) proceed to define the adaptation process of an innovation as having five characteristics:

- The innovation has a relative advantage compared to the previous product.
- The new product offers consistent compatibility with existing values and experiences.
- The innovation is more complex to use than existing products.
- The possibility to test the innovative product before purchase.
- The innovation is recognised as such by others.

The above five characteristics provide a variance explanation of adaptation ranging from 49% to 87%. In addition, the following influences can play a role in adoption: the type of innovation, the type of communication during the purchase decision process, the social environment, advertising incentives, interest, involvement, income and other situational factors (Midgley & Dowling, 1978, p. 229 f.; Summers, 1971, p. 313).

However, one characteristic alone is not enough to describe the diffusion of the innovation. A common description of the characteristics of an innovation using the five features is always required. Ideally, innovations are characterised by a high relative advantage, compatibility with existing practices and norms, low complexity, testability and observability of use by potential consumers (Dillon & Morris, 1996a, p. 6; Rogers, 2003, p. 6 ff.). (Dillon & Morris, 1996a, p. 6; Rogers, 2003, p. 15 ff.). Compatibility, relative advantageousness and complexity have the greatest impact on adoption (Tornatzky & Klein, 1982, p. 28). The subjective price expectations of customers are also important in this context. If the innovation offers better performance than substitute goods, higher prices can be realised compared to existing products on the market. If the performance of the innovation is equal to or better than that of the existing product on the market, the acceptable price level for consumers is below that of the substitute goods. At the time of market launch, innovative products outperform existing products in only some of the five characteristics, but are inferior in others (S. J. Kline & Rosenberg, 1986, p. 277). It often requires a change in social values, learning or the possibility of testing so that innovative products and disruptive technologies can establish themselves with consumers over time (Dattée & Weil, 2007, p. 1330; Orbach & Fruchter, 2011, p. 1210; Rogers, 2003, p. 1). It is worth noting that disruptive technologies do not necessarily need to reach the performance level of established products. The required performance level is defined by the degree of fulfilment of market requirements (Bower & Christensen, 1995, p. 50). Of course, in this context, the better a product is adapted to market requirements, the better the diffusion process progresses (S. J. Kline & Rosenberg, 1986, p. 301).

In addition to the above product features and requirements, it is also important to consider how many existing users are already utilising products on the market who are potential buyers due to the innovative product's potential (Fazel, 2014, p. 99). Disruptive innovation often leads to the establishment of new business models, as these models can promote the diffusion of the disruptive technology (Hwang & Christensen, 2008, p. 1331). Changing business models can also make a disruptive innovation accessible to new target groups, thereby increasing the number of potential users (Dattée & Weil, 2007, p. 583).

In addition to the five features described above that characterise an innovation, the successful diffusion of a technology also requires the interaction of four factors:

- Technology
- Business model
- Policy
- Willingness of consumers to accept and adopt the new technology (Johnson & Suskewicz, 2009, p. 57)

In the following, the four factors are briefly assessed in connection with electromobility and the importance of acceptance in this context is emphasised:

At a technological level, it can be stated that the market for EVs has grown considerably in recent years, and a wide range of products is available. The battery technology used has improved significantly over the past decade and is constantly being further developed (Sauer & Ringbeck, 2024, p. 129 ff.). However, the purchase prices for EVs are significantly higher compared to those of conventional combustion engines, and the cost gap for buyers has widened once again due to the now-suspended direct subsidisation of EVs by the German government (Car Maniac, 2023; Die Bundesregierung, 2023b, 2023c). The charging infrastructure has also been significantly expanded in recent years, and a network of standard and fast-charging points is now available (Calmbach et al., 2024, p. 487 ff.). Various business models have emerged around electromobility, including car-sharing services, battery rental, digital vehicle networking, and extended service offerings, to generate additional value creation potential. The aim is to enhance customer benefits and accelerate the transformation of the mobility sector by unlocking additional value creation potential (Kasperk et al., 2024, p. 613).

This leaves market acceptance as the only component that needs to be investigated further, and on which the further focus of this work will be placed. The aim is to be able to conclude the influencing factors that have a significant impact on the acceptance and willingness to buy EVs in the mid-2020s and which barriers need to be removed to improve market penetration in the classic target corridor of "quality, time and cost" (Heimes, Kampker, Dorn, et al., 2024, p. 29).

2.4 ACCEPTANCE

2.4.1 Focus on the concept of acceptance

The emergence of new technologies sparked research into acceptance in the late 1960s and early 1970s (Dinse, 2001, p. 38 f.). In the US, a meta-analysis shows that the terms "adaptation", "diffusion" and "acceptance" are used in connection with the acceptance of information systems (Williams et al., 2009, p. 9). In German-speaking countries, a distinction is made between adaptation and adoption acceptance. Adoption describes the conflict-free takeover through unrestricted acceptance of an object. This contrasts with adaptation, which is characterised by the fact that acceptance is only limited, as the characteristics of the object do not align with an individual's current value system. A corresponding individual adaptation of the value system is necessary (Kollmann, 1998, p. 62 f.). For electromobility, this means that it is more of an adaptation, as existing value systems must adapt to the radical innovation (K. Dudenhöffer, 2015, p. 76).

Human behaviour plays an important role in the innovation process. Contrary to popular belief, consumers do not always behave rationally, objectively and in a way that maximises benefits; rather, decisions about a technology are shaped by subjective convictions (Venkatesh & Davis, 2000, p. 345). For this reason, from a rational point of view, sensible innovations fail or take longer to gain broad consumer acceptance (Moons & De Pelsmacker, 2012, p. 195 ff.). This situation is also known in science as the paradox of learned behaviour. Consumers have developed habits and routines over a long period of time, through repeated use of a product. The individual consumer is reluctant to give up familiar solutions and processes, and endeavours to retain them instead of regularly seeking and adopting new solutions to meet their needs. If a new idea or a new product appears on the market and is not compatible with the familiar behaviour, this new product must offer a relative advantage over the old product in order to compensate for the perceived complexity of the changeover (G. C. Moore & Benbasat, 1991, p. 192 ff.).

Acceptance research attempts to gain a deeper understanding of the psychological and sociological determinants of individual user acceptance and to depict them using models (G. C. Moore & Benbasat, 1991, p. 192 ff.). User acceptance is defined as the positive acceptance or adoption of an idea, issue, or

product, through active adaptation, rather than mere adoption (Dethloff, 2004, p. 18).

In this context, acceptance research shows similarities with Rogers' theory of innovation diffusion (Rogers, 2003, pp. 5–25). Both research directions examine the diffusion of technologies and innovations within social systems, using differentiated starting points in each case. The theory of innovation diffusion primarily examines the spread of a new technology in a social system and provides insights into the different characteristics of the user groups. However, this theory offers little insight into the decision-making process that an individual undergoes during an adaptation (Dillon & Morris, 1996a, p. 22). This means that the theory of innovation diffusion cannot provide a deeper understanding of individual attitudes, so that the (innovation) diffusion of a technology could be accelerated. This makes it all the more important at this point to look at things through the lens of behavioural economics, which examines social, cognitive and emotional factors in the human decision-making process or situations of uncertainty (Kahneman & Tversky, 1979, p. 263; Tversky & Kahneman, 1974, p. 1124 ff.). Technology acceptance uses modelling to explore explanations of human acceptance factors for or against a technology (Fazel, 2014, p. 103).

2.4.2 Models of behavioural theories

Three authoritative models are cited in the literature to explain technology and user acceptance. The theory of reasoned action (TRA) forms the basis and has been expanded to include the theory of planned behaviour (TPB) and the technology acceptance model (TAM;(K. Dudenhöffer, 2015, p. 77). In the literature, the three models mentioned are considered robust and useful models for explaining technology acceptance (Fazel, 2014, p. 103) and will therefore be briefly introduced below.

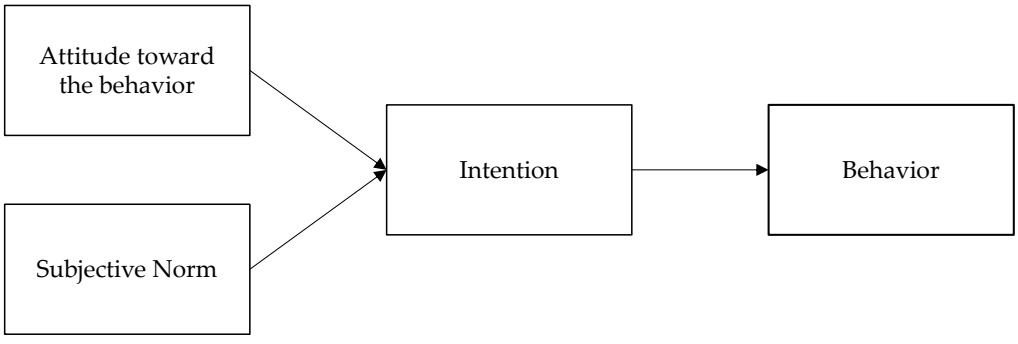
The TRA, which originates from social psychology, is considered one of the most important and influential theoretical approaches to explaining human behaviour in the field of behavioural research (Hilkenmeier & van Treeck, 2008, p. 1; Venkatesh et al., 2007, p. 269). The TRA was first published in 1967 by Martin Fishbein (Fishbein, 1967) and further developed and concretised by Ajzen and Fishbein in the following years (Ajzen & Fishbein, 1980; Fishbein & Ajzen, 1975).

The postulated TRA model states that the conscious behaviour of people can only be explained by their individual beliefs, attitudes and intentions. It is assumed that the outcome depends on a rational decision-making process and that the decision is made against the background of a defined goal expectation (Ozaki & Dodgson, 2010).

The basis of the model goes back to the assumption that an individual's opinion directly influences their attitude. The attitude in turn influences the behavioural intention and this ultimately influences the person's behaviour. In addition to the individual attitude, the subjective norm also influences behavioural intention. The subjective norm is defined as the perception of the social environment and its influence on a person's behaviour. A person's behaviour is therefore influenced by what they think their environment expects of them. Accordingly, it can be stated that the behavioural intention is formed by individual attitudes and the subjective norm (Ajzen & Fishbein, 1980, p. 67 ff.). The intention to use is in turn the direct determinant of behaviour. Based on this understanding of the model, it can be deduced that a person's behaviour can be predicted by referring back to the determinants of behaviour (attitude and subjective norm) and the determinants of attitude (opinions). Opinions in turn reflect past behaviour, creating a cycle (Ajzen & Fishbein, 1980, p. 90 ff.).

Figure 21 provides an overview of the determinants of the TRA model and illustrates the correlations and dependencies:

Figure 21: Theory of reasoned action

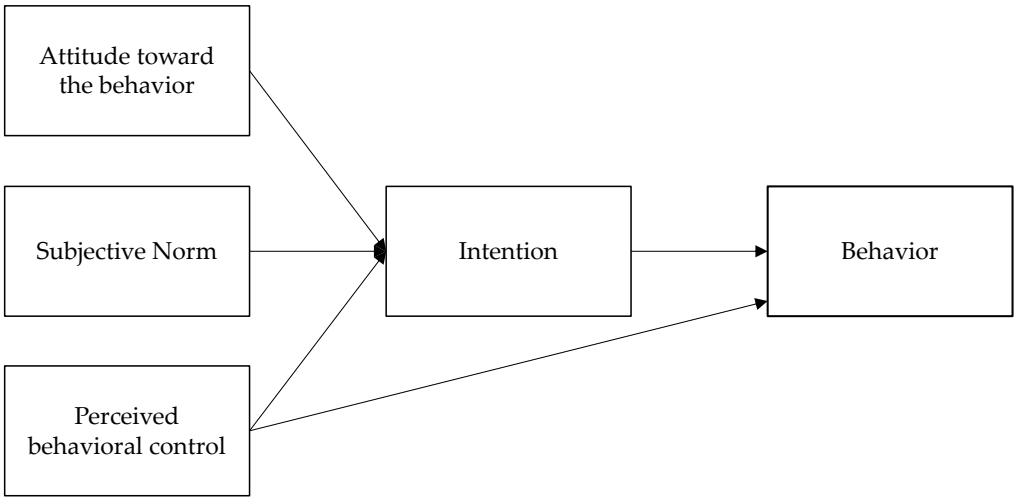


Source: Own illustration based on (Fishbein & Ajzen, 1975, p. 15 ff.)

The TRA, developed by Ajzen and Fishbein, has been widely used in a broad range of research contexts (Luarn & Lin, 2005, p. 875; Park et al., 2007, p. 165). The level of variance explanation or the value that indicates the extent to which the determinants can predict behaviour depends on the respective research context. In addition, the TRA has often been adapted or changed by researchers, meaning that no standardised statement can be made about the variance explanation (Fazel, 2014, p. 104 ff.; Rossmann, 2021, p. 11 ff.).

Ajzen's TPB, first published in 1991, is an extension of the TRA. The TPB model was expanded to include the influencing factor of perceived behavioural control. This is defined as a person's belief about how easy or difficult it will be to carry out a previously planned behaviour (Hilkenmeier & van Treeck, 2008, p. 6; Rossmann, 2021, p. 23 ff.). Behavioural intention is also at the centre of this model of human behaviour. However, behavioural intention only results in behaviour if the individual can decide for themselves how to behave. Every behaviour is dependent on the individual's possibilities and resources (Ajzen, 1991, pp. 181–182). Figure 22 shows the determinants, correlations and dependencies of the TPB model:

Figure 22: Theory of planned behaviour



Source: Own illustration based on (Ajzen, 1991, p. 182)

It can also be noted that the theory of planned action has been empirically confirmed several times, although it has sometimes been used for purposes for

which the model was not originally intended (Ajzen, 1991, p. 181 ff.; Sheppard et al., 1988, p. 338). The predictive power of the TPB fluctuates when the individual has several choices available (Sheppard et al., 1988, p. 326).

In conclusion, it is worth noting that both models yield the same prediction result for situations where no special hurdles are imposed on the person performing the behaviour. However, as soon as special hurdles are encountered, the TPB achieves a higher predictive power regarding a person's possible behaviour (Fazel, 2014, p. 109; Fishbein & Ajzen, 1975, p. 21 ff.).

Based on the two models above, Davis developed the TAM. The TAM is regarded as an extension of the TRA and was first used to investigate the acceptance of information systems in an organisational context and, as a measuring instrument for evaluating individual benefits, was intended to provide an explanatory approach for predicting individual behaviour in a specific context (Königstorfer, 2008, p. 86). The question was which determinants decide on the utilisation of an innovation or a new technology (F. D. Davis, 1989, p. 319 ff.). To determine acceptance, the principle was followed that a person's actual behaviour can be determined by their intention to use the product (Venkatesh et al., 2007, p. 272). Thus, the TAM is a model adapted to a specific context, whereas the TRA and TPB represent a general model for understanding human behaviour (Adams et al., 1992, p. 231).

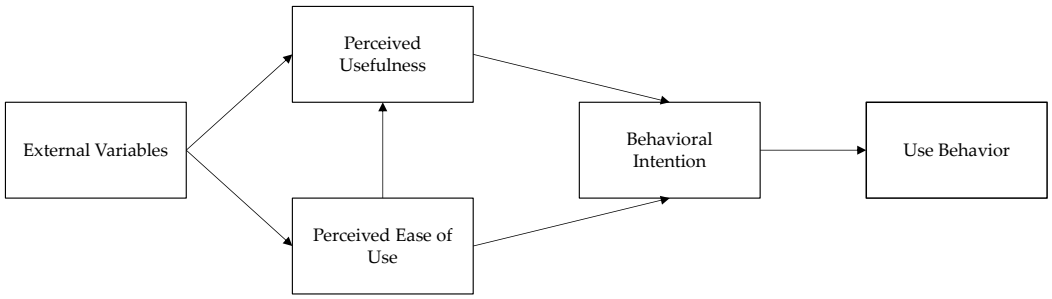
2.4.3 Technology acceptance model

As with the previously presented TRA and TPB models, Davis also focused on explaining individual attitudes. He examined human behaviour in relation to information systems and the predictors on which the influence of these systems depends, affecting behavioural intentions (BI) and behaviour (B) (Königstorfer, 2008, p. 86). According to Davis, in the TAM the basic assumption is that the behavioural intention (BI) to use an information system is determined by two predictors: perceived usefulness and perceived ease of use. The construct of perceived usefulness (PU) is defined as the degree to which a person thinks that using a particular system will improve their work performance and thus provide them with a benefit. The construct of perceived ease of use (PEOU) is defined as

the degree to which a person believes that using a particular system involves physical or mental effort (F. D. Davis, 1989, p. 320).

Both of the aforementioned predictors influence the behavioural intention, but the perceived ease of use also influences the perceived usefulness (F. D. Davis, 1989, p. 331; Venkatesh & Davis, 2000, p. 344). This is justified by the fact that the easier a system is to operate or use, the more useful it appears to be, all other things being equal (F. D. Davis, 1989, pp. 320, 334). Furthermore, the intention to use influences the actual usage behaviour. Based on this, some research proves that the intention to use can be directly inferred from the usage behaviour. However, it should be noted that this approach should be used in particular when researching technology innovations without (personal) consumer experience (F. D. Davis et al., 1989; K. Dudenhöffer, 2015, p. 111). Vice versa, research with (personal) consumer experience should always examine actual usage behaviour, as intentions do not necessarily have to result in behaviour (Ajzen & Fishbein, 1980, p. 188 f.). Figure 23 shows the TAM determined by Davis and illustrates the relationships and dependencies of the individual determinants:

Figure 23: Technology acceptance model



Source: Own illustration based on (F. D. Davis et al., 1989, p. 332 f.)

In recent years, the TAM has become one of the most widely used approaches to explain technology and system utilisation (Y. Lee et al., 2003, p. 2; Venkatesh & Davis, 2000, p. 187). It is described as the most extraordinary model in empirical acceptance research (R. Bagozzi, 2007, p. 252) and is also considered the most widely accepted model in this field of research (Jahangir & Begum, 2008, p. 33). One of the reasons for this is that, typically, around 40% of the variance in the empirical data can be explained by the TAM (Venkatesh & Davis, 2000, p. 186).

(Venkatesh & Davis, 2000, p. 186). In addition, the TAM is a popular model in research circles, as it is characterised by its ease of use and simplicity, while also offering a robust and powerful prediction of user acceptance (R. Bagozzi, 2007, p. 244; Venkatesh & Davis, 2000, p. 187). Furthermore, the TAM has already been adapted and extended to a wide variety of research contexts, further strengthening its call for a flexible and generalisable model (Fazel, 2014, p. 120; McCord, 2007, p. 306).

2.4.4 Models of technology acceptance research

According to Lee et al. (2003), TAM research to date can be divided into four phases: model introduction, model validation, model extension, and model refinement (Y. Lee et al., 2003, p. 755).

The development of the TAM by Davis in 1989 was followed by a phase that can be regarded as the introduction of the model. In this phase, the TAM was applied beyond its original field of application, for example, through the investigation of different technologies, long-term studies, or its application in various research contexts. Adams et al. (1992) investigated the TAM in five different application areas, while Davis (1993) applied his model to two further technologies and confirmed it empirically (Adams et al., 1992, p. 227 ff.; F. D. Davis, 1989, p. 475 ff.). This was mainly done to test the reliability and validity of the model. During this introductory phase, a branch of research emerged that compared the TAM with the TRA or the TPB and investigated whether the TAM offered added value compared to the original TRA model (Y. Lee et al., 2003, p. 754). Davis et al. (1989), Davis et al. (1992) and Hubona and Cheney (1994) were able to prove empirically that the TAM has a higher explanatory power than the original TRA and TPB models (F. D. Davis et al., 1989, p. 982 ff., 1992, p. 1111 ff.; Hubona & Cheney, 1994, p. 532 ff.).

The model validation phase followed the model introduction phase. This phase aimed to validate and verify the TAM as a reliable tool for measuring user acceptance in different technological environments, situations and contexts (Y. Lee et al., 2003, p. 756). Various studies, including those by Adams et al. (1992) and Davis and Venkatesh (1996), helped to establish the validity and reliability of the model (Adams et al., 1992, p. 227 ff.; F. D. Davis & Venkatesh, 1996, p. 19 ff.).

In the subsequent phase of model development, the main focus was on extending the model by integrating new variables and exploring the resulting relationships within the model. Determinants for the two main constructs of the TAM were also identified: perceived usefulness and perceived ease of use (Y. Lee et al., 2003, p. 756 f.). In addition, the influence of contextual factors was increasingly investigated during this phase. Straub (1994) and Teo et al. (2009), for example, were able to confirm the influence of various cultural backgrounds on technology acceptance (Straub, 1994, p. 23 ff.; T. Teo et al., 2009, p. 1000 ff.). Lee et al. (2003) found in their meta-analysis that by overcoming previous limitations, such as focusing on specific technologies or contexts, considering other theoretical models, integrating other external variables and applying it in different contexts, a steady and continuous development of the TAM has taken place (Y. Lee et al., 2003, p. 768).

Following the introduction of the TAM 2 by Venkatesh and Davis in 2000 and the proposal of an integrated unified theory of acceptance and use of technology by Venkatesh et al. in 2003, a phase of gradual model improvement began. This phase saw an increasingly context-specific application of the TAM (Venkatesh et al., 2003, p. 425 ff.; Venkatesh & Davis, 2000, p. 186 ff.). Venkatesh and Davis (2000) extended the model by integrating additional constructs within the TAM 2 to enhance its explanatory content (Venkatesh & Davis, 2000, p. 186 ff.) (Venkatesh & Davis, 2000, p 186 ff.). In his long-term study, Venkatesh (2000) introduced the measurement of the previously unexplored construct of voluntary use (voluntariness) and also looked at the actual use of the technology instead of the behavioural intention as used in the TAM (Venkatesh, 2000, p. 342). By developing the TAM 3, Venkatesh and Bala (2008) attempted to summarise the current state of research and to create an integrated model by transferring the results (Venkatesh & Bala, 2008, p. 273). The unified theory of acceptance and use of technology (UTAUT) was further refined and extended in scope when it was adapted to the consumer-oriented context by(Venkatesh et al., 2012, p. 157 ff.). Most recently, Blut et al. (2022) used a meta-analysis to derive a revised UTAUT[16] by means of a meta-

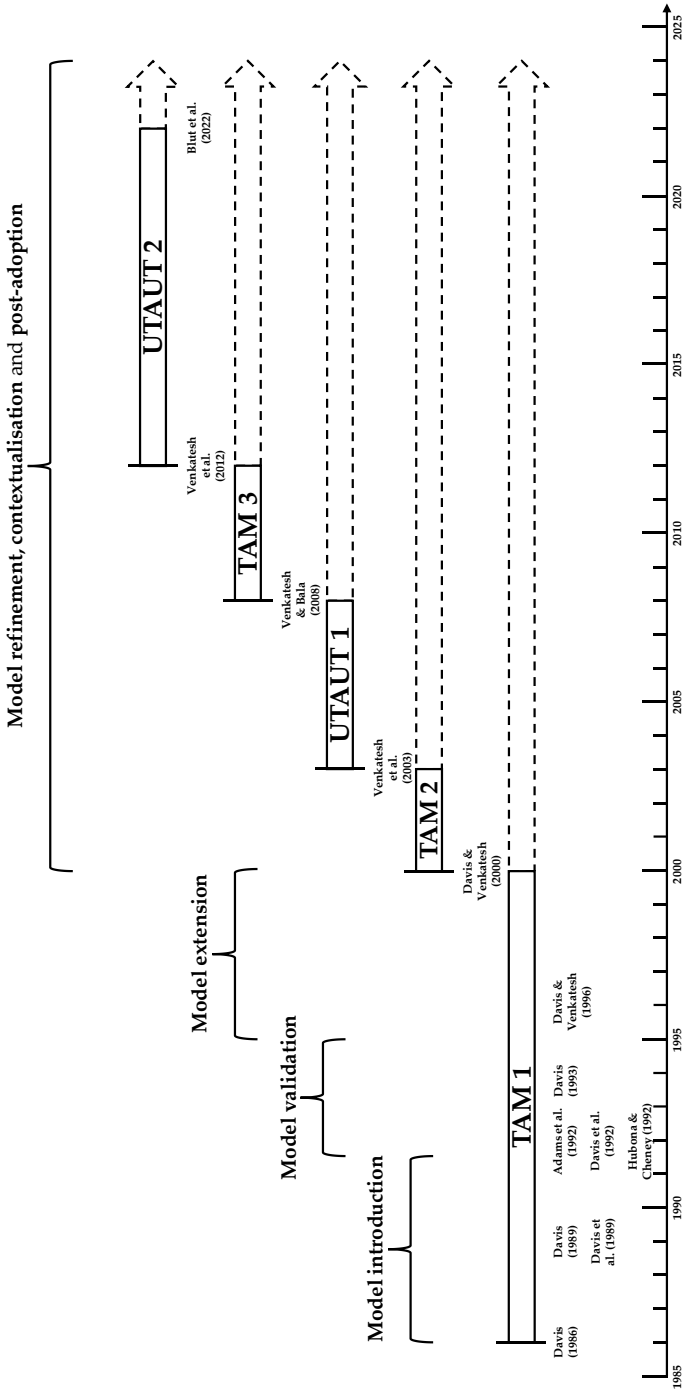
[16] The study by Blut et al 2022 will be referred to as "UTAUT 3" for ease of reading (Blut et al., 2022).

analysis. Data from over 1,935 independent samples were used to determine an updated, accurate and robust model that can be used in both the "Blue Ocean" and "Red Ocean" research contexts[17] (Blut et al., 2022, p. 29). According to Straub (2009), it is worth noting that Blue Ocean research does not always have to consider a new field of research, but rather that further research opportunities are identified using new key variables in the context of UTAUT (Blut et al., 2022, pp. 30–31; Straub, 2009, p. 3 ff.).

Figure 24 shows the different phases of technology acceptance research:

[17] The term "blue ocean" refers to a strategy in which companies enter unoccupied market segments that are free from direct competition. In contrast to the red ocean, where competition is intense, the blue ocean strategy focuses on identifying new customer needs and offering innovative products or services to gain a competitive advantage (Barsch et al., 2019; Kim; & Mauborgne, 2005).

Figure 24: Phases of TAM research to date and key publications



Source: Own illustration based on (Y. Lee et al., 2003, p. 755)

In addition to the above explanation of the phases of technology acceptance research to date, Table 3 provides a descriptive, summarised overview of the individual research papers in behavioural and acceptance research. In addition to the author(s), the common abbreviation in science, the title, the research focus, the research methodology used and the citation frequency in Google Scholar[18] are listed. When examining the citation frequency, it becomes clear that, in addition to the TPB, with 133,138 citations, the first publications on TAM, with 85,732 citations, are also listed. (F. Davis, 1989) and the UTAUT with 50,433 citations (Venkatesh et al., 2003) are among the most frequently cited works in this field of research. In addition to the originally conceived field of application, information and communication technology, the models of technology acceptance research are now also increasingly being used to evaluate other technologies, such as electromobility (Fazel, 2014, p. 127; Hung et al., 2003, p. 42 ff.; I.-L. Wu & Wu, 2005, p. 303 ff.).

[18] Citations derived from Google Scholar for the direct citation of the specific article. Date of request: February 26th, 2024.

Table 3: Overview of theoretical models of acceptance Research and their extensions

Author(s) and citation key	Abbreviation	Title	Theme / Constructs	Methodology	Citations in Google scholar
Martin Fishbein & Icek Ajzen (Fishbein & Ajzen, 1975)	TRA	*Belief, attitude, intention and behaviour: An introduction to Theory and Research*	The theory of reasoned action (TRA) postulates a direct relationship between attitude and usage behaviour.	General review	83,698
Icek Ajzen (Ajzen, 1991)	TPB	*The theory of planned behavior*	The theory of planned behavior (TPB) extends the TRA model to include behavioural control, which can be affected by internal or external factors.	General review	133,138
Fred D. Davis (F. D. Davis, 1986)	TAM* (*unpublished PhD-study of F. Davis)	*A technology acceptance model for empirically testing new end-user information systems: theory and results*	The technology acceptance model (TAM) was developed based on TRA model to establish a meaningful explanation of acceptance on user acceptance of computer-based information systems.	Field study of 100 organizational users and a laboratory experiment with 40 students	583
Fred D. Davis (F. D. Davis, 1989)	TAM	*Perceived usefulness, perceived ease of use, and user acceptance of information technology*	Conduct research on the constructs of "perceived usefulness" and "perceived ease of use" as key determinants of user acceptance.	Two studies involving a total of 152 users and four application programs	85,732
Viswanath Venkatesh & Fred. D. Davis (Venkatesh & Davis, 2000)	TAM 2	*A Theoretical Extension of the Technology Acceptance Model: Four Longitudinal Field Studies*	The TAM 2 model is a further development of the TAM model to test a theoretical extension that explains the perceived usefulness and usage intentions in regards of social influence and cognitive instrumental processes.	Empirical study via four longitudinal field studies with 156 users	31,003
Viswanath Venkatesh; Michael G. Morris; Gordon B. Davis; Fred D. Davis (Venkatesh et al., 2003)	UTAUT 1	*User Acceptance of Information Technology: Toward a Unified View*	This model refers to the prediction of IT usage within an organization. The aim was to provide a holistic model, which describes with all factors the behavioural intention to use a new technology.	Empirical study conducted as part of six field studies, online survey of 192 US consumers	50,433
Venkatesh, Viswanath & Hillol Bala (Venkatesh & Bala, 2008)	TAM 3	*Technology Acceptance Model 3 and a Research Agenda on Interventions*	Extension of the existing TAM 2 for the background of the organizational usage of information technology and their acceptance within the organization.	Empirical study via four longitudinal field studies with 156 users	9,822
Viswanath Venkatesh; James YL Thong; Xin Xu (Venkatesh et al., 2012)	UTAUT 2	*Consumer Acceptance and Use of Information Technology: Extending the Unified Theory of Acceptance and Use of Technology*	Extension of the original model Unified Theory of Acceptance and Use of Technology and was created to evaluate the use of new technology in consumer markets.	Empirical study with 1,512 users	15,776
Markus Blut; Alain Chong; Zayyad Tsiga; Viswanath Venkatesh (Blut et al., 2022)	Extended UTATÙT 2 ("UTAUT 3")	*Meta-Analysis of the Unified Theory of Acceptance and Use of Technology (UTAUT): Challenging its Validity and Charting a Research Agenda in the Red Ocean*	Latest attempt of Blut et al. to expand the explained variance of UTAUT and UTAUT 2. The model was created for the context of employees and consumers.	Meta-analysis of 1.,935 samples and 737,112 users	142

Source: Own illustration

III – THEORETICAL ANALYSIS

III THEORETICAL ANALYSIS

The aim of Chapter 3 is to systematically analyse the current state of research on technology and user acceptance in the context of electromobility and, building on this, to create a theoretically sound basis for our own research model. For this purpose, relevant meta-analyses, in particular those by Wicki et al., are analysed and integrated into existing technology acceptance models, primarily the UTAUT 3. Using the methodological approach of "Mapping - Select - Adapt - Set-up", research gaps are identified, the model is adapted and expanded to include additional influencing factors such as trust. Finally, the research model is developed and the hypotheses for explaining the acceptance of electromobility are derived and summarised.

3.1 STATE OF RESEARCH ON TECHNOLOGY AND USER ACCEPTANCE IN RELATION TO ELECTROMOBILITY

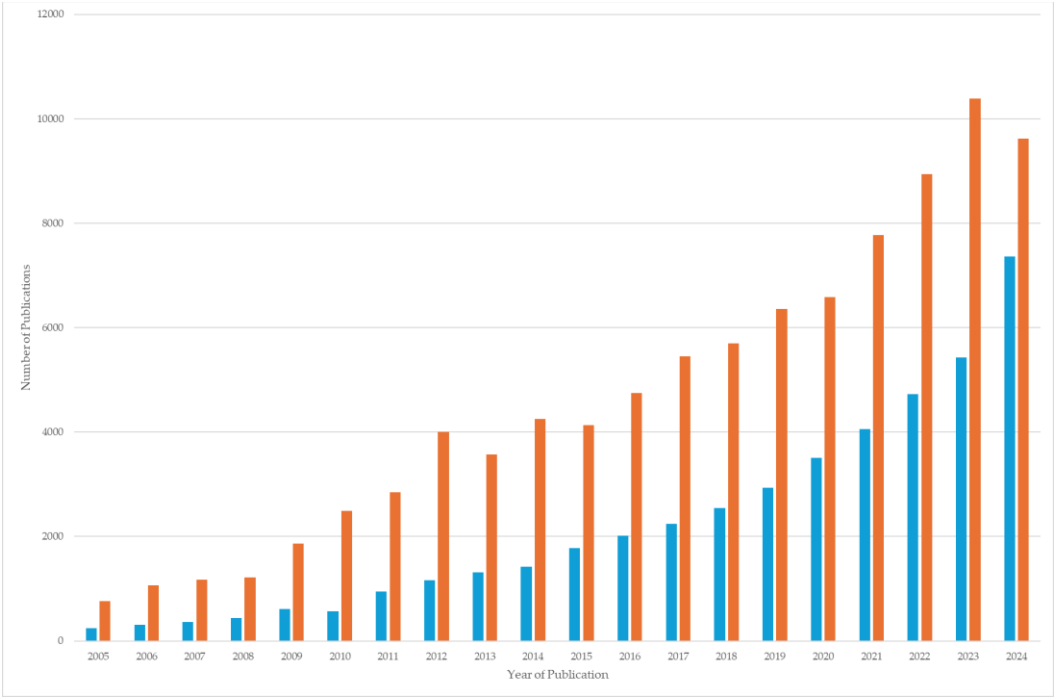
In addition to the above explanation of the technology acceptance models and their phase affiliation, it is useful to provide a descriptive overview of the existing literature in the field of acceptance research. For this purpose, the multidisciplinary, peer-reviewed abstract and citation database Scopus, which includes research literature and high-quality internet sources, was searched for articles containing the term "EV" in the title, abstract, or keywords. The list of hits was then systematically checked for content relevance (Holden & Karsh, 2009, p. 162; Yarbrough & Smith, 2008, p. 652).

The following chart illustrates the evolution of the total number of publications (orange columns) for the search terms "electric AND vehicle" in relation to the number of specialist articles (blue columns) from 2005 to 2024, encompassing the third EMOB wave. It should be noted that the publications found were filtered again according to the following keywords: electric vehicle, electric vehicles, vehicles, hybrid vehicles, EVs, HEVs, hydrogen, fuel cell, electrical vehicles, electric automobiles. This step also ensured that the publications reviewed belonged to the focus of the subject area.

The total number of publications is 92,942, while the number of specialist journals is 43,945. It can also be seen that since the 2020s, at least half of the publications have been specialist articles on the topic of electromobility. In addition to the large number of specialist articles, the total number of publications comprises conference papers, review articles, book chapters, short surveys, and books.

To categorise the importance of the topic of EVs within the overall context, the number of publications can be set in relation to the number of registrations (see Chapter 2.2.3). This comparison supports the assumption that this technological development has increasingly become the focus of both research and consumers in recent years.

Figure 25: Number of Publications for EVs from 2005 to 2024



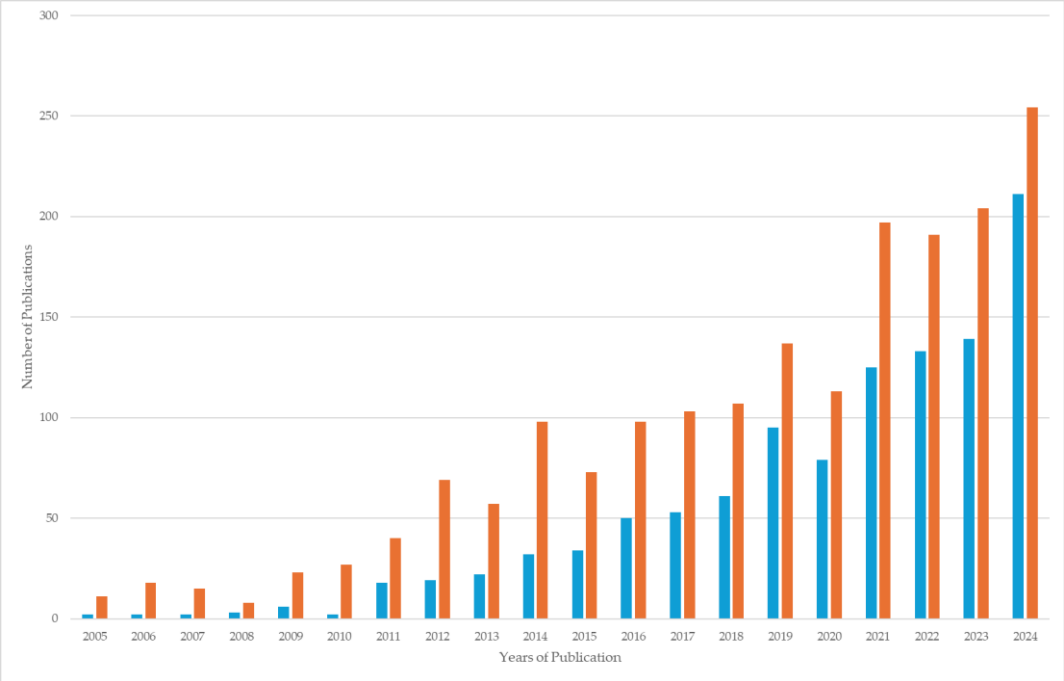
Source: Own illustration based on Scopus data[19]

[19] The figures for 2024 are extrapolated as the call-off date of the data is 31st May 2024.

In order to do justice to the research context of this work, the search term "electric AND vehicle" was expanded to include the terms "intention OR acceptance OR tam OR utaut OR "technology acceptance" OR "technology acceptance model". The time period and the filtering by keywords were retained for reasons of comparability.

Figure 26 shows that this focused search resulted in a significantly lower number of 1,843 total publications (orange columns) and 1,088 specialist articles. The proportion of total publications in the search results, adjusted to the search context, is 2.0% of the total number of search results when searching for "EV" only. The proportion of search results for specialised articles is 2.5% with the same comparison logic.

Figure 26: Number of publications for EVs from 2005 to 2024, extended search term



Source: Own illustration based on Scopus data[20]

[20] The figures 2024 are extrapolated as the call-off date of the data is 31st May 2024.

In addition, the publications were analysed according to scientific journals. It became clear that the affiliation with acceptance research in connection with the term 'EV' has a recognisable connection to specialist journals in the field of transport and sustainability. A total of 160 journals published articles in the research context. Around two-thirds of the publications were published in 29 of these 160 journals, as shown in Table 4:

Table 4: Number of publications in the field of research context according to scientific journals

Journal	Publications
Sustainability Switzerland	69
Transportation Research Part A Policy And Practice	44
Transportation Research Part D Transport And Environment	39
Journal Of Cleaner Production	33
World Electric Vehicle Journal	33
Energies	30
Energy Policy	30
Transport Policy	21
Energy	18
Transportation Research Part C Emerging Technologies	16
Transportation Research Part F Traffic Psychology And Behaviour	16
Journal Of Power Sources	13
Technological Forecasting And Social Change	13
Applied Energy	12
IEEE Access	12
Qiche Gongcheng Automotive Engineering	12
International Journal Of Electric And Hybrid Vehicles	11
International Journal Of Hydrogen Energy	11
International Journal Of Sustainable Transportation	11
Journal Of Energy Storage	11
Case Studies On Transport Policy	10
Environmental Science And Pollution Research	9
IEEE Transactions On Vehicular Technology	9
IEEE Transactions On Intelligent Transportation Systems	8
Dianli Xitong Baohu Yu Kongzhi Power System Protection And Contr	7
Energy Reports	7
Energy Research And Social Science	7
International Journal Of Automotive Technology	7
Research In Transportation Business And Management	7

Source: Own illustration based on Scopus data

The following two studies will be presented, which explore acceptance research using the TAM. It should be noted that many studies are tailored to a specific research context and therefore it is not usually possible to draw conclusions

about a generally valid model and universally applicable determinants (K. Dudenhöffer, 2015, p. 44 ff.; Fazel, 2014, pp. 83, 145; Wicki et al., 2022, p. 80 ff.).

The 2014 study by Fazel focuses on the development and validation of a model for the acceptance of electric mobility in the context of car-sharing. Based on the existing literature, a model is designed to answer the question of how a model must be structured to adequately explain the acceptance of electric mobility. The TAM is adapted to the research context of electromobility (Fazel, 2014, p. 5). The TAM has proven to be a robust and powerful model of technology acceptance, applicable beyond information systems, due to its simplicity. As part of the content and methodological expansion, seventeen existing and three new model constructs were used. The model was empirically validated as part of a population-representative sample survey with 424 participants and has a high explanatory power compared to other TAM research. The two key TAM constructs of "perceived utility" and "perceived simplicity" can be explained very well by Fazel's research model, as evidenced by the high coefficients of determination of 0.70 and 0.41 respectively (Fazel, 2014, p. 288). It was thus possible to show that the model has identified many key factors in the technology acceptance of electromobility. In addition, this research work is highly relevant to TAM research, as previous studies have been conducted primarily within the field of information and communication technology. The "general behavioural intention to use EVs", which, along with "perceived usefulness" and "perceived ease of use", is a key construct of Fazel's TAM, also has a very high explanatory power with a coefficient of determination of 0.60 (Fazel, 2014, p. 289). Accordingly, it was shown that after appropriate operationalisation of the construct, it can be transferred to other technologies and, under certain circumstances, it can be used universally and across technologies to measure acceptance (Fazel, 2014, p. 291 ff.).

Dudenhöffer's 2015 study examines the acceptance of EVs during the early phase of innovation diffusion, assessing this from the customer's perspective. In his study, Dudenhöffer analyses the factors influencing the acceptance of EVs, with scientific studies conducted in both Germany and China. The TAM forms the theoretical model guiding the research. The TAM was extended and adapted to the research subject of EVs to increase its explanatory power. The guiding theses of this work are that acceptance can be explained by a model of technology perception,

personality traits and mobility behaviour, that experience with the product changes acceptance and that the acceptance of EVs differs in cultures with strong individuality and cultures with strong collectivity (K. Dudenhöffer, 2015, pp. 7–9).

A key finding of the study is that personal experience with the innovative product of an electric car is essential. The respondents' knowledge of EVs is low, meaning that inexperienced users often misjudge the vehicles' suitability for everyday use. Furthermore, the data collected indicate that an electric car can be utilised by a significant proportion of the population. Supposed problems, such as a limited range, are in turn based on a lack of knowledge and experience. In addition, inexperienced users tend to prefer the conventional combustion engine over the electric car in a direct comparison (K. Dudenhöffer, 2015, pp. 315–316). In addition, it has been shown that subsidy programmes have not yet been able to have a multiplier effect on the sale of electric cars, even though the state supports both the demand and supply sides. New subsidy programmes must therefore be considered, as only those who are familiar with the technology can reduce the reluctance to buy. Dudenhöffer's study also concludes that everyday integration is a relevant factor in increasing consumer acceptance (K. Dudenhöffer, 2015, p. 318).

3.2 META-ANALYSES IN ACCEPTANCE RESEARCH AND PRESENTATION OF THE META-ANALYSIS BY WICKI ET AL.

It has become clear from the above that there is a large amount of individualised and specific research work in the field of "electric mobility and technology acceptance". As this study focuses on the general barriers to the acceptance of EVs, it is essential to examine not only the research findings that align with the research context, but also those that may not consider all relevant determinants of EV acceptance in their study. Instead, the results of meta-analyses in this area should be examined. The investigation into attitudes and preferences regarding EVs began in 2007. Table 5 provides an overview of the research carried out. It can be seen that not only Davis' TAM serves as the theoretical basis, but also studies that took into account the previously explained TPB and Rogers' diffusion theory were included in the results. Furthermore, it can be seen that all studies initially conducted a literature search, with only four of the eight studies taking peer-reviewed publications into account. Furthermore, it can be seen that only a

small number of studies included a second step in their research procedure to scientifically review, validate, and qualify their results from the literature search.

Table 5: Overview of EMOB meta-analysis and review

Author(s)	Title	EV-type	Method of factor identification	Research focus & Main theory	Categories to bundle the research determinants
Lane & Pott	The adoption of cleaner vehicles in the UK: exploring the consumer attitude–action gap	BEV	> Literature review > Qualitative and quantitative interviews via questionnaire	Adaption barriers of BEVs *via* > Theory of Planned Behavior (TPB) > Value-belief-norm theory > Habits > Diiffusion of Innovation Theory (DOI)	> Situational factors > Psychological factors
Rezvani et al., 2015	Advances in consumer electric vehicle adoption research: A review and research agenda	PHEV	> Literature review, Peer-reviewed journals only	Consumer intentions and adoption behavior towards EVs *via* > Theory of planned behavior (TPB)	> Technical factors > Contextual factors > Cost factors > Indiviual and social factors
Coffman et al., 2017	Electric vehicles revisited: a review of factors that affect adoption	EV	> Literature review, Peer-reviewed journals only	Adaption factors for EVs *via* > Gap analysis	> Internal factors > External factors
Li et al., 2017	A review of factors influencing consumer intentions to adopt battery electric vehicles	BEV	> Literature review, Peer-reviewed journals only	Adaption intention of BEVs *via* > Theory of Panned behavior (TPB) > Diffusion of Innovation theory (DOI) > Technology acceptance model (TAM)	> Demographic factors > Situational factors > Psychological factors
Liao et al., 2017	Consumer preferences for electric vehicles: a literature review	BEV. PHEV	> Literature review	Consumer preferences *via* > Identification of the variables for further research	> Financial attributes > Technical attributes > Infrastructure attributes > Policy attributes > Individual-specific attributes
Hardman et al., 2018	A review of consumer preferences of and interactions with electric vehicle charging infrastructure	BEV. PHEV	> Literature review	Recognise consumer preferences for charging infrastructure for market introduction via > Literature review	> Charge point activity and locations > Pricing and interoperability > Cost to charge > Number of public charging stations > Temporal distribution of charging and charge management > Information, education, and outreach
Daramy-Williams et al., 2019	A systematic review of the evidence on plug-in electric vehicle user experience	PHEV	> Literature review	User experience of PHEV via > Systematic literature review	> Driving behavior > Travel behavior > Interactions with the vehicle > Subjective aspects of the user experience
Wicki et al., 2022	What do we really know about the acceptance of battery electric vehicles? – Turns out, not much	EV	> Literature review, Peer-reviewed journals only > Meta-analysis (PRISMA)	Identify determinants for BEV adoption and prospective ownership via > Technology acceptance model (TAM)	> Technical determinants > Contextual determinants > Cost related determinants > Sociodemographic determinants > Attitudinal and behavioural determinants > BEV-specific experience > Social determinants

Source: Own illustration

The wide range of results, in terms of both the determinants and their grouping within individual studies, as well as their time lag and associated topicality, does not allow for a homogeneous research model to be derived from

today's perspective. For this reason, further research will focus on the most recently published article by Wicki et al. (2022), which is briefly presented below.

The meta-analysis "What do we really know about the acceptance of battery electric vehicles? - Turns out, not much" by Wicki et al. from 2022 shows that the debate as to which factors are relevant in different socio-cultural and decision-making contexts has still not been concluded.

As can be seen from Table 5, Wicki et al. focused mainly, but not exclusively, on research into the acceptance of BEVs. This means that studies on partially electrified vehicles such as plug-in hybrids are also included. It is worth noting that the work by Wicki et al. builds upon and incorporates the aforementioned reviews. Wicki et al. assess the study design, the reliability of the results and their relationship to moderators. The latter were taken from the existing literature and relate to the identified directions of effect of the moderators. Subsequently, Wicki et al. evaluated the reliability of the existing research results by assessing the study designs. The meta-analysis thus answers the following questions:

- To what extent can the existing studies on BEV acceptance be considered reliable in terms of replicability, generalisability and survey design?
- Which factors influence consumer preferences regarding the acceptance of BEVs?

As can be seen from Table 5, the research by Wicki et al. was based exclusively on peer-reviewed studies published between 2010 and 2019. Various quantitative survey methods as well as qualitative survey experiments were used as data collection methods(Wicki et al., 2022, p. 63). The studies were only taken into account after 2010, as BEVs had gained a significant market presence and visibility from this point onwards. In addition, the development of BEVs from a niche product to a market product can be observed from 2010 onwards (Middelkoop & Koppelaar, 2017, p. 34 ff.; Wicki et al., 2022, p. 64). Market visibility is of crucial importance, as people are more likely to develop defined attitudes and preferences towards things if they are familiar with them (Liberman et al., 2007, p. 353 ff.).

Using internet searches in the databases "Web of Science" and "Google Scholar", 196 articles were identified using different search term variations such as "EV" or "battery EV". Of these, 43 articles were identified through direct database

hits, and 153 were identified through forward and reverse snowball technology. After reviewing the 196 articles, the articles that either did not originate from peer-reviewed articles and/or had not been published between 2010 and 2019 were first excluded. This meant that conference papers, reports and working papers were excluded, as the peer-reviewed process was used as a quality criterion. The first hurdle was cleared by 163 articles, which were then reviewed in the next step to identify relevant factors promoting the acceptance of BEVs for further analysis. In the second step, further articles dealing exclusively with acceptance factors of hybrid vehicles were excluded. Following this selection, 94 articles were identified, which were published in 41 different peer-reviewed journals. After identifying the relevant articles, the factors influencing the introduction of BEVs could then be determined. During the further analysis, 25 different factors that can be attributed to the acceptance of BEVs were identified and coded. In addition, all 94 articles were examined to determine which of the 25 factors were included in the analyses and whether any effect on the acceptance of BEVs was discernible. In a final step, the analysed factors were examined and categorised for their overall statistical effect on BEV acceptance within a 95% confidence interval. The categorisation was based on whether there was an effect or whether there was a statistical null effect. Furthermore, only direct effects of the factors were analysed. However, the authors are aware that there are several potential interactions between the factors. Interaction effects were excluded, although several of the studies analysed by Wicki et al. take these into account and control for them in their research design.

Wicki et al. categorised the 25 determinants into seven groups. It should be emphasised that the 25 determinants function as a representative summary of the 94 individual studies, which are based on a wide variety of scientific disciplines and contexts. The heterogeneity of the individual studies also made it clear that different conceptualisations, definitions or measurements were used in the studies. Wicki et al. therefore focused on the directions of impact (positive, negative, or neutral effect) of the determinants and examined their influence on the acceptance of BEVs, rather than concentrating on the comparison of significance levels or the substantial effects in the respective statistical models. Table 2 below shows the identified determinants and their categorisation into the seven groups mentioned. Furthermore, the last column shows the effect of the determinants on the acceptance of BEVs, specifically in cases where this acceptance is increased.

Table 6: Identified determinants for acceptance of BEVs with concluded effect

Categorisation of the determinant groups	Determinant	Concluded effect when the value of the determinant is strengthened
Technical determinants	▪ Motor power ▪ Driving range ▪ Reliability ▪ Charging time	▪ (+) ▪ (+) ▪ (+) ▪ (-)
Contextual determinants	▪ Market availability ▪ Charging availability ▪ Environmental impact ▪ Policy & incentives	▪ (+) ▪ (+) ▪ (+) ▪ (+)
Cost determinants	▪ Purchase price ▪ Operational costs ▪ Fuel efficiency ▪ Resale value	▪ (-) ▪ (-) ▪ (+) ▪ (+)
Sociodemographic determinants	▪ Income ▪ Education ▪ Gender ▪ Age	▪ (+) ▪ (+) ▪ (+) (“+”=male) ▪ (-) (“-“=older)
Determinants of individual attitudes and behaviour	▪ Travel demand ▪ Vehicles per household ▪ Technology affinity ▪ Environmental attitudes	▪ (-) ▪ (+) ▪ (+) ▪ (+)
Determinants of BEV-specific experience	▪ Knowledge ▪ Familiarity	▪ (+) ▪ (+)
Social determinants	▪ Norms ▪ Neighbourhood ▪ Word-of-mouth	▪ (+) ▪ (+) ▪ (+)

Source: Own illustration based on (Wicki et al., 2022, p. 66)

In addition to the determinants, four limitations of the scientific work of Wicki et al. were also identified:

Many of the studies generalise their results in relation to consumers. Conclusions are also often drawn about individuals in a particular country without a representative population sample being available. In addition, the studies analysed provide little information about the response rates or the population of the samples examined. It is not possible to identify common survey or recording errors.

The studies analysed are rarely based on samples from more than one country. Due to the wide variety of survey methods and study designs, a homogeneous comparison of results between countries is not possible. It is required that the collected data be entered into databases for general availability.

In the studies analysed, there is no causal identification of factors that facilitate the acceptance of BEVs, assuming that all other factors are equal. The analysed studies mostly examine the correlation between various determinants and the acceptance of BEVs. Therefore, survey-based experiments or field experiments in which the determinant to be analysed is selectively manipulated should be carried out to investigate specifically influencing determinants.

The replication data analysed in this study are only freely available and usable for a small proportion of the studies investigated. This is due to the fact that only a small proportion of the authors were willing to share the data or the use of the data was subject to strict usage restrictions. From a scientific perspective, therefore, no conclusions can be drawn about the replicability of the studies.

In addition to the limitations mentioned above, Wicki et al. pointed out the following limitations of their study:

- Only English-language articles from peer-reviewed journals were included, so there may have been a bias towards English-language literature.
- Only articles published in 2010-2019 were included.
- Grey literature and internal company data could also not be considered due to availability.

The development of a standardised study design was identified as a priority for further research. This generic study design should ideally be tested in different

countries, each with a representative sample of the general population and at different times. Either surveys or field experiments are proposed as study designs to determine the causal effects of certain factors on the acceptance of BEVs. Finally, it is requested that both the study designs and the associated raw data (questionnaires, scales, etc.) be made publicly available so that future research can draw on them.

3.3 IDENTIFYING THE RESEARCH GAP

To gain a holistic understanding, we will first build on the explanations presented in the models of technology and user acceptance by summarising the individual determinants of the respective models in a table. This makes it easy to recognise the individual determinants of the acceptance models. It can be seen that many new determinants have been added through the continuous further development of the original TAM by Davis in 1989, while others have been no longer considered over time due to different directions of expansion. Each new model attempts to consolidate the latest research contributions into a generally valid model and to aggregate the research work that has been carried out up to this point. This goes hand in hand with the proclamation that the current state of research is reflected at the time of publication of the new model and that this new achievement can serve as a starting point for future work (Fazel, 2014, p. 145). It should also be mentioned that the complexity of the individual technology acceptance models has increased over time, whereas the original TAM by Davis 1989 was already characterised by its simplicity and wide range of possible applications and modifications (Dillon & Morris, 1996b, p. 13; J. S. C. Lin & Chang, 2011, p. 425; Luarn & Lin, 2005, p. 875; Mathieson, 1991, p. 187; Mcfarland & Hamilton, 2006, p. 429; Nysveen et al., 2005, p. 247).

Table 7: Determinants of the technology acceptance research

TAM	Variable (V) or Moderator (M)	TAM 2	Variable (V) or Moderator (M)	UTAUT 1	Variable (V) or Moderator (M)	TAM 3	Variable (V) or Moderator (M)	UTAUT 2	Variable (V) or Moderator (M)	UTAUT 3	Variable (V) or Moderator (M)
Davis 1989		Davis & Venkatesh 2000		Venkatesh et al. 2003		Venkatesh & Bala 2008		Venkatesh et al.2012		Blut et al.2022	
Use Behavior	V	Usage Behavior	V	Use Behavior	V	Use Behavior	V	Use Behavior	V	Use Behavior	V
Behavioral Intention	V	Intention to Use	V	Behavioral Intention	V	Behavioral Intention	V	Behavioral Intention	V	Behavioral Intention	V
Perceived Ease of Use	V	Perceived Ease of Use	V			Perceived Ease of Use	V				
Perceived Usefulness	V	Perceived Usefulness	V			Perceived Usefulness	V				
External Variables	V										
		Subjective Norm	V			Subjective Norm	V				
		Image	V			Image	V				
		Job Relevance	V			Job Relevance	V				
		Output Quality	V			Output Quality	V				
		Result Demonstrability	V			Result Demonstrability	V				
		Experience	M	Experience	M	Experience	M	Experience	M		
		Voluntariness of Use	M	Voluntariness of Use	M	Voluntariness of Use	M				
				Performance Expectancy	V			Performance Expectancy	V	Performance Expectancy	V
				Effert Expectancy	V			Effert Expectancy	V	Effert Expectancy	V
				Social influence	V			Social influence	V	Social influence	V
				Facilitating Conditions	V			Facilitating Conditions	V	Facilitating Conditions	V
				Gender	M			Gender	M		
				Age	M			Age	M		
						Computer Selfefficacy	V				
						Perceptions of External Control	V				
						Computer Anxiety	V				
						Computer Playfulness	V				
						Perceived Enjoyment	V				
						Objective Usability	V				
								Hedonic motivation	V	Hedonic motivation	V
								Price value	V	Price value	V
								Habit	V	Habit	V
										Compatability	V
										Education	V
										Personal innovativness	V
										Costs	V
										Individual Characteristics (age, gender, consumer/ employee)	M
										National Culture (individualism, masculinity)	M
										Technology (mobile, online, transcation)	M
										Controls (study year, sampling)	M

Source: Own Illustration based on (Blut et al., 2022; F. D. Davis, 1989; Venkatesh et al., 2003, 2012; Venkatesh & Bala, 2008; Venkatesh & Davis, 2000)

The ongoing definition and review of new model constructs has considerably expanded the toolbox of technology acceptance research, so that no decision can yet be made in favour of or against a model (Fazel, 2014, p. 145).

As can be seen from the previous knowledge development,[21] the acceptance of EVs is influenced by criteria such as range and charging time. On the other hand, a rational consideration of advantageous criteria such as the low maintenance costs of EVs cannot outweigh these disadvantages (Beggs et al., 1981, p. 2). The test subjects compare innovative electromobility with vehicles for which they have personal experience, predominantly vehicles with combustion engines. As most of the test subjects have little to no personal experience with EVs, features that could trigger enthusiasm for electric mobility (such as stepless acceleration) are not taken into account, although they have an influence (Aral AG, 2023, p. 7 ff.; K. Dudenhöffer, 2015, p. 45). It should therefore be noted that the use of disruptive technological innovations is not a sure-fire success, which is why many theoretical models in acceptance research are based on behavioural models (Dillon & Morris, 1996b, p. 8).

To make a decision in favour of or against one of the acceptance models, the determinants identified in the study by Wicki et al. must be assigned to those of the technology acceptance models. Here, not only are the determinants themselves taken into account, but also the categories to which the determinants are assigned. Table 8 below shows in the left-hand column the seven determinant groups to which Wicki et al. assigned the 25 determinants identified in the right-hand column of the table:

[21] Compare chapter 2.1.2.

Table 8: Determinants and categorisation by Wicki et al.

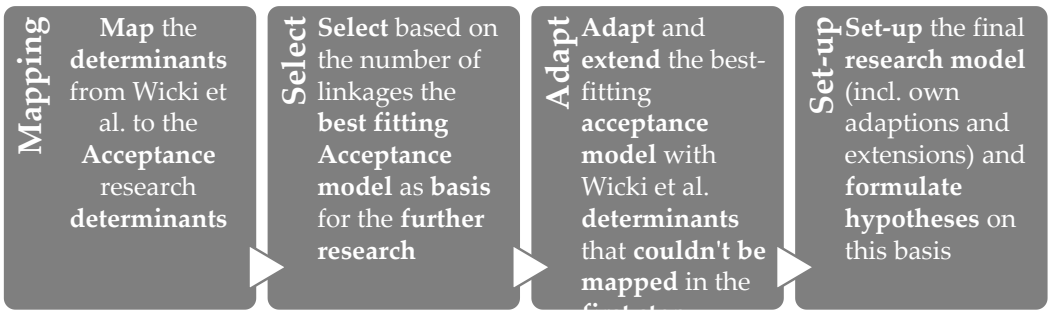
Determinant category	Determinant
Technical determinants	Motor power
	Driving range
	Reliability
	Charging time
Contextual determinants	Market availability
	Charging availability
	Environmental impact
	Policy & incentives
Cost determinants	Purchase price
	Operational costs
	Fuel efficiency
	Resale value
Sociodemographic determinants	Income
	Education
	Gender
	Age
Determinants of individual attitudes and behavior	Travel demand
	Vehicles per household
	Environmental attitudes
	Technology affinity
Determinants of BEV-specific experience	Knowledge
	Familiarity
Social determinants	Norms
	Neighbourhood
	Word-of-mouth

Source: Own illustration based on (Wicki et al., 2022, p. 66)

By comparing the explanations of Wicki et al. with the construct definitions of the acceptance models, it will first be determined which of the determinants of Wicki et al. can be assigned to the existing model constructs of technology acceptance. The focus here is on comparison and mapping, albeit without adapting or extending the model. Once the mapping has been carried out, a decision can be made regarding which TAM best fits, as it has the most overlap with the research by Wicki et al. The next step is to determine whether and to what extent a model extension and adjustment should be carried out once it is known how many of the

determinants could be assigned to the target model. The hypotheses are also derived in this step. In the final step, the research model is established, the research hypotheses are formulated, and the research project is summarised. Figure 27 shows the procedure described above for deriving the research model:

Figure 27: Procedure for deriving the research gap and setting up the research model



Source: Own illustration

Based on previous research, models from the field of technology acceptance can be expanded to the context of electromobility. This has already been demonstrated by various studies (K. Dudenhöffer, 2015; Fazel, 2014, p. 103; Kumar Jain et al., 2022, p. 3).

For comparison, the above table of determinants for the acceptance models was first simplified and supplemented with the respective definitions from the research, equivalent terms used (aliases), and, where available, their original constructs. The latter are not included in Table 9 as they are of only informational value and offer no added benefit for the subsequent comparison. To present the contents effectively, the table is divided into two separate tables: Part 1 of 2 and Part 2 of 2. The first table contains the determinants of TAM, TAM 2 and UTAUT 1. Table 2 contains the determinants of TAM 3, UTAUT 2 and UTAUT 3. It should be noted that only the newly added determinants of the acceptance models are named in each case. The entire set of determinants used for each model is presented in the table at the beginning of this chapter.

Table 9: Definitions of determinants of TAM, TAM 2 and UTAUT 1 (part 1 of 2)

Determinant	First used in which TAM or UTAUT model?	Used as Variable (V) or Moderator (M) in previous reserach	Definitions based on existing research	Alias(es) (if applicable)
Use Behavior	TAM	V	"Actual system use in the context of technology acceptance" (Davis, 1989).	Actual use, adoption, continuance usage, Usage of a Technology, Behavior
Behavioral Intention	TAM	V	"The strength of one's intention to perform a specified behavior" (Fishbein & Ajzen, 1975).	Intention to Use a Technology, Continuance intention, use intention
Perceived Ease of Use	TAM	V	"The degree to which a person believes that using a particular system would be free of effort" (Davis 1989, p. 320).	
Perceived Usefulness	TAM	V	"The degree to which a person believes that using a particular system would enhance his or her job performance" (Davis 1989, p. 320).	
	TAM	V	No specific definition given, was defined individually per TAM reserach: "In this sense, research on how usefulness and ease of use can be influenced by various externally controllable factors, such as the functional and interface characteristics of the system (Benbasat and Dexter, 1986; Bewley, et al., 1983; Dickson, et al., 1986), development methodologies (Alavi, 1984), training and education (Nelson and Cheney, 1987), and user involvement in design (Baroudi, et al. 1986; Franz and Robey, 1986) is important" (Davis, 1989, p. 335).	
Subjective Norm	TAM 2	V	Defined as a "person's perception that most people who are important to him think he should or should not perform the behavior in ques- tion" (Fishbein and Ajzen 1975, p. 302)	
Image	TAM 2	V	"The degree to which an individual perceives that use of an innovation will enhance his or her status in his or her social system" (Moore & Benbasat, 1991).	Reputation
Job Relevance	TAM 2	V	Defined as "an individual's perception regarding the degree to which the target system is applicable to his or her job. In other words, job relevance is a function of the importance within one's job of the set of tasks the system is capable of supporting (Venkatesh et al. 2000, p. 191).	
Output Quality	TAM 2	V	"The degree to which an individual believes that the system performs his or her job tasks well" (Venkatesh & Davis, 2000, p. 191).	
Result Demonstrability	TAM 2	V	"The tangibility of the results of using the innovation, including their observability and communicability" (Moore and Benbasat 1991, p. 203).	Results demonstrability
Experience	TAM 2	M	A user's prior experience using technology in general (Meuter et al., 2005, p. 66).	Familiarity, past use
Voluntariness of Use	TAM 2	M	Defined as "the extent to which potential adopters perceive the adoption decision to be non-mandatory" (Agarwal and Prasad 1997, Hartwick and Barki 1994; Moore and Benbasat 1991, p. 195; Venkatesh 2000, p. 188). *The degree to which the use of innovation is perceived as being voluntary, or of free will (Moore & Benbasat, 1991, p. 195).*	
Performance Expectancy	UTAUT 1	V	Performance expectancy is defined as the degree to which technology will provide benefits to users when performing certain activities (Venkatesh et al., 2003, p. 447).	
Effort Expectancy	UTAUT 1	V	The degree of ease associated with using the technology (Venkatesh et al., 2003, p. 450).	
Social influence	UTAUT 1	V	Social influence is defined as the degree to which an individual perceives that important others believe he or she should use the new system. (Venkatesh et al. 2003, p. 451).	
Facilitating Conditions	UTAUT 1	V	Facilitating conditions are defined as the degree to which an individual believes that an organizational and technical infrastructure exists to support use of the system (Venkatesh et al. 2003, p. 453).	
Gender	UTAUT 1	M	Gender of the user.	
Age	UTAUT 1	M	The age of the user.	

Source: Own illustration based on (F. D. Davis, 1989; Venkatesh et al., 2003; Venkatesh & Davis, 2000)

Table 10: Definitions of determinants of TAM 3, UTAUT 2 and UTAUT 3 (part 2 of 2)

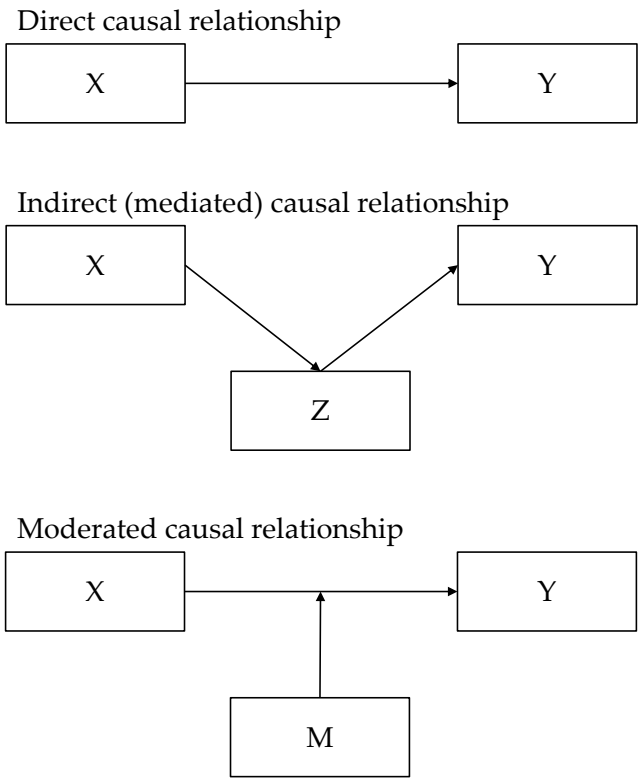
Determinant	First used in which TAM or UTAUT model?	Used as Variable (V) or Moderator (M) in previous reserach	Definitions based on existing research	Alias(es) (if applicable)
Computer Selfefficacy	TAM 3	V	"The degree to which an individual believes that he or she has the ability to perform a specific task/job using computer" (Compeau & Higgins, 1995a, 1995b).	
Perceptions of External Control	TAM 3	V	"The degree to which an individual believes that organizational and technical resources exist to support use of the system" (Venkatesh et al., 2003).	
Computer Anxiety	TAM 3	V	"The degree of "an individual's apprehension, or even fear, when she/he is faced with the possibility of using computers" (Venkatesh, 2000, p. 349).	
Computer Playfulness	TAM 3	V	"…the degree of cognitive spontaneity in microcomputer interactions" (Webster & Martocchio, 1992, p. 204).	
Perceived Enjoyment	TAM 3	V	"The extent to which "the activity of using a specific system is perceived to be enjoyable in its own right, aside from any performance consequences resulting from system use" (Venkatesh, 2000, p. 351).	
Objective Usability	TAM 3	V	A "comparison of systems based on the actual level (rather than perceptions) of effort required to complete specific tasks" (Venkatesh, 2000, pp. 350-351).	
Hedonic motivation	UTAUT 2	V	The fun or pleasure derived from using a technology (Venkatesh et al., 2012).	
Price value	UTAUT 2	V	Refers to the individual's cognitive tradeoff between the perceived benefits of the applications and the monetary cost for using them (Dodds, Monroe, & Grewal, 1991).	
Habit	UTAUT 2	V	The extent to which people tend to perform behavior automatically because of learning (Venkatesh et al.,2012).	
Compatability	UTAUT 3	V	The degree to which an innovation is perceived as being consistent with existing values, needs, and experiences of potential adopters (Moore & Benbasat, 1991, p. 195).	Perceived fit
Education	UTAUT 3	V	The education level of the user.	
Personal innovativness	UTAUT 3	V	Represents an individual characteristic reflecting a willingness to try out any new technology (Agarwal & Karahanna, 2000).	
Costs	UTAUT 3	V	The extent to which a user perceives that using a technology is costly (Zhang, Zhu, & Liu, 2012).	Cost effectiveness, price, financial costs, switching costs
Individual Characteristics (age, gender, consumer/ employee)	UTAUT 3	M	"UTAUT proposes that several user characteristics, namely age, gender, and experience, exert moderating effects on various relationships (Venkatesh et al., 2003)"; "In examining studies that apply UTAUT in the contexts of employees and consumers, we found that the constructs that predict behavioral intention and use vary across these categories. In the context of consumers, the UTAUT predictors typically show strong effects (Tan, 2013; Thong et al., 2011; Powell et al., 2012)" (Blut et al. 2022, pp. 13-14).	
National Culture (individualism, masculinity)	UTAUT 3	M	"When discussing future research or study limitations, many UTAUT studies regularly suggest conducting large-scale cross-country comparisons (Teo et al., 2015). We therefore consider national culture as moderator. Culture is defined as "the collective programming of the mind which distinguishes the members of one human group from another" (Hofstede, 1991, p. 5). Culture can influence individuals' social behaviors (Dinev et al., 2009) " (Blut et al. 2022, p. 15).	
Technology (mobile, online, transcation)	UTAUT 3	M	"Despite the maturity of technology acceptance research, many studies have not considered the effects of technology types (Im, Kim, & Han, 2008). As proposed by Venkatesh et al. (2016), technology type is a dimension of context that can be applied to UTAUT research. UTAUT was developed during a time when the Internet was still growing and not as widely used as it is today" (Blut et al. 2022, p. 21).	
Controls (study year, sampling)	UTAUT 3	M	Used as dummy variables to distinguesh between student and non-student samples. "Student samples tend to be more homogeneous than non-student samples (Pan & Zinkhan, 2006)" (Blut et al. 2022, p. 29).	

Source: Own illustration based on (Blut et al., 2022; Venkatesh et al., 2012; Venkatesh & Bala, 2008)

Figure 28 shows the three main relationships between the determinants/constructs in technology acceptance models: direct effects, indirect

effects (mediators) and moderators (influences on the relationship between two variables; (Henseler & Fassott, 2010, p. 715):

Figure 28: Relationships between the variables



Source: Own illustration based on (Henseler & Fassott, 2010, p. 715)

3.3.1 Mapping: Assignment of the determinants of Wicki et al. to the determinants of the technology acceptance models

As described above, the first step in identifying the research gap is to try to assign the determinants of Wicki et al. to the determinants of the technology acceptance models. Both individual determinants and entire categories are assigned to the determinants and constructs of the technology acceptance models. Unassigned determinants will be used in the further course of this chapter for an adaptation and extension of the designated technology acceptance model. This will ultimately ensure that all determinants identified by Wicki et al. are used in a holistic research model. The procedure in this chapter is first to present the

categories defined by Wicki et al. and the determinants they contain. This is followed by a discussion of whether the category and/or determinant can be assigned to the determinants of the technology acceptance models.

The first category identified by Wicki et al. through their research, "technical determinants", contains the determinants of motor power, driving range, reliability and charging time (Wicki et al., 2022, pp. 70–71), as shown below in Table 11:

Table 11: Technical determinants

Determinant category	Determinant
Technical determinants	Motor power
	Driving range
	Reliability
	Charging time

Source: Own illustration based on (Wicki et al., 2022, pp. 70–71)

Engine power refers to various concepts typically associated with performance. These include top speed, engine power and acceleration time (Larson et al., 2015; Mabit & Fosgerau, 2011; She et al., 2017; Ziegler, 2012).

The maximum distance a BEV can travel on a single full charge is defined as its range (Carley et al., 2013; Egbue & Long, 2012; Hackbarth & Madlener, 2013; Hidrue et al., 2011; Kempton, 2016).

The assessment and evaluation of electric drive technology by an individual in terms of quality and stability is referred to as reliability.

The total time required to charge an electric car, depending on battery capacity and charging power, is defined as charging time (Bockarjova & Steg, 2014; Hackbarth & Madlener, 2013; Helveston et al., 2015; Hidrue et al., 2011; Mabit & Fosgerau, 2011).

Taking into account the determinants presented, it becomes clear that the "technology" determinant from the UTAUT 3 shows the greatest correspondence with the "technical determinants" category from Wicki et al. and the determinants

contained therein. The technology determinants represent the dimension of technology in a context and can thus be applied to the UTAUT research in order to consider and compare the effects of different types of technology (Blut et al., 2022, p. 34; Im et al., 2008; Venkatesh, Thong, et al., 2016). Due to the context dependency of the category of "technology determinants", it is attributed a moderating role and should be used in the model according to its moderating influence of UTAUT 3 (Blut et al., 2022, p. 70). Whether individual variables are adapted or removed from the "Technical determinants" category is discussed in the next but one chapter.

The second category defined by Wicki et al is context-related determinants. These are the determinants of market availability, charging availability, environmental impact, and policy incentives (Wicki et al., 2022, pp. 71–73), as shown in Table 12 below:

Table 12: Contextual determinants

Determinant category	Determinant
Contextual determinants	Market availability
	Charging availability
	Environmental impact
	Policy & incentives

Source: Own illustration based on (Wicki et al., 2022, pp. 71–73)

Market availability describes the availability and number of EV models that are available to consumers on the market. The higher the number of models with an electric drive, the more likely consumers are to choose one of these models (Chorus et al., 2013; Hoen & Koetse, 2014).

Charging availability is one of the most important criteria, and many studies have proven the significance of the positive influence of charging options. Conversely, an inadequate charging infrastructure is often cited as one of the biggest obstacles to purchasing a new car. Charging facilities at home or at work also play a key role in this. Greater expansion of the charging infrastructure should help alleviate range anxiety and drive forward electric car adoption (Axsen et al., 2016; Egbue & Long, 2012; Graham-Rowe et al., 2012; Skippon & Garwood, 2011).

The environmental impact is a widely discussed topic in relation to EVs. On the one hand, studies generally show that consumers consider EVs a good alternative to vehicles with combustion engines, aiming to avoid harmful greenhouse gases. On the other hand, some studies also consider the reservations of consumers if or precisely because the electricity required is primarily generated from the combustion of fossil fuels. The majority of studies agree that EVs can fundamentally help to avoid harmful greenhouse gases and have a reduced environmental impact, which in turn supports the acceptance of EVs (Bockarjova & Steg, 2014; Choi et al., 2018; Hoekstra, 2019; Jensen et al., 2013; Kormos et al., 2019; Moro & Lonza, 2018; Peters & Dütschke, 2014; Rangaraju et al., 2015; Woo et al., 2017).

Numerous studies have analysed the effects of political framework conditions and incentives on the acceptance of EVs. These include not only government support in the form of lower vehicle prices but also measures to expand the public charging infrastructure. However, in addition to these direct effects, facilitating conditions for the use of EVs, such as separate lanes or special parking and charging facilities, are also important, especially in cities with high traffic volumes (Brückmann & Bernauer, 2020; Coffman et al. (Brückmann & Bernauer, 2020; Coffman et al., 2017; Egbue & Long, 2012; R. A. Huber & Wicki, 2021; S. Wang et al., 2018; Wicki et al., 2019).

Based on the explanations of Blut et al., there is no category within the technology acceptance models to which context-based determinants can be assigned. Accordingly, Blut et al. propose a context-dependent extension of the respective technology acceptance model (Blut et al., 2022). Chapter 5 explains how the context-based determinants complement the selected technology acceptance model.

The third category, defined by Wicki et al., deals with the costs associated with purchasing and operating an EV. The four determinants are purchase price, operation costs, fuel efficiency and resale value (Wicki et al., 2022, pp. 73–74), as shown in Table 13:

Table 13: Cost determinants

Determinant category	Determinant
Cost determinants	Purchase price
	Operational costs
	Fuel efficiency
	Resale value

Source: Own illustration based on (Wicki et al., 2022, pp. 73–74)

As with charging availability, the purchase price is also a very elementary determinant regarding the acceptance of EVs and indicates whether consumers are prepared to pay for this new technology. In particular, people who mostly buy used vehicles react very sensitively to costs. However, it has also been shown that income does not necessarily have a significant influence on the purchase price, but on the size of the vehicle (Hoen & Koetse, 2014; Jensen et al., 2013).

Regarding operational costs, the situation is very similar to the purchase price. However, it is less clear in parts, as the study designs differ. The studies use the energy costs to make the operational costs measurable. Energy costs are applied differently in each case, with some studies expressing them in terms of distance, efficiency, or in relation to the price of petrol. Some studies also include maintenance costs in the operational costs. It was found that operational costs have a negative impact on the acceptance of EVs. This leads to the conclusion that the higher the operational costs, the more negative the influence on the acceptance of EVs (Andor et al., 2020; Hess et al., 2012; Mabit & Fosgerau, 2011; Musti & Kockelman, 2011).

Compared to other determinants, the determinant fuel efficiency has been researched very little. However, it is also considered to be of great importance, as additional taxes may be levied on vehicle emissions in the future, and EVs can differentiate themselves favourably from vehicles with combustion engines in this respect in particular (Beck et al., 2011).

A higher resale value can serve as a way to compensate for the higher purchase prices and act as an incentive for consumers to buy. This has also been

investigated in some studies, and a correlation has been found between the expected higher sales price and consumer acceptance of EVs (Jensen et al., 2013; Wicki et al., 2022, p. 81).

Examining the determinants of technology acceptance models reveals that the "price value" determinant from UTAUT 2 overlaps with the two determinants: purchase price and resale value. The Price value construct is defined as follows: "Refers to the individual's cognitive tradeoff between the perceived benefits of the applications and the monetary cost for using them" (Dodds et al., 1991). Based on the above explanations, not only the interaction between the supposedly higher purchase price of EVs compared to vehicles with combustion engines can be found in this construct, but also the expected correlation between higher purchase price and comparatively higher resale value compared to vehicles with combustion engines, which is assumed by consumers as explained above (Venkatesh et al., 2012, p. 30 ff.).

On the other hand, the "costs" determinant from UTAUT 3 the determinants of operation costs and fuel efficiency identified by Wicki et al. The costs construct is defined as "the extent to which a user perceives that using a technology is costly" (L. Zhang et al., 2012). According to the above explanations, this classification is appropriate because, as the definition already describes, the perceived costs are put into relation by the user. In the case of the comparison between vehicles with an internal combustion engine and those with an electric drive (Blut et al., 2022, pp. 44–47).

The fourth category, as defined by Wicki et al., includes sociodemographic determinants. The four determinants of income, education, gender and age (Wicki et al., 2022, pp. 74–76) are shown in Table 14 below:

Table 14: Sociodemographic determinants

Determinant category	Determinant
Sociodemographic determinants	Income
	Education
	Gender
	Age

Source: Own illustration based on (Wicki et al., 2022, pp. 74–76)

The determinant income and associated research indicate that consumers with an income higher than the average in their country tend to accept EVs more readily than other consumers. Other studies emphasise this statement, as consumers with an above-average income are less price-sensitive. However, other studies show that a higher income can actually have the opposite effect, and consumers exhibit less electric vehicle-oriented purchasing behaviour (Hackbarth & Madlener, 2013; Hess et al., 2012; Mabit & Fosgerau, 2011; Trommer et al., 2015).

The situation is similar to the determinant of education. Here, again studies have shown that consumers with a higher level of education tend to be more considerate of the environment, which in turn promotes acceptance of the purchase of an EV (Carley et al., 2013; Hackbarth & Madlener, 2013; Hidrue et al., 2011; Sovacool, 2017; Sovacool et al., 2018).

The determinant of gender and the associated research results are not clear. On the one hand, only binary genders are assumed, while on the other hand, the influence of binary genders on opposite-sex consumers has not yet been investigated in connection with EV acceptance. However, the study results show that women tend to be more sceptical and less accepting of EVs. Studies have also shown that there are four ways in which gender can influence the acceptance of EVs: travel behaviour, the values perceived for the environment, the important preferences when choosing a vehicle, and the dependent role perception that comes with a gender. Furthermore, women seem to be more sceptical about EVs, as the

lack of infrastructure, such as charging facilities, and the reliability of EVs do not seem mature enough to them (Berkeley et al., 2018; Sovacool et al., 2018).

Similar to the age determinant described above, there are mixed results across the various studies. The studies conducted show an increased tendency for the acceptance of EVs to come predominantly from middle-aged men (Hidrue et al., 2011; Tran et al., 2013; Trommer et al., 2015).

Examining the determinants of technology acceptance models reveals that similar determinants were employed as moderator variables in UTAUT 2 and UTAUT 3, in particular (Blut et al., 2022; Venkatesh et al., 2012). However, UTAUT 3 also offers a greater overlap here, as it contains the determinants that represent the demographic individuality of consumers and are defined as moderators for the determinants of behavioural intention and usage behaviour that have a direct influence. In UTAUT 3, this is a moderator group labelled "individual characteristics." In the model postulated by Blut et al. (2022, p. 70), this includes the previously presented determinants age and gender. Accordingly, the conclusion suggests that this should be expanded to include the determinants of income and education, which is supported by the research of Sovacool et al. (Carley et al., 2013; Hackbarth & Madlener, 2013; Hess et al., 2012; Sovacool et al., 2018; Trommer et al., 2015). However, the latter extension is not in line with the postulated UTAUT 3, as Blut et al. have defined education as a directly influencing determinant (Blut et al., 2022, p. 51 ff.). However, previous research and studies published in parallel to the meta-study by Blut et al. suggest an opposing possibility, namely using the determinant of education as a moderator in the UTAUT. Due to the solution of using education as a moderator variable in the present research context, which is applied successfully in practice, education is included in the determinant group of individual characteristics as suggested above and is not used as an independent determinant in the research model (Buhmann & Criado, 2023; Chattopadhyay Mukherjee & Ryan, 2020; Hidrue et al., 2011; C. Lee et al., 2020; Mehdizadeh et al., 2023; Sovacool et al., 2018).

The fifth category established by Wicki et al. contains the attitudinal and behavioural determinants, namely travel demand, number of vehicles in the household, environmental attitudes, and technology affinity (Wicki et al., 2022, pp. 76–77), as shown in Table 15 below:

Table 15: Determinants of individual attitudes and behaviour

Determinant category	Determinant
Determinants of individual attitudes and behavior	Travel demand
	Vehicles per household
	Environmental attitudes
	Technology affinity

Source: Own illustration based on (Wicki et al., 2022, pp. 76–77)

Studies have confirmed that a higher need for travelling or driving leads to less acceptance of electric cars. This effect is further interpreted as suggesting that people with low annual mileage assign less importance to the characteristic of a high vehicle range (Hoen & Koetse, 2014). (Hoen & Koetse, 2014).

The number of vehicles available in the household has a positive effect on any range anxiety (Jakobsson et al., 2016; Karlsson, 2017; Tamor & Milačić, 2015). This applies to households with more than one vehicle and in particular when vehicles with an internal combustion engine or hybrid drive co-exist alongside purely electric cars (Axsen et al., 2016; Hidrue et al., 2011; Javid & Nejat, 2017; Jensen et al., 2013; J. H. Lee et al., 2019; Nazari et al., 2018; Priessner et al., 2018).

Regarding individual attitudes, two concepts are at play: first, the affinity for new technologies, and second, the importance of environmental and climate protection to a person. Both determinants are seen as having a positive correlation with EVs (Carley et al., 2013; Hidrue et al., 2011; Jensen et al., 2013; Wicki et al., 2022, pp. 76–77).

Examining the determinants identified by Wicki et al. regarding attitude and behaviour, it becomes clear that these cannot be directly attributed to any determinants of the technology acceptance models. This means further discussion and examination in the next but one chapter.

The sixth category established by Wicki et al. contains the BEV-specific determinants of knowledge and familiarity (Wicki et al., 2022, pp. 77–78), as shown in Table 16:

Table 16: Determinants of BEV-specific experience

Determinant category	Determinant
Determinants of BEV-specific experience	Knowledge
	Familiarity

Source: Own illustration based on (Wicki et al., 2022, pp. 77–78)

The concept of knowledge encompasses how much people know about the advantages of EVs and how they differ from other vehicles. Studies have found that a higher level of knowledge leads to a higher level of acceptance (S. Wang et al., 2018). On the other hand, it has been confirmed that ignorance of the advantages of EVs leads to a negative attitude towards this technology and makes adaptation less likely (Krause et al., 2013; Y. Zhang et al., 2011).

Experience with EVs, whether as an owner or just as a driver, is explained by the concept of familiarity, which is closely related to the concept of experience. Studies have found that people with experience and familiarity with the drive technology of EVs are willing to pay more for them than for conventional vehicles with combustion engines. Furthermore, this result is not limited to EVs, but can also be transferred to the experience with HEVs (Carley et al., 2013; Hidrue et al., 2011; Larson et al., 2015). Studies with direct experience have shown that after a period of three months, test persons travelled twice the range with their EV than at the beginning of the test period. This also appears to be due to the fact that although the development and expansion of the charging infrastructure has made significant progress, awareness and knowledge of charging points is not always transparent for users, which in turn inhibits the acceptance of EVs (Bailey et al., 2015; K. Dudenhöffer, 2015; Franke & Krems, 2013; Jensen et al., 2013).

As can be seen above, numerous studies have found that knowledge and familiarity are responsible for interest in EVs, so that the two determinants of "knowledge" and "familiarity" can be assigned to the construct "Experience" from the TAM 2 accordingly (Bühler et al., 2014; Burgess et al., 2013; Egbue & Long, 2012; Graham-Rowe et al., 2012; Jensen et al., 2013; Peters & Dütschke, 2014; Plötz et al., 2014; Schmalfuß et al., 2017). The construct of "experience" is defined by Meuter et

al. as follows: "A user's prior experience using technology in general" (Meuter et al., 2005). Alias constructs such as familiarity and past use are also included in the experience construct.

The seventh and final category identified by Wicki et al. is social determinants. This category contains the determinants of social and personal norms, neighbourhood effect and word-of-mouth effect (Wicki et al., 2022, pp. 78–79), as shown in Table 17 below:

Table 17: Social determinants

Determinant category	Determinant
Social determinants	Norms
	Neighbourhood
	Word-of-mouth

Source: Own illustration based on (Wicki et al., 2022, pp. 78–79)

Numerous studies have shown that the three determinants in the social determinants category generally have a positive influence on the acceptance of EVs. A distinction can be made between a direct effect, such as word-of-mouth, and an indirect effect, such as many owners in my neighbourhood own an EV and thus create social pressure on other individuals to also buy an EV (Wicki et al., 2022, p. 79).

In the context of social norms, studies have shown that society's perceived expectations of a person can lead them to accept and ultimately purchase an EV. Furthermore, the purchase can also be justified by the fact that the public sees the buyer as intelligent and responsible as well as an environmentalist and supporter of the nation (Axsen & Kurani, 2013; M. Barth et al., 2016).

As can be seen from the above, social determinants are primarily about fitting into the social fabric in the best possible way (Kotler & Keller, 2016, pp. 181–183). This leads to the conclusion that not only the three determinants, but the entire category "social determinants" can be assigned to the construct "social influence"

from UTAUT 1. Social influence is defined as "the degree to which the user perceives that important others believe he or she should use the technology" (Venkatesh et al., 2003). The expectations of peers, expected social conformity and norms also play an important role in the construct of social influence (Axsen & Kurani, 2013; M. Barth et al., 2016).

3.3.2 Select: The UTAUT 3 as a starting model for further research

The previous chapter has justified the selection of the most appropriate technology acceptance model by mapping directly assignable determinants or determinant categories from Wicki et al. to the determinants and/or determinant categories of the existing TAM and UTAUT models.

Table 18 summarises the status of this assignment. On the one hand, it is clear that a considerable proportion of the determinants and/or categories can be assigned to UTAUT 3. On the other hand, it can be seen that further analysis and adaptation are required to map all determinants and determinant categories in the final research model.

Table 18: Status of sorting after initial mapping

Determinant category	Determinant	Mapping to	Mapped to which original TAM or UTAUT model?
Technical determinants	Motor power	Overall category of "Technical determinants" was linked to moderating type "Technology" of UTAUT 3. Individual determinants will be checked later if they be kept within the category or have to be adapted and will extend the chosen model.	UTAUT 3
	Driving range		UTAUT 3
	Reliability		UTAUT 3
	Charging time		UTAUT 3
Contextual determinants	Market availability	Neither the overall category of "Contextual determinants" nor any of the individual determinants could be linked to any of the technology acceptance models determinants or categories directly.	TBD
	Charging availability		TBD
	Environmental impact		TBD
	Policy & incentives		TBD
Cost determinants	Purchase price	Mapped to "Price value", first used in UTAUT 2.	UTAUT 2
	Operational costs	Mapped to "Costs", first used in UTAUT 3.	UTAUT 3
	Fuel efficiency	Mapped to "Costs", first used in UTAUT 3.	UTAUT 3
	Resale value	Mapped to "Price value", first used in UTAUT 2.	UTAUT 2
Sociodemographic determinants	Income	Overall category was linked to the proposed moderating type of "Individual Characteristic" of UTAUT 3. Individual determinants will be checked later if they be kept within the category or have to be adapted and will extend the chosen model.	UTAUT 3
	Education		UTAUT 3
	Gender		UTAUT 3
	Age		UTAUT 3
Determinants of individual attitudes and behavior	Travel demand	Neither the overall category of "Determinants of individual attitudes and behavior" nor any of the individual determinants could be linked to any of the technology acceptance models determinants or categories directly.	TBD
	Vehicles per household		TBD
	Environmental attitudes		TBD
	Technology affinity		TBD
Determinants of BEV-specific experience	Knowledge	Mapped to "Experience", first used in TAM 2.	TAM 2
	Familiarity	Mapped to "Experience", first used in TAM 2.	TAM 2
Social determinants	Norms	Mapped to "Social influence", first used in UTAUT 1.	UTAUT 1
	Neighbourhood	Mapped to "Social influence", first used in UTAUT 1.	UTAUT 1
	Word-of-mouth	Mapped to "Social influence", first used in UTAUT 1.	UTAUT 1

Source: Own illustration[22]

[22] TBD means "to be defined". The further analysis and adaptation in the following chapter is required to map all determinants and determinant categories in the final research model.

Based on the above table and the current status of the mapping, it is recommended that the UTAUT 3 model be used as a justification for the research. This can be further justified by the fact that UTAUT 3 represents the latest major extension in the context of technology acceptance research (Blut et al., 2022). As also explained above, every new research model in the context of technology acceptance claims to represent the latest scientific status and thus the most suitable model for this research at present (Fazel, 2014, p. 145). In addition to these general arguments in favour of using the UTAUT 3 as a starting model for further research and although a context-specific adaptation seems necessary, the conclusion and call by Wicki et al. for the development of a generally valid research model for the context of EVs is also supported. This is accompanied by a review of whether the determinants identified by Wicki et al. actually influence the acceptance of EVs (Wicki et al., 2022, p. 82).

Like the study by Wicki et al., this research work will also focus on EVs and, as explained above, establish a generally valid research model based on the identified variables and assigned determinants, using UTAUT 3 as the framework. Accordingly, this work closes the gap of a holistic approach from a theoretical derivation to an empirical examination (Fazel, 2014, p. 150).

Previous empirical studies have used a wide variety of theoretical models as the basis of their research work to analyse acceptance and adaptation intentions. Studies beyond the original field of application of information and communication technology have been tested and it has been confirmed that the TAM can be used for a wide variety of fields of application (Benbasat & Barki, 2007, p. 216; F. D. Davis, 1989, p. 335; Y. Lee et al., 2003, p. 766; Morton et al., 2011, p. 10 f.; Ozaki & Dodgson, 2010, p. 311; Venkatesh, 2000, p. 200; Venkatesh et al., 2003, p. 470).

In the context of electromobility, the TRA (Adnan et al., 2017, 2018), the TPB (Alzahrani et al., 2019), the TAM (K. Dudenhöffer, 2015; Fazel, 2014; Wolff & Madlener, 2019) or the UTAUT (Kumar Jain et al., 2022; Kurniawan & Gabriel, 2022; Manutworakit & Choocharukul, 2022; Mashahadi et al., 2023) have already been used to analyse the adaptation intention and acceptance of consumers in a context-specific and empirical manner.

As mentioned in the previous chapter on the theoretical background, the UTAUT represents the integration and refinement of existing models related to

technology acceptance. Accordingly, in the context of technology acceptance, the UTAUT is not seen as a stand-alone model, but as a further development and harmonisation of the branching strands of research (Venkatesh et al., 2003, p. 467, 2012, p. 158). The UTAUT was developed from eight individual models to provide a holistic approach to explaining the intention to use a new technology through defined influencing variables (Venkatesh et al., 2003, p. 425 f.). The key variables influencing acceptance and technology use include "performance expectancy", "effort expectancy", "social influence" and "facilitating conditions". This model is supplemented by the moderating variables of "gender", "age", "experience" and "voluntariness of use", which moderate the above four key variables (Venkatesh et al., 2003, p. 447).

UTAUT 1 was developed to evaluate the intention to use a new technology within an organisation. As this does not offer sufficient explanatory power for the requirements of a consumer study, Venkatesh et al. developed UTAUT 2 in 2012. The UTAUT was supplemented by the variables of "hedonic motivation", "price value" and "habit", which offer additional explanatory power, particularly for the consumer context (Venkatesh et al., 2012, p. 7 ff.). (Venkatesh et al., 2012, p. 157 ff.). Except for the moderator of "voluntariness of use", the moderators from UTAUT 1 were retained. According to Venkatesh et al. (2012, p. 162), voluntariness of use has no explanatory relevance for the use of a technology in consumer markets, as voluntariness of use is assumed to be a prerequisite here.

UTAUT 1 and UTAUT 2 are considered to be models that produce a complex overall structure due to a large number of variables and moderators. To reduce complexity, UTAUT models are often used without moderators (Fazel, 2014, p. 140 f.). Despite all the criticism levelled at the UTAUT models, they must be credited with having the highest variance explanation of all standard technology acceptance models. UTAUT 1 explains 56% of the variance in "behavioural intention" and 40% of the variance in "actual use" of the technology. In comparison, UTAUT 2 even manages to explain 74% of the "behavioural intention" and 52% of the "actual use" of a technology (Venkatesh et al., 2012, p. 157). In addition to this high explanatory power, the UTAUT models also provide a useful overview of which factors of a new technology hold increased relevance for the end customer (Venkatesh et al., 2012, p. 170 ff.).

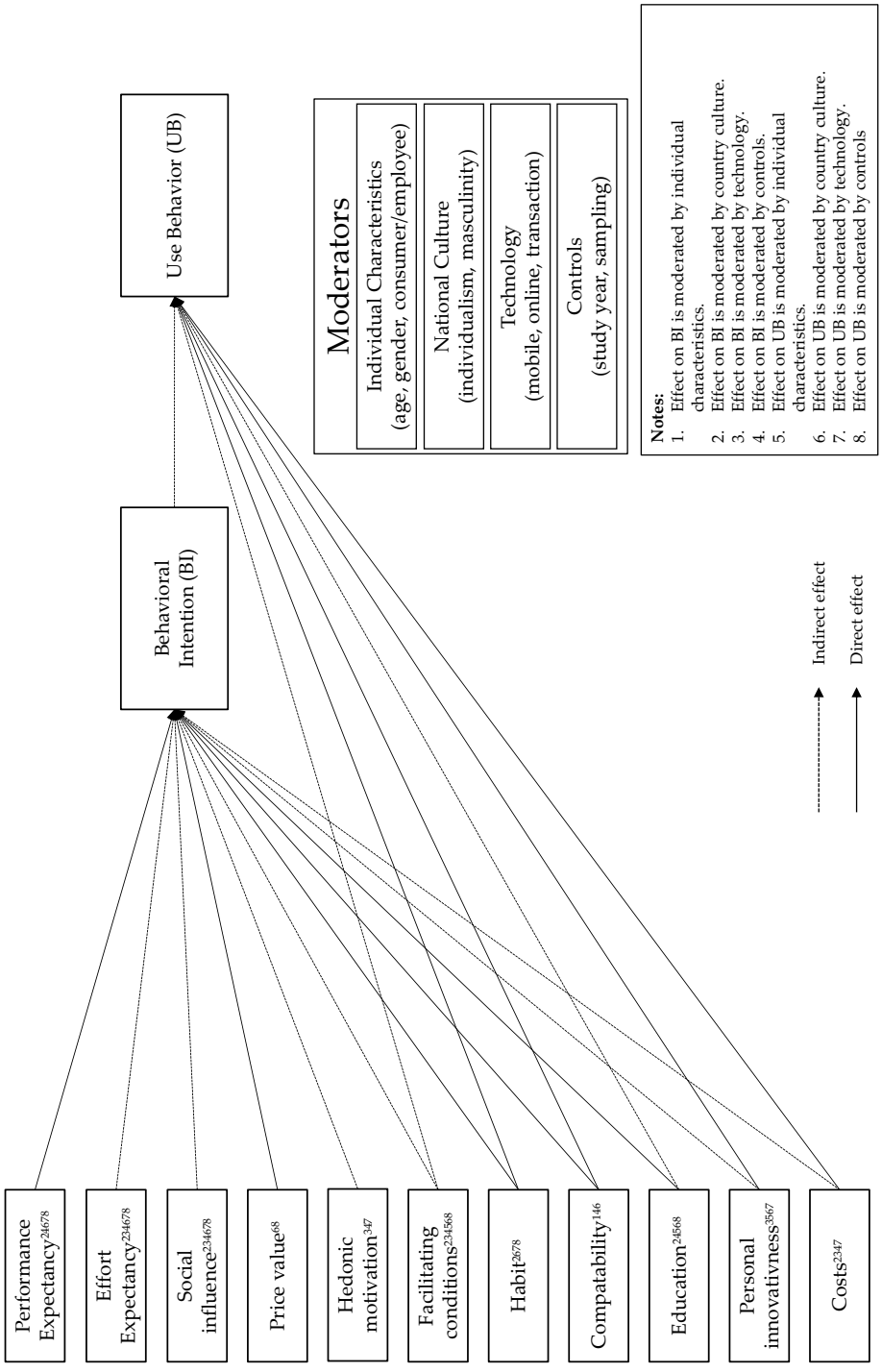
The most recent major expansion of the UTAUT model in which Venkatesh was involved took place in 2022 in the form of a meta-analysis. For this, 25,619 influencing variables from 1,935 independent samples were analysed, in which a total of 737,112 users participated. The aim was to enhance the variance clarification provided by UTAUT1 and UTAUT2. The new model should also be applicable to both corporate and consumer contexts (Blut et al., 2022, p. 13).

Compared to the UTAUT 2, four new predictors of "compatibility", "education", "personal innovativeness" and "costs" as well as four moderator categories were added. The first moderator category contains individual characteristics about the respondent, which are already known from UTAUT 2 (Blut et al., 2022, p. 26 f.). The second category deals with whether the national culture is individualistic or collectivistic, as this can have an influence on the answers of the respondents, especially when country comparisons are made (Blut et al., 2022, p. 28 f.; Hofstede, 2001). The third moderator category asks which technology characteristics are relevant from the respondents' point of view and how respondents assess various technology types. Blut et al. (2022, p. 34 f.) identified three different technology types for the research context of the internet, namely transactional and non-transactional technologies, internet and non-internet technologies, and mobile and non-mobile technologies. The fourth moderator category was used as a control or dummy variable within the meta-study and provided information about the study year and sample size (Blut et al., 2022, p. 42).

As before, UTAUT 3 must also face criticism for being a complex model due to its large number of predictors and moderators. However, this is offset by the advantages that not only is a country comparison and/or cultural comparison possible, but also various moderating technological aspects and their influence on the predictors can be considered (Blut et al., 2022, p. 64 ff.).

Figure 29 below shows UTAUT 3, as a result of the meta-analysis and synthesis of various extensions within the UTAUT research:

Figure 29: UTAUT 3



Source: Own illustration based on (Blut et al., 2022, p. 70)

3.3.3 Adapt: Final adjustment and supplementation of UTAUT 3 with the missing determinants from Wicki et al.

Based on the explanations in the two previous chapters and the selection of UTAUT 3 as the research model on which further research is based, the final adjustments and additions to the still open assignments of the determinants from the research by Wicki et al. are made in this chapter.

As proposed by Venkatesh et al. 2016, the determinant category of **technical determinants** (motor power, driving range, reliability and charging time) determined by Wicki et al. is incorporated into the research model as a dimension of the context of the "electromobility" technology as the moderating category of "technology characteristics" with the electric vehicle-specific variables of motor power, driving range and charging time (Meuter et al., 2005; Venkatesh, Thong, et al., 2016; Wicki et al., 2022). The "Technology" category is included in accordance with the definition in UTAUT 3 (Blut et al., 2022, p. 34 ff.).

The determinant "Reliability" is not included in the "technology" category, as it is not yet a context-based variable based on the above explanations, but represents a fundamental requirement for a vehicle as a key influencing factor (Jensen et al., 2013; She et al., 2017). Reliability is defined as "the degree to which the system is dependable over time" (B. Kim & Han, 2011).

Based on existing research, reliability can be used as a directly influencing variable of intention to use (Berkeley et al., 2018; Egbue & Long, 2012; Hackbarth & Madlener, 2013; Hilale & Chakor, 2024; Mabit & Fosgerau, 2011; She et al., 2017). The influence of moderating categories is explained in the next chapter.

Based on the statements by Venkatesh et al. that more context-based effects should be used in the UTAUT, the category of **contextual determinan**ts (market availability, charging availability, environmental impact and policy and incentives), as already named by Wicki et al., is included in the research model as a supplementary moderating category (Borrero et al., 2014; Venkatesh, Thong, et al., 2016; Wicki et al., 2022). The effects on the independent variables are assumed to be analogous to those of the "technology" category (Blut et al., 2022, p. 60 ff.; Im et al., 2008).

The determinant category of **cost determinants** (purchase price, operational costs, fuel efficiency and resale value) determined by Wicki et al. is assigned to the two variables of "price value" from UTAUT 2 and "costs" from UTAUT 3 following the allocation already explained (Blut et al., 2022; Venkatesh et al., 2012; Wicki et al., 2022).

Not only individual determinants (demographic), but also situational determinants (sociographic) from the personal living environment of the respondents have a moderating influence on the independent variables of the UTAUT 3 model (Blut et al., 2022; Kotler & Keller, 2016, pp. 179–187; Venkatesh, Thong, et al., 2016). Based on this consideration, the determinant categories, as determined by Wicki et al., and the determinants of income, education, age, and gender, as well as the two determinants of travel demand and vehicles per household from the attitudinal and behavioural determinants category, will be assigned to two new moderating categories. One category will focus on individual or person-related determinants, whereas the other moderating category will focus on situational determinants from the respondents' personal living environment (Calmbach et al., 2024; Calmbach & Hecht, 2024; Kotler & Keller, 2016, p. 179 ff.; Rutschmann, 2019). The determinants of age, gender, daily travel demand in km, occupation/job and education can then be assigned to the category of individual characteristics. It should be mentioned here that the determinants of occupation/job and EV driving experience are newly included in this category based on existing research. As explained in the previous chapter, the education determinant is used as a moderating variable, not as an independent variable, as postulated in the UTAUT 3 model by Blut et al. Additionally, the travel demand is also attributed to the individual determinant category. In addition, the category of situational determinants includes the following determinants: household size, household income, vehicles per household, types of vehicles in the household, and available charging opportunities. The latter four determinants were supplemented with existing research to obtain a better understanding of the living conditions of the test subjects. The influence of both categories is assumed according to the moderation defined by Blut et al. from UTAUT 3 (Blut et al., 2022, p. 51 ff.; Buhmann & Criado, 2023; Carley et al., 2013; Chattopadhyay Mukherjee & Ryan, 2020; Hackbarth & Madlener, 2013; Hess et al., 2012; Hidrue et al., 2011; C. Lee et

al., 2020; Mehdizadeh et al., 2023; Sovacool et al., 2018; Trommer et al., 2015; Wicki et al., 2022).

The remaining two determinants of environmental attitudes and technology affinity from the a**ttitudinal and behavioural determinants** category can be understood as attitude variables. In this specific case, this means the attitude towards the environment and technology in the context of electromobility. Ajzen and Fishbein defined the attitude variable in the TRA as early as 1975 as "an individual's positive or negative feelings (evaluative affect) about performing the targeted behaviour" (Fishbein & Ajzen, 1975). Accordingly, a positive attitude towards EVs is assumed to result in an increased willingness to buy (Carley et al., 2013; Hidrue et al., 2011; Jensen et al., 2013; Wicki et al., 2022, pp. 76–77). Accordingly, the variable is included as a determinant in the research model under the name of "attitude towards environment and technology" (F. Davis, 1989; Walter & Abendroth, 2020; N. Wang et al., 2022).

The determinants of knowledge and familiarity of the **BEV-specific experience** category are assigned to the experience variable from TAM 2 in accordance with the above explanation. Furthermore, experience is used as a moderating determinant category in the further research model, to which the two original determinants of knowledge and familiarity are still inherent (Bühler et al., 2014; Burgess et al., 2013; Egbue & Long, 2012; Graham-Rowe et al., 2012; Jensen et al., 2013; Meuter et al., 2005; Peters & Dütschke, 2014; Plötz et al., 2014; Schmalfuß et al., 2017; Wicki et al., 2022). The moderating influences on the independent variables are adopted according to UTAUT 2, and an adjustment to the research model is made for UTAUT 3 in the next chapter (Blut et al., 2022; K. Dudenhöffer, 2015; Fazel, 2014; Venkatesh et al., 2012; Venkatesh & Davis, 2000).

Finally, the determinant category of **social determinants** (Norms, Neighbourhood and Word-of-mouth) determined by Wicki et al. is assigned to the Social influence variable from UTAUT 1 in accordance with the assignment already explained and thus included in the model (Axsen & Kurani, 2013; M. Barth et al., 2016; Blut et al., 2022; Kotler & Keller, 2016, pp. 181–183; Venkatesh et al., 2003; Wicki et al., 2022).

Table 19 summarises the previously explained assignments and final adaptations concerning use in the research model; specific extensions of the determinants identified by Wicki et al. can be found at the end of the table:

Table 19: Status of sorting after final adaptation

Determinant category	Determinant	Final mapping and adaption (if necessary)	To be used as Variable (V) / Moderator (M)
Technical determinants	Motor power	Will be kept in moderating category "Technology" of UTAUT 3.	M
	Driving range	Will be kept in moderating category "Technology" of UTAUT 3.	M
	Reliability	Is detached from the moderating category "Technology" and assigned to the construct Reliability as a directly influencing variable.	V
	Charging time	Will be kept in moderating category "Technology" of UTAUT 3.	M
Contextual determinants	Market availability	A new category called "Contextual determinants" is created to group the four determinants into a moderating category.	M
	Charging availability		M
	Environmental impact		M
	Policy & incentives		M
Cost determinants	Purchase price	Mapped to "Price value", first used in UTAUT 2.	V
	Operational costs	Mapped to "Costs", first used in UTAUT 3.	V
	Fuel efficiency	Mapped to "Costs", first used in UTAUT 3.	V
	Resale value	Mapped to "Price value", first used in UTAUT 2.	V
Sociodemographic determinants	Income	This variable is transferred to the moderating category of "Situational determinants" as "Household income".	M
	Education	These variables are kept as moderating determinats in the category "Individual Characteristics".	M
	Gender		M
	Age		M
Determinants of individual attitudes and behavior	Travel demand	The determinant "Travel demand" is transferred to the category of "Individual Characteristics" and will be named "Daily travel demand in km".	M
	Vehicles per household	A new moderating category "Situational determinants" is created to reflect important situational factors of the respondents around life & household situation. The determinant "Vehicles per household" is added as "Number of vehicles per household".	M
	Environmental attitudes	The variable "attitude" will be added to the model as following "Attitude towards Environment & Technology".	V
	Technology affinity		V
Determinants of BEV-specific experience	Knowledge	Mapped to moderating construct of "Experience", first used in TAM 2.	M
	Familiarity		M
Social determinants	Norms	Mapped to "Social influence", first used in UTAUT 1.	V
	Neighbourhood	Mapped to "Social influence", first used in UTAUT 1.	V
	Word-of-mouth	Mapped to "Social influence", first used in UTAUT 1.	V
Model-extending Determinants	Occupation/ Job	Added as moderating determant to the category of "Individual Characteristics".	M
	Household size	Added as moderating determant to the category of "Situational determinants" as "Household size".	M
	EV driving experience	Added as moderating determant to the category of "Individual Characteristics".	M
	Types of vehicles in household	Added as moderating determant to the category of "Situational determinants" as "Types of vehicles in household".	M
	Available charging opportunity in household or neighbourhood	Added as moderating determant to the category of "Situational determinants" as "Charging opportunity".	M

Source: Own illustration

3.3.3.1 Trust as driver of acceptance?!

Passenger cars are currently widespread and one of the most widely used means of personal transport. To achieve the specified climate targets and mitigate harmful greenhouse gas emissions, EVs are considered a proven solution, particularly in reducing local greenhouse gas emissions. The number of new EV registrations in Germany reached its highest level to date in 2023. Nevertheless, the registration figures for BEVs in 2024 also slumped just as sharply, or, from a different perspective, consumers made a paradigm shift and bought more HEVs and HPEVs again, rather than an above-average number of BEVs, as in the previous year (see Chapter 2.1.2.3). It can be deduced from this that the situation in Germany is not safe enough for customers to want to rely fully on an EV for their individual transport needs. The reasons for this may be manifold: the discontinuation of state subsidies, accompanied by higher entry prices for electric mobility; the lower range of EVs in some cases; or the lack of a charging network in Germany, including charging speed (see Chapter 2.1.2.4). If this approach is taken further, it can be recognised that trust in a technology can help to resolve the complexity that consumers face in the purchasing decision process.

In their research on UTAUT 3, Blut et al. investigated **trust** as an influencing determinant of behavioural intention and usage. However, unlike McKnight et al. 2009 or Hilale & Chakor 2024, Blut et al. did not conclude that trust in a technology is a valid concept if the associated dependent and related characteristics allow/justify it (Blut et al., 2022; Hilale & Chakor, 2024, p. 2; H. McKnight et al., 2009).

Trust in a technology is defined as "a willingness to depend on the specific technology in a given situation in which negative consequences are possible" (H. McKnight et al., 2009, p. 5). Trust is created through mutual dependencies and risks. Dependencies are characterised by the fact that one party cannot achieve its interests and goals without having to rely on another party (Rousseau et al., 1998). On the other hand, there are the risks that arise for the user-provider if the user does not ensure trustworthy behaviour in connection with use (H. McKnight et al., 2009; Rousseau et al., 1998).

In research, there are two ways in which trust can be conceptualised. On the one hand, trust has been integrated as an independent variable in the established

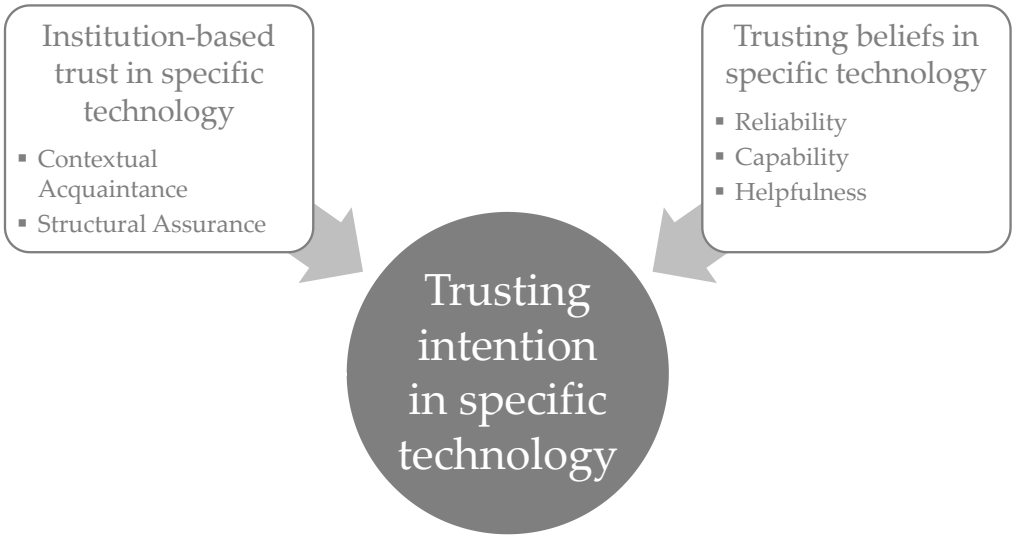
TRA, TAM, UTAUT 1 and UTAUT 2 models. Most research has proven the positive significant influence of trust on the dependent variables (Al-Sabaawi et al., 2023; Al-Saedi et al., 2020; Arora et al., 2023; Chen et al., 2021; de Blanes Sebastián et al., 2023; Jena, 2023; Merhi et al., 2019; Mohd Thas Thaker et al., 2023; Musyaffi et al., 2021; Nur & Panggabean, 2021; Patil et al., 2020; Rousseau et al., 1998; Subasinghe et al., 2020; Sudirjo et al., 2023; Tomić et al., 2023; Zaid Kilani et al., 2023).

On the other hand, trust can also be introduced into acceptance research through a more complex approach that involves an interplay of several constructs. The existing literature favours the latter approach as it provides more practical insights into which constructs influence trust in a technology (Ashrafi et al., 2022; Chakraborty et al., 2022; Franque et al., 2023; Lian & Li, 2021; X. Lin et al., 2022; Lisana & Handarkho, 2023; Nangin et al., 2020; Shao et al., 2019; Stewart & Jürjens, 2018; Talwar et al., 2020; W. Zhang et al., 2023).

McKnight et al. also follow the second approach and state that the distinction between trusting intentions and trusting beliefs follows the defined typology of Ajzen & Fishbein, which divides the constructs into beliefs, attitudes, intentions and behaviours (Fishbein & Ajzen, 1975; D. H. McKnight et al., 1998). Following this approach, further research focuses on the influence of the cognitive aspects of trust on actual behaviour (Hilale & Chakor, 2024, p. 3).

According to the research by McKnight et al., trust intentions are influenced by trusting beliefs and institutional trust in technology. In this context, it is necessary to mention that the focus of this research is on trust in technology (specifically electromobility). In this context, McKnight et al. have identified three key constructs for trust in certain technologies: helpfulness, functionality (capability) and reliability (H. McKnight et al., 2009). Figure 30 shows the relationships between technology-related constructs of trust:

Figure 30: Trusting intentions



Source: Own illustration based on (H. McKnight et al., 2009)

The constructs named in Figure 30 are defined as follows:

Table 20: Concept and construct definitions of trust in technology

Construct	Definition
Reliability	The belief that the specific technology will consistently operate properly (D. McKnight & Chervany, 2002).
Functionality	The belief that the specific technology has the capability, functionality, or features to do for one what one needs to be done (Mayer et al., 1995; D. McKnight & Chervany, 2002).
Helpfulness	The belief that the specific technology provides adequate and responsive help for users (Mayer et al., 1995; D. McKnight & Chervany, 2002).
Trusting intention	A willingness to depend on the specific technology in a given situation in which negative consequences are possible (Mayer et al., 1995; D. H. McKnight et al., 1998).
Situational normality	The belief that success with the specific technology is likely because one feels comfortable or favourable when one uses the general type of technology of which this specific technology is an instance (D. H. McKnight et al., 1998).
Structural assurances	The belief that success with the specific technology is likely because, regardless of the characteristics of the specific technology, one believes structural conditions like guarantees, contracts, support, or other safeguards exist in the general type of technology that make success likely (D. H. McKnight et al., 1998).

Source: Own illustration based on (H. McKnight et al., 2009)

Many of the studies cited above have attempted to include individual constructs of trust in their research. Among other things, attempts were made to incentivise the use of a technology through cost reductions or promotional measures (Lisana & Handarkho, 2023; Shao et al., 2019; Stewart & Jürjens, 2018). However, none of the studies simultaneously examined all three key constructs in a technology (reliability, functionality, helpfulness) and the two constructs in institutional trust (situational normality, structural assurances) together (Hilale & Chakor, 2024, p. 8). However, based on Lewis and Weigert's explanations, these constructs are inextricably linked, and the omission or exclusion of one aspect can lead to misunderstandings and misinterpretations, so that trust in a technology is confused with belief or prediction (Lewis & Weigert, 1985, p. 972).

The integration of the aforementioned constructs of trust is based on the model proposal by Hilale & Chakor (2024). On the one hand, existing constructs of UTAUT 2 were harmonised with the constructs of trust or constructs were added to the model.

First, the **trusting intention in electromobility** construct is added as a dependent construct to the previously presented trust constructs (reliability, functionality, helpfulness, situational normality and structural assurances) of this research work. This is justified by the fact that consumers are prepared to take a risk if they have sufficient trust in a technology to adopt it. This means that trust in a technology reduces the perceived risk and has a positive influence on consumers' behavioural intention (Merhi et al., 2019). In other words, a lack of trust leads to an increased perceived risk, and consumers opt for a safer technology alternative with which they are familiar (Nur & Panggabean, 2021).

In addition, numerous studies have investigated the influence of trust on behavioural intention (Arora et al., 2023; Hammouri et al., 2023; Jena, 2023; X. Lin et al., 2022; Mohd Thas Thaker et al., 2023; Nur & Panggabean, 2021; Sudirjo et al., 2023; Tomić et al., 2023)as well as on the actual utilisation (Al-Sabaawi et al., 2023; Chakraborty et al., 2022; Lian & Li, 2021; Zaid Kilani et al., 2023)so that this influence is also assumed in this research.

Based on the assumption that performance expectancy reflects the benefits and features that the customer needs when using an EV, this corresponds to the concept and definition of the construct of **functionality**, trust in a particular

technology. Accordingly, it can be deduced that the higher the expected performance expectancy of a technology, the greater the willingness to trust it (Hilale & Chakor, 2024, pp. 10–11; H. McKnight et al., 2009). The above derivation also applies to the construct of effort expectancy. The performance of a technology is measured by how easy it is to use. It is therefore deduced that the belief in the capabilities of a technology can be measured by effort expectancy and performance expectancy (Hilale & Chakor, 2024, p. 12). Accordingly, the construct of functionality, comprising performance expectancy and effort expectancy, influences trusting intention in electromobility.

Facilitating conditions describes how helpful a technology can be to consumers in satisfying their needs. Accordingly, it can be assumed that trust in a technology increases if it is perceived as helpful by the consumer (Hilale & Chakor, 2024, p. 12; H. McKnight et al., 2009). Accordingly, the facilitating conditions can be considered synonymous with the previously defined construct helpfulness. Accordingly, the **helpfulness** construct affects trusting intention in electromobility.

The previously mentioned construct of **reliability** is described as a feeling that conveys reliability and consistency to the user in connection with the use of a technology. To analyse not only the reliability of the technology, but also the reliability of the various stakeholders associated with it, is also examined. It becomes clear that the two definitions of the construct of reliability used are congruently defined (B. Kim & Han, 2011; D. McKnight & Chervany, 2002). Previous studies have focused on the reliability of the various stakeholders, but not on the reliability of the technology. As a result of the above, the need to investigate not only the effect of reliability on trusting intention in electromobility, but also on the intention to use electromobility becomes clear (Berkeley et al., 2018; Egbue & Long, 2012; Hackbarth & Madlener, 2013; Hilale & Chakor, 2024; Mabit & Fosgerau, 2011; She et al., 2017).

The construct situational normality refers to the feeling that something new in a similar situation can also be trusted if the situation appears normal, orderly, or favourable (H. McKnight et al., 2009). Confirming this, Gefen et al. (2003, p. 51 ff.) argue that people are more willing to trust if they perceive an interaction as typical or expectable.

The construct familiarity is not dissimilar to the construct situational normality. However, the latter differs from situational normality in that it measures the degree of knowledge the consumer has about the specific type of vehicle they drive (Gefen, 2000; D. J. Kim et al., 2008).

A closer look at the context of electromobility reveals that the transition between situational normality and familiarity is a fluid one. In electromobility, a clear distinction can be made between a positive feeling that things are going well when the consumer buys an EV or participates in individual passenger transport in an EV (situational normality) and a good understanding of electromobility (familiarity). The reason for this is that EVs do not work in the same way; they differ in terms of design, drive power or individual functions. With regard to electromobility, the focus is not on a specific type of EV, but on the general drive options available on the market. If a consumer is already familiar with EVs, this means they have already familiarised themselves with the electrified drive, which works in the same way in other EVs. Its use can be regarded as universal. Based on the above, it is proposed that the two constructs (situational normality and familiarity) be summarised in the construct of **contextual acquaintance**. This construct is thus able to measure the extent to which consumers feel comfortable when driving EVs, as they can recognise a situation perceived as normal that has arisen through familiarity and experience in using EVs. When a consumer feels comfortable and perceives a situation as normal, this reflects a combination of familiarity and situational normality (Hilale & Chakor, 2024, p. 13). Finally, it is worth noting that the construct of contextual acquaintance differs from that of consumer awareness, as consumer awareness only examines the general knowledge of consumers about a technology at the beginning of innovation diffusion (Rogers, 2003). Contextual acquaintance, on the other hand, refers to an advanced stage of technology diffusion in which some consumers have already had direct experience with electromobility (Hilale & Chakor, 2024, p. 13). Accordingly, it can be assumed that the higher the contextual acquaintance of electromobility, the stronger the intention to use and willingness to adopt electromobility.

The second component of institution-based trust in technology is the **structural assurance** construct. This construct refers to the consumer's belief that adequate support, in terms of infrastructure and other supporting technology, is

available to ensure successful utilisation of the technology, in this case electric mobility (H. McKnight et al., 2009).

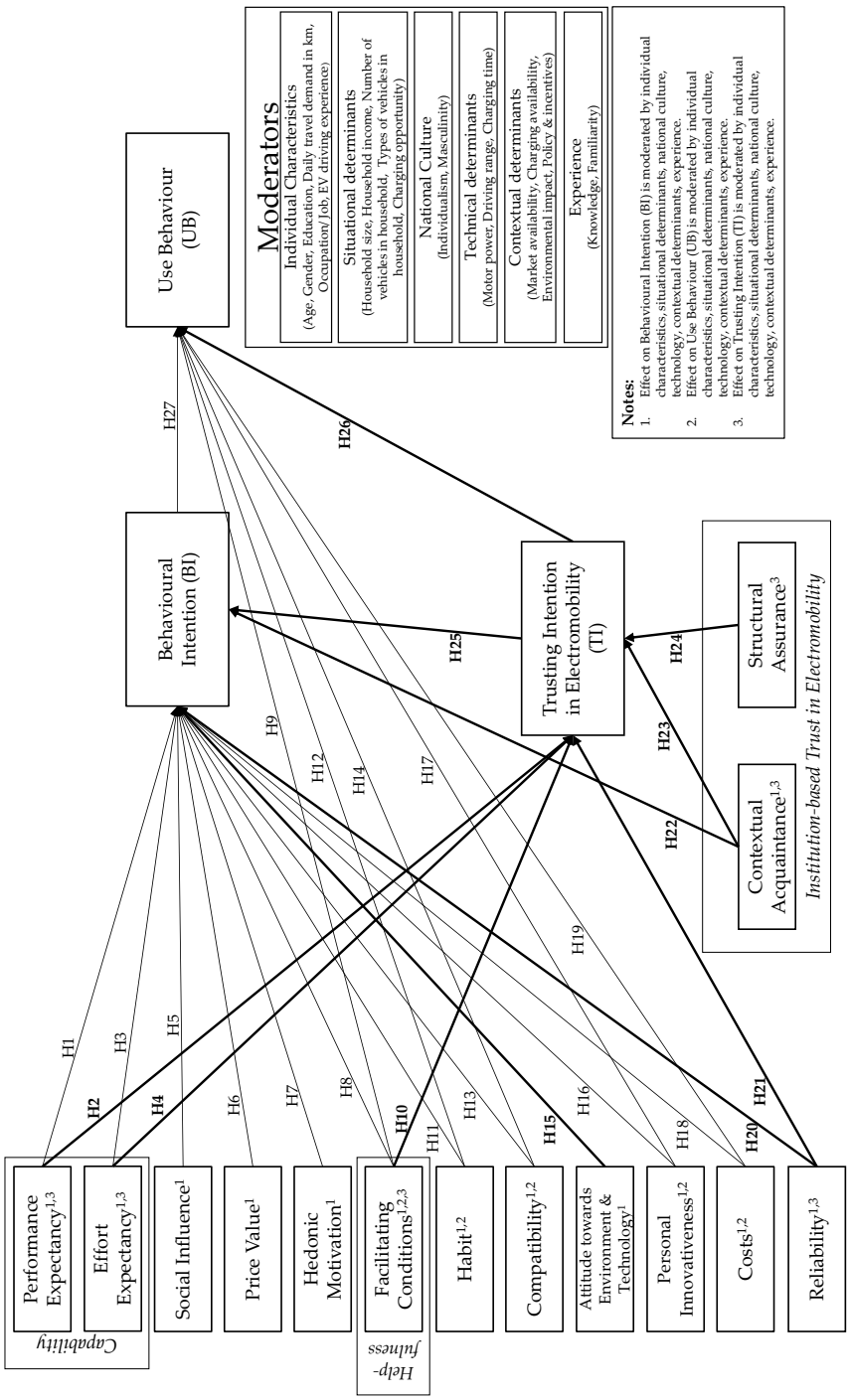
The construct operates at both a legal level (e.g., vehicle tax exemption until 2030) and a physical level (e.g., free charging facilities, charging point coverage, etc.). Structural security yields benefits for consumers through technology-dependent mechanisms that facilitate adaptation and/or protect them from harm (Hilale & Chakor, 2024, p. 13). Various legal measures have been introduced by the German federal government to support the adoption of EVs (cf. Chapter 2.2.6). A central component of structural safety is the formation of trust (X. Lin et al., 2022; R. Wu et al., 2021). Furthermore, there is also the synonymous use of consumer perception of security and reliability of institutional structures (T. Zhou, 2011).

The influences and determinants of trust explained above are included and integrated into the research model as supplementary determinants. The additions are possible without any problems, as the initial constructs of the UTAUT, already defined by Hilale and Chakor, were also used in UTAUT 3 by Blut et al. (Hilale & Chakor, 2024, p. 12).

3.3.4 Set-up: Setting up the research model, formulating hypotheses and summarising the research project

Figure 31 presents the adapted research model for investigating the acceptance of EVs. The research model is essentially based on UTAUT 3 and was expanded using the determinants identified by Wicki et al. 2022 (Blut et al., 2022; Wicki et al., 2022). In addition, this work will investigate the construct of trusting intention in electromobility, along with the associated influencing determinants for the use of this technology (Hilale & Chakor, 2024; H. McKnight et al., 2009). The thickly marked arrows emphasise additional influencing mechanisms in comparison to UTAUT 3.

Figure 31: Research model



Source: Own illustration

3.3.4.1 Model variables

The individual model components are explained below and the corresponding hypotheses are formulated. Although the model parameters have already been explained in previous chapters, they are briefly presented again here to emphasise their specific relation to electric mobility technology in the context of this research.

Performance expectancy

Performance expectancy (PE) is a concept that describes the extent to which a person believes that a particular technology or system will improve work performance or efficiency. It is one of the components of the UTAUT model, indicating the perceived advantages or benefits of a technology for the user. High-performance expectancy means that the technology enables the user to work on a task more efficiently, faster or better. Studies on technology acceptance have shown that PE is one of the strongest predictors of the intention to use a technology (Adnan et al., 2017; Kapser & Abdelrahman, 2020; Patil et al., 2020; Venkatesh et al., 2003). This allows the following hypothesis to be formulated:

H1: Performance expectancy has a positive influence on behavioural intention (BI) to use EVs.

In the present research model, performance expectancy further defines the expectation of users that the electromobility technology will effectively fulfil their requirements and needs. From the perspective of the Trusting Intentions in Electromobility construct, this implies that users' trust level is higher when they are certain that EVs are powerful and beneficial (Hilale & Chakor, 2024, p. 10 f.; Mayer et al., 1995; D. McKnight & Chervany, 2002; H. McKnight et al., 2009). The following hypothesis can be formulated:

H2: Performance expectancy has a positive influence on the trusting intention in electric mobility (TI) to use EVs.

Effort expectancy

Effort expectancy is the degree of ease with which a person believes they can use a particular technology product or system. It is a central construct in the UTAUT model, describing the user experience of how easy it is to access and use the technology. In essence, "simplicity" is the definition of effort expectancy and

refers to how the user experience and offering of a system or technology is intuitive and easy to understand or use. Effort expectancy has also emerged as an important predictor in the early stages of technology adoption, particularly for new systems or less tech-savvy audiences when analysing technology usage (Kumar Jain et al., 2022, p. 3; Venkatesh et al., 2003, p. 450). The following hypothesis can therefore be formulated:

H3: Effort expectancy has a positive influence on the behavioural intention (BI) to use EVs.

Effort expectancy, like performance expectancy, has an influence on the trusting intention in Electromobility. Easy-to-use and intuitive user experiences strengthen users' trust in electromobility technology. The perception that EVs and the associated charging infrastructure are user-friendly and easy to use promotes users' willingness to trust the system (Hilale & Chakor, 2024, p. 10 f.; Mayer et al., 1995; D. McKnight & Chervany, 2002; H. McKnight et al., 2009). The following hypothesis can therefore be formulated:

H4: Effort expectancy has a positive influence on the trusting intention in electromobility (TI) to use EVs.

Social influence

Social influence refers to the effect of the social environment on a person's decisions and behaviour. This environment includes family, friends, colleagues or social opinion leaders. In technology acceptance research, social influence refers to the extent to which a person's general or personal social environment expects or recommends that they use a system (Venkatesh et al., 2003, p. 451). For example, social influence on the acceptance of electromobility means that potential users are more likely to use EVs if members of their circle approve of or are receptive to such vehicles. This will also increase interest and acceptance if the users' social environment uses EVs themselves or at least approves of their use (Almansour, 2022; Fedorko et al., 2021; Hardman et al., 2018; Kapser & Abdelrahman, 2020; Kumar Jain et al., 2022; Patil et al., 2020; Tsu Wei et al., 2009). The following hypothesis is put forward:

H5: Social influence has a positive influence on behavioural intention (BI) to use EVs.

Price value

Price value refers to the perceived benefit of a technology relative to the cost of acquiring and utilising it. It is a balance between the perceived value or benefit and the price paid for it. A positive price value occurs when users feel that the value of the technology or benefit justifies the financial outlay (Dodds et al., 1991; Goldsmith et al., 2005; Venkatesh et al., 2003). In the case of electromobility, price value refers to whether potential users perceive the electric car as justified in terms of price. They might proceed with the technology if the purchase is actually cheaper, among other benefits such as environmental friendliness and lower energy costs, or if it is a long-term investment. Users often buy when the perceived benefits justify a higher price (Adnan et al., 2017; Goularte & Zilber, 2019; Han et al., 2017; Venkatesh et al., 2012). The following hypothesis can be formulated:

H6: Price value has a positive influence on behavioural intention (BI) to use EVs.

Hedonic motivation

Specifically, hedonic motivation categorises the joy or pleasure experienced while using a technology. It describes the emotional benefit or positive experience that people experience when using a technology, regardless of functional or practical benefits (Venkatesh et al., 2012). In the case of electromobility, this concept could be applied if driving is perceived as exciting, modern or enjoyable. Silent driving, acceleration dynamics or the feeling of making a green choice involves hedonic motivation and could therefore increase the willingness to buy and regular use of EVs (Han et al., 2017; Kapser & Abdelrahman, 2020; M. Zhou et al., 2021). The following hypothesis is put forward:

H7: Hedonic motivation has a positive influence on behavioural intention (BI) to use EVs.

Facilitating conditions

Facilitating conditions are external factors that encourage, facilitate and enable the use and adoption of a technology. These factors, such as resources and technological enablers, allow the user to utilise certain technologies without difficulty (Venkatesh et al., 2012). Examples of facilitating conditions in the field of electromobility include charging stations, financial support, and providing information and advice to users. If the relevant conditions are met, the acceptance

and user share of EVs increases (Azman Ong et al., 2023; Dhinakaran et al., 2021; Goularte & Zilber, 2019). The following hypotheses can be formulated:

H8: Facilitating conditions have a positive influence on the behavioural intention (BI) to use EVs.

H9: Facilitating conditions have a direct positive influence on the use behaviour (UB) of EVs.

Facilitating conditions, i.e., the supporting framework conditions such as charging infrastructure, access to technical information, and the availability of support systems, have a positive effect on the trusting intention in electric mobility. Users build trust in a new technology if they perceive that the necessary conditions have been created for its successful utilisation (Mayer et al., 1995; D. McKnight & Chervany, 2002; H. McKnight et al., 2009). In the case of electric mobility, this means that factors such as a well-developed charging infrastructure, technical support and relevant resources (e.g. information on range and charging technology) can increase confidence in the technology. People feel more willing to switch to EVs if they can be sure that barriers to use are minimised and support is available when needed. Easier conditions reduce uncertainty and increase acceptance by strengthening the perception that EVs are a reliable alternative to conventional drives (Hilale & Chakor, 2024). The following hypothesis is put forward:

H10: Facilitating conditions have a positive influence on the trusting intention in electromobility (TI) to use EVs.

Habit

Habits are the tendency of a person to perform certain actions automatically and without much conscious thought, based on repeated experience. Habits are formed by regularly performing a behaviour in a stable environment so that it becomes routine. This means that when a certain behaviour becomes established, it becomes a habitual response to specific stimuli and is less dependent on a conscious decision (Venkatesh et al., 2012). In relation to electric mobility, habit refers to the extent to which users perceive driving or charging an EV as a natural part of their daily lives. A strong habit of using an EV could be maintained through repeated use, regular charging routines and an overall positive user experience. Habits are crucial for the long-term success of electric mobility as they reduce

uncertainty and the need for conscious decision-making (Azman Ong et al., 2023; Goularte & Zilber, 2019; M. Zhou et al., 2021).

H11: Habit has a positive influence on the behavioural intention (BI) to use EVs.

H12: Habit has a direct positive influence on the use behaviour (UB) for the use of EVs.

Compatibility

In the field of technology acceptance research, the term "compatibility" refers to the extent to which a new technology can be harmonised with the values, needs and previous experiences of users. A technology is considered compatible if the level can be integrated into the lifestyle of service users without forcing them to change their behaviour significantly. The higher the compatibility, the more likely users are to adopt and use a technology (Blut et al. (Blut et al., 2022; Jansson, 2011; Meuter et al., 2005; G. C. Moore & Benbasat, 1991). In the context of EVs, "compatibility" refers to how well EVs integrate into consumers' daily routines and values. Factors such as the number of chargers, the charging speed, the distance travelled, and the environmental friendliness of a car all influence perceived compatibility. For example, if driving style and infrastructure adoption are oriented towards the features offered by an electric car, the technology should be appropriate. A high degree of compatibility can significantly increase the likelihood of purchasing an electric car (Chong et al., 2012).

H13: Compatibility has a positive influence on the behavioural intention (BI) to use EVs.

H14: Compatibility has a direct positive influence on the use behaviour (UB) for the use of EVs.

Attitude towards the environment and technology

Attitude towards the environment and technology is the fundamental, often stable personal attitude of a person towards the environment and technological developments. It contains positive or negative judgements about the reasonableness of technological solutions such as EVs, the perceived environmental friendliness of their use and their compatibility with a person's value system. This attitude influences the perception of whether new technologies

should be viewed as tools for a sustainable future (Fishbein & Ajzen, 1975). In the field of electromobility, attitudes towards the environment and technology are decisive for the acceptance and intention to use EVs. People with a positive attitude towards environmentally friendly technologies develop purchase or usage intentions to recognise EVs as a contribution to environmental protection. They often view driving as one of the ways to reduce large amounts of carbon footprint and actively impact the environment. On the contrary, a negative attitude towards technological innovations or scepticism about the environmental benefits of EVs could reduce the acceptance of these vehicles. Therefore, attitudes towards environmental and technological issues are an important variable in models of technology acceptance to explain trust and behaviour in relation to their use(Carley et al., 2013; Hidrue et al., 2011; Jensen et al., 2013; Wicki et al., 2022, p. 76 f.). The following hypothesis is put forward:

H15: A positive technological and environmental attitude significantly increases the behavioural intention (BI) to use EVs.

Personal innovativeness

Personal innovativeness refers to an individual's tendency to adopt and try out new technologies and innovations at an early stage. It is a person's willingness to take risks and embrace even less established technologies. People who demonstrate a high degree of personal innovativeness show curiosity, a willingness to experiment and openness towards new technologies (Agarwal & Karahanna, 2000; Blut et al., 2022; Jansson, 2011; Parasuraman, 2000). In terms of electromobility, this means that people with a high level of innovativeness are more willing to accept and use EVs as an alternative to combustion engines. They showed curiosity about the benefits and fields of application, including environmentally friendly mobility and access to modern features such as autonomous driving and charging infrastructure. As EVs still cause concerns, including range and charging time, high personal innovativeness positively influences adoption. Individuals with high personal innovativeness could therefore play a pioneering role during the transition to electric mobility and increase indirect acceptance through their experiences (Agarwal & Prasad, 1998; Fazel, 2014, p. 155 f.; Kuo & Yen, 2009; Kwon et al., 2007). The following hypotheses are put forward:

H16: A high level of personal innovativeness has a positive influence on the behavioural intention (BI) to use EVs.

H17: A high level of personal innovativeness has a direct positive influence on the use behaviour (UB) for the use of EVs.

Costs

In technology acceptance, costs are defined as the perceived financial and non-financial costs associated with the need to pay for the purchase, use, and maintenance of a technology. These include direct financial costs, such as the purchase price and operating costs, as well as indirect costs, including the time, effort, and learning process involved in using the new technology. It is generally assumed that higher perceived costs result in lower acceptance and willingness to use the technology (Blut et al., 2022; L. Zhang et al., 2012). In the field of electromobility, costs are a crucial factor in determining technology acceptance. Accordingly, costs determine the economic attractiveness of the technology. The perception of high costs acts as a deterrent to potential buyers. On the contrary, if the costs are lower or offset by subsidies, electric cars are accepted (Y.-F. Liu et al., 2018; Shuhaiber & Mashal, 2019; Tsu Wei et al., 2009; R. Wang et al., 2021; S. Wang et al., 2017; J.-H. Wu & Wang, 2005). The following hypotheses are formulated:

H18: Perceived high costs have a negative influence on the behavioural intention (BI) to use EVs.

H19: Perceived high costs have a direct negative influence on the actual use behaviour (UB) to use EVs.

Reliability

In technology acceptance research, the term reliability is used to describe the extent to which a technology is consistent, error-free, and functions as expected by the user. A technology is said to be reliable if it is always available and consistently delivers its results in a wide variety of environments and usage variants. Reliability is also a factor in user acceptance; users trust reliable technology and tend to avoid unreliable ones. Reliability of their performance is ultimately an important feature that users can rely on (Blut et al., 2022; D. McKnight & Chervany, 2002). In electromobility, reliability is the factor that positively influences acceptance. Electromobility users must trust that their EV and charging are reliable (B. Kim & Han, 2011; Wixom & Todd, 2005). The following hypothesis is formulated:

H20: A high perceived reliability has a positive influence on the behavioural intention (BI) to use EVs.

The influence of reliability on the trusting intention in electric mobility is direct and positive. The perceived reliability of EVs and the associated infrastructure increases user trust in the technology. It therefore has a positive effect on user acceptance and willingness. As reliability is relevant to the study, it is included in the regression analysis using the hypothesis path mentioned above. Reliability strengthens the trusting intention in electromobility by increasing user confidence and giving them the certainty that EVs will function reliably. Low uncertainty leads to a positive attitude towards the use of the technology, which ultimately fuels its rise and the high level of electromobility (Berkeley et al., 2018; Egbue & Long, 2012; Hackbarth & Madlener, 2013; Hilale & Chakor, 2024; Mabit & Fosgerau, 2011; She et al., 2017). The following hypothesis can be formulated:

H21: High perceived reliability has a positive influence on the trusting intention in electromobility (TI) to use EVs.

Contextual acquaintance

Contextual acquaintance refers to a person's knowledge and familiarity with a particular technology, particularly in terms of its usage situation and the circumstances surrounding it. In the case of the electric car, it refers to the knowledge inherent in the use of an EV, including the charging infrastructure, costs, functionality, and range. The higher the contextual acquaintance, the higher the likelihood that a person will develop a behavioural intention to use an electric car. People who have a high level and quality of information about the use of electric cars are less insecure and more willing to include electric cars in their everyday lives (Gefen, 2000; D. J. Kim et al., 2008; D. H. McKnight et al., 1998). This results in the following hypothesis:

H22: A high level of contextual acquaintance has a positive influence on the behavioural intention (BI) to use EVs.

Trusting intention in electromobility is also positively influenced by contextual acquaintance because if users have the relevant knowledge about how electromobility works and the framework conditions, their uncertainty is reduced and, in turn, their trust in the underlying processes is strengthened. Users trust the technology and its safety more if they know and can assess their own specific

circumstances and challenges. Contextual awareness supports users' expectations of being more realistic and better prepared, thereby reducing the likelihood of unexpected challenges (Hilale & Chakor, 2024; H. McKnight et al., 2009; Rogers, 2003). The following hypothesis is formulated:

H23: A high level of contextual acquaintance has a positive influence on the trusting intention in electromobility (TI) towards EVs.

Structural assurance

Structural assurance refers to trust in the external safety, regulatory and support systems of a technology. It describes the trust in institutional, legal and infrastructural framework conditions that aim to ensure the safe and reliable use of the technology. This includes measures such as a stable charging infrastructure, government funding programmes, regulatory safety standards and a network of maintenance and service centres. These external measures enable and empower the technology and reduce the risk of utilisation (D. H. McKnight et al., 1998; H. McKnight et al., 2009). Regarding electromobility, structural assurance positively influences the intention to trust. This is because users' trust in the technology increases when they know that there are assurance mechanisms such as a well-developed charging infrastructure and government support in the area. In addition, knowing that the government regulates EVs and meet important technological standards, users can better understand the risks and decide that the technology is safe to use (Hilale & Chakor, 2024; X. Lin et al., 2022; R. Wu et al., 2021; T. Zhou, 2011). The following hypothesis can be formulated:

H24: A high level of structural assurance has a positive influence on the trusting intention in electromobility (TI) towards EVs.

Trusting intention in electromobility

Trusting intention refers to the extent to which a person trusts a technology (in this case electromobility) and regards it as safe, reliable and beneficial (Mayer et al., 1995; D. H. McKnight et al., 1998). In relation to electric mobility, the trusting intention describes people's confidence in the safety, reliability, and long-term benefits of the electric car and its infrastructure, i.e., the vehicles themselves, the charging infrastructure, and the maintenance systems. When the trust intention is high, people believe that electric cars will fulfil their mobility needs and will not cause unexpected risks or problems. Trust intention can have a strong effect on

behavioural intention and actual behaviour. When people trust a technology such as electromobility, they are much more likely to accept it, use it and integrate it more easily into their everyday lives (Al-Sabaawi et al., 2023; Arora et al., 2023; Azman Ong et al., 2023; Chakraborty et al., 2022; Hammouri et al., 2023; Jena, 2023; Lian & Li, 2021; X. Lin et al., 2022; Merhi et al., 2019; Nur & Panggabean, 2021; Sudirjo et al., 2023; Tomić et al., 2023; Zaid Kilani et al., 2023). The following hypotheses can therefore be formulated:

H25: A high trusting intention in electromobility has a positive influence on the behavioural intention (BI) to use EVs.

H26: A high trusting intention in electromobility has a positive influence on the actual use behaviour (UB) of EVs.

Behavioural intention

"Behavioural intention implies a person's intention to perform a certain action. Therefore, Behavioural Intention is an important indicator of how likely it is that one's interest in actual usage will or will not be realised. It is an important factor for actual behaviour and usually a powerful predictor of use behaviour (F. D. Davis, 1989; Fishbein & Ajzen, 1975; Venkatesh et al., 2003). In the case of electromobility, this is the use or purchase of an EV. For electromobility, "behavioural intention" refers to the willingness to use or own an EV. A high behavioural intention means that a person is determined to purchase EVs and use them in their everyday life. Behavioural intention is a key predictor of actual use and records whether a person is interested in using their own vehicle (Adnan et al., 2017; Azman Ong et al., 2023; Han et al., 2017; Kumar Jain et al., 2022; M. Zhou et al., 2021). The following hypothesis is formulated:

H27: A high behavioural intention has a positive influence on the actual use behaviour (UB) of EVs.

3.3.4.2 Moderator variables

As can be seen in the research model above, the model contains various constructs that influence behavioural intention (BI), use behaviour (UB) and trusting intention in electromobility (TI) as direct or mediating variables. The mediating effects are only moderated in the first half of the mediation, i.e. from the independent variable to the dependent variable. The second half of the mediation

is not moderated, as the model is based on theoretical considerations from acceptance research, in which moderator variables are typically used to explain differences in the influence of exogenous constructs on intentional or cognitive intermediate variables, whereby the moderation takes place exclusively in the first half of the mediation. In contrast, the second half of the mediation, i.e. the path from the mediator to the dependent final variables such as "use behaviour" or "trusting intention", remains unmoderated (Blut et al., 2022; Venkatesh et al., 2003). In addition, according to McKnight et al. (2009) and Hilale et al. (2024), these relationships are considered to be comparatively stable and less context-sensitive. Furthermore, selective moderation also serves methodological requirements. It prevents the model from being overloaded while maintaining the interpretability of the results (Hilale & Chakor, 2024; H. McKnight et al., 2009).

Furthermore, there are six groups of moderators whose influence on these constructs and the dependent variables will be analysed.

Based on the concept of Blut et al. 2022 to form moderator groups and to adapt and supplement these to the research context based on UTAUT 3, six groups of moderators were identified for this research. These six groups influence the relationship between the research model's constructs and provide a detailed picture of the external and internal factors that can impact the acceptance and use of electromobility (Blut et al., 2022, p. 74). Each individual moderator can contribute to weakening or strengthening the acceptance in the respective context of the users. Based on this holistic, exploratory, and comprehensive modelling study, hypotheses are formulated for each group to identify possible influences in a context without excluding certain constructs beforehand (Creswell & Guetterman, 2018; Venkatesh et al., 2013; Venkatesh, Brown, et al., 2016).

The following section discusses the reasons why it may be reasonable to assume that the constructs affecting behavioural intention, use behaviour and trusting intention in electromobility are moderated by all moderator groups and the variables they contain, and what points should be taken into account when considering this:

- If the hypotheses can be considered exploratory and the model is intended to account for the influence of an extremely wide range of possible individual differences, the holistic approach is important.

- Previous research has demonstrated that some of these moderators have a proven impact on certain constructs. This assumption could be followed up by formulating appropriate hypotheses and focusing on known influences.
- The number of hypotheses that follow from the above consideration cannot be dismissed out of hand. There is a risk of over-modelling the data, where the analysis contains too many potentially misleading interactions. The probability of multicollinearity may increase due to the model's complexity.
- Another aspect, similar to the second consideration, highlights the risk of false-positive results. Due to the number of hypotheses tested, these can statistically lead to effects being shown as significant, even though they are not in reality.
- Another point to consider is practicability, which is determined by the number of moderators, the necessary sample size, and the resulting availability of data. If too many assumptions are made in the aforementioned considerations, this can lead to inconsistent data and less precise results. Accordingly, it may make sense to limit the number of hypotheses by formulating them at moderator group level rather than at individual moderator level.

This study aims to identify the influencing moderators as comprehensively and exploratively as possible. Accordingly, it is plausible that all moderators are analysed concerning a moderating effect. This also makes sense in light of the use of the UTAUT and the large number of moderators identified, as there are few or no previous studies and the present study is the first comprehensive investigation (J. F. Hair et al., 2017, p. 36 ff.; Henseler & Fassott, 2010; Sarstedt et al., 2021, p. 22 ff.; Weiber & Sarstedt, 2021, p. 314 ff.).

The six groups of moderators and the specific moderators assigned to each are briefly explained below and the hypotheses are formulated:

Individual characteristics (IC)

This group contains the demographic factors that can influence the variables in the model. IC takes into account different user characteristics that influence their attitude and trust towards EVs. The following moderators are summarised in the

IC group: age, gender, education, daily travel demand in km, EV driving experience and occupation/job (Blut et al., 2022; Kotler & Keller, 2016, p. 179 ff.; Venkatesh, Thong, et al., 2016).

Influence on behavioural intention (BI)

Various demographic characteristics can cause respondents to react differently to the aforementioned constructs. These include technology affinity, ease of use, social influence and financial conditions. For example, younger users may be more likely to respond to performance claims, and income level has a stronger influence on cost perception (Berkeley et al., 2018; Carley et al., 2013; Hidrue et al., 2011; Hoen & Koetse, 2014; Sovacool, 2017).

H28: The individual characteristics (age, gender, education, income, daily distance travelled, EV driving experience, occupation) moderate the influence of the following constructs on the behavioural intention (BI) to use EVs:

a) Performance expectancy
b) Effort expectancy
c) Social influence
d) Price value
e) Hedonic motivation
f) Facilitating conditions
g) Habit
h) Compatibility
i) Attitude towards the environment and technology
j) Personal innovativeness
k) Costs
l) Contextual acquaintance
m) Reliability

The hypothesis is confirmed if at least one moderating aspect of the individual characteristics, e.g. gender, shows a significant moderator effect.

Influence on trusting intention in electromobility (TI)

Trust in technology could also vary on this basis. Older people are likely to place more value on trust in technology and structural security, and income level is positively correlated. Moreover, gender might hold particular interest as it is respected as a moderator of social influence on trust (Chattopadhyay Mukherjee & Ryan, 2020; Hilale & Chakor, 2024; Krause et al., 2013; Trommer et al., 2015).

H29: The individual characteristics (age, gender, education, income, daily distance travelled, EV driving experience, occupation) moderate the influence of the following constructs on the trusting intention in electromobility (TI) when using EVs:

a) Performance expectancy
b) Effort expectancy
c) Facilitating conditions
d) Reliability
e) Contextual acquaintance
f) Structural assurance

The hypothesis is confirmed if at least one moderating aspect of the individual characteristics, e.g. gender, shows a significant moderator effect.

Influence on use behaviour (UB)

The actual level of use is also linked to various demographic characteristics. Younger people may be more willing to act on their intentions. People with a higher level of education may be more willing to expand usage due to their knowledge. People with higher incomes are more likely to encounter fewer barriers to usage. People with longer daily transport times may have higher demands for consumer options (Buhmann & Criado, 2023; C. Lee et al., 2020; Mehdizadeh et al., 2023; Sovacool et al., 2018).

H30: The individual characteristics (age, gender, education, income, daily distance travelled, EV driving experience, occupation) moderate the influence of the following constructs on the actual use behaviour (UB) of EVs:

a) Facilitating conditions
b) Habit
c) Compatibility

d) Personal innovativeness

e) Costs

The hypothesis is confirmed if at least one moderating aspect of the individual characteristics, e.g. gender, shows a significant moderator effect.

Situational determinants (SD)

This group describes the personal situation of users, particularly in relation to their household situation and the infrastructure available there. It is expected to have an influence on the practicability and willingness to use an EV. The SD group contains the following moderators: household size, household income, number of vehicles in household, types of vehicles in household and charging opportunity (Blut et al., 2022; Kotler & Keller, 2016, pp. 179–187; Sovacool et al., 2018; Venkatesh, Thong, et al., 2016).

Influence on behavioural intention (BI)

The life situations and personal environments in which users find themselves may have different influences on the aforementioned constructs. For example, it can be assumed that someone who already has several vehicles in their household is more willing to test an electric car as an additional vehicle (Calmbach & Hecht, 2024; Jakobsson et al., 2016; Karlsson, 2017; Rutschmann, 2019).

H31: The situational determinants (household size, household income, number of vehicles in the household, vehicle types in the household, possibility of charging) moderate the influence of the following constructs on the behavioural intention (BI) to use EVs:

a) Performance expectancy

b) Effort expectancy

c) Social influence

d) Price value

e) Hedonic motivation

f) Facilitating conditions

g) Habit

h) Compatibility

i) Attitude towards the environment and technology

j) Personal innovativeness
k) Costs
l) Contextual acquaintance
m) Reliability

The hypothesis is confirmed if at least one moderating aspect of the situational determinants, e.g. household size, shows a significant moderator effect.

Influence on trusting intention in electromobility (TI)

Trust in electromobility can vary depending on situational characteristics. For example, the ability to charge, e.g. at home or at work, influences confidence in the practicality of use (Axsen et al., 2016; Hilale & Chakor, 2024; Javid & Nejat, 2017; J. H. Lee et al., 2019; Nazari et al., 2018; Tamor & Milačić, 2015).

H32: The situational determinants (household size, household income, number of vehicles in the household, vehicle types in the household, possibility of charging) moderate the influence of the following constructs on the trusting intention in electromobility (TI) when using EVs:

a) Performance expectancy
b) Effort expectancy
c) Facilitating conditions
d) Reliability
e) Contextual acquaintance
f) Structural assurance

The hypothesis is confirmed if at least one moderating aspect of the situational determinants, e.g. household size, shows a significant moderator effect.

Influence on use behaviour (UB)

Actual usage behaviour can vary depending on situational characteristics. For example, people with the ability to charge at home are more willing to realise their behavioural purpose, while people without this option may have more barriers. It also opens up the possibility that people with higher incomes will switch to EVs more quickly, as the financial barriers are less important (Hackbarth & Madlener, 2013; Hess et al., 2012; Mabit & Fosgerau, 2011; Priessner et al., 2018; Trommer et al., 2015).

H33: The situational determinants (household size, household income, number of vehicles in the household, vehicle types in the household, possibility of charging) moderate the influence of the following constructs on the actual use behaviour (UB) of EVs:

a) Facilitating conditions
b) Habit
c) Compatibility
d) Personal innovativeness
e) Costs

The hypothesis is confirmed if at least one moderating aspect of the situational determinants, e.g. household size, shows a significant moderator effect.

National culture (NC)

The NC moderator group examines cultural attitudes in various countries and analyses the differences and their impact on EVs. The moderators of this group are individualism and masculinity (Blut et al., 2022, p. 28 ff.; Hofstede, 1980).

Influence on behavioural intention (BI)

The reactions of people in different cultures to the aforementioned constructs may vary. As the influence is much stronger in collectivist cultures, personal expectations such as performance expectancy and personal innovativeness may play a more significant role in individualistic cultures. Similarly, men in male-centred societies may be more achievement-oriented and more successful in response to performance xpectancy (Triandis, 2004, p. 90 f.).

H34: National culture (individualism, masculinity) moderates the influence of the following constructs on the behavioural intention (BI) to use EVs:

a) Performance expectancy
b) Effort expectancy
c) Social influence
d) Price value
e) Hedonic motivation
f) Facilitating conditions
g) Habit

h) Compatibility
i) Attitude towards the environment and technology
j) Personal innovativeness
k) Costs
l) Contextual acquaintance
m) Reliability

The hypothesis is confirmed if at least one moderating aspect of national culture, e.g. individualism, shows a significant moderator effect.

Influence on trusting intention in electromobility (TI)

Users in collectivist cultures can only develop a high level of trust in technologies through positive experiences and recommendations from social groups. In individualistic cultures, on the other hand, the trust process centres on reliability and the ability of the technology to satisfy individualistic needs. In addition, the cultural characterisation in terms of masculinity could influence the weighting of performance aspects and structural safeguards (Hilale & Chakor, 2024; H. McKnight et al., 2009; Triandis & Gelfand, 1998).

H35: National culture (individualism, masculinity) moderates the influence of the following constructs on the trusting intention in electromobility (TI) when using EVs:

a) Performance expectancy
b) Effort expectancy
c) Facilitating conditions
d) Reliability
e) Contextual acquaintance
f) Structural assurance

The hypothesis is confirmed if at least one moderating aspect of national culture, e.g. individualism, shows a significant moderator effect.

Influence on use behaviour (UB)

In collectivist cultures, the trusting intention in electromobility could contribute more strongly to actual use, as in such cultures, the group dynamics embedded in individual action and the behavioural intention are positively

correlated with it. In individualistic cultures, for example, the conversion of behavioural intention into actual behaviour is more dependent on personal conviction and the actual desire to use ABFs, depending on the assessment of their performance and reliability. In male-dominated cultures, such influence is more likely to be evident in actual behaviour (Hofstede, 1980; Triandis, 1995; Y. Zhang et al., 2018).

H36: National culture (individualism, masculinity) moderates the influence of the following constructs on the actual use behaviour (UB) of EVs:

a) Facilitating conditions
b) Habit
c) Compatibility
d) Personal innovativeness
e) Costs

The hypothesis is confirmed if at least one moderating aspect of national culture, e.g. individualism, shows a significant moderator effect.

Technical determinants (T)

This group of technical determinants contains the moderators with technical characteristics of EVs and should help to determine how well technical moderators can fulfil the needs of users and thus influence the acceptance of EVs. This group includes the moderators of motor power, driving range and charging time (Blut et al., 2022, p. 34 ff.; Im et al., 2008; Meuter et al., 2005; Venkatesh, Thong, et al., 2016; Wicki et al., 2022, pp. 71–72).

Influence on behavioural intention (BI)

Depending on the nature of the technological features of electric cars, such as motor power and range, users may react differently to the aforementioned constructs. For example, high motor power may strengthen performance expectancy and increase behavioural intention, especially fans of performance and driving enjoyment. On the other hand, a high range would likely strengthen the influence on facilitating conditions, as users need to worry less about the number of charging sessions (Larson et al., 2015; Mabit & Fosgerau, 2011; She et al., 2017; Ziegler, 2012).

H37: The technical determinants (motor power, range, charging time) moderate the influence of the following constructs on the behavioural intention (BI) to use EVs:

a) Performance expectancy
b) Effort expectancy
c) Social influence
d) Price value
e) Hedonic motivation
f) Facilitating conditions
g) Habit
h) Compatibility
i) Attitude towards the environment and technology
j) Personal innovativeness
k) Costs
l) Contextual acquaintance
m) Reliability

The hypothesis is confirmed if at least one moderating aspect of the technical determinants, e.g. motor power, shows a significant moderator effect.

Influence on trusting intention in electromobility (TI)

Some features of the technology could also strengthen trust in electromobility as a technology. This is particularly the case if the distance to be travelled is long. For example, a long range could increase both the confidence in the use and the level of trust in the practicability of EVs. Charging the vehicles could also relativise the reliability and facilitating conditions. If the charging time is short, this could also strengthen confidence in EVs (Carley et al., 2013; Egbue & Long, 2012; Hackbarth & Madlener, 2013; Hilale & Chakor, 2024).

H38: The technical determinants (motor power, range, charging time) moderate the influence of the following constructs on the trusting intention in electromobility (TI) when using EVs:

a) Performance expectancy

b) Effort expectancy
c) Facilitating conditions
d) Reliability
e) Contextual acquaintance
f) Structural assurance

The hypothesis is confirmed if at least one moderating aspect of the technical determinants, e.g. motor power, shows a significant moderator effect.

Influence on use behaviour (UB)

Two technical moderators that are assumed to influence the transition from behavioural intention to actual use are range and charging times. A longer range could facilitate actual usage behaviour, as users will need to undertake fewer charging cycles in practice. In addition, a short charging cycle can help to lower the hurdle towards actual utilisation (Bockarjova & Steg, 2014; Hidrue et al., 2011; Kempton, 2016).

H39: The technical determinants (motor power, range, charging time) moderate the influence of the following constructs on the actual use behaviour (UB) of EVs:

a) Facilitating conditions
b) Habit
c) Compatibility
d) Personal innovativeness
e) Costs

The hypothesis is confirmed if at least one moderating aspect of the technical determinants, e.g. motor power, shows a significant moderator effect.

Contextual determinants (CD)

This group encompasses framework conditions, such as market availability or political conditions, that can either support or hinder the acceptance of EVs. They thus influence how attractive EVs are for consumers. The CD group includes the following moderators: market availability, charging availability, environmental impact and policy and incentives (Blut et al., 2022, p. 60 ff.; Borrero et al., 2014; Venkatesh, Thong, et al., 2016; Wicki et al., 2022, pp. 71–73).

Influence on behavioural intention (BI)

Depending on moderators of the context, such as charging availability or political decisions and incentives, users could react differently to these constructs. If charging availability is high, then effort expectancy has a weaker influence on behavioural intention, as the perceived ease of use increases. Government incentives could reduce the influence on costs, which in turn leads to a strengthening of behavioural intention (Axsen et al., 2016; Brückmann & Bernauer, 2020; Egbue & Long, 2012).

H40: The contextual determinants (market availability, charging availability, environmental impact, politics and incentives) moderate the influence of the following constructs on the behavioural intention (BI) to use EVs:

a) Performance expectancy
b) Effort expectancy
c) Social influence
d) Price value
e) Hedonic motivation
f) Facilitating conditions
g) Habit
h) Compatibility
i) Attitude towards the environment and technology
j) Personal innovativeness
k) Costs
l) Contextual acquaintance
m) Reliability

The hypothesis is confirmed if at least one moderating aspect of the contextual determinants, e.g. market availability, shows a significant moderator effect.

Influence on trusting intention in electromobility (TI)

Charging availability and environmental impacts under the contextual conditions could affect trust in EMOB. Facilitating conditions and structural assurance could be improved by a well-developed charging infrastructure, which

would strengthen the perception of reliability and support, thereby increasing trust in the technology. Political decisions and incentives in favour of electromobility would also have a positive effect on the confidence of users, as they would feel understood and supported by politicians to embark on the path towards a new drive technology (Coffman et al., 2017; Graham-Rowe et al., 2012; Hilale & Chakor, 2024; S. Wang et al., 2018).

H41: The contextual determinants (market availability, charging availability, environmental impact, politics and incentives) moderate the influence of the following constructs on the trusting intention in electromobility (TI) when using EVs:

a) Performance expectancy
b) Effort expectancy
c) Facilitating conditions
d) Reliability
e) Contextual acquaintance
f) Structural assurance

The hypothesis is confirmed if at least one moderating aspect of the contextual determinants, e.g. market availability, shows a significant moderator effect.

Influence on use behaviour (UB)

Politics and incentives and market availability are contextual moderators and can influence the transition from the intention to use to actual use. For example, behavioural intention could be supported by government subsidies or tax incentives by reducing financial barriers. High market availability is another key variable that could have a supportive effect by supporting consumers in their purchasing decisions, provided that a sufficient number of suppliers and model diversity are available on the market (Chorus et al., 2013; Hoen & Koetse, 2014; R. A. Huber & Wicki, 2021; Wicki et al., 2019).

H42: The contextual determinants (market availability, charging availability, environmental impact, politics & incentives) moderate the influence of the following constructs on the actual use behaviour (UB) of EVs:

a) Facilitating conditions

b) Habit
c) Compatibility
d) Personal innovativeness
e) Costs

The hypothesis is confirmed if at least one moderating aspect of the contextual determinants, e.g. market availability, has a significant moderator effect.

Experience

This moderator group comprises the variables of the user's experience (knowledge, familiarity) with or about EVs. Experience is a relevant factor that contributes to the decision of whether users accept and use EVs (Blut et al., 2022; K. Dudenhöffer, 2015; Venkatesh et al., 2012; Venkatesh & Davis, 2000).

Influence on behavioural intention (BI)

Users with greater knowledge and familiarity with electric mobility technology may react to the aforementioned constructs in different ways. For example, familiarity with the user operation could reduce the influence of effort expectancy, as more experienced users find the operation less demanding. knowledge about the technology could also increase the influence of performance expectancy by making the perceived benefits clearer and thus strengthening the behavioural intention (Carley et al., 2013; Y. Zhang et al., 2011).

H43: The experience group (knowledge and familiarity) moderates the influence of the following constructs on the behavioural intention (BI) to use EVs:

a) Performance expectancy
b) Effort expectancy
c) Social influence
d) Price value
e) Hedonic motivation
f) Facilitating conditions
g) Habit
h) Compatibility
i) Attitude towards the environment and technology

j) Personal innovativeness
k) Costs
l) Contextual acquaintance
m) Reliability

The hypothesis is confirmed if at least one moderating aspect of the experience group, e.g. knowledge, shows a significant moderator effect.

Influence on trusting intention in electromobility (TI)

Users who have further knowledge about electromobility may have a higher trusting intention. Knowledge and familiarity may increase the influence of structural assurance by strengthening users' perceptions of how government subsidies or institutional assurances will work. Similarly, higher knowledge could alter the influence of reliability on trust intention, as informed users are better able to judge the technical benefits and risks (Hidrue et al., 2011; Hilale & Chakor, 2024; Larson et al., 2015).

H44: The experience group (knowledge and familiarity) moderates the influence of the following constructs on the trusting intention in electromobility (TI) when using EVs:

a) Performance expectancy
b) Effort expectancy
c) Facilitating conditions
d) Reliability
e) Contextual acquaintance
f) Structural assurance

The hypothesis is confirmed if at least one moderating aspect of the experience group, e.g. knowledge, shows a significant moderator effect.

Influence on use behaviour (UB)

Experience with electric mobility can also facilitate the perception of use from behavioural intention to actual use. Users who are familiar with EVs may tend to strengthen their intention, as there are fewer uncertainties and concerns associated with them. In addition, knowledge can increase the influence of trust intention on

usage behaviour, as the user's technical knowledge gives them the feeling of knowing and being able to use the technology (Bühler et al., 2014; Burgess et al., 2013; Globisch et al., 2018; Schmalfuß et al., 2017).

H45: Experience (knowledge and familiarity) moderates the influence of the following constructs on the actual use behaviour (UB) of EVs:

a) Facilitating conditions
b) Habit
c) Compatibility
d) Personal innovativeness
e) Costs

The hypothesis is confirmed if at least one moderating aspect of the experience group, e.g. knowledge, has a significant moderator effect.

3.3.4.3 Hypothesis summary

Table 21 lists the 45 research hypotheses identified:

Table 21: Conclusion of research hypothesises

Basic hypotheses based on the constructs of the research model that can be directly influenced.	
H1	Performance expectancy has a positive influence on the behavioural intention (BI) to use EVs.
H2	Performance expectancy has a positive influence on the trusting intention in electric mobility (TI) to use EVs.
H3	Effort expectancy has a positive influence on the behavioural intention (BI) to use EVs.
H4	Effort expectancy has a positive influence on the trusting intention in electromobility (TI) to use EVs.
H5	Social influence has a positive influence on behavioural intention (BI) to use EVs.
H6	Price value has a positive influence on the behavioural intention (BI) to use EVs.
H7	Hedonic motivation has a positive influence on the behavioural intention (BI) to use EVs.

H8	Facilitating conditions have a positive influence on the behavioural intention (BI) to use EVs.
H9	Facilitating conditions have a direct positive influence on the use behaviour (UB) of EVs.
H10	Facilitating conditions have a positive influence on the trusting intention in electromobility (TI) to use EVs.
H11	Habit has a positive influence on the use behaviour (UB) to use EVs.
H12	Habit has a direct positive influence on the use behaviour (UB) for the use of EVs.
H13	Compatibility has a positive influence on the behavioural intention (BI) to use EVs.
H14	Compatibility has a direct positive influence on the use behaviour (UB) for the use of EVs.
H15	A positive technological and environmental attitude significantly increases the behavioural intention (BI) to use EVs.
H16	A high level of personal innovativeness has a positive influence on behavioural intention (BI) to use EVs.
H17	A high level of personal innovativeness has a direct positive influence on the use behaviour (UB) for the use of EVs.
H18	Perceived high costs have a negative influence on the behavioural intention (BI) to use EVs.
H19	Perceived high costs have a direct negative influence on the actual use behaviour (UB) to use EVs.
H20	A high perceived reliability has a positive influence on the behavioural intention (BI) to use EVs.
H21	High perceived reliability has a positive influence on the trusting intention in electromobility (TI) to use EVs.
H22	A high level of contextual awareness has a positive influence on behavioural intention (BI) to use EVs.
H23	A high level of contextual acquaintance has a positive influence on the trusting intention in electromobility (TI) towards EVs.
H24	A high level of structural assurance has a positive influence on the trusting intention in electromobility (TI) towards EVs.

H25	A high trusting intention in electromobility has a positive influence on the behavioural intention (BI) to use EVs.
H26	A high trusting intention in electromobility has a positive influence on the actual use behaviour (UB) of EVs.
H27	A high behavioural intention has a positive influence on the actual use behaviour (UB) of EVs.
Additional hypotheses based on the moderating groups and the variables they contain.	
H28	The individual characteristics (age, gender, education, daily distance travelled, EV driving experience, occupation) moderate the influence of the following constructs on the behavioural intention (BI) to use EVs: a) Performance expectancy b) Effort expectancy c) Social influence d) Price value e) Hedonic motivation f) Facilitating conditions g) Habit h) Compatibility i) Attitude towards the environment and technology j) Personal innovativeness k) Costs l) Contextual acquaintance m) Reliability The hypothesis is confirmed if at least one moderating aspect of the individual characteristics, e.g. gender, shows a significant moderator effect.
H29	The individual characteristics (age, gender, education, daily distance travelled, EV driving experience, occupation) moderate the influence of the following constructs on the trusting intention in electromobility (TI) when using EVs: a) Performance expectancy b) Effort expectancy c) Facilitating conditions d) Reliability e) Contextual acquaintance

	f) Structural assurance The hypothesis is confirmed if at least one moderating aspect of the individual characteristics, e.g. gender, shows a significant moderator effect.
H30	The individual characteristics (age, gender, education, daily distance travelled, EV driving experience, occupation) moderate the influence of the following constructs on the actual use behaviour (UB) of EVs: a) Facilitating conditions b) Habit c) Compatibility d) Personal innovativeness e) Costs The hypothesis is confirmed if at least one moderating aspect of the individual characteristics, e.g. gender, shows a significant moderator effect.
H31	The situational determinants (household size, household income, number of vehicles in the household, vehicle types in the household, possibility of charging) moderate the influence of the following constructs on the behavioural intention (BI) to use EVs: a) Performance expectancy b) Effort expectancy c) Social influence d) Price value e) Hedonic motivation f) Facilitating conditions g) Habit h) Compatibility i) Attitude towards the environment and technology j) Personal innovativeness k) Costs l) Contextual acquaintance m) Reliability The hypothesis is confirmed if at least one moderating aspect of the situational determinants, e.g. household size, shows a significant moderator effect.

H32	The situational determinants (household size, household income, number of vehicles in the household, vehicle types in the household, possibility of charging) moderate the influence of the following constructs on the trusting intention in electromobility (TI) when using EVs: a) Performance expectancy b) Effort expectancy c) Facilitating conditions d) Reliability e) Contextual acquaintance f) Structural assurance The hypothesis is confirmed if at least one moderating aspect of the situational determinants, e.g. household size, shows a significant moderator effect.
H33	The situational determinants (household size, household income, number of vehicles in the household, vehicle types in the household, possibility of charging) moderate the influence of the following constructs on the actual use behaviour (UB) of EVs: a) Facilitating conditions b) Habit c) Compatibility d) Personal innovativeness e) Costs The hypothesis is confirmed if at least one moderating aspect of the situational determinants, e.g. household size, shows a significant moderator effect.
H34	National culture (individualism, masculinity) moderates the influence of the following constructs on the behavioural intention (BI) to use EVs: a) Performance expectancy b) Effort expectancy c) Social influence d) Price value e) Hedonic motivation f) Facilitating conditions g) Habit h) Compatibility i) Attitude towards the environment and technology

	j) Personal innovativeness k) Costs l) Contextual acquaintance m) Reliability The hypothesis is confirmed if at least one moderating aspect of national culture, e.g. individualism, shows a significant moderator effect.
H35	National culture (individualism, masculinity) moderates the influence of the following constructs on the trusting intention in electromobility (TI) when using EVs: a) Performance expectancy b) Effort expectancy c) Facilitating conditions d) Reliability e) Contextual acquaintance f) Structural assurance The hypothesis is confirmed if at least one moderating aspect of national culture, e.g. individualism, shows a significant moderator effect.
H36	National culture (individualism, masculinity) moderates the influence of the following constructs on the actual use behaviour (UB) of EVs: a) Facilitating conditions b) Habit c) Compatibility d) Personal innovativeness e) Costs The hypothesis is confirmed if at least one moderating aspect of national culture, e.g. individualism, shows a significant moderator effect.
H37	The technical determinants (motor power, range, charging time) moderate the influence of the following constructs on the behavioural intention (BI) to use EVs: a) Performance expectancy b) Effort expectancy c) Social influence d) Price value e) Hedonic motivation f) Facilitating conditions

	g) Habit h) Compatibility i) Attitude towards the environment and technology j) Personal innovativeness k) Costs l) Contextual acquaintance m) Reliability The hypothesis is confirmed if at least one moderating aspect of the technical determinants, e.g. motor power, shows a significant moderator effect.
H38	The technical determinants (motor power, range, charging time) moderate the influence of the following constructs on the trusting intention in electromobility (TI) when using EVs: a) Performance expectancy b) Effort expectancy c) Facilitating conditions d) Reliability e) Contextual acquaintance f) Structural assurance The hypothesis is confirmed if at least one moderating aspect of the technical determinants, e.g. motor power, shows a significant moderator effect.
H39	The technical determinants (motor power, range, charging time) moderate the influence of the following constructs on the actual use behaviour (UB) of EVs: a) Facilitating conditions b) Habit c) Compatibility d) Personal innovativeness e) Costs The hypothesis is confirmed if at least one moderating aspect of the technical determinants, e.g. motor Power, shows a significant moderator effect.
H40	The contextual determinants (market availability, charging availability, environmental impact, politics & incentives) moderate the influence of the following constructs on the behavioural intention (BI) to use EVs: a) Performance expectancy b) Effort expectancy

	c) Social influence d) Price value e) Hedonic motivation f) Facilitating conditions g) Habit h) Compatibility i) Attitude towards the environment and technology j) Personal innovativeness k) Costs l) Contextual acquaintance m) Reliability The hypothesis is confirmed if at least one moderating aspect of the contextual determinants, e.g. market availability, shows a significant moderator effect.
H41	The contextual determinants (market availability, charging availability, environmental impact, politics & incentives) moderate the influence of the following constructs on the trusting intention in electromobility (TI) when using EVs: a) Performance expectancy b) Effort expectancy c) Facilitating conditions d) Reliability e) Contextual acquaintance f) Structural assurance The hypothesis is confirmed if at least one moderating aspect of the contextual determinants, e.g. market availability, shows a significant moderator effect.
H42	The Contextual Determinants (market availability, charging availability, environmental impact, politics & incentives) moderate the influence of the following constructs on the actual use behaviour (UB) of EVs: a) Facilitating conditions b) Habit c) Compatibility d) Personal innovativeness e) Costs The hypothesis is confirmed if at least one moderating aspect of the contextual determinants, e.g. market availability, has a significant moderator effect.

H43	The experience group (knowledge and familiarity) moderates the influence of the following constructs on the behavioural intention (BI) to use EVs: a) Performance expectancy b) Effort expectancy c) Social influence d) Price value e) Hedonic motivation f) Facilitating conditions g) Habit h) Compatibility i) Attitude towards the environment and technology j) Personal innovativeness k) Costs l) Contextual acquaintance m) Reliability The hypothesis is confirmed if at least one moderating aspect of the experience group, e.g. knowledge, shows a significant moderator effect.
H44	The experience group (knowledge and familiarity) moderates the influence of the following constructs on the trusting intention in electromobility (TI) when using EVs: a) Performance expectancy b) Effort expectancy c) Facilitating conditions d) Reliability e) Contextual acquaintance f) Structural assurance The hypothesis is confirmed if at least one moderating aspect of the experience group, e.g. knowledge, shows a significant moderator effect.
H45	Experience (knowledge and familiarity) moderates the influence of the following construct on the actual use behaviour (UB) of EVs: a) Facilitating conditions b) Habit c) Compatibility d) Personal innovativeness

	e) Costs The hypothesis is confirmed if at least one moderating aspect of the experience group, e.g. knowledge, has a significant moderator effect.

Source: Own illustration

IV – METHODOLOGY

IV METHODOLOGY

The aim of Chapter 4 is to present the methodological approach for empirically testing the research model developed. To this end, the structural equation modelling procedure is first explained, including the model structure, estimation procedure and interaction effects. This is followed by the detailed operationalisation of the model variables, including scaling, indicator selection and questionnaire development. In addition, the study design is described, including data collection, sample description and the use of a market research institute. Chapter 4 thus lays the methodological foundation for the subsequent evaluation and validation of the model, ensuring that the empirical analysis is based on a valid, reliable, and theory-driven foundation.

4.1 PRELIMINARY CONSIDERATIONS FOR THE METHODOLOGY CHAPTER

Based on the research model described and the hypotheses derived, a study design based on quantitative methods is proposed. This design will be used to comprehensively analyse the moderating and direct influences on the acceptance and use of EVs. The quantitative survey is the key method for testing the derived hypotheses. It makes it possible to measure and statistically test the moderating effects of the various determinants and constructs in the research model (Chin, 1998, p. 306; Raithel, 2008, p. 14 ff.).

- **Sample**: The sample should include as large and representative a number of participants as possible, covering different demographic groups in terms of age, gender, income and cultural contexts such as different countries or regions. There should be enough participants to test the effects of the moderators in a statistically plausible way (Gäde & Schermelleh-Engel, 2023, p. 935).
- **Questionnaire**: The questionnaire should cover all relevant variables of the model. The relevant constructs are performance expectancy, effort expectancy, trusting intention, behavioural intention, use intention and moderators such as individual characteristics,

situational characteristics, national culture and experience. The questionnaire should be administered using a Likert scale, for example, from 1 to 7, to measure the study participants' opinion statements (Bühner, 2006; Moosbrugger & Kelava, 2020).

- **Survey method**: The method could be online to have a wider reach and accessibility for different groups. Face-to-face aspects could also be useful, for example, with older people or in rural areas, to achieve a more balanced distribution of different groups across the samples (Eichhorn, 2004; Lippold, 2015b; Stein, 2022).

Analysis plan:

- Structural equation modelling (SEM): This enables the examination of direct and indirect paths between the constructs in the model. In this case, SEM is suitable for testing the relationships between PE, trusting intention, behavioural intention and use behaviour (Backhaus et al., 2021; Chin, 1998, p. 297; J. F. Hair et al., 2006, p. 711; Kornmeier, 2009a, p. 167).
- Moderation analysis: A hierarchical regression analysis with separate integration of the relevant moderator within the SEM is used to explore the moderating effects for IC, SC, NC, and Experience (Kohl, 2021).

The strengths and weaknesses of this survey method will be discussed and evaluated below. This will begin with a consideration of the advantages of structural equation modelling:

Objectivity and generalisability

- A quantitative survey is characterised by the ability to collect objective and quantifiable data. This leads to a statistical analysis that is less susceptible to the subjective biases that often occur in qualitative work (Homburg & Klarmann, 2006, p. 11; Schmidt, 2009, p. 246).
- With a sufficiently large sample and a representative population group, the survey can also be transferred to the general public. This is particularly evident when determining the acceptance and behaviour

of EVs in the population as a whole (Backhaus et al., 2016; Weiber & Mühlhaus, 2014, p. 65).

Statistical validation of the hypotheses

- The electromobility model contains a complex set of hypotheses that can be tested quantitatively. Quantitatively collected information is ideal for validating these hypotheses with structural equation modelling and moderation analyses, which explain the direct and indirect effects and interactions between the constructs (Globisch et al., 2018).
- Furthermore, it is an excellent method for determining causal relationships, especially since the model encompasses numerous constructs and moderator variables. However, due to the cross-sectional research design, a sufficient causal validation of identified influences is not given, regardless of the complexity of the SEM (Ashrafi et al., 2022; L. Zhang et al., 2012).

Efficiency of data collection

- A quantitative survey enables the collection of data quickly through an online survey. This makes it a cost-effective and time-efficient method for collecting a large amount of information from a relatively small number of resources (Hecht et al., 2024).
- A large sample size also enables studies that include subgroup analyses, allowing for more specific results to be obtained (Cornesse et al., 2020).

Moderators and control variables

- The quantitative survey enables the systematic recording of numerous moderators and control variables, allowing for the statistical examination of their respective influence on behavioural intention and use behaviour. Factors such as age, gender, charging availability, or political incentives can be relevant to the acceptance of EVs (Foscht et al., 2017; Janzik, 2022).

In addition to the aforementioned advantages of a quantitative survey, there are also some potential disadvantages associated with it, particularly in relation to data collection and analysis.

Limited in-depth information:

- A purely quantitative survey does not provide detailed information about why respondents have certain reasons and motivations. Qualitative methods, such as interviews or focus groups, could help gain deeper insights into why certain factors are important or perceived, for example (Blatter et al., 2018).
- These are missing in a purely quantitative approach. Potentially subtle and context-specific influences, such as personal concerns or cultural characteristics, cannot be fully captured (Lippold, 2019, p. 8; Sauer & Ringbeck, 2024, p. 5).

Dependence on self-reporting:

- A quantitative survey is based on participants' self-reporting, which can lead to socially desirable behaviour and personal bias. Respondents may tend to embellish their attitudes towards electric mobility, especially with regard to the environmental aspect (Gordon & Nelke, 2017; Königstorfer, 2008).
- A standardised questionnaire also offers less flexibility to respond to individual differences in the respondent's understanding or background (Schlipphak & Isani, 2020, p. 353 ff.; Schnapp et al., 2006, p. 21).

Complexity of the model and data analysis:

- The research model, with a large number of variables and moderators, is complex and requires an elaborate data analysis. The implementation of structural equation modelling requires extensive knowledge of statistics as well as very clean data collection in order to obtain valid and trustworthy results (Blut et al., 2022).
- There is also a risk of multicollinearity if many thresholds are analysed simultaneously. This could affect the robust results,

especially if the sample is not sufficiently large (Eid & Schmidt, 2014; Homburg & Klarmann, 2006).

As a result, it can be stated that the choice to use only a quantitative survey as the primary method is a sensible and efficient decision if the aim is to conduct a generalisable, objective, and statistically valid analysis of the acceptance of EVs (Fazel, 2014). It will be helpful to quantify the hypotheses and test the moderators, as this will enable a statistically reliable statement to be made regarding which factors have the strongest influence on behavioural intention and actual usage behaviour (Kasperk et al., 2024; Sauer & Ringbeck, 2024; Stumpp et al., 2021). Furthermore, the quantitative analysis enables the identification of differences between various demographic and situational moderator groups. However, it is necessary to consider the potential limitations. Without a qualitative component, it is not possible to gain deeper insights into users' motivations. In addition, subtle contextual differences could be overlooked (Blatter et al., 2018). It is therefore essential to acknowledge these limitations in the interpretation of the results and to recognise potential biases resulting from self-reporting and social desirability. To counter these disadvantages, it is necessary to deepen the findings from the quantitative survey through a further qualitative study, if necessary. It can be stated that the quantitative study can serve as a starting point for further research work (Gordon & Nelke, 2017; Königstorfer, 2008).

In conclusion, it should be noted that the quantitative survey represents an efficient, objective and generalisable way of analysing the research model and the hypotheses. However, it does not provide fully detailed insights into the motivations of the respondents. This could be achieved through a complementary qualitative method in a further phase (Tausendpfund, 2018).

4.2 STRUCTURAL EQUATION MODELLING

4.2.1 Structural equation modelling to test theoretical cause-and-effect relationships

The previous chapter has made it clear that SEM is the method of choice for investigating the theoretical research model. The structural equation modelling

method is a causal analysis. SEM allows empirical testing and validation of theoretically derived statements about causal relationships. Structural equation modelling is one of the multivariate analysis methods. Multivariate analysis methods are characterised by the fact that several statistical variables can be examined in parallel. In comparison, univariate analysis methods only allow one variable to be analysed (Backhaus et al., 2018; Chin, 1998, p. 297).

The basic mode of operation of SEM is that they test theoretically assumed relationships, which is why SEM have a theory-testing (confirmatory) character. There are numerous fields of application, for example in psychology, social sciences, economics and, last but not least, in technology research. A combination of theory-testing and theory-building (explorative) approaches is often used. This is because the theoretical relationship has not necessarily been fully proven in all application situations and certain (additional) model specifications may be required. This can also include the present research model, which is based on an existing research model (UTAUT3) but has been extended with additional variables and hypotheses to best reflect the research objective (J. F. Hair et al., 2006, p. 711; Kornmeier, 2009b, p. 167).

Before the actual structural equation analysis can be started, modelling must first have taken place. This means that a theoretical derivation of the hypotheses about the relationship structures of the variables has taken place. In the further course, the theoretically derived causal relationships are checked by means of path analysis. The results are visualised in a path diagram so that the dependency relationships are shown and the model structure is made comprehensible (Herrmann et al., 2006, p. 35; Hildebrandt & Görz, 1997, p. 2 f.).

At the core of structural equation analysis is the examination of latent variables, i.e. constructs in the structural equation model that cannot be measured directly. The latent variables are identified via manifest indicators (observable items). The expression of a latent variable is based on a weighted linear combination of the indicators and a residual error (Bortz & Döring, 2023; Eichhorn, 2004, p. 14 f.; Homburg & Klarmann, 2006, p. 728). This means that the structural equation models combine multivariate analysis methods such as regression or factor analysis. Factor loadings (also known as "weights") determine the relationship between indicators and latent variables. A distinction can be made

between two types of measurement models: reflective and formative measurement models. Reflective measurement models enable the testing of a causal effect of a latent variable on one or more indicators, whereas formative measurement models assess the causal effects of items on a factor. The factor loadings provide information about the variance distribution between items and latent variables (Henseler, 2005, p. 74; Herrmann et al., 2006, p. 37). In order to make the latent variables measurable, the indicators must be described and operationalised. This means that the indicators must explain the constructs (latent variables) in the most effective way possible (Zinnbauer & Eberl, 2005, p. 4).

In terms of significance and prevalence, structural equation models are generally recognised as suitable for depicting complex cause-and-effect relationships (interdependencies). A combination of econometric methods and the concept of latent variables is possible here. Structural equation modelling was introduced by Bagozzi in 1980 and has since become widely adopted worldwide. In addition to Bagozzi, Fornell and Larcker (1981) and Jöreskog and Wold (1982) have also contributed significantly to this with their further developments. (R. P. Bagozzi, 1980; Baumgartner & Homburg, 1996, p. 139; Eberl, 2004, p. 11; Fornell & Larcker, 1981; K. G. Jöreskog & Wold, 1982).

Today, structural equation models have established themselves as a quasi-standard in empirical research, as they are ideal for analysing causal relationships. In addition to their original field of application in innovation and marketing research, they are now widely used in social and market research. The importance of SEM for analysing observable and latent variables should be particularly emphasised here (Baumgartner & Homburg, 1996, p. 140 f.; J. F. Hair et al., 2017; Hildebrandt & Görz, 1997).

In order to correctly classify the significance of SEM, it is worth taking a look at the past: the first generation of data analysis methods was based on regression analyses, with which the effect of independent variables on dependent variables could be investigated. In contrast, structural equation modelling, which is widely used today, represents the second generation of data analysis methods. These allow the modelling of complex interdependency structures, including the consideration of reciprocal relationships and chains of effects between independent variables. Accordingly, further research questions can also be investigated, as SEM can

extend beyond a simple 1-to-1 relationship (Gefen, 2000, p. 3 f.; Zinnbauer & Eberl, 2005, p. 2).

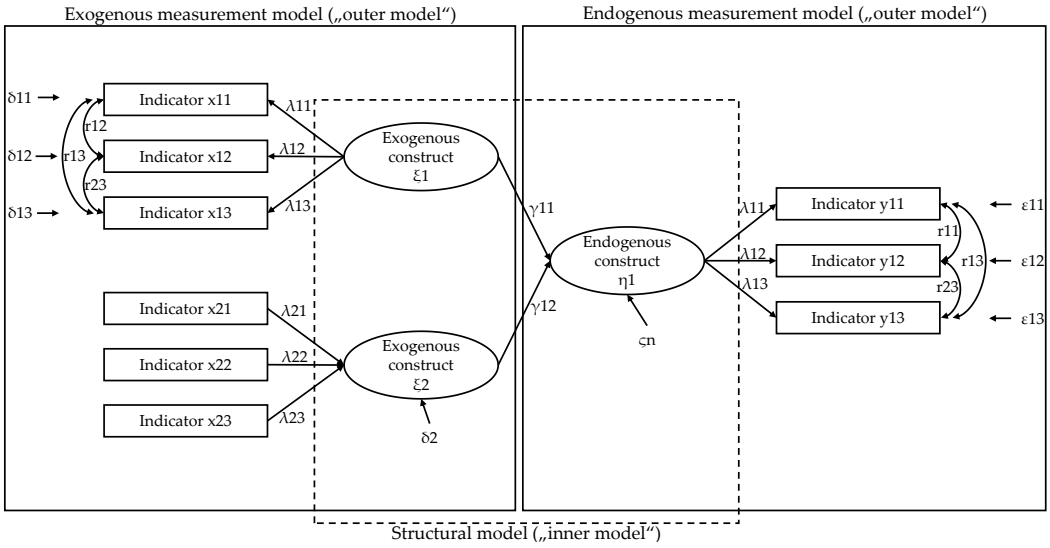
Another advantage of SEM over regression analyses is the modelling of complex processes and interdependencies. As a result, SEMs make a greater contribution to the theoretical and practical gain in knowledge (Gefen, 2000, p. 4 f.). Additionally, the exploratory investigation of causal relationships enables the empirical testing of theoretical hypotheses. Due to these advantages, structural equation modelling has identified new problem areas in recent years and triggered research activities. As a result, the methodology has also been continuously developed (Frein et al., 2007, p. 2; Hildebrandt & Görz, 1997, pp. 1, 7).

This development has also led to improvements in statistical programmes that enable the calculation of relationships between independent and dependent variables as well as the evaluation and estimation of latent constructs in a single calculation operation. In the past, this was achieved using tedious individual calculations in programmes such as SPSS. Today, programmes such as Lisrel, MPlus, SmartPLS or Amos are used, which also offer predominantly user-friendly interfaces, which in turn enables access to structural equation modelling and has increased acceptance in the research community (Albers & Hildebrandt, 2006, p. 5; Gefen et al., 2000, p. 3 ff.; Hildebrandt & Görz, 1997, p. 1; Urban & Mayerl, 2006, p. 15).

4.2.2 Structure of structural equation models

Structural equation models combine factor and path analysis in their basic principle. The dependency relationships between the latent variables are estimated based on the variances and covariances between model indicators. A structural equation model can be divided into the exogenous measurement model, the endogenous measurement model and the structural model (Hildebrandt & Görz, 1997, p. 2 f.; Zinnbauer & Eberl, 2005, p. 2), as shown in Figure 32:

Figure 32: Structure of structural equation models



Source: Own illustration based on (Hildebrandt & Görz, 1997, p. 2 f.)

The structural model, also known as the inner model, specifies the dependencies of the latent, not directly measurable variables. The path coefficients are measured using directed correlations (regression). The path coefficients are also referred to as partial standardised regression weights and can assume values ranging from +1 to -1. The path coefficients describe the effect of the change that a latent independent variable has on a latent dependent variable. For example, a value of +1 means that an increase in the independent variable by one standard deviation leads to an increase in the dependent variable by one standard deviation (Bühner, 2006, p. 237 f.; Herrmann et al., 2006, p. 36; Jahn, 2016; Zinnbauer & Eberl, 2005, p. 2).

The measurement model, on the other hand, describes the relationships between the manifest indicators (x,y) and the latent variables. The measurement model consists of the exogenous measurement model and the endogenous measurement model. The exogenous measurement model contains the independent latent variables (ξ1, ξ2), and the endogenous measurement model contains the dependent latent variable (η1). In practice, the complete explanation of the latent variables is rarely successful; accordingly, the residual variance(ςn) is used to explain variance that has not been fully captured (Herrmann et al., 2006, p. 36).

Measurement errors (so-called residuals or residual measurement errors) are used to counter and take into account the errors of the indicators or constructs that occur during measurement. These measurement errors are labelled with δn and εn. By taking measurement errors into account, a further advantage of SEM becomes clear: in addition to analysing the structural and measurement model, the measurement error is also evaluated and included as unexplained model variance of the structural model and the observable indicators of the measurement model(Gefen et al., 2000, p. 5; Herrmann et al., 2006, p. 36).

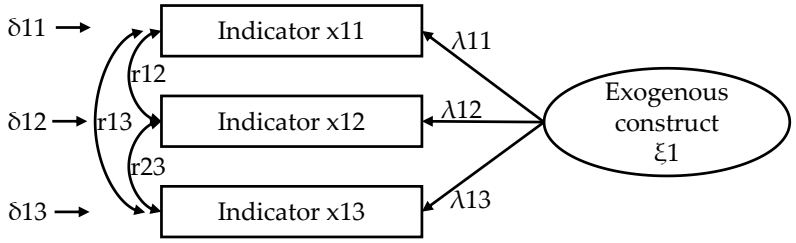
4.2.3 Measurement of model constructs

Latent variables can be operationalised using reflective and formative measurement models. The difference lies in the direction of the effect relationship between the construct and the associated indicators/items (Albers, 2010, p. 409 ff.). The two options are explained in the following.

Reflective measurement models:

In reflective measurement models, the latent variable causes the characteristics of the assigned indicators (Eberl, 2004, p. 4; Edwards & Bagozzi, 2000, p. 157; Henseler & Fassott, 2010), as shown in Figure 33:

Figure 33: Structure of reflective measurement models



Source: Own illustration based on (Fassott & Eggert, 2005, p. 37).

A fundamental characteristic of measurement models is that a change in the latent variable results in a corresponding change in all indicators. If the indicators are fully correlated with each other, they can be exchanged flexibly. Accordingly, the random measurement error δn (exogenous residuals) or εn (endogenous

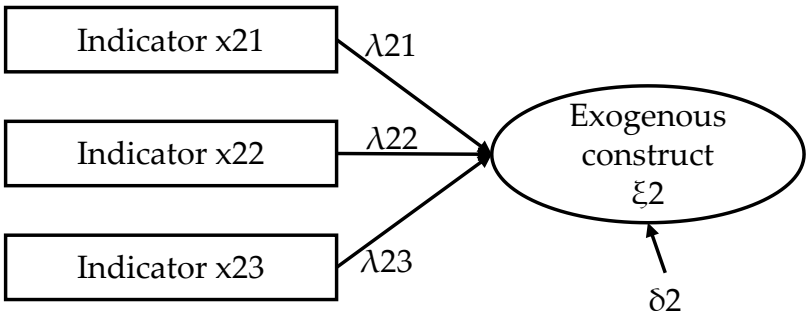
residuals) to be taken into account always leads to a correlation of less than 1 (Herrmann et al., 2006, p. 36; Jarvis et al., 2003, p. 200).

Indicators that show no or only a low correlation r with other indicators point to a different construct. These other constructs are either located elsewhere or not included in the research model at all. They are therefore not suitable for measuring the latent variable being analysed and must be removed. The adjustment of the indicators is based on statistical quality criteria (Churchill, 1979, p. 64 f.; Rossiter, 2002, p. 313; Zinnbauer & Eberl, 2005, p. 4).

Formative measurement models:

In formative measurement models, on the other hand, the indicators shape the latent variable, which means that a reversal of the effect relationship between construct and indicators is assumed (Albers, 2010, p. 409 ff.; Eberl, 2004, p. 5).

Figure 34: Structure of formative measurement models



Source: Own illustration based on (Fassott & Eggert, 2005, p. 37).

The most significant difference between reflective measurement models and formative measurement models is that the indicators in a formative measurement model do not need to correlate with each other, as only a causal relationship between the indicator and the latent variable is required. This also means that a change in the indicator also causes a change in the construct. It is also not possible to remove an indicator, as this would also result in a change to the construct or an incomplete construct. It is therefore not possible to subsequently remove one or more indicators. Analogue to the procedure for reflective measurement models, an error term δn must also be included in formative measurement models, which indicates deviations between indicators and the actually measured construct value

(Diamantopoulos & Winklhofer, 2001, p. 271; Herrmann et al., 2006, p. 36; Jarvis et al., 2003, p. 201; Zinnbauer & Eberl, 2005, p. 4 f.).

Determination of the specification parameters

In conclusion, it can be stated that reflective models are the dominant approach in the literature. It has also been established that many constructs can be specified both reflectively and formatively (Eberl, 2004, p. 15; Fassott & Eggert, 2005, p. 42 ff.; Jarvis et al., 2003, p. 205 ff.; Rossiter, 2002, p. 317). It has also been found that misspecification often occurs in about 30-35% of scientific misspecifications (Fassott, 2006, p. 67).

Based on these findings, the literature recommends using predominantly reflective indicators and only using formatively specified indicators selectively. The type of specification should be adapted to the theoretical background and the object of research (Diamantopoulos & Winklhofer, 2001, p. 271; Eberl, 2004, p. 15; Homburg & Klarmann, 2006, p. 731; Jarvis et al., 2003, p. 203).

Based on these references from the research literature, the primary aim of this study is to develop a reflective model specification.

4.2.4 Different estimation methods for structural equation models

Structural equation models can be estimated using two main methods. One is the covariance-based method and the other is the variance-based method (J. F. Hair et al., 2017, p. 13). This chapter will first discuss the different characteristics of the two methods before concluding with the justification of the method used in this thesis.

Covariance-based method

The aim of the covariance-based method (CB-SEM) is to obtain the most accurate estimate of the model parameters, considering all the information contained in the covariance matrix. The model parameters are estimated for this purpose. This is achieved by reproducing the empirically collected data as closely as possible, based on the covariance matrix of all indicators. For this reason, this is also referred to as a parameter-oriented approach, as the difference between the empirical and theoretical covariance matrix is minimised. For example, the

maximum likelihood method or the generalised least squares method can be used for this purpose (Herrmann et al., 2006, p. 34 ff.; Sosik et al., 2009, p. 16).

The prerequisite for a covariance-based method is a strong theoretical basis and a proven research model. For this reason, the covariance-based method is usually used for confirmatory research projects, such as the validation of an existing theory. The theoretical basis is used to create the hypothetical covariance matrix, which is then used as a reference to the covariance matrix of the collected data (A. Fuchs, 2011, p. 38; Gefen, 2000, p. 27,41). The quality assessment is usually based on one or more global model criteria (so-called global model fits). This allows different model specifications to be compared with each other, and the model that best matches the collected data can be identified (Bühner, 2006, p. 252 ff.; Sosik et al., 2009, p. 16; Tenenhaus et al., 2005, p. 173).

In principle, covariance-based methods can depict both reflective and formative measurement models, although formative models require a higher level of specification effort. In addition, it should be noted that at least two paths lead from each formative construct to reflective operationalising constructs and that the researcher must also map a higher evaluation effort (Albers & Hildebrandt, 2006, p. 29; Eberl, 2004, p. 23 f.; A. Fuchs, 2011, p. 38; Herrmann et al., 2006, p. 55). In addition, latent variables cannot be calculated directly as concrete factor or index values (so-called latent variable scores) (Chin, 2010, p. 667; Hoyle, 1999, p. 311). The minimum sample size for covariance-based methods is specified as approximately. 200 test subjects (Herrmann et al., 2006, p. 44; Nitzl, 2010, p. 20).

Variance-based methods

Compared to covariance-based methods, variance-based methods aim to explain the variance in a dataset. This is achieved by maximising the covariance between exogenous and endogenous latent variables, thereby offering the best possible reproduction of the initial data matrix. The information from the covariance matrix is not used in full, but only in blocks. Although this leads to less accurate estimates, it is consciously accepted (Herrmann et al., 2006, p. 37; Sosik et al., 2009, p. 16).

Basically, variance-based methods are forecast-oriented, and their aim is to minimise the variance of the error terms in the measurement model (δn, εn) and the structural model (ςn). This is done using iterative estimation procedures (least

squares) so that the quadratic deviations between the model and the observed data points are minimised and thus optimally approximated(Herrmann et al., 2006, p. 37 f.). In the practice of using the least squares method, this means that a corresponding curve (a model in the case of SEM) is sought for each existing data point in the data point cloud. The aim is for the curve to be as close as possible to the data points. The required parameters are determined through iterative estimation, aiming to minimise the sum of the quadratic deviations (residuals) between the model and the observed data points. This should enable the collected data to be predicted by the model in the most accurate way possible (Bühner & Küchenhoff, 2008, p. 3; A. Fuchs, 2011, p. 38).

Accordingly, variance-based methods are ideal for investigating new or modified models, as they focus on an exploratory approach (Albers & Hildebrandt, 2006, p. 29; Sosik et al., 2009, p. 16). For this reason, partial least squares (PLS) methods are also categorised as exploratory methods (Gefen, 2000, p. 27). The quality of the model is measured using the coefficient of determination (R^2). This provides information on the proportion of the total variance that can be explained by the model (Bühner, 2006, p. 255 ff.).

Variance-based methods are suitable for both reflective and formative constructs, as the PLS methods can both depict and calculate them (Herrmann et al., 2006, p. 44; Wetzels et al., 2009, p. 190). Another advantage is that variance-based methods can also analyse small samples (≥30) (Nitzl, 2010, p. 20).

Table 22 provides a final overview of the two methods presented above and their main differences:

Table 22: Comparison of covariance- and variance-based structural equation approaches based on key criteria

Criteria	Covariance-based methods	Variance-based methods
Focus	Best possible replication of the covariance structure of the initial data matrix (parameter-oriented)	Best possible prediction and explanation of the empirical data matrix (prognosis-oriented)
Estimation principle	Minimisation of the distance between model-theoretic and empirical covariance	Iterative and non-iterative least squares estimation
Applicable sample size	Relatively large samples necessary (≥ 200)	Small sample sizes also possible (≥ 30)
Distribution assumptions	Normal distribution necessary (exception ULS: no restrictions)	None
Model complexity	Small to medium complexity (≤ 100 indicators)	Models with very high complexity can also be mapped
Values of latent variables	Not determined Variance-based approach	Explicitly estimated
Examination of moderating variables and conducting multi-group analyses	Not possible	Possible
Applicable quality criterion	Global quality criteria	Only partial quality criteria can be used to predict the data matrix
Consideration of formative construct operationalisation	Only possible under certain conditions and using a special procedure	Possible without difficulty

Theoretical basis	Investigation of established theories (theory-testing, confirmatory)	Theoretical basis available, but specific relationships between constructs still need to be verified (theory-building, exploratory)
Software	LISREL, AMOS, M-PLUS, EQS	SmartPLS, PLSGraph, LVPLS, PLS-SEM

Source: Own illustration based on (A. Fuchs, 2011; J. F. Hair et al., 2011; Herrmann et al., 2006; Nitzl, 2010)

4.2.5 Choice of procedure for the present work

Based on the research model presented in Chapter 3, a variance-based method using partial least square structural equation modelling is proposed.

This is due to the fact that the research model contains many constructs whose relationships and effects are to be analysed. The focus here is on variance explanation (or the explanation of the final variables of "behavourial intention and use behaviour"). In addition, variance-based methods are particularly suitable when new models are to be tested: the research model is based on UTAUT 3, was considerably extended by means of the determinants of trust and adapted to the research context of electromobility in a context-specific manner (J. F. Hair et al., 2011, p. 144). This contrasts with covariance-based methods, which require a strong theoretical basis and are primarily used to validate the theory, but this is not the main objective here. The complexity of the research model becomes clear when considering the seventeen latent constructs, the 27 direct relationships, and the 162 effect relationships of the moderators. Compared to other structural equation models, this is a complex SEM (Henseler et al., 2009, p. 296; Ringle et al., 2012, p. 6; Zinnbauer & Eberl, 2005, p. 2).

Furthermore, it becomes clear that the research model primarily contains reflective constructs (e.g., performance expectancy, hedonic motivation) and only a few, if any, formatively specified constructs (e.g., costs or contextual acquaintance). Here, the PLS method proves to be more flexible than covariance-based methods, as it simultaneously allows the modelling of reflective and formative constructs without elaborate specification (Chin, 2010, p. 661). This also

avoids the misspecification of the formative constructs when choosing the covariance-based method (Albers & Hildebrandt, 2006, p. 29; Eberl, 2004, p. 23 f.; A. Fuchs, 2011, p. 38; Herrmann et al., 2006, p. 55).

The choice in favour of an exploratory method also seems straightforward regarding the sample size, as variance-based methods already yield robust results with small samples (≥ 30). This means that a comprehensive empirical study can already be carried out with a small or medium sample size and analysed using the PLS method. In contrast, the covariance-based method requires a larger sample of 200 or more (Herrmann et al., 2006, p. 44; Nitzl, 2010, p. 20).

The model aims to determine the explanatory power of behavioural intention and use behaviour through the latent constructs. As the PLS procedure maximises the explanatory power of these final variables, it provides robust results for the path coefficients and effect sizes. Covariance-based methods, on the other hand, focus on reproducing the covariance matrix and achieving global model fits. As a result, this method is not suitable for the exploratory approach of this study (Albers & Hildebrandt, 2006, p. 29; Bühner, 2006, p. 252 ff.; A. Fuchs, 2011, p. 38; Gefen, 2000, pp. 27, 41; Homburg & Klarmann, 2006, p. 739; Nitzl, 2010, p. 42; Sosik et al., 2009, p. 16). A variance-based method should be employed, particularly in light of the research model and the associated research question, as these generate well-founded index values for the constructs or latent variables as part of the model estimation using the collected data. Following the procedure, the index values can be interpreted directly and used for subsequent analyses if necessary. As this research project aims to determine the barriers to the acceptance of electromobility, the PLS method should be used (J. F. Hair et al., 2011, p. 144).

In terms of practicability and ease of use, it can be said that PLS methods are more user-friendly, as they enable iterative estimation procedures that require faster and simpler analysis steps. Furthermore, there are software programmes such as SmartPLS or PLS-SEM that offer intuitive user interfaces and generate robust tools for PLS models. With regard to the analysis of covariance-based methods, AMOS or LISREL are suitable for analysis, although both programmes require complex and extensive model validation steps (Albers & Hildebrandt, 2006, p. 29; Eberl, 2004, p. 23 f.; A. Fuchs, 2011, p. 38; J. F. Hair et al., 2011, p. 144; Herrmann et al., 2006, pp. 44, 55; Wetzels et al., 2009, p. 190).

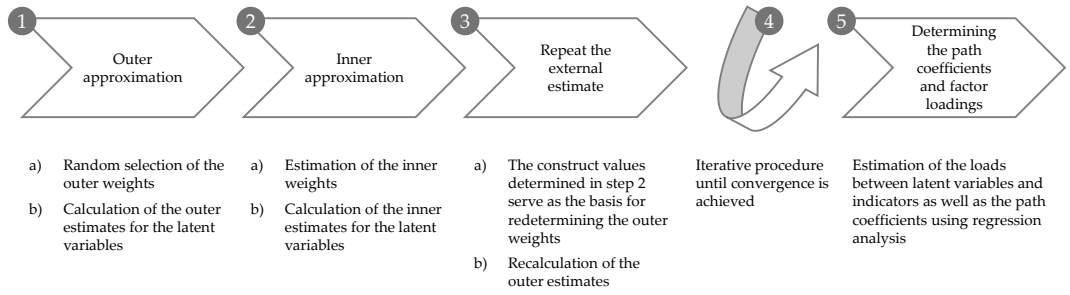
To summarise, the variance-based method via PLS-SEM is the better choice for this model because:

- it can deal more flexibly with reflective and formatively specified constructs;
- it is also considered robust with small samples with high testing strength;
- it aims to clarify the variance, i.e. it works exploratively; and
- it is more practical and faster to use.

4.2.6 Estimation procedure in the PLS algorithm

The PLS algorithm aims to check the theoretically assumed causal relationships between exogenous and endogenous latent variables. An iterative estimation procedure is employed, which generates approximate values for the latent variables. This process is illustrated in Figure 35:

Figure 35: PLS estimation procedure



Source: Own illustration based on (Henseler et al., 2009, pp. 287–288)

It can be observed that the PLS estimation process comprises five steps.

In the first step (the outer estimation), initial construct values are estimated for the exogenously and endogenously measured latent variables. These are the expected values of the indicator variables, which are used as the starting point for the weights. Depending on the measurement model, different calculation methods are used. If it is a reflective construct, the weights are determined by the simple regression coefficients. If, on the other hand, the construct is formative, multiple regression coefficients are used as weights. As a result of this external estimation

(expected values), initial construct values are available for the latent variables (J. F. Hair et al., 2011, p. 142, 2012, p. 423; Henseler et al., 2009, p. 287; Herrmann et al., 2006, p. 37).

In the following second step, the inner estimation is carried out. Here, the internal weights are estimated based on hypothetically assumed causal relationships between endogenous and exogenous latent variables. This generates improved values for the endogenous constructs on the basis of the exogenous constructs (J. F. Hair et al., 2011, p. 142, 2012, p. 426; Henseler et al., 2009, p. 287; Herrmann et al., 2006, p. 38).

In the third step, the construct values improved from step two are used for a new external estimation. The weights and the associated construct values of the latent exogenous variables are redetermined. In the further course - step 4 - the procedure described above (repetition of the outer and inner estimation) is repeated until convergence between the newly generated values of the latent variables and the previously generated values is achieved and there are therefore no more significant changes in the construct values (Henseler et al., 2009, p. 288).

In the final fifth step, the factor loadings between the latent variables and the indicators are determined. Furthermore, the path coefficients are also estimated in the structural model (Henseler et al., 2009, p. 288; Herrmann et al., 2006, p. 38).

With the PLS method, it should be noted that the estimated values are inconsistent between the measurement model and the structural model (Fornell & Cha, 1994, p. 66).

The measurement model describes the relationship between the latent variables (or constructs) and their corresponding indicators (or observable variables). Due to the PLS procedure, the strength of the link between the latent variables and the indicators is estimated higher in the measurement model than it actually is. The reason for this overestimation lies in the variance-based estimation procedure. This optimises the variance elucidation of the latent variables, whereby the correlation between indicators and constructs can be artificially strengthened. The resulting measurement errors (residuals) in the indicators are not completely filtered out and therefore contribute to overestimation. As a result, the measurement models appear more robust than they actually are, although this has

no direct influence on the predictive power of the overall model (Lohmöller, 1989, p. 28 f.).

An underestimation of the structural model offsets the overestimation of the measurement model. The structural model describes the causal relationship between the latent variables. The underestimation is due to the fact that the PLS method estimates the strength of the links between the latent variables to be lower than they actually are. Conversely, this means that the PLS procedure maximises the variance explained by the latent variables and thus leaves less room for variance explanation in the structural model. This means that the strength of the causal relationships (the path coefficients) between the latent variables is underestimated (Herrmann et al., 2006, p. 38).

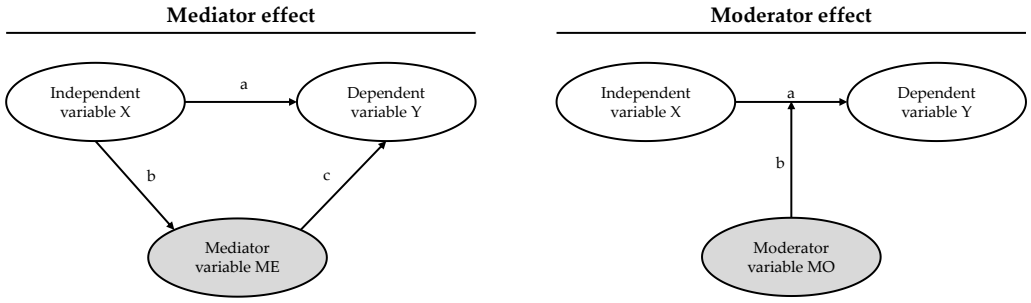
Nevertheless, the predictive power of the research model remains stable, as the overestimation in the measurement model (resulting from the stronger weighting of the indicators) and the underestimation in the structural model (resulting from the weaker weighting of the path relationships) have a balancing effect. Studies also show that the consistency of the correlation between indicators and latent variables remains stable, ensuring the overall quality of the results (Chin & Newsted, 1999, p. 329; Herrmann et al., 2006, p. 41). Thus, the PLS method is considered suitable for theory-building research and is valued for its predictive qualities, as the effect size is maintained despite overestimation in the measurement model and underestimation in the structural model (Chin & Newsted, 1999, p. 329; Fornell & Cha, 1994, p. 67; Herrmann et al., 2006, p. 41; K. Jöreskog, 1978, p. 445 ff.; Lohmöller, 1989, p. 211 ff.).

In conclusion, the quality of the estimation procedure increases with a larger sample and a higher number of indicators, known as the consistency-at-large effect (Chin & Newsted, 1999, p. 328; Fornell & Cha, 1994, p. 67; Lohmöller, 1989, p. 212; Ringle et al., 2012, p. vii). The consequence of fulfilling both conditions is that the consistency and thus the quality of the estimate increases with variance-based methods, as the expected values generated by the modelling approach the true values (Babakus et al., 1987, p. 197; Gefen, 2000, p. 197; Qureshi & Compeau, 2009, p. 197). (Babakus et al., 1987, p. 227; Gefen, 2000, p. 20; Qureshi & Compeau, 2009, p. 197).

4.2.7 Investigation of the interaction effects

The investigation of moderator and control variables plays a central role alongside the consideration of direct causal relationships. Not considering interaction effects is no longer considered up-to-date in business research and is therefore inadequate. Due to the selected research model (UTAUT 3) and its associated extensions and additions, it is necessary to explain the influence of moderator and control variables (which are assigned to the interaction effects) and provide a brief overview of possible interaction effects. Two types of interaction effects can be distinguished, namely the mediator effect and the moderator effect (Nitzl, 2010, p. 41). Figure 36 illustrates this:

Figure 36: Overview interaction effects



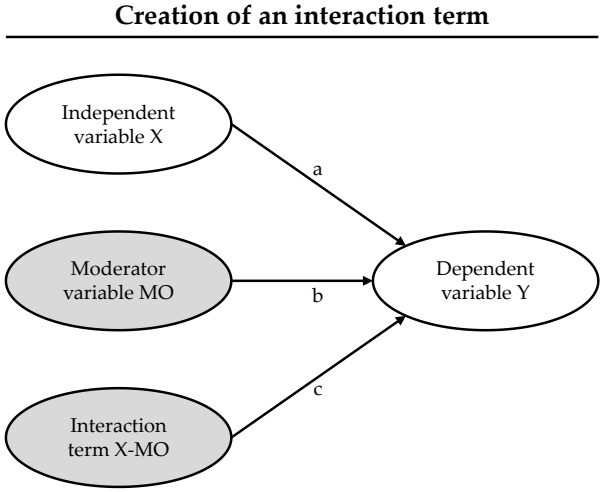
Source: Own illustration based on (Henseler & Chin, 2010, p. 85; Nitzl, 2010, p. 40)

A mediator effect (ME) exists when a mediator variable mediates the relationship between the independent variable (X) and the dependent variable (Y). The mediator effect is formed via the path coefficients b and c, which in turn means that the path coefficient a (X → Y) is weakened (Nitzl & Schloderer, 2011, p. 433). A distinction can be made between two types of mediation: partial mediation and total mediation. In partial mediation, the direct effect a remains, whereas in total mediation the effect a disappears completely (Nitzl & Schloderer, 2011, p. 432). The mediator effect is measured by the z-test (Sobel, 1982, p. 298 f.).

The moderator effect occurs when the moderator variable (MO) influences the strength and/or the direction of the relationship (a) between the independent variable X and the dependent variable Y. The path coefficient expresses the strength of the influence. The path coefficient expresses the strength of the influence (Baron

& Kenny, 1986, p. 1174). Figure 37 illustrates the formal formation and measurement of the moderation effect:

Figure 37: Creation of an interaction term to measure the moderator effect



Source: Own illustration based on (Baron & Kenny, 1986, p. 1174)

The measurement of the moderating effect b on the direct link a between independent variable X and dependent variable Y is carried out by forming an auxiliary variable of a so-called interaction term (X-MO) (Henseler & Chin, 2010, p. 84 f.; Herrmann et al., 2006, p. 85). This interaction term encompasses all pairwise product combinations of the indicators for X and MO, and formally represents a latent variable. If a significant influence (c) by the interaction term X-MO on the dependent variable Y is determined in the analysis, the moderating effect of MO is thereby also proven (Henseler & Chin, 2010, p. 105). Additionally, the direct effect (b) of the moderator variable on the dependent variable can be determined (Langer, 2002, p. 15). This direct effect can be used to determine the extent to which the expression of the dependent variable Y is influenced by the moderator variable MO. This means that the dependent variable Y is controlled by the moderator variable MO, which is why MO is also referred to as a control variable. Control variables can be used to avoid distortions and clarify additional variance (Liang et al., 2007, p. 65).

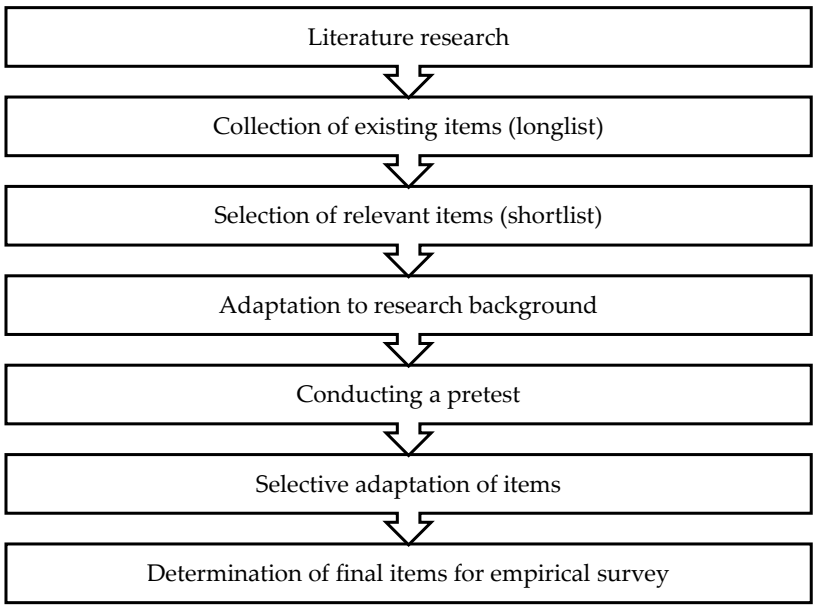
4.3 OPERATIONALISATION OF THE MODEL VARIABLES

4.3.1 Operationalisation process

The operationalisation of constructs comprises the development of constructs using several indicators (items). Furthermore, it is intended that statements be made about the constructs, and then the individual degree of agreement be asked of the participants in the study. The basic approach is to use existing, validated items from the literature, ideally those that have demonstrated high reliability in previous research. However, there is no general rule on how items are identified, developed and formulated (Boßow-Thies & Gansser, 2022, p. 14; Schnell et al., 2023; Tausendpfund, 2018, p. 108). Nevertheless, the general procedure for developing the items involves using suitable indicators from the literature to derive a catalogue of questions for the research work. Ideally, reflective items that have already been tried and tested are used; however, formative items can also be employed. The factor loadings of the items and the average variance extracted (AVE) calculated from them can be used to determine the validity of the reflective construct. Validity refers to the extent to which the items accurately represent the entire construct in terms of content. Reliability, on the other hand, refers to the extent to which the items within a construct correlate with each other. This can be expressed either via Cronbach's alpha(α) or alternatively via the composite reliability (CR)(Henseler, 2005, p. 74; Herrmann et al., 2006, p. 37).

In principle, the operationalisation process of Homburg and Giering is used as a guide (Backhaus et al., 2016, p. 169; Herrmann et al., 2006, p. 47; Homburg & Giering, 1998, p. 127). This provides for the identified items to be first checked for comprehensibility and relevance of content through a pre-test. The pre-test is used as a preliminary test before the actual data collection in order to improve the quality of the survey (DeVellis, 2017, p. 79 f.; C. Fuchs & Diamantopoulos, 2009, p. 200 ff.). This procedure for operationalising the model constructs is shown in Figure 38 and described below:

Figure 38: Procedure for operationalising the model constructs



Source: Own illustration based on (C. Fuchs & Diamantopoulos, 2009; Homburg & Giering, 1998)

In the literature research phase, potential constructs were taken from existing TAM and UTAUT research, as well as constructs from the Marketing Scales Handbook. Through this collection of possible constructs, including their measurement model specification, the construct specification (reflective or formative), and their indicators, an initial set of possible indicators can be identified (Bruner II, 2023).

After compiling this comprehensive list of possible indicators, the collected indicators were analysed for relevance and their possible explanatory contribution and redundant items were eliminated. Furthermore, items that had not yet been customised were adapted to the research background of electromobility (Churchill, 1979, p. 69; Gerbing & Anderson, 1988, p. 189).

The preliminary questionnaire was then finalised. The preliminary questionnaire contained indicators for testing all model constructs and variables.

A pre-test was also carried out. The questionnaire contains both reflective and formative constructs. For the formatively specified constructs in particular, it is very important to obtain a statement as to whether the items are comprehensible,

unambiguous and lead to coverage of the construct or whether further items need to be added or changed. For this purpose, the questionnaire was sent via e-mail to fifteen individuals, including three experts in the field of electromobility. The primary objective of the pre-test was to assess the questionnaire's content completeness and linguistic comprehensibility using a small sample of the target group, and to provide any necessary suggestions for changes. Following the pre-test, feedback was obtained from each participant via e-mail or in individual meetings. In each case, a detailed telephone or video call (via Zoom) was conducted with the experts. As the questionnaire was based exclusively on existing constructs and therefore predominantly tried-and-tested indicators, only minor changes were made to the questionnaire based on the feedback received (Anderson & Gerbing, 1988, p. 412 ff.; Chin, 1998; Homburg & Giering, 1998, p. 127; Weichbold, 2022, p. 443 ff.).

4.3.2 Single- vs. multi-item measurement

There is no clear recommendation in the literature on the optimal number of indicators per construct. However, it should be noted that constructs should be measured with more than one item. Multi-item measurement is therefore recommended. This has the advantage that measurement errors are avoided and content-related aspects are better mapped (Nitzl, 2010, p. 14).

No clear statement can be drawn from the literature regarding a minimum number of items per construct either. According to Drolet and Morrison (2001), at least two items per construct should ensure sufficient content coverage, but far more frequently the recommendation is made to use three to four items per latent variable and according to Ringle et al (2012), an average of 3.5 indicators should be used per reflective construct (Morrison, 2001, p. 6; Nitzl, 2010, p. 14; Ringle et al., 2012, p. 6; Schiele & Wink, 2008, p. 31; Schimmelpfennig, 2011, p. 86).

The advantages of multi-item constructs include the minimisation of measurement errors that can arise from misunderstandings in single-item measurements. Multi-items depict different facets of a construct. This results in greater precision and differentiation of abstract constructs, for example,e for analysing psychological attitudes. The "consistency-at-large effect" paradigm is

followed, which states that a higher consistency of model quality is achieved through more indicators (C. Fuchs & Diamantopoulos, 2009, p. 205).

However, the use of single-item constructs can be useful under certain circumstances: first, when general constructs such as satisfaction are being investigated, and second, for asking about moderator and control variables (e.g., age, income, or number of vehicles in the household). The advantage of a single-item measurement is that the respondents feel less the need to answer redundant questions on a latent variable and/or become tired less quickly due to fewer items and there is a risk that the respondents will lose the desire to answer the questions seriously (Fassott, 2006, p. 73 f.; C. Fuchs & Diamantopoulos, 2009, p. 204 f.; Morrison, 2001, p. 197). However, the use of single-item measurements also has disadvantages. For example, single items make differentiated measurement more difficult due to their one-dimensionality. There is a risk that participants will have to summarise all aspects of a construct in a single answer. This reduces the validity and resilience of the results (Churchill, 1979, p. 45 ff.; DeVellis, 2017, p. 150 ff.; Ringle et al., 2012, p. 6).

It can be said that, in practice, both single-item constructs and multi-item constructs are commonly used in surveys. Finally, a warning is issued against multi-item abuse. The danger of multi-item abuse is that too many identical items can create a feeling of redundancy and repetition in the respondent, thereby tiring them out. This can also lead to artificially inflated constructs that offer little or no scientific added value (Fassott, 2006, p. 76; Morrison, 2001, p. 197; Ringle et al., 2012, p. 6).

The final recommendation from the literature is that multi-item constructs should be used in particular for the central constructs of the research work. This is justified by the fact that single-item measurements are too risky for core constructs, as important sub-aspects of a latent variable cannot be adequately represented by one item. However, this can be guaranteed by multi-item constructs, as these produce reliable results through differentiated items (C. Fuchs & Diamantopoulos, 2009, p. 205). As a result, multi-item measurement is used for the central constructs in this research work. The reasons for this are that technology acceptance requires a precise measurement of the psychological attitudes of the test subjects, so that the measurement inaccuracy when using single-item constructs is avoided. Constructs

that have not yet been sufficiently tested or adapted are measured mutlidimensionally. A valid result can be expected via the number of items, thus utilising the consistency-at-large effect (DeVellis, 2017, p. 148 ff.; C. Fuchs & Diamantopoulos, 2009, p. 205; Ringle et al., 2012, p. 6).

4.3.3 Scaling of indicators

Another point in the operationalisation process is the scaling of the indicators. The scaling refers to the answer options provided to survey participants for answering individual questions. The scaling is defined by the response format, which in turn offers either digital response options or can be depicted using a rating scale or absolute values. In addition, scaling plays an important role. The scaling specifies which behaviour is assigned to which number. In other words, this means how the number and quality of the scaling is used for differentiation and which method is used to measure characteristics, traits or abilities (Bühner, 2006, p. 73; Schendera, 2015, p. 39 ff.).

Five different scale levels can be distinguished (Schnell et al., 2023, p. 124 ff.):

- Nominal scales: These include qualitative categories such as gender or nationality.
- Ordinal scales: These depict rankings without absolute distances, such as rankings.
- Interval scales: Have equal intervals but also have no natural zero point (an example of this is the temperature in °C).
- Ratio scales: Have a natural zero point and can be used to determine height or income.
- Absolute scales: Have a natural unit of measurement and cannot be transformed; this can be used, for example, to determine the frequency (number of vehicles in the household)

Table 23 shows the five scale levels once again. It is important to note that the higher scale levels always contain the characteristics of the lower scale levels as well (Bühner, 2006, p. 73 f.):

Table 23: Characteristics and features of different scale levels

Scale		Description	Example
Non-metric scales	Nominal scale	Fundamental difference, classification of qualitative characteristics	Gender, Nationality
	Ordinal scale	Formation of rank values	Ranking of participants in a car race
Metric scales	Interval scale	Scale with identical sections, but without natural zero	Temperature (degrees Celsius)
	Rational scale	Scale with identical sections, with natural zero, but without natural unit	Temperature (degrees Kelvin), income (EUR), height (cm)
	Absolute scale	Scale with identical sections, with natural zero point and natural unit of measurement	Number

Source: Own illustration based on (Bühner, 2006, p. 73 f.; Schnell et al., 2023, pp. 124–126)

As the focus of this research project is on examining individual factors related to attitudes towards technology acceptance of electromobility, a multi-level interval scaling method is used to measure the associated characteristics of the individual indicators. The interval scaling can be traced back to the social scientist Rensis Likert (1932) (Likert, 1932). The Likert scale measures agreement or disagreement with statements using several response categories, such as "strongly agree" or "disagree" (Zinnbauer & Eberl, 2005, p. 3). By definition, it is an ordinal scale, but in research it is often treated as a "quasi-metric" scale. The Likert scale allows statistical procedures due to its property of assumed equal distances between the scale points (equidistance) (Eichhorn, 2004, p. 16; Homburg, 2017, p. 314).

When using Likert scales, it is first necessary to clarify whether even or odd scaling will be used for the number of response options. Odd-numbered scaling enables a neutral centre category. This is particularly suitable when analysing comparatively new, possibly little or untested technologies (see electromobility). This contrasts with even-numbered scaling, which demands a directional tendency from the respondents. Here, there is a risk of an arbitrary answer due to an unclear

opinion and the compulsion to decide in one direction (Klarmann, 2008, p. 49). Five or seven-point Likert scales are mainly used in research. The recommendation is to use at least five and ideally even seven levels. An excessively high number of scale levels, in turn, offers the possibility of further differentiation; however, the high number can also negatively influence the judgement of the test participants (R. P. Bagozzi, 1980, p. 200; Bortz & Döring, 2023, p. 269 ff.; Klarmann, 2008, p. 56).

In accordance with the above explanations, a seven-point Likert scale is used in this research work to measure all constructs of the latent model constructs. The agreement scale ranges from 1 ("strongly disagree") to 7 ("strongly agree"). Nominal, ordinal and rational scales are also used for the moderator variables from the individual characteristics and situational determinants groups. For the remaining groups (national culture, technical determinants, contextual determinants and experience), a seven-point Likert scale is used for the defined items.

Table 24: Overview of the scaling of moderator variables that are not examined using a Likert scale

Type of Scale	Construct
Nominal scale	▪ Gender ▪ Occupation/Job ▪ EV driving experience ▪ Types of vehicles in household ▪ Charging opportunity
Ordinal scale	▪ Household income per month in EUR (net) ▪ Education ▪ Daily travel demand in km
Ratio scale	▪ Age ▪ Household size ▪ Number of vehicles per household

Source: Own illustration

4.3.4 Poling of indicators

The polarity of the items plays a crucial role in operationalisation. Polarity refers to the use of both positive and negative formulations for items, aiming to influence the response qualities. There is no consensus in the literature on the preferred formulation of the items. It is noted that negatively worded items should

be used to avoid response patterns and thereby promote cognitive control over responses (Hinkin, 1995, p. 967; Idaszak & Drasgow, 1987, p. 69). However, negatively worded items also increase the probability of measurement errors, as participants may be overwhelmed by the double negation and find it disturbing if the item wording is otherwise positive. This results in the recommendation to use negatively worded items only to a limited extent and in a targeted manner (Bortz & Döring, 2023, p. 271; Felser, 2015, p. 307; Harvey et al., 1985, p. 461; Motl & DiStefano, 2002, p. 562; Schmitt & Stults, 1986, p. 1 ff.; Tausendpfund, 2018, p. 150).

In addition to negatively and positively worded items, reverse-coded (or inverted) items can also be created. The difference between negative and inverted items is that the negatively worded items have a negative formulation. Whereas inverted items can consist of both a positive and a negative statement and. With reverse-coded items, the scaling is reversed. The aim here is similar to that of negatively worded items: yes-say tendencies (so-called acquiescence tendencies) are to be avoided, thereby testing the respondents' attention and avoiding misjudgements. The use of reverse-coded items is only recommended to a limited extent, similar to negatively worded items. A proportion of 10-30% reverse-coded items is considered sufficient (Döring & Bortz, 2016, p. 507; Moosbrugger & Kelava, 2020, p. 83 f.; Weiber & Sarstedt, 2021, p. 130).

In conclusion, it can be stated that a negatively polarised item can be reverse-coded, although a reverse-coded item does not have to be negative. The latter also depends on the questionnaire structure and the measurement's aim (Bortz & Döring, 2023, p. 271; Felser, 2015, p. 307). Table 25 summarises the statements made above:

Table 25: Comparison of negative and reverse-coded items

Main differences	Negative polarity	Reverse-coded item
Formulation of the item	The statement is negatively formulated.	The scaling of the item is reversed
Aim	Balanced statements (positive vs. negative) in the questionnaire.	This helps to prevent response tendencies (e.g. yes-saying).
Example	'I don't find EVs helpful.'	Original: 'I find EVs helpful.' Reverse: 'I find EVs unhelpful.'
How to evaluate	The answer is directly interpreted.	The answer must be mathematically reversed.

Source: Own illustration based on (Döring & Bortz, 2016, p. 271; Moosbrugger & Kelava, 2020, p. 83 f.; Schnell et al., 2023, p. 165 f.)

The procedure in this study assumes that negatively polarised and/or reverse-coded items are used sparingly. The reasons for this are, on the one hand, that already validated constructs and indicators are taken from the literature. Secondly, the risk of measurement errors is minimised by the fact that item validation has already taken place in preliminary studies (Schnell et al., 2023, p. 165 f.).

4.3.5 Concept operationalisation for investigating the acceptance of EVs

In this chapter, the constructs of the structural model are operationalised. This means that indicators are added to the constructs to obtain the endogenous and exogenous measurement models. In some cases, moderators are also measured using operationalised constructs via items. Other directly measured variables that act as moderators (e.g. age) do not have to be operationalised. These variables and their response options can be found in the next chapter (Hildebrandt & Görz, 1997, p. 2 f.; Zinnbauer & Eberl, 2005, p. 2).

The following operationalisation initially includes the constructs from the structural model: performance expectancy, effort expectancy, social influence, price value, hedonic motivation, facilitating conditions, habit, compatibility, attitude towards environment & technology, personal innovativeness, costs, reliability, contextual acquaintance, structural assurance, trusting intention in electromobility,

behavioural intention and use behaviour. Item formulations marked with an "*" were formulated as reverse-coded items, see for example PE3 or EE1.

The performance expectancy (PE) construct is consistent with existing TAM and UTAUT research and reflects the general usefulness, efficiency and productivity aspects of an EV. In addition to the adaptation to the research object, an integration based on the research of McKnight et al. also took place. As a result, the aspects of functionality and capability were taken into account, so that these were also taken into account against the background of the research model (Kapser & Abdelrahman, 2020; Kumar Jain et al., 2022; H. McKnight et al., 2009; Venkatesh et al., 2012).

Table 26: Operationalisation of the performance expectancy construct

Construct	Item#	Item	Source
Performance Expectancy	PE1	I find an EV useful in my daily life because it offers the functions that support me in achieving my personal goals.	Venkatesh et al. 2012; Kapser & Abdelraham 2020; Kumar et al. 2022; McKnight et al. 2009
	PE2	Using an electric car helps me to realise my personal goals and values.	
	PE3	For me, using an electric car has no practical added value.*	

Source: Own illustration

The effort expectancy (EE) construct is also taken from the literature, operationalised and adapted to the research context of electromobility:

Table 27: Operationalisation of the effort expectancy construct

Construct	Item#	Item	Source
Effort Expectancy	EE1	I am having a hard time learning how to operate an EV.*	Venkatesh et al. 2012; Kapser & Abdelraham 2020; Kumar et al. 2022; McKnight et al. 2009
	EE2	The operation of an EV is clear and understandable to me.	
	EE3	I find electric cars easy to use.	

Source: Own illustration

Below is the operationalised social influence (SI) construct, which is also an integral part of UTAUT research. In addition to the obligatory adaptation to the

object of research, existing items are adapted and new items are added due to the assignment of the variables "norms", "neighbourhood" and "word-of-mouth" from the research by Wicki et al. (Almansour, 2022; Fedorko et al., 2021; Kumar Jain et al., 2022; Tsu Wei et al., 2009; Venkatesh et al., 2012; Wicki et al., 2022).

Table 28: Operationalisation of the social influence construct

Construct	Item#	Item	Source
Social Influence	SI1	People whose opinion matters to me are influenced by my use of an EV.	Tsu Wei et al. 2009; Venkatesh et al. 2012; Kumar et al. 2022; Fedorko et al. 2021; Almansour 2022
	SI2	Friends and family influence my decision to use an EV.	
	SI3	Media (e.g., TV, newspapers, social media platforms) affect my decision to use an EV.	

Source: Own illustration

Furthermore, the price value (PV) construct is operationalised and adapted to the research context. It should also be mentioned that the assigned variables purchase price and resale value from Wicki et al. (2022) are taken into account accordingly (Bockarjova & Steg, 2014; Dodds et al., 1991; Goldsmith et al., 2005; Han et al., 2017; Jaiswal, Deshmukh, et al., 2022; Kapser & Abdelrahman, 2020; Venkatesh et al., 2012; Wicki et al., 2022).

Table 29: Operationalisation of the price value construct

Construct	Item#	Item	Source
Price value	PV1	The costs of EVs are disproportionate to their benefits.*	Han et al. 2017; Venkatesh et al. 2012; Adnan et al. 2017; Wicki et al. 2022; Goldsmith et al. 2005; Kapser & Abdelraham 2020; Kumar et al. 2022, Dodds et al. 1991; Bockarjova & Steg 2014
	PV2	I believe that the price of EVs is reasonable.	
	PV3	I think EVs offer good value for money.	

Source: Own illustration

The following is the operationalisation of the hedonic motivation (HM) construct, whereby the item formulations are very close to the original formulations and merely adapted to the research context (Azman Ong et al., 2023; Han et al., 2017; Venkatesh et al., 2012; M. Zhou et al., 2021).

Table 30: Operationalisation of the hedonic motivation construct

Construct	Item#	Item	Source
Hedonic Motivation	HM1	I feel joy when using an EV.	Venkatesh et al. 2012; Zhou M. et al. 2021; Han et al. 2017; Ong et al. 2023
	HM2	Driving an electric car is comfortable and enjoyable.	

Source: Own illustration

This is followed by the operationalisation of the facilitating conditions (FC) construct and adaptation to the research context. It should be mentioned here that FC3 was adapted to include a supplementary example of the use of compatible technologies. In addition, FC4 was adapted against the background of the research model and the extension by McKnight et al. (Azman Ong et al., 2023; Kumar Jain et al., 2022; D. McKnight & Chervany, 2002; H. McKnight et al., 2009; Venkatesh et al., 2012).

Table 31: Operationalisation of the facilitating conditions construct

Construct	Item#	Item	Source
Facilitating Conditions	FC1	I have the necessary technical and financial resources to use an EV.	Venkatesh et al. 2012; Kumar et al. 2022; Ong et al. 2023; McKnight et al. 2002/2009
	FC2	An electric car is compatible with other technologies that I use (e.g. a photovoltaic system).	
	FC3	I can easily access help or support, whether from others or EV manufacturers, when I encounter difficulties using an EV.	

Source: Own illustration

In the following, the habit (Ha) construct is operationalised and adapted to the research context; it should be noted that both users and non-users can answer the questions in the item formulation (Azman Ong et al., 2023; Venkatesh et al., 2012; M. Zhou et al., 2021).

Table 32: Operationalisation of the habit construct

Construct	Item#	Item	Source
Habit	Ha1	Using an EV is/would be a regular part of my daily routine.	Venkatesh et al. 2012, Ong et al. 2023; Zhou M. et al. 2021
	Ha2	I could easily manage without using an EV.*	
	Ha3	Using an electric car will quickly become a routine habit for me.	

Source: Own illustration

The operationalised items of the compatibility (Com) construct, adapted to the research context, can also be found below (Blut et al., 2022; Jansson, 2011; Meuter et al., 2005; G. C. Moore & Benbasat, 1991).

Table 33: Operationalisation of the compatibility construct

Construct	Item#	Item	Source
Compatibility	Com1	An EV is compatible with my daily requirements.	Moore & Benbasat 1991; Jansson 2011; Meuter et al. 2005; Blut et al. 2022
	Com2	Using an EV is compatible with my lifestyle.	

Source: Own illustration

The operationalised attitude towards the environment and technology (AtET) construct refers to the general attitude of an individual towards technological innovations and their application in the field of electromobility to promote/achieve environmental goals. It should be mentioned here that the items are fundamentally based on the construct of attitude towards using a technology by Davis (1989), but were adapted against the research background as well as through the assignment of the determinants of "environmental attitudes" and "technology affinity" by Wicki et al. (2022; (F. D. Davis, 1989; J. Liu et al., 2024; Walter & Abendroth, 2020; N. Wang et al., 2022; R. Wang et al., 2021; R. Wu et al., 2021).

Table 34: Operationalisation of the attitude towards the environment and technology construct

Construct	Item#	Item	Source
Attitude towards the environment and technology	AtET1	Promoting the use of EVs is essential for green travel and our responsibility toward the environment and future generations.	Liu et al. 2024; Wang R. et al. 2021; Wu et al. 2021; Wang N. et al. 2022; Davis F.D. 1989; Walter & Abendroth 2020
	AtET2	I have a positive attitude toward EV technology and support its promotion and application.	
	AtET3	I am not sure if EV technology will gain widespread public acceptance.*	

Source: Own illustration

In the following, the personal innovativeness (PI) construct is operationalised and adapted to the research context (Agarwal & Karahanna, 2000; Agarwal & Prasad, 1998; Blut et al., 2022; Jansson, 2011; Kuo & Yen, 2009; Kwon et al., 2007; Meuter et al., 2005; Parasuraman, 2000; M. Zhou et al., 2021).

Table 35: Operationalisation of the personal innovativeness construct

Construct	Item#	Item	Source
Personal innovativeness	PIn1	If I heard about a new vehicle drive technology (i.e. EVs), I would look for ways to experiment with it.	Parasuraman (2000); Prasad, Agarwal (1997); Kwon et al. (2007); Kuo, Yen (2009); Jansson (2011); Agarwal & Karahanna (2000); Blut et al. (2022); Yi et al. 2006; Zhou et al. 2021; Meuter et al. 2005
	PIn2	In general, I am open to trying out new vehicle drive technologies (i.e. EVs).	
	PIn3	I enjoy exploring and experimenting with new vehicle drive technologies (i.e. EVs).	

Source: Own illustration

Furthermore, the costs (Co) construct is operationalised and adapted to the research context. It should also be mentioned that the assigned variables of operational costs and fuel efficiency from Wicki et al. (2022) are taken into account accordingly by the item formulations (Blut et al., 2022; Han et al., 2017; Y.-F. Liu et al., 2018; Shuhaiber & Mashal, 2019; Tsu Wei et al., 2009; R. Wang et al., 2021; Wicki et al., 2022; I.-L. Wu & Wu, 2005; L. Zhang et al., 2012).

Table 36: Operationalisation of the costs construct

Construct	Item#	Item	Source
Costs	Co1	The purchase price of an EV is too high compared to traditional vehicles.*	Wu, Wang 2005; Tsu Wie et al. 2009; Zhang et al. 2012; Blut et al. 2022; Wang R. et al. 2021; Shuhaiber & Mashal 2019; Liu et al. 2018; Wicki et al. 2022; Wang Z. et al. 2017
	Co2	The charging and maintenance costs of EVs are higher than those of traditional vehicles.*	
	Co3	Using an EV helps me save on travel costs, including fuel and maintenance expenses, compared to traditional vehicles.	
	Co4	The total cost of owning an EV, including charging, maintenance, and insurance, is reasonable.	

Source: Own illustration

This is followed by the operationalisation of the reliability (Re) construct and its adaptation to the research context. The construct itself was assigned to the research model by the research of Wicki et al. (2022) and subsequently Re3 and Re4 were formulated and adapted against the background of the research model and the extension of McKnight et al. (Gefen et al., 2003; B. Kim & Han, 2011; H. McKnight et al., 2009; Wicki et al., 2022; Wixom & Todd, 2005).

Table 37: Operationalisation of the reliability construct

Construct	Item#	Item	Source
Reliability	Re1	I think EVs will work reliably.	Kim & Han 2011; Wixom & Todd 2005; McKnight et al. 2009; Gefen et al. 2003; Wicki et al. 2022
	Re2	EVs won't let me down.	
	Re3	I have doubts that EVs will always work as expected.*	

Source: Own illustration

The next operationalised construct adapted to the research context is contextual acquaintance (CA), which was included according to the extension by the constructs of familiarity (trust) by McKnight et al. (2009; (Gefen et al., 2003; D. McKnight et al., 2002; D. McKnight & Chervany, 2002; H. McKnight et al., 2009).

Table 38: Operationalisation of the contextual acquaintance construct

Construct	Item#	Item	Source
Contextual acquaintance	CA1	I feel safe and confident using EVs because I am convinced of their reliable operation.	McKnight et al. 2009; Gefen et al. 2003; McKnight et al. 2002; McKnight & Chervany 2002
	CA2	I trust that EVs integrate seamlessly into my daily routine and meet my expectations.	
	CA3	Using EVs feels as natural and intuitive as using traditional vehicles.	

Source: Own illustration

Furthermore, the operationalisation and adaptation to the research context of the structural assurance (SA) construct follows. This construct was included in the research model according to the model of McKnight et al. (2009) (Gefen et al., 2003; D. McKnight et al., 2002; D. McKnight & Chervany, 2002; H. McKnight et al., 2009).

Table 39: Operationalisation of the structural assurance construct

Construct	Item#	Item	Source
Structural assurance	SA1	I feel confident using EVs because they are supported by vendor protections and product guarantees.	McKnight et al. 2009; Gefen et al. 2003; McKnight et al. 2002; McKnight & Chervany 2002
	SA2	I feel assured that the infrastructure for EVs (e.g., charging stations) is well-developed and dependable.	
	SA3	Favourable legal structures and consumer protection laws make me feel secure in using EVs.	

Source: Own illustration

This is followed by the final expanded construct from McKnight et al. (2009), termed as trust in technology or, in this specific case, "trust in electromobility" (TI). This construct was also operationalised and adapted to the research context (Gefen et al., 2003; D. McKnight et al., 2002; D. McKnight & Chervany, 2002; H. McKnight et al., 2009).

Table 40: Operationalisation of the trusting intention in electromobility construct

Construct	Item#	Item	Source
Trusting intention in electromobility	TI1	I trust that EVs will get me to important appointments on time.	McKnight et al. 2009; Gefen et al. 2003; McKnight et al. 2002; McKnight & Chervany 2002
	TI2	I am unsure whether EVs will get me to my destination reliably.	
	TI3	I trust that EVs will get me to my destination reliably, especially when it matters.	

Source: Own illustration

This is followed by the operationalisation and adaptation to the research context of the behavioural intention (BI) construct, as one of the most important constructs in the research model (Azman Ong et al., 2023; Blut et al., 2022; F. Davis, 1989; F. D. Davis et al., 1992; Venkatesh, 2000; Venkatesh et al., 2012; M. Zhou et al., 2021).

Table 41: Operationalisation of the behavioural intention construct

Construct	Item#	Item	Source
Behavioural intention	BI1	I plan to use an EV for my daily journeys.	Davis et al. (1989); Davis et al. (1992); Venkatesh (2000); Ong et al. 2023; Zhou M. et al. 2021; Venkatesh et al. 2012; Blut et al. 2022
	BI2	If I buy a car, I prefer an EV over a traditional vehicle.	
	BI3	I am committed to adopt an EV in the future.	

Source: Own illustration

Finally, the operationalised construct of use behaviour (UB) follows, which was also adapted to the research context and is the most important construct within the research model (Adnan et al., 2017; Azman Ong et al., 2023; Blut et al., 2022; F. Davis, 1989; F. D. Davis et al., 1992; M. Zhou et al., 2021).

Table 42: Operationalisation of the use behaviour construct

Construct	Item#	Item	Source
Use Behaviour	UB1	I use an EV for most of my daily journeys.	Adnan et al. 2017; Blut et al. 2022; Davis 1989; Zhou M. et al. 2021; Ong et al. 2023; Davis et al. 1992
	UB2	Using an EV has become a regular part of my life.	
	UB3	An EV is my primary choice for commuting and errands.	

Source: Own illustration

The following constructs from the area of moderators are also operationalised: individualism, masculinity, motor power, driving range, charging time, market availability, charging availability, environmental impact, policy and incentives, knowledge and familiarity.

From the moderator group of national culture, the constructs of individualism (In) and masculinity (Ma) are operationalised and adapted to the research context (Ayyash et al., 2022; Blut et al., 2022; Goularte & Zilber, 2019; Yuniaristanto et al., 2024).

Table 43: Operationalisation of the individualism construct

Construct	Item#	Item	Source
Individualism	In1	I prefer making decisions about adopting EVs independently, without relying on others' opinions.	Blut et al. 2022; Yuniaristanto et al. 2024; Goularte & Zilber 2019; Srite & Karahanna 2006; Ayyash et al. 2022
	In2	I value personal benefits of EVs over community advantages.	
	In3	My decision to adopt an EVs is primarily influenced by my individual preferences and goals.	

Source: Own illustration

Table 44: Operationalisation of the masculinity construct

Construct	Item#	Item	Source
Masculinity	Ma1	I associate owning an EV with personal success and technological leadership.	Blut et al. 2022; Yuniaristanto et al. 2024; Goularte & Zilber 2019; Srite & Karahanna 2006; Ayyash et al. 2022
	Ma2	I value the competitive advantage EVs offer in terms of innovation and efficiency.	

Source: Own illustration

From the moderator group of "technical determinants", the constructs of motor power (MP), driving range (DR) and charging time (CT) are operationalised and adapted to the research context. These constructs were assigned from the research by Wicki et al. and used as moderators (AutoScout24, 2024; Blut et al., 2022; Bockarjova & Steg, 2014; Chang & Tung, 2008; Erick Ayapana, 2023; Fazel, 2014; Hackbarth & Madlener, 2013; Hidrue et al., 2011; Roca et al., 2006; Schmalfuß et al., 2017; Shin, 2009; R. Wang et al., 2021; Z. Wang et al., 2017; Wicki et al., 2022).

Table 45: Operationalisation of the motor power construct

Construct	Item#	Item	Source
Motor power	MP1	The motor power of an EV is insufficient for my daily needs.*	Roca et al. 2006; Chang & Tung 2008; Shin 2009; Fazel 2014; Schmalfuß et al. 2017
	MP2	I believe EVs provide comparable performance to conventional vehicles, especially with their instant and sporty acceleration.	
	MP3	The quick and smooth acceleration of EVs enhances my overall driving experience.	

Source: Own illustration

Table 46: Operationalisation of the driving range construct

Construct	Item#	Item	Source
Driving range	DR1	The range of a EV is sufficient for my daily mobility needs.	Wang R. et al. 2021; Wang Z. et al. 2017; Roca et al. 2006; Chang & Tung 2008; Shin 2009; Fazel 2014; Bockarjova & Steg 2014; Schmalfuß et al. 2017
	DR2	I feel restricted in my freedom due to the limited range of an EV.*	
	DR3	I can accept the cruising range of EVs for my application.	

Source: Own illustration

Table 47: Operationalisation of the charging time construct

Construct	Item#	Item	Source
Charging time	CT1	I can integrate the charging process of an EV into my daily life without any problems.	Hackbarth & Madlener 2013; Hidrue et al. 2011; Bockarjova & Steg 2014; Roca et al. 2006; Chang & Tung 2008; Autoscout24 2024; Ayapana 2023; Schmalfuß et al. 2017; Fazel 2014
	CT2	Shorter recharging times would encourage me to use an EV.	
	CT3	Fast charging (5-80% within 20 minutes) makes EVs convenient for me.	

Source: Own illustration

From the moderator group of "contextual determinants", the constructs of market availability (MAv), charging avaiability (CAv), environmental impact (EI) and policy and incentives (PI) are operationalised and adapted to the research context. These constructs were assigned from the research by Wicki et al. and used as moderators (Bockarjova & Steg, 2014; Butt & Singh, 2023; Dhinakaran et al., 2021; Fazel, 2014; Hasan, 2021; Kautish et al., 2024; Nguyen et al., 2024; Quy Nguyen-Phuoc et al., 2022; She et al., 2017; R. Wang et al., 2021; S. Wang et al., 2019, 2017; Wicki et al., 2022).

Table 48: Operationalisation of the market availability construct

Construct	Item#	Item	Source
Market Availability	MAv1	The availability of nearby dealers influences my decision to adopt an EV.	Kautish et al. 2024; Hasan 2021; Wicki et al.
	MAv2	A wide variety of EV models makes adoption more attractive to me.	
	MAv3	The availability of EV models from reputable manufacturers encourages me to adopt one.	

Source: Own illustration

Table 49: Operationalisation of the charging availability construct

Construct	Item#	Item	Source
Charging availability	CAv1	There are sufficient charging facilities near my home or workplace to support using an EV.	Wang R. et al. 2021; Wang S. et al. 2019; Wang Z. et al. 2017; Bockarjova & Steg 2014; She et al. 2017
	CAv2	The current lack of public charging stations limits my decision to adopt an EV.*	
	CAv3	I am concerned that public charging stations might not always be available when needed.*	

Source: Own illustration

Table 50: Operationalisation of the policy and incentives construct

Construct	Item#	Item	Source
Policy & Incentives	PI1	Priority parking for EVs in urban areas would encourage me to adopt an EV.	Kautish et al. 2024; Kumar et al. 2021; Wang S. et al. 2017; Bockarjova & Steg 2014
	PI2	A government direct subsidy policy would be attractive to me to adopt an EV.	
	PI3	The government should provide more incentives for using EVs.	

Source: Own illustration

Table 51: Operationalisation of the environmental impact construct

Construct	Item#	Item	Source
Environmental impact	EI1	EVs can reduce emissions, but battery production and disposal remain challenges.	Wang R. et al. 2021; Wu et al. 2019; Nguyen M. et al. 2024; Nguyen-Phouc et al. 2022; Butt & Singh 2023; Fazel 2014
	EI2	EVs may have little environmental impact if the power source is not sustainable or battery production is environmentally harmful.*	
	EI3	The environmental benefits of EVs are considerable, but their limited range and long charging times are among the drawbacks.	

Source: Own illustration

From the moderator group of "experience", the constructs of knowledge (Kn) and familiarity (Fa) are operationalised and adapted to the research context. These constructs were assigned from the research by Wicki et al. and used as moderators (Bennett & Vijaygopal, 2018; Blut et al., 2022; Jiang, 2023; Kalmbach et al., 2011; Meuter et al., 2005; Schmalfuß et al., 2017; R. Wang et al., 2021; S. Wang et al., 2019).

Table 52: Operationalisation of the knowledge construct

Construct	Item#	Item	Source
Knowledge	Kn1	I understand how EVs work, but there are still details I could learn.	Schmalfuß et al. 2017; Jiang 2023; Wang R. et al. 2021, Wang S. et al. 2019; Meuter et al., 2005; Blut et al. 2022; Fazel 2014; Bennet & Vijaygopal 2018
	Kn2	I know the advantages of EVs over conventional vehicles, but I am wondering how big the actual difference is in practice.	
	Kn3	I don't know exactly how the charging process for EVs works, and I'm unsure whether I understand all the steps correctly.*	

Source: Own illustration

Table 53: Operationalisation of the familiarity construct

Construct	Item#	Item	Source
Familiarity	Fa1	I have a clear understanding of the practical requirements of owning and operating an EV.	Schmalfuß et al. 2017; Jiang 2023; Wang R. et al. 2021, Wang S. et al. 2019; Meuter et al., 2005; Blut et al. 2022; Fazel 2014; Bennet & Vijaygopal 2018
	Fa2	I feel confident in my knowledge of how to use an EV.	

Source: Own illustration

4.3.6 Summary and overview of the final questionnaire

The operationalisation of the constructs resulted in nineteen reflective constructs being operationalised in the structural model and nine formatively specified constructs, with eight of the formatively specified constructs acting as moderators. In summary, this means that 28 constructs with 81 indicators were operationalised. The cover letter of the questionnaire can be found in Appendix 8. It should also be emphasised that there are fifteen negatively worded items, which are also reverse-coded items. As described, these serve as control variables and are intended to ensure balanced responses and avoid response tendencies (Döring & Bortz, 2016, p. 271; Moosbrugger & Kelava, 2020, p. 83 f.; Schnell et al., 2023, p. 165 f.).

In addition, the constructs and items were grouped to provide a structured questionnaire and to facilitate respondents' understanding of the thematic changes more easily. As a result, six groups were defined for the 28 constructs (Moosbrugger & Kelava, 2020, p. 59 f.). Table 54 provides an overview of the groupings in the questionnaire:

Table 54: Grouping of constructs

Cluster	Cluster description	Constructs contained	Number of items
1	**Use, user-friendliness and compatibility**	▪ Performance expectancy ▪ Effort expectancy ▪ Compatibility ▪ Facilitating conditions	11
2	**Personal attitudes and social influences**	▪ Social influence ▪ Hedonic motivation ▪ Attitude towards the environment and technology ▪ Individualism ▪ Masculinity	13
3	**Costs and technical features**	▪ Price value ▪ Costs ▪ Motor power ▪ Driving range ▪ Charging time	16
4	**Infrastructure, support and environmental aspects**	▪ Charging availability ▪ Market availability ▪ Policy and incentives ▪ Structural assurance ▪ Environmental impact	15
5	**Trust, behaviour and Context**	▪ Reliability ▪ Trusting intention ▪ Behavioural intention ▪ Use behaviour ▪ Knowledge	15
6	**Habits and personal innovation**	▪ Habit ▪ Contextual acquaintance ▪ Familiarity ▪ Personal innovativeness	11

Source: Own illustration

Regarding the quality assurance of the indicators used, Table 55 provides information on the validity and reliability of the reflectively specified constructs from the questionnaire. In addition to the factor loadings, the AVE and the composite reliability (CR) are also given. The factor loadings represent the strength of the correlation between an observable indicator and the underlying construct (or variable). This coefficient shows how strongly an indicator correlates with a latent variable. The values typically range from -1 to +1. The higher a factor loading, the better the item represents the latent variable, whereby a factor loading greater than 0.7 is considered very good. An AVE greater than 0.5 indicates that, on average, the

majority of the indicator variance is explained by the construct. Thus, the AVE should be greater than 0.50 to ensure sufficient convergence validity. In turn, the CR should be >0.70 to be acceptable, and values >0.80 are considered good (R. P. Bagozzi & Yi, 1988; Fornell & Larcker, 1981; J. F. Hair et al., 2019; Henseler, 2005, p. 74; Herrmann et al., 2006, p. 37).

Based on the assumption that the formatively specified items influence the constructs and that the constructs take into account specific facets of electric mobility (for example, range), it can be determined whether these different factors influence the acceptance of EVs (Blalock Jr, 1985). As the validity and reliability of the formatively specified constructs cannot be determined using the traditional quality criteria for measuring validity and reliability, several steps were taken to ensure that these are nevertheless as good as possible (Bollen, 1989, p. 65; Diamantopoulos, 2006, p. 7 ff.). During the literature research, care was taken to ensure that the item formulations originated from frequently cited sources and that the facets to be considered in the items had already been identified as relevant factors for electromobility (see Wicki et al. 2022). Furthermore, the items were checked and validated by means of a pre-test. This pre-test demonstrated that the formatively formulated items effectively cover the constructs and yield a good level of understanding among the test subjects. In addition, subject matter experts were also involved in the pre-test, who assessed the questionnaire from their position as experts. It was confirmed that the formatively designed items capture the research focus well and that the items cover all relevant facets of the constructs well (Rossiter, 2002; Weichbold, 2022, p. 443 ff.).

Table 55: Validity and reliability of the questionnaire constructs (part 1 of 2)

Construct	Item #	Specification of the Construct	Polarity of the item	Reverse coded items	Factorloading of the item	Average Variance Extracted (AVE) Validity Test	Composite Reliability (CR) Reliability Test
Perfromance Expectancy	PE1	reflective	Positive	No	0,87	0,7273	0,8841
	PE2		Positive	No	0,85		
	PE3		Negative	Yes, reverse coded	0,82		
Effort Expectancy	EE1	reflective	Negative	Yes, reverse coded	0,78	0,6436	0,8392
	EE2		Positive	No	0,82		
	EE3		Positive	No	0,82		
Social Influence	SI1	reflective	Positive	No	0,8	0,5726	0,8036
	SI2		Positive	No	0,77		
	SI3		Positive	No	0,69		
Price Value	PV1	reflective	Negative	Yes, reverse coded	0,88	0,5669	0,8159
	PV2		Positive	No	0,7		
	PV3		Positive	No	0,73		
Hedonic Motivation	HM1	reflective	Positive	No	0,85	0,6881	0,8108
	HM2		Positive	No	0,81		
Facilitating Conditions	FC1	reflective	Positive	No	0,8	0,6861	0,8654
	FC2		Positive	No	0,82		
	FC3		Positive	No	0,85		
Habit	Ha1	reflective	Positive	No	0,84	0,6877	0,8691
	Ha2		Negative	Yes, reverse coded	0,82		
	Ha3		Positive	No	0,83		
Compatibility	Com1	reflective	Positive	No	0,86	0,7313	0,8461
	Com2		Positive	No	0,85		
Attitude towards Environment & Technology	AtET1	reflective	Positive	No	0,81	0,7176	0,8972
	AtET2		Positive	No	0,84		
	AtET3		Negative	Yes, reverse coded	0,89		
Personal Innovativeness	PIn1	reflective	Positive	No	0,76	0,5051	0,7497
	PIn2		Positive	No	0,56		
	PIn3		Positive	No	0,79		
Costs	Co1	formative	Negative	Yes, reverse coded	n/a	n/a	n/a
	Co2		Negative	Yes, reverse coded			
	Co3		Positive	No			
	Co4		Positive	No			
Reliability	Re1	reflective	Positive	No	0,95	0,9025	0,9744
	Re2		Positive	No	0,95		
	Re3		Negative	Yes, reverse coded	0,95		
Contextual Acquaintance	CA1	reflective	Positive	No	0,94	0,7815	0,9337
	CA2		Positive	No	0,95		
	CA3		Positive	No	0,78		
Structural Assurance	SA1	reflective	Positive	No	0,9	0,8359	0,9539
	SA2		Positive	No	0,94		
	SA3		Positive	No	0,89		

Source: Own illustration

Table 56: Validity and reliability of the questionnaire constructs (part 2 of 2)

Construct	Item #	Specification of the Construct	Polarity of the item	Reverse coded items	Factorloading of the item	Average Variance Extracted (AVE) Validity Test	Composite Reliability (CR) Reliability Test
Trusting Intention in Electromobility	TI1	reflective	Positive	No	0,85	0,7402	0,9175
	TI2		Negative	Yes, reverse coded	0,84		
	TI3		Positive	No	0,88		
Behavioural Intention	BI1	reflective	Positive	No	0,92	0,8283	0,9591
	BI2		Positive	No	0,9		
	BI3		Positive	No	0,91		
Use Behaviour	UB1	reflective	Positive	No	0,93	0,8569	0,97
	UB2		Positive	No	0,92		
	UB3		Positive	No	0,94		
Individualism	In1	formative	Positive	No	n/a	n/a	n/a
	In2		Positive	No			
	In3		Positive	No			
Masculinity	Ma1	formative	Positive	No	n/a	n/a	n/a
	Ma2		Positive	No			
Motor Power	MP1	formative	Negative	Yes, reverse coded	n/a	n/a	n/a
	MP2		Positive	No			
	MP3		Positive	No			
Driving range	DR1	formative	Positive	No	n/a	n/a	n/a
	DR2		Negative	Yes, reverse coded			
	DR3		Positive	No			
Charging Time	CT1	formative	Positive	No	n/a	n/a	n/a
	CT2		Positive	No			
	CT3		Positive	No			
Market Availability	MAv1	formative	Positive	No	n/a	n/a	n/a
	MAv2		Positive	No			
	MAv3		Positive	No			
Charging Availability	CAv1	formative	Positive	No	n/a	n/a	n/a
	CAv2		Negative	Yes, reverse coded			
	CAv3		Negative	Yes, reverse coded			
Policy & Incentives	PI1	formative	Positive	No	n/a	n/a	n/a
	PI2		Positive	No			
	PI3		Positive	No			
Environmental Impact	EI1	reflective	Positive	No	0,88	0,6995	0,8853
	EI2		Negative	Yes, reverse coded	0,88		
	EI3		Positive	No	0,76		
Knowledge	Kn1	reflective	Positive	No	0,92	0,645	0,8648
	Kn2		Positive	No	0,8		
	Kn3		Negative	Yes, reverse coded	0,73		
Familiarity	Fa1	reflective	Positive	No	0,8	0,6128	0,7586
	Fa2		Positive	No	0,76		

*Reverse coded.

Source: Own illustration

The other variables in the model are the moderators of age, gender, education, daily travel demand in km, occupation/job, EV driving experience, household size, household income, number of vehicles in household, types of vehicles in household and charging opportunity, which are listed with their direct response options. As each variable is asked directly, no operationalisation was carried out (Schnell et al., 2023, p. 165 f.).

Table 57 shows the variables of the individual characteristics moderator group, whose response options were prepared based on existing research (Adnan et al., 2018; Blut et al., 2022; Chong et al., 2012; Kapser & Abdelrahman, 2020; Shuhaiber & Mashal, 2019; Sovacool et al., 2018):

Table 57: Questionnaire contents for individual characteristics

Construct	Item #	Item	Answer options		Source
Age	IC1	How old are you? (Please select only one answer.)	18-24 years	O	Blut et al. 2022; Adnan et al. 2017; Han et al. 2017; Kapser & Abdelraham 2020; Sovacool et al. 2018; Chong et al. 2012; Shuhaiber & Mashal 2019
			25-34 years	O	
			35-44 years	O	
			45-54 years	O	
			55-64 years	O	
			65-74 years	O	
			>75 years	O	
Gender	IC2	Please indicate your gender: (Please select only one answer.)	Female	O	
			Male	O	
Education	IC3	What is the highest level of education you have completed? (Please select only one answer.)	No school-leaving certificate	O	
			Secondary school certificate	O	
			Secondary school leaving certificate, intermediate school leaving certificate or equivalent	O	
			Completed apprenticeship	O	
			Vocational baccalaureate diploma, entrance qualification for studies at a university of applied sciences	O	
			A levels, university entrance qualification	O	
			Technician's or master's certificate	O	
			Degree from a university of applied sciences or university	O	
			Doctorate/postdoctoral qualification	O	
			Other qualification, please specify:		
Daily travel demand in km	IC4	How many kilometres do you drive on average each day? (Please select only one answer.)	<10 km	O	
			10-20 km	O	
			21-50 km	O	
			51-80 km	O	
			81-100 km	O	
			>100 km	O	
Job/ Occupation	IC5	What is your current occupation or Job? (Please select only one answer.)	Employed	O	
			Pensioner	O	
			Pupil, trainee, student or similar	O	
			Family carer	O	
			Currently unemployed	O	
			Others, please specify:		
EV driving experience	IC6	Do you have any driving experience with electric vehicles? (Please select only one answer.)	Yes	O	
			No	O	
			I am not certain	O	

Source: Own illustration

Furthermore, the variables of the situational determinants moderator group are listed, whose answer options were prepared based on existing research (Egbue & Long, 2012; Helveston et al., 2015; Herndler, 2024; Sovacool et al., 2018):

Table 58: Questionnaire contents for situational determinants

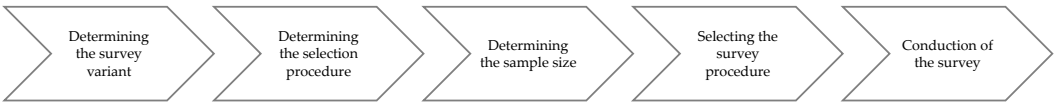
Construct	Item #	Item	Answer options		Source
Household size	SD1	How many people live in your household? (Please select only one answer.)	1	O	Helveston et al. 2015; Egbue und Long 2012; Sovacool et al. 2018; Herndler 2024
			2	O	
			3	O	
			4	O	
			≥5	O	
Household income	SD2	What is your household's monthly net income? (Please select only one answer.)	>5.000 EUR	O	
			3.501 - 5.000 EUR	O	
			2.501 - 3.500 EUR	O	
			2.001 - 2.500 EUR	O	
			1.251 - 2.000 EUR	O	
			<1.250 EUR	O	
Number of vehicles in household	SD3	How many vehicles do you have in your household? (Please select only one answer.)	0	O	
			1	O	
			2	O	
			3	O	
			≥4	O	
Type of vehicles in household	SD4	What type of vehicles do you have in your household? (Multiple selection possible.)	Car with combustion engine	O	
			Car with hybrid drive	O	
			pure electric vehicle	O	
			No car	O	
EV Charging possibility	SD5	What charging options are available for an electric vehicle? (Multiple selection possible.)	I have the option of charging my electric vehicle at home.	O	
			I have the option of charging my electric vehicle within 5 minutes' walking distance of my home.	O	
			I can charge my electric vehicle at my employer's premises.	O	
			I can charge my electric vehicle within 5 minutes' walking distance of my employer's premises.	O	
			No charging option for my electric vehicle – neither at my home nor in the area around my home/apartment, nor at my employer's premises nor in the area around my employer's premises.	O	

Source: Own illustration

4.4 DATA AND SAMPLE DESCRIPTION // STUDY DESIGN

The following chapter describes the preparation of the empirical study. Important aspects here include the definition of the selection procedure and the target quotas, as well as the determination of the sample size, the survey procedure, and the implementation of the survey. Figure 39 visualises this process:

Figure 39: Procedure for defining the study design



Source: Own illustration based on (Böhler, 2004, p. 30)

Definition of the survey variant

The aim of the survey is to obtain a picture of the German population with regard to the characteristics of the model and acceptance behaviour towards electromobility. A distinction can be made between two survey methods (Diekmann, 2020, p. 390 ff.). On the one hand, there is the full survey (all elements are analysed), and on the other hand, there is the partial survey (only a part of the population is analysed, referred to as the sample). A sample is defined as follows: A sample consists of a selection of "n" elements of the population of all elements "N. The aim of the sample is to represent the population and to allow generalisation. This is referred to as a representational inference, which attempts to replicate the population in the most accurate way possible to investigate hypotheses and research questions (Friedrichs, 1990, p. 125; Homburg, 2017, p. 299).

For the present research project, a partial survey was chosen due to time and cost constraints. In the partial survey, only selected survey and study units are included in the survey as representatives of the population (Stein, 2022, p. 155; Weis & Steinmetz, 2005, p. 30). Survey units are defined as elements of the population on which the survey is based (e.g. companies, families). On the other hand, elements on which the actual measurement is carried out (e.g. employees, family members) are defined as survey units. It is essential that the units of investigation and survey units align, allowing for the investigation of individual acceptance behaviour regarding electromobility through surveys of individuals (Friedrichs, 1990, p. 127).

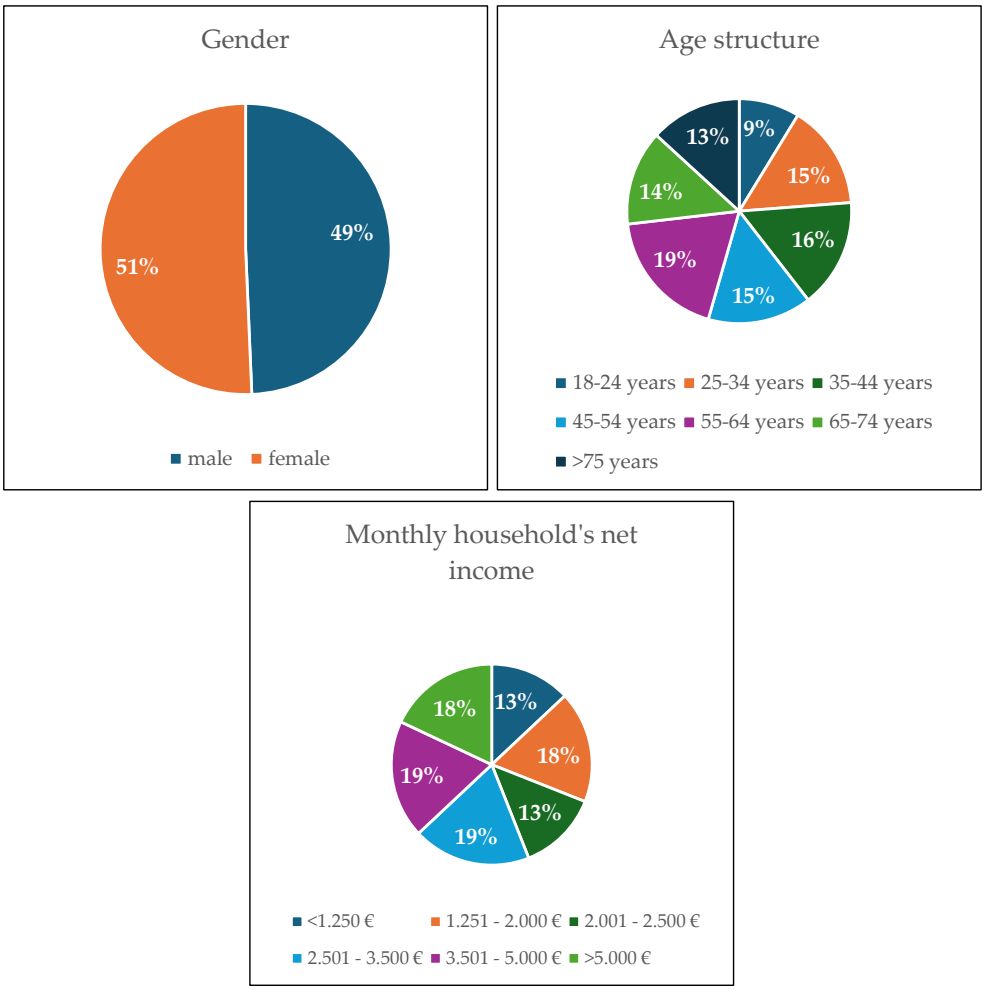
Determining the selection procedure

In addition to the survey variant, the selection of sample elements also plays a crucial role. When selecting sample elements, a distinction can be made between probability-based selection and deliberate selection. With simple probability selection, each element has the *same* probability of being drawn. In a deliberate

selection, the elements are defined in advance on the basis of selected characteristic values. The so-called quota method is used to achieve a representative sample that reflects the population. The quota method involves setting target quotas for some moderator variables, which are to be achieved with the survey. This procedure is intended to ensure that a representative cross-section of the German population is reached (Bortz & Döring, 2023, p. 307; Boßow-Thies & Gansser, 2022, pp. 16–17; Schnell et al., 2023, p. 243 ff.; Tausendpfund, 2018, p. 221).

The statistical basis for the ratios of gender, age and household income is the publications of the Federal Statistical Office (Statistisches Bundesamt, 2024b, 2024a, 2024c). Figure 40 shows the target distributions determined:

Figure 40: Target values for the distributions of the moderator variables of gender, age and monthly net household income



Source: Own illustration

In addition to the relative target rates, two additional requirements are placed on the sample. First, a minimum sample size of the study population for the subgroup "EV driving experience" of n ≥150 should be achieved (Kish, 1965, p. 78; Kumar et al., 2019, p. 242 ff.; Sudman, 1976, p. 30). This should help to achieve the best empirical reliability of this subgroup for significant analyses and evaluate the respective subgroups separately (Moosbrugger & Kelava, 2020, p. 62; Schnell et al., 2023, p. 410 ff.). Among other things, the survey participants must be natural persons, have their main place of residence in Germany and be at least 18 years old.

These criteria are important as this is the only way to conduct a population-representative survey of the Federal Republic of Germany for all adults according to the law (Przyborski & Wohlrab-Sahr, 2014, p. 127).

Sample size

The next step is to determine the sample size. The aim here is to determine a representative sample size with which generalisable results and a significant level of significance for the research can be achieved. In contrast to covariance-based methods, the variance-based PLS method also allows the use of small samples, enabling even small study sizes to be equalised and transferred into supposedly representative results, although this is not recommended (G. Marcoulides & Saunders, 2006, p. 8).

Several meta-analyses have examined approaches to determining the optimal sample size for a research project. For studies in the field of acceptance research, some researchers suggest using samples with sizes ranging from 25 to 2500 participants, with an average of 290 people. Others recommend a minimum sample size of 200 participants (Boomsma, 1982, p. 171; Boomsma & Hoogland, 2001, p. 139 ff.; Legris et al., 2003, p. 193). There are also different approaches concerning the rules for determining an appropriate sample size for PLS procedures: Chin (2000), for example, recommends either a) ten times the maximum number of indicators of a formative construct or b) ten times the number of path links converging to an endogenous variable (Chin, 2000b). Kline (2010) also recommends at least five times, and preferably ten times, the number of model variables (R. B. Kline, 2023, p. 309). As the majority of reflective constructs are analysed in this study, the first option mentioned is not an option. To determine an appropriate sample size in the context of PLS-SEM, Chin (2000) recommends using ten times the maximum number of structural paths directed towards an endogenous variable as a lower limit. In the model developed here, the endogenous variable "Behavioural Intention" (BI) has the highest load with fourteen incoming path connections. This results in a recommended minimum sample size of 140 participants (10 × 14). Applying this rule to the total number of all paths in the model (27) would not be methodologically correct, as it contradicts the original recommendations of Chin (2000) (Chin, 2000a, p. 94; Chin & Newsted, 1999, p. 301 ff.). Costello and Osborne (2005) concluded in their meta-analysis that the sample size can be determined by

the ratio of participants to indicators. Either a ratio of 2:1 or 5:1 is suggested. With 92 items, this results in a sample size range of 184 to 540 (Costello & Osborne, 2005, p. 4; Osborne, 2014, p. 46 ff.).

The final decision for the present study was based on the upper third of Costello and Osborne's range, resulting in a target sample size of N = 450. This guideline value is also based on the average number of test subjects reported in earlier studies in the field of acceptance research, which is approximately 300 (Costello & Osborne, 2005, p. 8). The selected sample size has the advantage of allowing for a reduction in sampling error and greater generalizability. Against the research background of investigating the factors influencing the acceptance of electromobility, a high degree of generalizability of the work should be achieved. This was to be guaranteed by the sample size of $N = 450$ and the risk of limiting the validity of the research results due to a sample size that was too small was to be largely avoided (Legris et al., 2003, p. 194). It should be noted that the postulated moderation hypotheses H28 to H45 are tested by means of a separate estimation of the base model I (27 paths), in which one moderator (e.g. age) is integrated in each case in a dichotomous variant (0 vs. 1). Therefore, instead of estimating one large model with the addition of all relevant moderators, a separate model is estimated for each moderation, consisting of 27 paths and 27 interaction effects between the moderator and the respective constructs. This results in a moderation model with 27x2 (0 vs. 1) = 52 paths. Taking into account the guideline of at least ten observations per pathway, as frequently used in the literature (Chin, 2000a, p. 94; J. F. Hair et al., 2017, p. 24), results in a recommended sample size of 520 people. The sample size of $N = 450$ planned here falls slightly short of this target value, but is well above the minimum value of 260 people (52 × 5) when applying the more conservative threshold of five respondents per path. Against this background, the targeted sample size is assessed as appropriate and robust for the planned moderation analyses within the framework of the PLS approach (J. F. Hair et al., 2017, p. 24; R. B. Kline, 2023, p. 419 ff.).

In addition, the selection of a sufficiently large sample is based on the central limit theorem (CLT). This states that the distribution of sample mean values approaches the normal distribution as the sample size increases, regardless of the distribution of characteristics of the population. This is particularly relevant for

inferential statistical methods, as it means that the requirements for many parametric tests are approximately fulfilled even if the characteristics in the population are not normally distributed. With a target sample size of $N = 450$, a sufficient approximation to the normal distribution can therefore be assumed, which additionally increases the robustness of the analysis (Biemann, 2009, p. 208; Bortz & Schuster, 2010, p. 85 ff.; Moosbrugger & Kelava, 2020, p. 625).

Selection of the survey method

Regarding the choice of survey method, a distinction can be made between an oral and a written survey. The oral survey has the advantage of interaction with the respondents and therefore offers the opportunity to clarify any queries. In contrast, the written survey does not allow direct interaction, so clear formulations are necessary. Nevertheless, the decision was made in favour of the written survey method, even if this has the disadvantage that no questions can be answered. This is mitigated or even compensated for by suitable measures. On the one hand, suitable definitions of terms are used at the relevant points. On the other hand, attention is paid to the clear formulation of items and the avoidance of overly long and complex questions. The pre-test and a final revision of unclear items ensure this. In addition, there is an introductory text for the study participants, which introduces them to the research topic and emphasises the importance of their participation (Eichhorn, 2004, p. 7; Schnell et al., 2023, p. 295 f.; Weichbold, 2022, p. 443 ff.).

Carrying out the survey

The online survey was conducted over a period of one month (03/04/2025 to 03/05/2025). The data basis is an online questionnaire. This is constructed using the LimeSurvey programme and sent via a link (Schnell et al., 2023, p. 345 f.). The LimeSurvey programme is specially designed for scientific surveys (LimeSurvey GmbH, 2025). To achieve a reliable statement and generalizability of the results, a sample must be drawn using the quota method, which reflects certain characteristics of the population. For this reason, the widespread snowball method is not suitable, as sampling is arbitrary in this method and depends on the respondents forwarding the survey to their social contacts. Depending on the survey method, this can be distributed by forwarding the internet link via various social media channels such as Facebook, Twitter, Instagram, Xing, LinkedIn, as

well as by e-mail and WhatsApp. This is a non-probabilistic random sample (Döring & Bortz, 2016, pp. 465–469; Goodman, 1961, p. 148 ff.; Schnell et al., 2023, p. 276).

The advantages of an online survey are that the participants can be reached quickly and the survey data is then available directly in digital form. One of the challenges of online surveys is selecting a representative sample. Participation is based on voluntary participation, so that no coercive measures are used, unlike in government-ordered censuses, for example. To achieve voluntary participation, a convincing process or, in the case of an online survey, a compelling presentation or text is required to persuade respondents to participate.

In addition, an online survey carries the risk of a distorted and therefore unrepresentative sample composition. The use of the market research institute Lightspeed Research[23] ensures that representative distributions of the previously defined quotas of age, gender and household income are achieved. As the market research service provider offers access to 4.3 million registered people in Germany, it can be ensured that the total sample size of N = 450 is achieved (Kantar Group, 2023, p. 14). This means that a minimum sample size of 150 or more can be achieved for test subjects with experience with EVs. To ensure that the test subjects fulfil the further defined characteristics: Main residence in Germany and possession of a class B driving licence, confirmation should be obtained from the test persons at the beginning of the survey via a so-called screener questionnaire that they meet this requirement (Boßow-Thies & Gansser, 2022, p. 16; Lightspeed Research, 2024, p. 39). Furthermore, the survey should be conducted until the necessary quotas in the categories have been achieved. If necessary, the market research institute can

[23] Lightspeed was originally a separate company specialising in market research and data collection. However, it was acquired by Kantar, a global market research and consulting firm, in 2008. Kantar is part of WPP, one of the largest communications and marketing services companies in the world. Lightspeed continues to specialise in surveys and market research as part of Kantar, providing data collection and analysis solutions. Kantar offers a wide range of market research services, and Lightspeed is one of the brands within this portfolio.

address the questionnaire again specifically to one or more groups of respondents. Categories that have been reached are closed, so further participation is no longer possible (Wisbert & Knappe, 2021, p. 60).

With regard to quality assurance, the response behaviour of the participants is analysed. This means that, among other things, uniform answers, i.e., items with a positive or negative polarity, all of which are answered with the same answer option (so-called flat linings), can be excluded from further investigation. Furthermore, participants who answered faster than a third of the median value of the length of interview (LOI) were also excluded from the study. To obtain a representative sample, 10% of each category was added to the specified quotas, ensuring a total sample of at least N = 495. This allows non-qualified responses to be excluded as invalid at the end of the survey period, after data export and analysis, without risking a loss in the overall sample size (Boßow-Thies & Gansser, 2022, pp. 16–17; Lightspeed Research, 2024, p. 39).

V – RESULTS

V RESULTS

This chapter aims to empirically analyse the theoretically postulated research model and present the results based on the data collected. Initially, an overview is provided of all the steps involved in preparing the data using the R analysis software. A short overview chapter then outlines the further course of the empirical analysis. Building on this, the model constructs are tested at the measurement model level, and then the overall model is validated at the structural model level, concerning the overall model quality. In addition, the effect of the moderator variables is analysed. A final summary summarises the key findings and leads to a discussion, interpretation, and deduction of implications in the following chapter. While Chapter 5 thus concentrates on the methodological implementation and presentation of results, Chapter 6 deals with the discussion of the content.

5.1 DATA PREPARATION

5.1.1 Preparatory work and preparation of the data in "R"

In empirical studies, it is necessary to process the available raw data once data collection has been completed (Bortz & Schuster, 2010, p. 47; Weiber & Sarstedt, 2021, pp. 190–191). The analysis software "R" is used for data preparation (e.g. creating new variables) and data cleansing (e.g. filtering implausible values or coding the items appropriately;(J. F. Hair et al., 2021, p. 3 ff.).

The reasons for this can be (depending on the type of data collection):

- incomplete questionnaires;
- questions were not thoroughly read and understood and a random answer was selected;
- knowingly / accidentally false information was given (Boßow-Thies & Gansser, 2022, pp. 17–18).

The recommended procedure for data cleansing is described below:

The first step is to determine which data are available and how they were described and measured. To do this, an overview of the variable structure must first be obtained in order to determine:

- which scalings (nominal, ordinal, metric) are present;
- which data types (logical, numerical, character or factor) were used;
- which of the scale levels used require which type of statistical evaluation;
- which inspection functions are used to check the statistical key figures (Boßow-Thies & Gansser, 2022, p. 18).

It is also necessary to create a codebook. With online survey platforms such as LimeSurvey, this codebook is already built into the system, or the codes are generated automatically when the question catalogue is created in LimeSurvey. This means that no additional effort is required in the data preparation step (Boßow-Thies & Gansser, 2022, p. 18; LimeSurvey GmbH, 2025; Netscher & Katsanidou, 2018, p. 5; Wicki et al., 2022, p. 67).

Data preparation also includes:

- Imputation of missing values
- Identification of cases with conspicuous response behaviour (flat linings) or with conspicuously fast response behaviour (speeders)
- Inconsistent answers
- Recoding of variables, which means that inverted queried variables must be recoded
- Data transposition from a wide to a long format (necessary for experimental designs)
- Check whether variables can be summarised into superordinate factors (Göthlich, 2009, p. 119 ff.; J. F. Hair et al., 2017; Leiner, 2019, p. 229 ff.; Stoetzer, 2020, p. 297 ff.)

In addition to imputing missing values (see the following chapter), the sample (n = 548) was examined for conspicuous response patterns to ensure data quality. Two criteria were applied:

- Flatlining: Uniform response behaviour was classified as flatlining if more than 80% of the items on a scale were answered with the same value.

- Speeding: Cases were defined as speeding if the processing time was less than 3.55 minutes (this corresponds to the empirically determined threshold value based on the time distribution; median = 10.77 minutes).

A total of 63 cases were identified as flatliners or feeders and were excluded from the dataset. The final, adjusted sample thus comprises n = 485 valid cases (Göthlich, 2009, p. 119 ff.; J. F. Hair et al., 2017; Leiner, 2019, p. 229 ff.; Stoetzer, 2020, p. 297 ff.).

Furthermore, all items in R are reverse-coded to the content-related polarity of the items in the respective construct block to ensure that the numerical scales have the same directional polarity. This is relevant for the subsequent determination of construct values and the subsequent integration into structural equation modelling (Boßow-Thies & Gansser, 2022, p. 18).

5.1.2 Imputation of missing values

The imputation of missing values refers to the handling of missing data points (data omissions) to avoid analysis bias, so-called non-response bias (Armstrong & Overton, 1977, p. 396). The aim is to ensure that missing values are used to complete the data matrix through plausible substitution.

This counteracts the problem of the elimination method, as this method simply removes data records with missing values. However, the disadvantages of this method include strong distortion in cases with many missing values, a high loss of information, and a reduction in the significance of the analysis. The alternative is mean value imputation. Here, missing values are replaced by the arithmetic mean of the existing values of a variable. The advantages of this are that no complete elimination of cases is necessary, the loss of information is minimised and there is a neutral influence on the evaluation, i.e. no distortion (Fazel, 2014, pp. 234–235; Göthlich, 2009, p. 119 ff.; Leiner, 2019, p. 229 ff.; Rohrbach-Schmidt & Alda, 2011, p. 7 f.).

The need to impute missing values is only relevant for one variable, namely the moderator and quota variable of "available monthly net household income". At the beginning of the fieldwork, the market research institute conducted a pilot

study with approximately 10% of the target sample (n = 450). In addition to the answer options presented above, the questionnaire also contained the answer option of "no response", whereby four people selected this answer option. Based on the assumption that four missing values from the total sample size (n = 45) represent a high number due to the simulated scaling by a factor of 10 (40 out of 450 cases) and would have to be added using mean imputation, the answer option "No response" was removed from the questionnaire after the pilot. As a result, all other respondents in this survey are forced to select the category of their monthly household income that applies to them or to cancel the survey. All questions in the survey are defined as mandatory questions, which ensures that all questions are answered in full or that respondents can withdraw from the survey during the course of the survey, which in turn is recognised by LimeSurvey as an incomplete data set (Lightspeed Research, 2024; LimeSurvey GmbH, 2025; Stoetzer, 2020, p. 297 ff.).

The imputation of missing values is therefore only necessary for a subset of respondents. In order to supplement four missing pieces of information on monthly net household income, a mean value imputation was carried out in accordance with Temme (2006). The distribution was not strictly proportional to the target quota, but rather focused on underrepresented categories (€2,001-€ 2,500 and €3,501-€ 5,000) to achieve an approximation to the defined sample structure. This is implemented in the data matrix in Microsoft Excel before the data is processed in R and subsequently analysed at the measurement model level in SmartPLS (Temme et al., 2006, p. 7). Table 59 shows the final number and final ratios after imputation of the four missing values for monthly net household income:

Table 59: Final number and odds after input of missing values[24]

Categorie	Sub-Categroie	Quota	Minimum target sample size of n=450	Number achieved	Quota achieved	Number achieved after inputting 4 missing values	Actual quota achieved after inputting 4 missing values
Monhtly net household income	<1.250 €	13,0%	59	64	13,3%	64	13,2%
	1.251 - 2.000 €	18,0%	81	87	18,1%	87	17,9%
	2.001 - 2.500 €	13,0%	59	61	12,7%	63	13,0%
	2.501 - 3.500 €	19,0%	86	93	19,3%	93	19,2%
	3.501 - 5.000 €	19,0%	86	89	18,5%	91	18,8%
	>5.000 €	18,0%	81	87	18,1%	87	17,9%
	sample size		452	481		485	

Source: Own illustration

5.1.3 Representativeness of the database

Once the data processing was complete, 485 data records were available. Before analysing the empirical survey, a comparison of the target and actual rates of the control variables—gender, age, and net household income — as well as the additional requirement for the test subjects that at least 150 participants in the study already have experience with EVs, should be carried out. Table 60 provides an overview:

[24] Due to rounding to whole numbers, the target minimum sample size is N = 452.

Table 60: Final number and odds after input of missing values[25]

Categorie	Sub-Categorie	Required Quota	Minimum target sample size of n=450	Number achieved	Quota achieved	Required quota fulfilled
Gender	male	49%	221	238	49%	Yes
	female	51%	230	247	51%	Yes
	sample size		451	485		
Age	18-24 years	9%	40	41	8%	(Yes)
	25-34 years	15%	68	69	14%	(Yes)
	35-44 years	16%	71	74	15%	(Yes)
	45-54 years	15%	68	74	15%	Yes
	55-64 years	19%	85	94	19%	Yes
	65-74 years	14%	61	68	14%	Yes
	>75 years	13%	59	65	13%	Yes
	sample size		452	485		
Monhtly net household income	<1.250 €	13%	59	64	13%	Yes
	1.251 - 2.000 €	18%	81	87	18%	Yes
	2.001 - 2.500 €	13%	59	63	13%	Yes
	2.501 - 3.500 €	19%	86	93	19%	Yes
	3.501 - 5.000 €	19%	86	91	19%	Yes
	>5.000 €	18%	81	87	18%	Yes
	sample size		452	485		
Experience with Electric vehicles	n/a	33%	n≥150	166	34%	Yes
	sample size		450	485		

Source: Own illustration

The quota specifications related to the characteristics of gender, age, monthly net household income, and experience with EVs were based on distributions representative of the population (see Chapter 4.4).

- The gender distribution was exactly as specified, with 49% male and 51% female participants.
- In the age range, seven categories between 18 and over 75 years were covered. The quotas were consistently achieved or were within the acceptable range with a maximum of -1 percentage point.
- The income distribution also met the specifications with an even coverage of the six specified income classes.
- The required sample size of ≥ 150 participants with experience with EVs was also achieved with n=166.

This means that all quotas were successfully met, providing a solid basis for the planned hypothesis-testing analyses.

[25] Due to rounding to whole numbers, the target minimum sample size varies between n=450 and n=452.

Despite careful recruitment, it was not possible to fulfil the target quotas exactly in all cases in the field (see age). Minor deviations occurred, particularly due to non-response, hard-to-reach target groups, and practical limitations in the recruitment process. To maintain a balance between sample quality and feasibility, a tolerance limit of ±5 percentage points per quota characteristic was accepted. This form of tolerance is common practice in empirical social research and is considered acceptable by standard methodological works and market and social research guidelines (e.g. through weighting) (ADM Arbeitskreis & Deutscher Markt- und Sozialforschungsinstitute e.V., 2023, p. 23; Hill, 2024, p. 349 ff.; Kromrey et al., 2016, p. 271 ff.; Porst, 2014, pp. 31, 74; Schnell et al., 2023, p. 279 ff.).

In conclusion, it can be said that the available database allows a representative conclusion to be drawn about the German population.

To summarise, it can be said that electromobility in Germany is currently in the early adopter phase,[26] so that individual dependencies within the research model have changed or will change compared to past and future research (Peters et al., 2011; Peters & Dütschke, 2014). As the study took place in Germany, the results are not easily transferable to other contexts. However, due to the starting point of a holistic research model, the same study can be carried out in other countries, which allows investigating other markets with different customer needs and/or other legal decisions (subsidies or emission regulations). In addition to exploring the status quo of the acceptance of electric mobility, this study also examines the 25 factors influencing the acceptance of EVs identified by Wicki et al. (2022).

5.1.4 Quality of the database

In contrast to covariance-based methods, structural equation modelling using variance-based methods does not require any strict distribution assumptions. However, a normal distribution of the data is recommended when using them (Bühner, 2006, p. 80). The normal distribution is determined by the skewness and kurtosis of the individual items (Bortz & Schuster, 2010, p. 72 f.).

[26] See Appendix 6 and Chapter 2.3.2.

The skewness describes the degree of symmetry of the data distribution. A skewness that is > 0 is left-skewed and a skewness that is < 0 is right-skewed (G. Held, 2009, p. 162 f.). A skewness = 0 is given with a perfect normal distribution. According to Kline (2010), the limit values at which an extreme deviation can be spoken of are > + 3 or < - 3 (R. B. Kline, 2016, p. 74).

Kurtosis, in turn, describes the steepness or curvature of the distribution of the data (G. Held, 2009, p. 162 f.). If the distribution is normal, the kurtosis is 3. Excess kurtosis refers to the deviation from the normal distribution value. A distinction is made between positive excess kurtosis (leptokurtic) and negative excess kurtosis (platykurtic). Positive excess kurtosis is characterised by a more acute distribution with a greater concentration of individual values around the mean value. On the other hand, a negative excess kurtosis describes a flatter, more widely scattered distribution (Bühner, 2006, p. 88 f.). According to Kline (2010), values of excess kurtosis of ±8 are considered the upper limit for many statistical methods as a guideline for acceptable deviations (R. B. Kline, 2023, p. 59).

Based on the empirical data collection, it was possible to calculate both the skewness and the kurtosis of the 81 indicators, which were recorded using a Likert scale. The calculations were carried out using the statistical software "R". The results can be seen in Table 61:

Table 61: Skewness and kurtosis of the indicators

Construct	Item	Skewness ±3	Kurtosis ±8
Performance Expectancy	PE1	-0.03	-1.29
	PE2	0.1	-1.23
	PE3	0.29	-1.22
Effort Expectancy	EE1	-0.79	-0.6
	EE2	-0.64	-0.63
	EE3	-0.53	-0.68
Facilitating Conditions	FC1	0.13	-1.34
	FC2	0.44	-1.15
	FC3	0.1	-1.01
Compatibility	Com1	-0.2	-1.21
	Com2	-0.13	-1.22
Social Influence	SI1	0.5	-1.06
	SI2	0.63	-0.92
	SI3	0.52	-0.97
Hedonic Motivation	HM1	0.05	-1.23
	HM2	-0.23	-1.02
Attitude towards Environment & Technology	AtET1	-0.38	-0.93
	AtET2	-0.25	-1.15
	AtET3	0.38	-0.74
Individualism	In1	-0.81	-0.03
	In2	0.0	-0.91
	In3	-0.65	-0.37
Masculinity	Ma1	0.36	-1.15
	Ma2	0.08	-1.19
Price Value	PV1	0.48	-0.76
	PV2	0.55	-0.77
	PV3	0.41	-0.94
Costs	Co1	1.0	0.31
	Co2	0.27	-0.79
	Co3	0.09	-1.0
	Co4	0.18	-0.83
Motor Power	MP1	-0.29	-1.08
	MP2	-0.26	-0.79
	MP3	-0.26	-0.69
Driving Range	DR1	-0.4	-0.86
	DR2	0.22	-1.22
	DR3	-0.25	-0.98
Charging Time	CT1	-0.03	-1.17
	CT2	-0.35	-0.96
	CT3	-0.43	-0.76

Construct	Item	Skewness ±3	Kurtosis ±8
Market Availability	MAv1	0.25	-1.25
	MAv2	0.03	-1.32
	MAv3	0.15	-1.31
Charging Availability	CAv1	0.25	-1.28
	CAv2	0.47	-0.9
	CAv3	0.65	-0.55
Policy & Incentives	PI1	-0.06	-1.26
	PI2	-0.23	-1.13
	PI3	-0.54	-0.86
Environmental Impact	EI1	-1.04	0.44
	EI2	0.71	-0.21
	EI3	-0.67	-0.11
Structural Assurance	SA1	-0.14	-1.05
	SA2	0.16	-1.18
	SA3	0.01	-1.0
Reliablity	Re1	-0.41	-0.72
	Re2	-0.14	-0.9
	Re3	0.16	-1.03
Trusting Intention in Electromobility	TI1	-0.31	-0.85
	TI2	0.01	-1.11
	TI3	-0.32	-0.82
Behavioural Intention	BI1	0.31	-1.34
	BI2	0.2	-1.35
	BI3	0.16	-1.36
Use Behaviour	UB1	0.7	-1.04
	UB2	0.76	-0.95
	UB3	0.55	-1.22
Knowledge	Kn1	-0.42	-0.71
	Kn2	-0.36	-0.61
	Kn3	-0.14	-1.07
Habit	Ha1	0.1	-1.45
	Ha2	0.87	-0.34
	Ha3	-0.14	-1.26
Contextual Acquaintance	CA1	-0.06	-1.16
	CA2	-0.2	-1.19
	CA3	-0.22	-1.16
Familiarity	Fa1	-0.32	-0.94
	Fa2	-0.25	-0.93
Personal Innovativeness	PIn1	-0.05	-1.16
	PIn2	-0.43	-0.84
	PIn3	-0.07	-1.14

Source: Own illustration

None of the recorded items exceeds the critical limits for skewness (±3) or kurtosis (±8), which are considered robust tolerance thresholds for normal distribution assumptions in the literature (R. B. Kline, 2023, p. 59). In fact, all values for skewness and kurtosis are below ±2, which indicates a small deviation from the normal distribution (Byrne, 2010, p. 103; J. F. Hair et al., 2017, pp. 52–53; West et al., 1995). A graphical overview of the item distributions can be found in Appendix 9. The histograms shown illustrate that most of the items do not show any significant deviation from the normal distribution.

Given the sample size of $n = 485$, the CLT can also be used. This states that for sufficiently large samples, the distribution of the sample mean values approximates the normal distribution, regardless of the initial distribution of the characteristics. Overall, the application of inferential statistical procedures within the framework of the following structural equation models based on the classical normal distribution assumption is therefore methodologically unobjectionable. The CLT ensures that the (conditional) mean values of arbitrarily distributed test characteristics always approximate the symmetrical Gaussian distribution in probability for large sample sizes (Biemann, 2009, p. 208; Bortz & Schuster, 2010, p. 85 ff.). Simulation studies indicate that this convergence is typically achieved with $n > 30$ (Moosbrugger & Kelava, 2020, p. 625).

In addition to checking the normal distribution, the existence of a common bias method must also be investigated (G. Held, 2009, p. 163; Spector, 2006, p. 221; Straub, 2009, p. 225). This analysis determines the proportion of variance that is attributable to measurement instruments, rather than to the actual construct (Temme et al., 2009, p. 123). There is always a risk of method bias if the respondent serves as a source for exogenous and endogenous variables and draws conclusions about the underlying hypotheses based on the context of the question, thereby adjusting their response behaviour (Jarvis et al., 2003, p. 199 ff.).

The relevance of checking for method bias is addressed inconsistently in the literature, leading Spector (2006) to argue that the misinterpretation of data caused by method bias is negligible (Spector, 2006, p. 221). In contrast, however, Podsakoff et al. (2003) and Sharma (2009) are in favour of their explicit review, so that the review for a method bias is also carried out in this work (Podsakoff et al., 2003, p. 879 ff.; Sharma et al., 2009, p. 473 ff.).

The test is performed using Harman's single-factor test, which aims to check whether one factor explains more than 50% of the total variance of the model. If this is the case, it can be assumed that there is a common method bias. The investigation is carried out using exploratory factor analysis (PCA) and examines the extent to which the characteristics (covariances) of the indicators can be attributed to the presence of a single factor (G. Held, 2009, p. 163; Podsakoff et al., 2003, p. 889; Podsakoff & Organ, 1986, p. 536; Sharma et al., 2009, p. 473).

The Harman single-factor test is also carried out using the statistical software "R". According to Held (2009), an exploratory principal component analysis (Harman's single-factor test) is conducted without rotation on all Likert indicators (G. Held, 2009, p. 183). The results can be seen in Tablee 62:

Table 62: Result of Harman's single-factor test

Factor	Declared variance (%)	Declared cumulative variance (%)
1	41%	41%
2	7%	48%
3	6%	54%
4	3%	57%
5	2%	59%

Source: Own illustration

The analysis shows that the first factor extracted explains only 41% of the total variance (G. Held, 2009, p. 163; Kaiser & Dickmann, 1959, p. 425). This value is below the critical threshold of 50 % and therefore does not indicate the presence of a dominant common factor (Podsakoff et al., 2003, p. 879 ff.). The other extracted components (factors 2-5) were reported to illustrate the decreasing variance explanation, but are not relevant for assessing the CMB, as the assessment relates exclusively to the first factor.

Overall, based on the available results, it can be assumed that there is no significant common method bias. The distribution of variance across several factors, along with the moderate proportion of the first factor, supports this assessment. Thus, there are no concerns regarding methodologically distorted response patterns (G. Held, 2009, p. 184).

5.2 PROCEDURE OF THE EMPIRICAL ANALYSIS

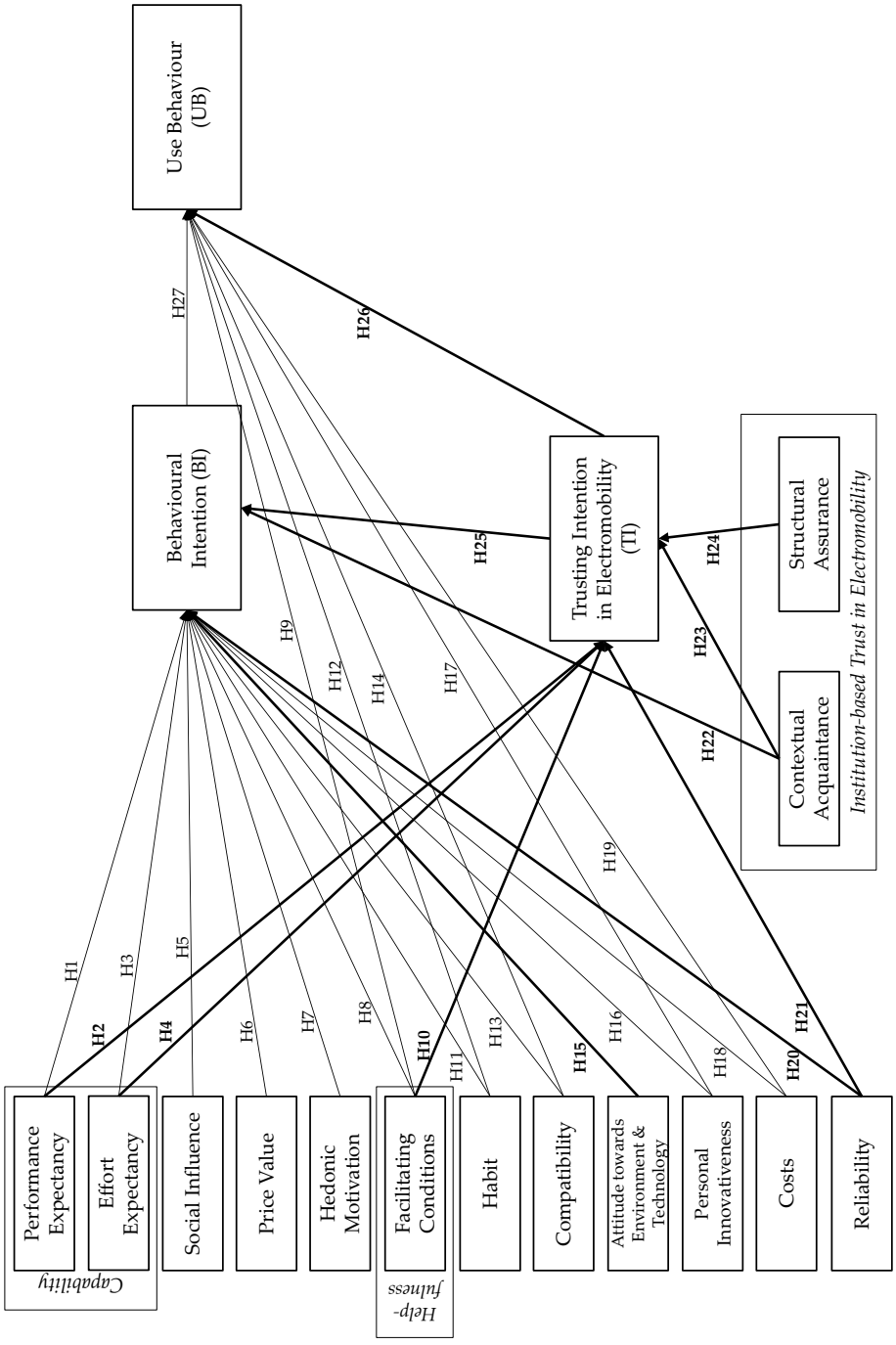
In this chapter, the theoretically derived structural equation models are estimated using the PLS approach in SmartPLS and evaluated concerning construct reliability, path relationships and global model quality (Fornell & Cha, 1994; Lohmöller, 1989; SmartPLS GmbH, 2025).

The PLS approach determines the statistical relationships between the latent constructs and the target variables using partial linear least squares regressions (PLS) and is characterised by the fact that complex model relationships can be estimated plausibly and with high test power even with small to moderate sample sizes. Furthermore, estimation using PLS enables a quantitative prediction of the dependent target variables as a function of the regressed construct values and is therefore suitable for predictive questions. In addition, the quality of the prediction can be precisely determined and compared using measures such as the (adjusted) R^2 (Reinartz et al., 2009; SmartPLS GmbH, 2025).

A basic model without moderator effects (Model I) is first presented for the step-by-step assessment of the model quality and the relevant path relationships. This is followed by an extension to a complete model with theory-based moderators (Model II) to test the influences of moderation (J. Hair et al., 2022, p. 165 ff.; Henseler et al., 2009, p. 277 ff., 2014, p. 105 ff.).

Figure 41 illustrates Model I in relation to the included constructs and paths of explanation and prediction.

Figure 41: Model I - Analysis Scope

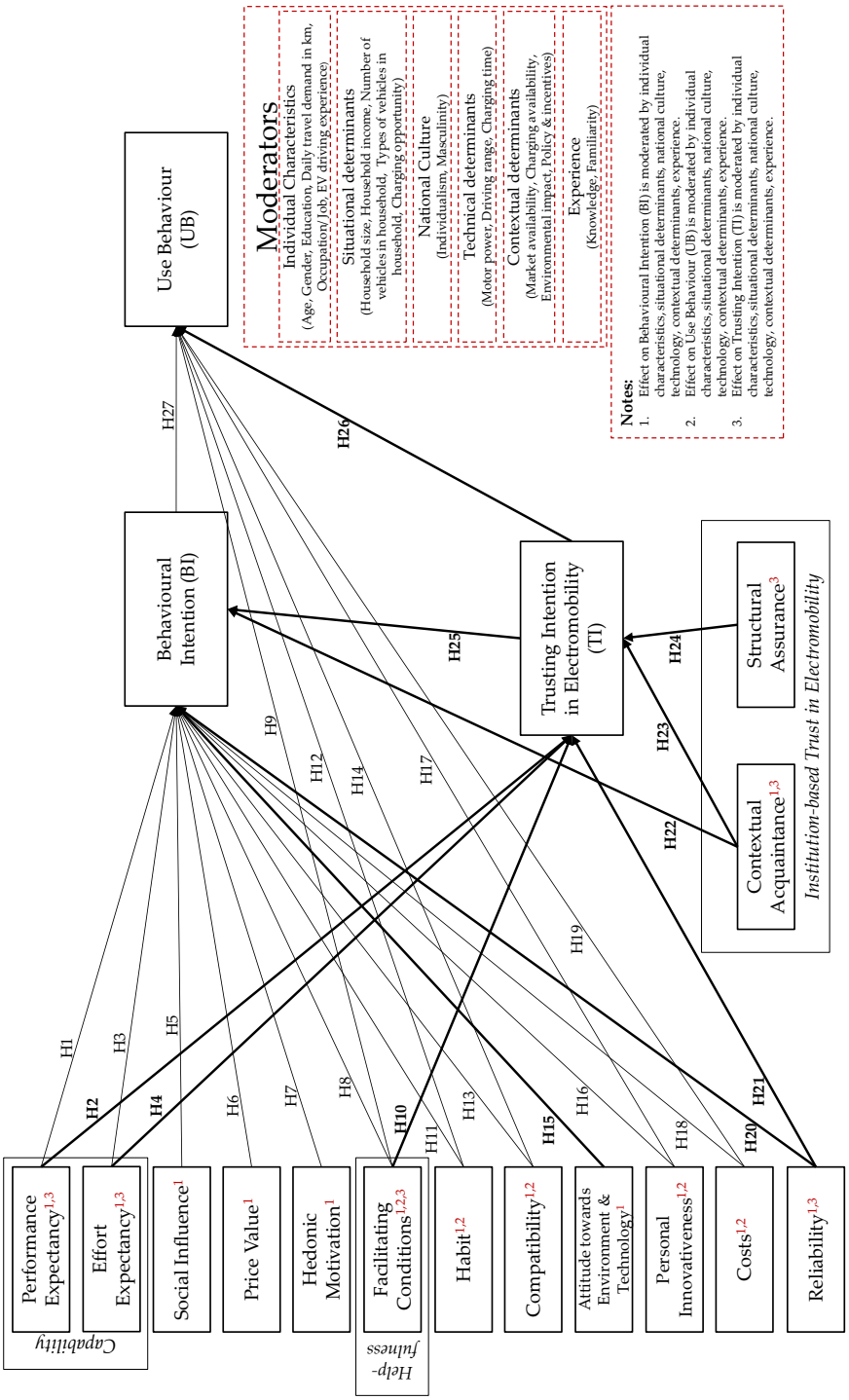


Source: Own illustration

Model II, which depicts the complete research model, is shown in Figure 42. In contrast to Model I, Model II also includes the theoretically postulated moderator variables and their interaction effects with selected predictors.

It can be seen that all constructs and paths contained in Model I were retained and expanded to include the moderation effects. The moderator variables have been highlighted in colour (red) in the figure to make them easier to understand.

Figure 42: Model II - Analysis Scope



Source: Own illustration

In line with the procedure described above, Model I without moderator effects is analysed first in Sections 5.4 and 5.5. The analysis of the extended Model II, which also includes the postulated moderators, follows in Chapter 5.6. Chapter 5.6 also provides a systematic comparison of both model variants to identify differences in explanatory power and potential moderation effects.

Chapter 5.7 provides an overall assessment of the postulated research model (Model II) and the hypothesis test.

5.3 SETTINGS OF THE VARIANCE ANALYSIS SOFTWARE "SMARTPLS"

In addition to the statistical software R, the variance analysis and structural equation software SmartPLS was also used for the empirical evaluation of the present research work (SmartPLS GmbH, 2025). SmartPLS is a powerful programme for variance-based structural equation models and includes all relevant calculation logarithms. It also offers individual setting options for all model parameters (Temme et al., 2006, p. 19).

Regarding the parameter settings of SmartPLS, there is no uniform recommendation in the literature; therefore, the types of calculations used in this research work are briefly described below. SmartPLS uses the PLS algorithm to carry out the estimation procedure to determine the model parameters of the structural equation model. Among other things, the level of the loadings and path coefficients is determined. In addition, the factor reliability (composite reliability), the average recorded variance and the Fornell-Larcker criterion are calculated (Götz & Liehr-Gobbers, 2004, p. 714 ff.; Henseler & Chin, 2010, p. 82 ff.; Ringle et al., 2006, p. 81 ff.; Tenenhaus et al., 2005, p. 166 ff.).

The bootstrapping method checks the significance of path connections by iteratively drawing samples and uses this to calculate the test statistic (Albers et al., 2009, p. 250; Backhaus et al., 2021, p. 73).

The blindfolding procedure analyses the predictive validity of the measurement instruments. A part of the data matrix is gradually suppressed and simultaneously reconstructed using estimated parameters. The predictive validity can be determined by comparing the actual data with the estimated data (J. F. Hair et al., 2012, p. 424; Schleer, 2014, p. 125).

Table 63 shows the parameter settings for the three SmartPLS calculation methods:

Table 63: Selected parameter settings of the SmartPLS variance analysis software

Category	Parameter	Selected setting
PLS Algorithm	Weighting scheme	Path weighting
	Data metric	Mean 0, variance 1
	Maximum iterations	3,000
	Abort criterion	10^{-7}
	Initial weights	1
Bootstrapping Method	Sign changes	No sign change
	Cases	485
	Samples	5,000
	Confidence interval	Percentile method
Blindfolding Procedure	Omission distance	7

Source: Own illustration based on (SmartPLS GmbH, 2025)

The "path weighting scheme" was selected for the PLS algorithm, as this correctly takes into account the direction of the hypotheses in the model. The default setting for the data metric was retained, with a mean of 0 and a variance of 1 (i.e., an average of 0 with a variance of 1). The maximum number of repetitions for the estimation algorithm is increased to 3000. The value1-7is used as the cancellation criterion for the iteration procedure. This means that no further iteration takes place if the 7th decimal place of the weights or loadings no longer changes. The weights of the indicators initially set for the first step of the estimation procedure (outer estimation) are left at the programme's default setting of 1. The empirical bootstrap is based on B = 5,000 replication samples, which is sufficient for a precise approximation of the unknown probability distribution of the corresponding standard errors and test statistics and for the determination of confidence intervals. Parameter estimates with changing signs (sign changes) are included in the determination of the distribution of the coefficients and test statistics, as excluding such bootstrap replications can lead to distorted and implausible model results. To determine the predictive quality of the model, the blindfolding procedure with an omission distance of 7 is selected, which

corresponds to a prediction of the seventh data point by the predetermined model parameters of the (partial) OLS regressions (Preacher & Hayes, 2008, p. 879 ff.).

5.4 QUALITY ASSESSMENT OF THE MEASUREMENT MODEL (MODEL I)

5.4.1 Overview of relevant quality criteria

The aim of quality assessment of measurement models is to verify whether the constructs are measured accurately. The focus here is on the local quality criteria of objectivity, reliability and validity (Fazel, 2014, p. 245).

Objectivity is defined as the independence of the measurement from the person using the measurement instrument. Further subcategories can be distinguished here.

- Implementation objectivity, which stands for the same test conditions during implementation.
- Evaluation objectivity, which means that the same results are achieved regardless of the evaluator.
- Objectivity of interpretation, which means that the same conclusions are drawn from the same evaluation.

The central question when examining objectivity is whether different analyses lead to different results. Since in the present case the data collection and analysis were carried out by the author himself, objectivity can be considered to be fulfilled (Bühner, 2006, p. 34; Ebster & Stalzer, 2017, p. 171).

Reliability measures how reliably an instrument measures a characteristic, regardless of its accuracy. Random measurement errors are considered here, but not systematic ones. The central question to be answered by testing reliability is whether the instrument yields identical results when administered repeatedly. If the random measurement error is 0, complete reliability is given (Bühner, 2006, p. 35; Carmines & Zeller, 1979, p. 29; Ebster & Stalzer, 2017, p. 170).

On the other hand, validity measures whether the instrument actually measures what it is supposed to measure. Systematic measurement errors (consistent and recurring) are considered here. If the systematic measurement error

is 0, complete validity is given (Carmines & Zeller, 1979, p. 11; Ebster & Stalzer, 2017, p. 169).

Reliability is a necessary but not a sufficient prerequisite for validity. Both reliability and validity must be fulfilled for a correct measurement. This means that reliability is used to verify whether the measurement is accurate, and validity is used to ensure that the correct thing is being measured (Ebster & Stalzer, 2017, p. 172).

In the literature, various approaches exist for assessing local quality criteria of structural equation models using the PLS approach. Table 64 provides an overview of the types of quality criteria analysed as part of the validation of the measurement models and the quality measures used for this purpose (Krafft et al., 2005, p. 71 ff.; Nitzl, 2010, p. 21 ff.; Zinnbauer & Eberl, 2005, p. 6 ff.):

Table 64: Quality types and quality measures for validating the measurement models

Quality type	Quality measure	Relation	Setpoint	Source
Indicator reliability	Factor loading	λ	≥ 0,7	(Bühner, 2006)
	Commonality	h^2	≥ 0,4	(Baumgartner & Homburg, 1996)
	t-statistics for calculating the significance level	t	≥ 1,65 (resp. 1,96)	(Homburg & Giering, 1998)
	Item-to-total correlation	ITC	≥ 0,4	(Churchill, 1979)
Construct reliability	Cronbachs's Alpha	α	≥ 0,7	(Cronbach, 1951)
	Composite Reliability	ϱ_c	≥ 0,7	(R. P. Bagozzi, 1994; R. P. Bagozzi & Yi, 1988; J. F. Hair et al., 2011)
	Average recorded variance	AVE (ξ_j)	≥ 0,5	(R. P. Bagozzi, 1994; R. P. Bagozzi & Yi, 1988)
Content validity	Explorative factor analysis	EFA	Unidimensionality	(Krafft et al., 2005)
Construct validity	Fornell-Larcker criterion	-	DEV (ξ_j) ≥ φ_{ji}^2	(Fornell & Larcker, 1981)
	Correlation between latent variables	r	≤ | 0,9 |	(Klarmann, 2008)

Source: Own illustration based on (R. P. Bagozzi, 1994; R. P. Bagozzi & Yi, 1988, p. 82; Baumgartner & Homburg, 1996, p. 170; Bühner, 2006, p. 179 ff.; Churchill, 1979, p. 68; Cronbach, 1951, p. 299; Fornell & Larcker, 1981, p. 46; J. F. Hair et al., 2011, p. 139 ff.; Homburg & Giering, 1998, p. 119; Klarmann, 2008, p. 192; Krafft et al., 2005, p. 73)

Indicator and construct reliability are closely linked conceptually, but are methodologically assessed separately at the construct level. On the other hand,

content and validity are evaluated in the context of the overall research model and used for the overarching assessment of measurement quality.

Following the general presentation of the evaluation criteria for the quality of the theoretical measurement models, the characteristic values for Model I without specified moderations are presented below. The presentation begins with an analysis of the measurement model, based on item-specific factor loadings, and a qualitative classification based on the defined threshold values for the individual criteria.

Model I is then evaluated at the construct level in terms of construct reliability using Cronbach's alpha, composite reliability and the average proportion of explained variance (AVE). This is followed by a categorisation of content validity using exploratory factor analysis (EFA) and finally the presentation of construct validity using the Fornell-Larcker criterion.

Building on this, the structural model is evaluated, taking into account the regression paths and significance. The model evaluation concludes with a presentation of the general model fit using standardised root mean square residual (SRMR) and the proportion of explained variance (R^2) in the respective target constructs. The evaluation of the model concludes with a determination of the specific predictive validity using the Stone-Geisser criterion Q^2.

To determine the quality of the measurement model, the latent reflective constructs are presented in tabular form using Cronbach's alpha, composite reliability (CR) and the average proportion of explained indicator variance (AVE). Composite reliability (CR) is preferable to Cronbach's alpha for assessing construct reliability, as this reliability measure does not assume equal item loadings on the common construct, but uses the actual loading structures to estimate reliability (Peterson & Kim, 2013, p. 194 ff.).

5.4.2 Indicator reliability

Indicator reliability indicates the proportion of the variance of an indicator that is explained by the assigned factor in the total variance. It provides information on how well an indicator (item) measures the underlying factor (construct) (G. Held, 2009, p. 168). The validation is carried out through factor loading, which

describes the correlation between an item and the construct (Zinnbauer & Eberl, 2005, p. 7). Commonality expresses the proportion of the total variance explained and is calculated as the square of the factor loading (Baumgartner & Homburg, 1996, p. 170). The minimum requirement for factor loading is that more than 50% of the variance of an indicator must be explained by the underlying factor (Carmines & Zeller, 1979, p. 27). This means that the factor loading should be more than 0.707 (since $0.7072 \approx 0.5$). Accordingly, indicators with a factor loading of < 0.707 should be successively eliminated from the measurement models(R. P. Bagozzi & Baumgartner, 1994, p. 402; Krafft et al., 2005, p. 73).

Various authors also suggest other factor loadings that may be acceptable under certain circumstances:

- Huber et al. (2007) suggest factor loadings of 0.6, provided that a significance level of at least 5% is reached (this corresponds to 1.645 for a one-sided t-test) (F. Huber et al., 2007, p. 86 f.).
- Hulland (1999) notes that lower factor loadings are to be expected for new constructs, and thus he recommends a cut-off value of 0.4 (Hulland, 1999, p. 198).
- Bagozzi and Baumgartner (1994) and Peter (1997) require a minimum factor loading of 0.4 and an associated minimum commonality of 0.16 (R. P. Bagozzi & Baumgartner, 1994, p. 402; Peter, 1999, p. 197 f.).

A threshold value of 0.6 is selected for this study and additional t-values are used to test the significance level.

An additional test that is carried out is the item-to-total correlation. This measures the correlation of an indicator variable with the sum of all indicators of a construct (Homburg & Giering, 1998, p. 119). The higher the correlation, the greater the contribution to reliability (Nunnally & Bernstein, 1978, p. 279). This also enables ranking the indicators by construct according to their quality. This serves to identify and eliminate weak indicators, and improve the quality criteria at the construct level (e.g., Cronbach's alpha). According to Churchill, a minimum requirement for an item-to-total correlation = 0.5 (Churchill, 1979, p. 68).

Table 65 shows the results of the analyses of indicator reliability:

Table 65: Results of the validation of indicator reliability

Construct	Indicator	Factor loading ≥ 0,6	Commo-nality ≥ 0,4	t-value ≥ 1,64	Item-to-Total-Correlation ≥ 0,4
Attitude towards Environment & Technology	AtET1	0.91	0.84	74.57	0.61
	AtET2	0.94	0.88	112.36	0.61
	AtET3	**0.28**	0.08	Mrz 37	**0.11**
Behavioural Intention	BI1	0.93	0.86	103.85	0.83
	BI2	0.91	0.83	73.49	0.81
	BI3	0.94	0.89	161.66	0.87
Contextual Acquaintance	CA1	0.93	0.86	111.56	0.83
	CA2	0.93	0.87	120.44	0.83
	CA3	0.89	0.79	57.74	0.77
Costs	Co1	0.58	0.34	Nov 87	0.41
	Co2	**0.52**	0.27	Aug 99	**0.38**
	Co3	0.86	0.74	47.95	0.57
	Co4	0.88	0.78	74.46	0.61
Compatibility	Com1	0.95	0.90	114.44	0.82
	Com2	0.96	0.92	206.94	0.82
Effort Expectancy	EE1	**0.37**	**0.13**	Mrz 22	0.44
	EE2	0.95	0.90	54.57	0.75
	EE3	0.96	0.92	73.39	0.71
Facilitating Conditions	FC1	0.87	0.75	52.73	0.68
	FC2	0.80	0.64	30.78	0.60
	FC3	0.87	0.76	64.72	0.65
Habit	Ha1	0.94	0.88	142.69	0.82
	Ha2	0.39	0.15	Mai 84	0.82
	Ha3	0.91	0.83	79.86	0.69
Hedonic Motivation	HM1	0.96	0.92	227.80	0.22
	HM2	0.95	0.90	133.58	0.62
Performance Expectancy	PE1	0.94	0.88	127.20	0.72
	PE2	0.94	0.88	137.32	0.73
	PE3	**0.55**	**0.30**	Sep 58	**0.35**
Personal Innovativeness	PIn1	0.89	0.80	73.59	0.76
	PIn2	0.90	0.80	75.19	0.78
	PIn3	0.92	0.85	107.37	0.81
Price Value	PV1	**0.57**	**0.32**	Okt 64	**0.36**
	PV2	0.94	0.88	110.99	0.73
	PV3	0.95	0.90	156.68	0.77
Reliability	Re1	0.91	0.83	79.93	0.69
	Re2	0.92	0.85	99.34	0.73
	Re3	0.66	0.43	13.98	0.46
Structural Assurance	SA1	0.90	0.82	73.57	0.76
	SA2	0.87	0.75	52.52	0.73
	SA3	0.93	0.86	117.44	0.82
Social Influence	SI1	0.93	0.86	95.96	0.82
	SI2	0.93	0.86	101.22	0.83
	SI3	0.87	0.75	50.45	0.71
Trusting Intention in Electromobility	TI1	0.94	0.88	132.54	0.74
	TI2	0.60	0.36	Okt 90	0.44
	TI3	0.93	0.86	82.02	0.69
Use Behaviour	UB1	0.95	0.89	121.90	0.88
	UB2	0.95	0.90	124.23	0.89
	UB3	0.94	0.87	114.68	0.85

Source: Own illustration

As can be seen from the analysis, a total of five indicators (AtET3, Co2, EE1, PE3, PV1) do not fulfil the specified limit values with regard to the required factor loading of ≥ 0.6 and the associated commonality of ≥ 0.4. In addition, only two of these five indicators (Co2 and EE1) fulfil the minimum requirement for the quality criterion of item-to-total correlation ≥ 0.4. Indicator reliability therefore cannot be regarded as given for these five variables. In accordance with the Churchill (1979) procedure and taking into account the recommendations of Bagozzi and Baumgartner (1994) and Peter (1997), these items were eliminated in the further course and no longer included in the subsequent analyses (R. P. Bagozzi & Baumgartner, 1994, p. 402; Churchill, 1979, p. 68; Peter, 1999, p. 197 f.).

In addition, five further indicators (Co1, Ha2, HM1, Re3, TI2) were identified whose values are borderline or do not completely fulfil individual criteria. These items were retained for the time being, as they either have high t-values or sufficient item-to-total correlations and can therefore theoretically remain in the model structure. However, their further inclusion should be critically considered as part of the model validation.

As a result of the elimination, the number of indicators used for construct measurement was reduced from the original 50 to 45. As the excluded items (AtET3, Co2, EE1, PE3, PV1) were negatively formulated (reverse-coded items) and did not fulfil the defined quality criteria, it can be assumed that there is a reverse item bias or a measurement artefact. This effect indicates a systematic bias in response behaviour, as described in the literature in connection with misresponse to reversed items (Barnette, 2000, p. 361 ff.; Sonderen et al., 2013; Swain et al., 2008, p. 116 ff.; Weijters et al., 2013, p. 320 ff.; X. Zhang et al., 2016).

5.4.3 Construct reliability

Construct reliability, also known as factor reliability, measures the suitability of your construct to explain the variance of its indicators. The prerequisite for this is a strong correlation between the indicators. A low correlation, on the other hand, leads to a high overall variance, which in turn cannot explain the construct (Krafft et al., 2005, p. 74 f.; Ringle & Spreen, 2007, p. 212). The three options for assessing construct reliability are briefly presented below.

A popular criterion for testing construct reliability is Cronbach's alpha (α) (Cronbach, 1951, p. 299). This measures the average correlation between the indicators, adjusted for their number (Homburg & Giering, 1998, p. 119). The value range is between 0 and 1, where a high value indicates high reliability. The minimum value of α is defined as 0.7, which is also used in this paper (Nunnally & Bernstein, 1978, p. 245; Peter, 1999, p. 180; Zinnbauer & Eberl, 2005, p. 6). If the alpha value is undercut, a gradual elimination of the indicators with the lowest item-to-total correlation (α-maximisation) is required (Churchill, 1979, p. 68). However, it should not be forgotten that the number of indicators positively influences the alpha value and that no inferential statistical evaluation is possible. Despite criticism, Cronbach's alpha is a widely used criterion for determining construct reliability (Homburg & Giering, 1998, pp. 119–120; Ringle et al., 2006, p. 87).

A more suitable criterion for assessing construct reliability in confirmatory measurement models (especially in PLS-SEM) is the quality measure of composite reliability (CR; (Götz & Liehr-Gobbers, 2004, p. 727). This is a more suitable criterion than Cronbach's alpha, as weighted factor loadings are taken into account and there is no equal distribution of indicator contributions. Similar to Cronbach's alpha, the value range for CR is between 0 and 1; the higher the value, the higher the reliability of the construct (Ringle et al., 2006, p. 20). A CR of 1 describes the perfect measurement without error (Homburg & Giering, 1998, p. 122). Nunnally & Bernstein (1978), Peterson & Kim (2013) and Bagozzi & Yi (1988) define minimum values for CR as 0.7 and ≥ 0.6, respectively, as a minimum measure (R. P. Bagozzi & Yi, 1988, p. 82; Nunnally & Bernstein, 1978, p. 245; Peterson & Kim, 2013, p. 194 ff.). In this paper, the threshold value is defined as 0.7. If the value falls below the set limit, items with a factor loading that is too low or with a high measurement error can be eliminated. This is done in an iterative process until the limit value is reached (Fassott & Eggert, 2005, p. 33). Composite reliability is used because it offers two major advantages over Cronbach's alpha:

1. It is independent of the number of items, so that short scales are not penalised.
2. The inclusion of the actual loading weights increases the validity of the quality measure and enables a more precise assessment of the

measurement quality at construct level (R. P. Bagozzi & Yi, 1988, p. 82).

In addition to Cronbach's alpha and the composite reliability, AVE measures how well a construct is explained by its indicators, i.e. the explained indicator variance by the construct (G. Held, 2009, p. 168; Ringle et al., 2006, p. 19 f.). The minimum value here is 0.5, i.e. at least 50% of the indicator variance must be explained by the construct. Compared to composite reliability, AVE is considered a stricter quality criterion. While acceptable values can sometimes be achieved for composite reliability, even though a considerable proportion of the variance is attributable to measurement errors, AVE requires direct evidence of sufficient explained variance of the indicators (Homburg & Giering, 1998, p. 130). Therefore, the AVE is a central criterion of convergent validity, especially for new constructs or reflective measurement models, and was included in the present analysis accordingly (Nitzl, 2010, p. 26).

Table 66 shows the results of the analyses of construct reliability:

Table 66: Results of the validation of construct reliability

Construct	Cronbach's Alpha	Composite Reliability (Rho_C)	AVE (%)
AtET	0.87	0.94	88.3%
BI	0.92	0.95	86.0%
CA	0.91	0.94	84.2%
Co	0.70	0.83	63.3%
Com	0.90	0.95	91.1%
EE	0.91	0.96	91.4%
FC	0.80	0.88	71.4%
HM	0.90	0.95	90.8%
Ha	0.66	0.82	62.2%
PE	0.92	0.96	92.8%
Pin	0.89	0.93	81.6%
PV	0.94	0.97	93.9%
Re	0.79	0.87	70.3%
SA	0.88	0.93	80.9%
SI	0.89	0.93	82.3%
TI	0.78	0.87	69.8%
UB	0.94	0.96	89.1%

Source: Own illustration

With Cronbach's alpha values ranging from 0.70 to 0.94, all constructs demonstrate consistently satisfactory to excellent internal consistency. With Cronbach's alphas ranging from α = .70 to α = .94, all constructs demonstrate satisfactory to very good measurement accuracy regarding the manifest indicators that operationalise the respective constructs. Only the construct "Ha", with a value of 0.66, is slightly below the accepted threshold value, but remains acceptable in an exploratory context. The average alpha across all constructs is $Ø(\alpha) \sim .86$ and thus within the range of good measurement accuracy (Homburg & Giering, 1998, pp. 119–120; Ringle et al., 2006, p. 87). The theoretically more plausible composite reliability for the constructs is between $\varrho c = .83$ and $\varrho c = .97$ and thus in the range of good to very good measurement accuracy (G. Held, 2009, p. 168; Ringle et al., 2006, p. 19 f.). The average proportion of explained variance (AVE) is between

62.2% and 93.9% and thus consistently above the usual threshold value of good variance explanation of at least 50% (Homburg & Giering, 1998, p. 130). This confirms that there is sufficient convergence validity for all constructs, as more than 50% of the indicator variance is explained by the underlying construct in each case (Fornell & Larcker, 1981, p. 39 ff.).

5.4.4 Content validity

Content validity refers to the extent to which the meaning of a construct is accurately represented by its indicators. The basis for this is the correlation of the indicators and their clear assignment to constructs. The criterion of content validity is considered to be fulfilled if the factor loadings of an indicator on the associated construct are high and the loadings on other constructs are significantly lower. In this case, we speak of unidimensionality or simple structure (Bühner, 2006, p. 185).

In addition to a qualitative assessment of the items to be included, the test is usually carried out using an EFA (Bühner, 2006, p. 179; Krafft et al., 2005, p. 73). This was carried out in this work with the statistical programme "R" (R. P. Bagozzi & Phillips, 1982, p. 465; J. F. Hair et al., 2021, p. 3; Rigdon et al., 2019, p. 772 ff.).

Principal component analysis is used to perform the factor extraction, which aims to fully explain the indicator variance by hypothesised factors (Backhaus et al. (Backhaus et al., 2021, p. 413; F. Huber et al., 2007, p. 93). The Varimax method is used as a rotation method, which serves to enhance the interpretability of assigning indicators to factors. The adjusted data matrix (see Section 5.4.2) with the 41 indicators is used as the data basis.

A minimum factor loading of 0.6 is required, analogous to the indicator reliability test. The results can be seen in Table 67.

Table 67: Results of exploratory factor analysis to verify unidimensionality

Item	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
AtET1	.07	.22	.14	.09	.09	.10	.19	.07	.05	.05	-.02	**.72**	.23	.03	.06	.40	.09
AtET2	.04	.18	.17	.12	.23	.18	.24	.04	.03	.14	.06	**.63**	.35	.10	.07	.32	.05
BI1	.25	.25	.05	.10	**.58**	.18	.34	.00	.12	.17	.04	.18	.27	.07	.04	.25	-.06
BI2	.32	.27	.08	.03	**.47**	.21	.23	-.05	.05	.06	.03	.18	.28	.20	.22	.33	-.08
BI3	.29	.30	.10	.08	**.49**	.23	.35	.03	.08	.03	.03	.18	.27	.15	.08	.32	-.08
CA1	.24	.14	.15	.10	.27	.14	.29	.04	-.04	.13	.08	.27	.20	.20	.22	**.53**	.14
CA2	.26	.13	.12	.14	.32	.13	.29	.11	.05	.13	.08	.15	.24	.07	.19	**.59**	.14
CA3	.46	.13	.20	-.01	.18	.04	.24	.15	.05	.08	.08	.13	.17	.09	.11	**.57**	.21
Co1	.02	.12	-.08	.10	.19	.24	.07	.03	.14	.04	**.89**	.01	.08	.10	.04	.03	.01
Co3	.06	.28	.07	.04	.26	.34	.15	.11	.00	.13	.00	.16	.23	.16	.10	.30	**.59**
Co4	.17	.26	.14	.07	.25	**.57**	.14	-.08	.03	.19	.11	.15	.09	.02	.13	.29	.34
Com1	.07	.24	.20	.13	.16	.07	.25	.00	.02	.36	.02	.06	**.60**	.10	.02	.33	.12
Com2	.11	.27	.16	.07	.22	.11	.25	.04	.07	.33	.06	.21	**.59**	.12	.03	.32	.07
EE2	.04	.05	**.90**	.03	.07	.06	.11	.09	-.03	.11	-.05	.06	.14	.01	.02	.17	-.01
EE3	.04	.07	**.90**	.04	.11	.05	.13	.03	-.01	.11	-.02	.09	.10	.04	.04	.18	.06
FC1	.01	.16	.27	.03	.31	.10	.16	.24	.06	**.70**	.02	.10	.18	.01	.02	.17	.10
FC2	.05	.30	.17	-.01	.24	.12	.09	**.80**	.04	.22	.04	.07	.14	.01	.05	.12	.05
FC3	.12	.29	.34	.04	.17	.21	.12	.17	.05	**.48**	.10	.06	.26	.09	.24	.26	-.03
Ha1	.36	.21	.14	.09	**.44**	.20	.26	.05	.09	.06	-.01	.07	.36	.03	.04	.40	.07
Ha2	.02	.10	-.05	.08	.14	.10	.03	.03	**.95**	.04	.13	.04	.06	.09	.04	.02	.00
Ha3	.35	.15	.18	.15	.29	.18	.36	.14	.03	.11	-.06	.10	.33	.00	-.06	**.47**	.03
HM1	.16	.28	.25	.00	.36	.20	.27	.08	.12	.04	.08	.28	**.48**	.03	.03	.27	.13
HM2	.12	.20	.33	.02	.27	.16	.30	.15	.01	.00	.06	.20	**.45**	.04	-.01	.38	.22
PE1	.07	.23	.14	.06	.28	.19	.15	.14	.03	.06	.07	.20	**.69**	.10	.11	.33	.02
PE2	-.03	.33	.16	.05	.31	.20	.19	.12	.07	.03	.09	.22	**.58**	.07	.21	.27	.04
PIn1	-.01	.19	.10	.07	.32	.20	**.68**	.10	.06	.07	-.03	.13	.18	-.02	.19	.27	-.05
PIn2	.13	.14	.19	-.01	.12	.08	**.73**	.00	.00	.10	.08	.16	.21	.11	.03	.36	.07
PIn3	.05	.23	.16	.00	.32	.15	**.69**	.08	.02	.11	.10	.11	.18	.06	.08	.25	.15
PV2	.02	.25	.06	.01	.31	**.76**	.15	.12	.07	.05	.17	.07	.19	.06	.08	.20	.05
PV3	.03	.28	.06	.02	.32	**.71**	.18	.11	.12	.07	.20	.10	.16	.04	.10	.24	.02
Re1	.09	.16	.14	.01	.15	.18	.21	.01	-.04	.14	-.05	.21	.17	.21	.00	**.73**	-.01
Re2	-.03	.16	.13	.00	.21	.22	.13	.10	.02	.12	.00	.18	.15	.32	.03	**.72**	-.05
Re3	.05	-.09	.04	.31	.07	.06	.09	.00	.13	.02	.12	.06	.14	**.80**	.04	.29	.08
SA1	.03	.19	.13	.02	.31	.16	.31	.02	.04	.14	.01	.19	.27	.07	.32	**.49**	.14
SA2	.07	.23	.04	.02	.30	.32	.25	.09	.10	.11	.15	.05	.15	.01	**.52**	.37	.10
SA3	.06	.24	.14	.07	.31	.27	.27	.04	.04	.06	.01	.14	.15	.12	.47	**.48**	.07
SI1	.09	**.80**	.03	.01	.24	.15	.16	.10	.01	.09	.07	.09	.19	-.03	.18	.13	.03
SI2	.08	**.82**	.05	-.01	.18	.19	.16	.15	.05	.09	.02	.05	.18	-.05	.10	.14	.06
SI3	-.04	**.73**	.12	-.05	.25	.19	.12	.06	.11	.08	.09	.19	.16	.01	-.11	.15	.11
TI1	.06	.10	.14	.23	.17	.09	.13	.02	-.02	.03	.01	.09	.17	-.01	.03	**.83**	.02
TI2	.03	-.04	.06	**.87**	-.02	.03	.03	-.01	.09	.04	.10	.10	.10	.24	.02	.30	.02
TI3	-.03	.07	.11	.15	.18	.11	.14	.04	.09	.04	.08	.06	.15	-.01	.11	**.82**	.12
UB1	-.06	.16	.08	-.01	**.85**	.18	.14	.10	.05	.11	.09	.03	.13	.02	.05	.19	.06
UB2	.00	.17	.11	-.02	**.83**	.18	.14	.07	.09	.11	.11	.04	.14	.01	.08	.21	.12
UB3	.14	.22	.09	-.01	**.77**	.15	.15	.15	.04	.11	.08	.12	.15	.06	.09	.24	.07

Source: Own illustration

After excluding five indicators (AtET3, Co2, EE1, PE3, PV1) due to insufficient indicator reliability, a principal component analysis with Varimax rotation was performed. The analysis is based on seventeen extracted factors and 45 remaining items.

The factor loading matrix shows that eleven of seventeen constructs (including AtET, BI, CA, EE, HM, PE, PIn, PV, SI, UB) have a clear and high main loading (> 0.60) of their assigned items on a common component in each case. This speaks in favour of a clear unidimensionality and supports the content validity of these constructs.

For the remaining constructs (e.g. Co, Re, TI, Ha, SA), there are inconsistent or split loading patterns, which may indicate possible multidimensionality or semantic ambiguity of the associated items. These findings should be conceptually reflected upon in the further course and, if necessary, discussed on a theoretically sound basis.

Overall, the factor analysis confirms the expected content homogeneity for the majority of the constructs, although the examination of content validity should not only be carried out statistically, but also on the basis of the content-related item formulations (Fornell & Larcker, 1981, p. 39 ff.; J. Hair et al., 2022, p. 190 ff.; Henseler et al., 2009, p. 277 ff.)

5.4.5 Construct validity

Construct validity describes the quality of the measurement of a construct. This involves establishing an internal relationship between indicators and the construct, while simultaneously differentiating it from other constructs (Homburg & Giering, 1998, p. 117). In this measurement, it must be ensured that exactly what is to be measured is measured without being influenced by external constructs or measurement errors (Weiber & Mühlhaus, 2014, p. 159). Construct validity comprises three sub-aspects: nomological validity, convergent validity, and discriminant validity (Ahlert et al., 2007, p. 33; A. Fuchs, 2011, p. 27).

Nomological validity examines whether the theoretically justified causal relationships between the constructs within a so-called nomological network can be empirically confirmed (R. P. Bagozzi, 1994, p. 25). For this purpose, the

constructs are embedded in a superordinate model. The review is conducted using a causal analysis, in which the strength of theoretically substantiated relationships is measured (Bortz & Döring, 2023, p. 488; Weiber & Mühlhaus, 2014, p. 159). The prerequisite for nomological validity is theoretical justification and empirical confirmation. At the measurement model level, this relationship has already been confirmed by the indicator and construct reliability (see Chapters 5.4.2 and 5.4.3). Chapter 5.5 also illustrates that a significant portion of the causal relationships derived from the theory and postulated in advance can be empirically confirmed at the structural model level. Accordingly, nomological validity can be assumed.

Convergent validity measures the extent to which a construct is mapped consistently by several indicators (R. P. Bagozzi, 1994, p. 20; Homburg & Giering, 1998, p. 117). In the context of economic and social sciences, an alternative survey is rather difficult to implement (Bortz & Döring, 2023, p. 49 ff.; Weiber & Mühlhaus, 2014, p. 160) and thus Hair (2006) recommends the assessment of convergence validity using composite reliability or AVE (J. F. Hair et al., 2006, p. 776). Both measures were fulfilled in this study (see Chapter 5.4.3), so that the convergence validity is confirmed.

The Fornell-Larcker criterion was used to ensure discriminant validity. This requires that the average variance observed (AVE) of a construct is greater than its squared correlation with all other latent variables in the model (Fornell & Larcker, 1981, p. 46; Hulland, 1999, p. 199; Ringle & Spreen, 2007, p. 213; Weiber & Mühlhaus, 2014, p. 162). The results can be seen in Table 68.

Table 68: Quadrated correlations between the constructs of the model

	AtET	BI	CA	Co	Com	EE	FC	HM	Ha	PE	PIn	PV	Re	SA	SI	TI
AtET	**1**															
BI	0.46	**1**														
CA	0.52	0.60	**1**													
Co	0.36	0.47	0.46	**1**												
Com	0.50	0.53	0.53	0.38	**1**											
EE	0.17	0.12	0.19	0.09	0.22	**1**										
FC	0.31	0.38	0.40	0.35	0.48	0.28	**1**									
HM	0.56	0.60	0.59	0.45	0.6	0.27	0.44	**1**								
Ha	0.44	0.68	0.64	0.42	0.52	0.17	0.4	0.62	**1**							
PE	0.53	0.57	0.52	0.43	0.62	0.16	0.43	0.64	0.55	**1**						
PIn	0.43	0.59	0.57	0.37	0.47	0.18	0.35	0.55	0.53	0.46	**1**					
PV	0.28	0.44	0.33	0.60	0.28	0.06	0.32	0.39	0.38	0.4	0.34	**1**				
Re	0.46	0.45	0.62	0.35	0.42	0.15	0.28	0.42	0.47	0.41	0.39	0.27	**1**			
SA	0.46	0.62	0.66	0.52	0.46	0.14	0.41	0.54	0.56	0.52	0.57	0.48	0.52	**1**		
SI	0.29	0.42	0.27	0.38	0.35	0.07	0.39	0.4	0.34	0.42	0.32	0.4	0.16	0.37	**1**	
TI	0.38	0.36	0.60	0.29	0.36	0.14	0.21	0.36	0.42	0.33	0.32	0.2	0.63	0.47	0.12	**1**
UB	0.25	0.60	0.39	0.40	0.31	0.09	0.38	0.43	0.47	0.41	0.38	0.43	0.25	0.45	0.33	0.2

Source: Own illustration

Based on these squared correlations between the latent constructs, the Fornell-Larcker criterion is empirically tested for each construct in Table 69. The criterion is fulfilled if the average explained variance (AVE) of the construct is always higher than all squared correlations of the construct with all other constructs.

Table 69: Results of the review of the Fornell-Larcker criteria

Construct	AVE	Largest quadratic correlation	Value (r^2)	AVE ≥ r^2?
AtET	0.88	HM	0.56	Yes
BI	0.86	Ha	0.68	Yes
CA	0.84	SA	0.66	Yes
Co	0.63	PV	0.60	Yes
Com	0.91	PE	0.62	Yes
EE	0.91	FC	0.28	Yes
FC	0.71	Com	0.48	Yes
HM	0.91	Ha	0.64	Yes
Ha	0.62	BI	0.68	No
PE	0.93	HM	0.64	Yes
PIn	0.82	BI	0.59	Yes
PV	0.94	Co	0.60	Yes
Re	0.70	TI	0.63	Yes
SA	0.81	CA	0.66	Yes
SI	0.82	BI / PE	0.42	Yes
TI	0.70	Re	0.63	Yes
UB	0.89	BI	0.60	Yes

Source: Own illustration

After determining the highest squared correlation of each construct with another construct and comparing it with the AVE, the Fornell-Larcker criterion is fulfilled for all constructs except "Ha", as the own AVE is always greater than the highest squared correlation with an external construct (cf. Table 70) (Fornell & Larcker, 1981).

Multicollinearity between the included constructs is used as a further criterion of construct validity (Klarmann, 2008, p. 192). Multicollinearity is present when two constructs show very high pairwise correlations with each other and are considered to be given according to a common rule of thumb with a value of ≥0.9 or greater (Backhaus et al. (Backhaus et al., 2021, p. 121). It is therefore checked whether pairwise correlations between constructs ≥ 0.9 can be observed. The

squaring of the pairwise correlations in Table 69 above results in a critical threshold of ≥~0.80, since √0.80 corresponds to approximately 0.90 (Klarmann, 2008, p. 192).

Overall, the fulfilment of the Fornell-Larcker criteria and the exclusion of multicollinearity demonstrate a high level of discriminant validity in the model.

5.5 QUALITY ASSESSMENT OF THE STRUCTURAL MODEL (MODEL I)

The analysis is conducted after validating the measurement model at the structural model level, where global quality criteria are used to assess the model's quality. Furthermore, the postulated path relationships between constructs and dependent variables are presented using standardised regression weights (β) to test the empirical plausibility of the research hypotheses. The SRMR, as a measure of model fit, and the R^2 values of all explained or predicted constructs are used to assess the overall model quality. The empirical bootstrap with B = 5000 replication samples is used to derive inference statistics (standard errors, p-values, 95% confidence intervals). Based on the 5000 bootstrap samples, the (unknown) probability distribution of the model parameters can be approximated and estimated. The determination of the respective 95% confidence intervals is based on the percentile method (Albers et al., 2009; Efron & Tibshirani, 1993; Weiber & Mühlhaus, 2014, p. 326).

Table 70 provides an overview of the quality types and measures used to assess the quality of the structural model, which are discussed in more detail in the following chapters.

Table 70: Quality types and quality measures for validating the structural model

Type of quality	Quality measure	Designation	Setpoint	Source
Sign, magnitude and significance of the estimation procedure	Sign of the path coefficients β	Positive / negative	≥ | 0,1 |	(Backhaus et al., 2021)
	t-test for calculating the significance level	t	≥ 1,65 (resp. ≥ 1,96)	(Homburg & Giering, 1998)
Goodness of fit of the estimation procedure	Coefficient of determination	R^2	≥ 0,33	(Chin, 1998)
Substantial explanatory contribution	Effect size	f^2	≥ 0,02	(Chin, 1998)
Predictive validity	Stone-Geisser criterion	Q2	> 0	(Geisser, 1974; Stone, 1974)

Source: Own illustration based on (Backhaus et al., 2021, p. 85 ff.; Chin, 1998, p. 320 ff.; Geisser, 1974, p. 101 ff.; Henseler et al., 2009, p. 303; Homburg & Giering, 1998, p. 131; Stone, 1974, p. 111 ff.)

5.5.1 Sign, magnitude and significance of the path coefficients

To determine whether the research hypotheses can be confirmed or rejected, the sign, extent, and significance of the path coefficients must be analysed. This is accomplished using SmartPLS and its bootstrapping method (see Section 5.3).

Path coefficients correspond to standardised regression coefficients, allowing for the interpretation of corresponding causal relationships in a manner analogous to regression analyses. In order to prove a causal relationship between two constructs, the path coefficient should exceed a value of 0.1 (F. Huber et al., 2007, p. 104). In addition, the sign should correspond to the theoretically postulated hypothesis (Chin, 1998, p. 324; F. Huber et al., 2007, p. 104; Lohmöller, 1989, p. 60).

In addition, a significance test must be performed to validate the statistical relevance of the effect relationships (Bühner, 2006, p. 117; J. F. Hair et al., 2011, p. 145). Significance stands for probability and uses a predefined probability to test

whether the relationship between two variables is random or actual (Backhaus et al., 2021, p. 36 ff.; Urban & Mayerl, 2006, p. 6 ff.).

A distinction is made between two types of hypotheses: the null hypothesis (H0) states that there is no significant influence of the exogenous variable on the endogenous variable, whereas the alternative hypothesis (H1) states that there is a significant influence of the exogenous variable on the endogenous variable(Bühner, 2006, p. 117).

In addition to the hypothesis test, an α error (error of the first kind) must be defined for the significance test. This defines the significance level, or the probability of error, and describes the probability that H0 is incorrectly rejected when it is true. On the other hand, there is the β error (error of the second kind), which describes the probability that H0 is retained although H1 is true (Backhaus et al., 2021, p. 36 ff.; Bühner, 2006, p. 117). In this research model, a significance level of at least $\alpha = 5\%$ is required. This means that a path coefficient with less than 5% probability of error is considered statistically significant (J. F. Hair et al., 2011, p. 145). Significance is tested using the t-test. The t-value is calculated from the mean value of the parameter estimates divided by the standard deviation (Ringle & Spreen, 2007, p. 213). The limit value for the significance level of 5% is $t \geq 1.96$. Higher significance levels can result depending on the height of the t-value, e.g. $t \geq 2.33$ → 2% significance level, $t \geq 2.58$→ 0.1% significance level or $t \geq 3.29$ → 0.1% significance level (Herrmann et al., 2006, p. 61). The signs, magnitudes and significances of the path connections determined are shown in Table 71:

Table 71: Results of the review of the path coefficients and the significance of the path connections for Model I

Path	Weight (β)	t-value	Significance level	Criterion fulfilled
AtET -> BI	+0.01	+0.28	n.s.	No
BI -> UB	+0.59	+9.20	***	Yes
CA -> BI	+0.12	+2.05	*	Yes
CA -> TI	+0.38	+6.32	***	Yes
Co -> BI	+0.02	+0.31	n.s.	No
Co -> UB	+0.16	+3.43	**	Yes
Com -> BI	+0.07	+1.45	n.s.	No
Com -> UB	-0.19	+3.49	***	Yes
EE -> BI	-0.07	+2.10	*	Yes (weak)
EE -> TI	+0.05	+1.27	n.s.	No
FC -> BI	-0.04	+0.91	n.s.	No
FC -> TI	-0.11	+2.77	**	Yes
FC -> UB	+0.24	+6.14	***	Yes
Ha -> BI	+0.32	+6.09	***	Yes
Ha -> UB	+0.13	+1.75	n.s.	Yes
HM -> BI	+0.07	+1.08	n.s.	No
PE -> BI	+0.08	+1.49	n.s.	No
PE -> TI	-0.02	+0.41	n.s.	No
PIn -> BI	+0.20	+4.58	***	Yes
PIn -> UB	+0.00	+0.09	n.s.	No
PV -> BI	+0.09	+1.68	n.s.	Yes (weak)
Re -> BI	+0.07	+1.50	n.s.	No
Re -> TI	+0.47	+9.56	***	Yes
SA -> TI	+0.10	+2.05	*	Yes
SI -> BI	+0.10	+2.55	*	Yes
TI -> BI	-0.05	+0.97	n.s.	No
TI -> UB	-0.08	+2.05	*	Yes (weak)

Significance level (two-sided): * 5%; ** 1%; *** 0.1%; n.s. = not significant

Source: Own illustration

Based on the partial OLS regressions, both the criteria of a sufficiently large path weight ($\beta \geq 0.10$) and a sufficiently large T-value ($|t| \geq 1.65$) are completely

fulfilled for the following path relationships, meaning that these path relationships can be interpreted as systematic and significant relationships for the population:

- BI → UB, CA → BI, CA → TI, Co → UB, Com → UB, FC → TI, FC → UB, Ha → BI, PIn → BI, Re → TI, SA → TI, SI → BI

The path connections EE → BI, PV → BI and TI → UB only fulfil the criterion regarding significance or a sufficiently large t-value, but do not show a substantial effect size, as $\beta < 0.10$.

5.5.2 Goodness of fit of the estimation procedure

The examination of the goodness of fit of the estimation procedure to the empirical data (so-called goodness of fit) provides insights into how precisely a latent endogenous variable is measured in the research model by the latent exogenous variables acting on it (Ringle & Spreen, 2007, p. 214). This test is performed in addition to the significance test of the path coefficients by measuring the coefficient of determination R^2. The coefficient of determination R^2 captures the proportion of the variance of a construct that is explained by upstream latent variables(F. Huber et al., 2007, p. 107).

The R^2 values are between 0 and 1, whereby the higher the value, the higher the explained variance proportion. $R^2 = 1$ means that the exogenous influencing variables fully explain the variance of an endogenous variable. There are various statements in the literature regarding the requirement of the coefficient of determination. Chin (1998), for example, gives the following breakdown: $R^2 \geq 0.67$ substantial, $R^2 \geq 0.33$ moderate and $R^2 \geq 0.19$ weak (Chin, 1998, p. 320 ff.). In contrast, Falk and Miller (1992) state that a coefficient of determination of $R^2 \geq 0.1$ can already be regarded as sufficient (Falk & Miller, 1992, p. 80). Hulland (1999), Huber et al. (2007) and Henseler et al. (2009) state that the R^2 should be at least 0.3. In the present study, the minimum value for R^2 is set at 0.3 (Henseler et al., 2009, p. 303; F. Huber et al., 2007, p. 107; Hulland, 1999, p. 202).

The endogenous constructs to be assessed are behavioural intention, use behaviour and trusting intention in electromobility. Table 72 shows the coefficient of determination R^2:

Table 72: Variance explanation of the dependent target variables

Declared construct	R^2 (adjusted)	95%-Confidence Interval
Behavioural intention (BI)	78.3%	[0.756 ; 0.828]
Trusting intention in electromobility (TI)	68,8%	[0.638 ; 0.745]
Use behaviour (UB)	65,1%	[0.596 ; 0.714]

Source: Own illustration

The results show that the adjusted coefficient of determination with values between 0.783 and 0.651 is both far above the value of 0.19 required by Chin and well above the stricter limit value of 0.3 according to Hulland, Huber et al. and Henseler et al. (Chin, 1998; Falk & Miller, 1992; Henseler et al., 2009; F. Huber et al., 2007; Hulland, 1999).

All three endogenous constructs exhibit at least a moderate degree of variance explanation with an $R^2 > 0.50$, whereby the construct of behavioural intention (BI) in particular with $R^2 = 0.783$ and the construct of trust in electromobility with $R^2 = 0.688$ even induced a substantial degree of determination by the exogenous predictors following Chin (1998). The difference between BI and UB (behavioural intention vs. actual behaviour) suggests that intentional and behavioural constructs are not completely congruent, reflecting a typical finding in acceptance research that is relevant for further discussion (J. Hair et al., 2022, p. 257; Henseler et al., 2009, p. 277 ff.).

Given the scope (45 indicators, seventeen constructs) and the complexity of the research model's content, these are excellent values, some of which are significantly higher than those of comparable studies that used the structural equation modelling method. In addition to the minimum requirements for the level of the coefficient of determination applicable to structural equation models, an above-average value can also be determined in a direct and model-specific comparison. According to the meta-analysis by Venkatesh et al. (2003), comparable TAM research contributions typically have a coefficient of determination of 0.4, which is in some cases significantly exceeded by the values achieved in the present Model I (Venkatesh et al., 2003, p. 425 ff.).

In summary, it can be stated that the theoretical research model has a high to very high explanatory power concerning all modelled latent endogenous variables and can therefore be rated as particularly powerful.

In addition to the assessment of the local quality measure using the coefficient of determination R^2, which measures the explained variance of an individual endogenous construct, SRMR is used to assess the global model quality. SRMR measures the average difference between empirically observed and model-based correlation values. It is an absolute fit measure: the smaller the value, the better the fit of the model to the data. The SRMR evaluates the model fit independently of model structure and complexity(J. Hair et al., 2022, p. 194 ff.).

According to Hu and Bentler (1999), the following threshold values apply for the investigation of the SRMR: An SRMR ≤ 0.08 stands for an acceptable model quality, an SRMR ≤ 0.05 stands for a good model quality and an SRMR of > 0.10 stands for an inadequate model quality (Henseler et al., 2014, p. 182 ff.; Hu & Bentler, 1999, p. 27 f.).

The SRMR is particularly suitable for PLS-SEM as it can be interpreted independently of the model and is easy to understand. This becomes particularly clear as R^2 only considers the local explanatory quality of individual constructs, whereas SRMR considers the global fit of the model to the empirical data. Good R^2 values can conceal the global error adjustment, but the SRMR recognises this. Therefore, in addition to the R^2 value for the explanatory quality, the SRMR for the adjustment quality is also presented in this analysis(Henseler et al., 2016, p. 9). Table 73 shows the SRMR for Model I:

Table 73: General model quality of Model I

Model	SRMR (Sample)	SRMR (Average)	SRMR (95%-Confidence interval)
Modell I	0.059	0.038	[; 0.042]

Source: Own illustration

Based on the SRMR value of the sample (0.059), the general model quality of SEM Model I can be categorised as acceptable. The SRMR is thus below the recommended threshold value of 0.08 (Hu & Bentler, 1999, p. 27 f.), which indicates a satisfactory model fit to the actual data structure.

The average SRMR value for all 5,000 randomly drawn bootstrap samples is 0.038, indicating a stable and above-average model fit (Henseler et al., 2014, p. 182 ff.). The 95% confidence interval (upper limit = 0.042) also confirms that there is no systematic model misfit under uncertainty. This emphasises the robustness of the model specification and the reliability of the structural estimates.

Overall, Model I is therefore an empirically plausible and methodologically sound model for the systematic description of the correlation structures in the research sample analysed concerning the general model fit. In conjunction with the previously tested R^2 values, Model I provides a substantively viable and theoretically consistent basis for analysing the causal relationships (Henseler et al., 2016, p. 9).

5.5.3 Predictive validity

The predictive validity (predictive relevance) is a further quality criterion for validating the structural model and is determined using the Stone-Geisser criterion Q^2. Q^2 shows how well the model can estimate the value of the data matrix on the basis of the model parameters (Geisser, 1974, p. 101 ff.; Stone, 1974, p. 111 ff.). The blindfolding procedure (cf. Chapter 5.3) is used for the calculation, which aims to determine the quality with which the collected database is mapped by the estimated model (Fornell & Cha, 1994, p. 72 f.; Herrmann et al., 2006, p. 58). The procedure is a two-step process. In the first step, individual data points are deliberately omitted from the raw data matrix and assumed to be missing (Ringle & Spreen, 2007, p. 215). In the second step, the missing data points are then estimated based on the research model and the PLS parameters (Krafft et al., 2005, p. 85). The predictive relevance is calculated by comparing the estimated values with the actual values. In the literature, a Q^2 value of ≥ 0 is regarded as an indication of sufficient predictive validity (Herrmann et al., 2006, p. 61; Ringle & Spreen, 2007, p. 215). The results of the analysis for Model I can be seen in Table 74.

Table 74: Predictive validity of the latent endogenous variables Model I

Predictive validity	Predictive validity $Q^2 \geq 0$
BI	0.77
TI	0.68
UB	0.57

Source: Own illustration

As can be seen from the results, all the predictive validities of the latent endogenous variables are significantly greater than 0, meaning that the quality criterion of predictive validity can be considered fully met (Geisser, 1974, p. 101 ff.; Stone, 1974, p. 111 ff.). This is due to the high coefficient of determination R^2. As this is relatively high for all latent variables, a significant portion of the variance can be explained by research model I (J. Hair et al., 2022, p. 217). This in turn means that the model parameters can provide a correspondingly "good" estimate of the data if individual data points are omitted as part of the blindfolding procedure (Herrmann et al., 2006, p. 61; Ringle & Spreen, 2007, p. 215).

After presenting all essential quality criteria and path connections within Model I without moderation effects, the following chapters examine the influence of the theoretically established moderator variables on the relationships between exogenous predictors and endogenous target constructs (BI, UB and TI).

5.6 INFLUENCE OF MODERATOR AND CONTROL VARIABLES (MODEL II)

In order to test the postulated hypotheses (H28-H45) about moderating influences on the central path connections in Model I, the interaction effects of the respective moderator (e.g. age) on the 27 previously determined paths from Model I are determined and presented in a table.

As part of the research project, a separate SEM is estimated for each sub-aspect of a group of content-relevant moderators (e.g., individual characteristics) with this moderator. This results in a separate model estimate for each moderation hypothesis. This is due to the complexity of the interaction terms to be tested (see Chapter 4.4) (J. Hair et al., 2022, p. 151).

A systematic representation and mapping of all potentially moderating sub-aspects (for example,e in the area of education) within a group is carried out with

the aid of the 27 path connections. For this purpose, a linear interaction term between the moderator and path variable is modelled (West et al., 1995, p. 56 ff.). In the present study, a simultaneous integration of the relevant moderators into a common SEM is not possible, as this model estimation requires an extremely large sample, which is not available in this study. Furthermore, the moderators included are dichotomised, i.e. they are divided into exactly two contrasting comparison groups. This serves to avoid problems with model estimation such as multicollinearity or unstable model matrices (Chin, 2000a, p. 94; J. F. Hair et al., 2017, p. 24). These problems arise due to the unfavourable ratio of the number of paths to the available sample size (n=485;(MacCallum et al., 1996, p. 130 ff.).

The metric scales, which are based on multiple Likert-type items (individualism, masculinity, motor performance, range, charging time, market availability, charging availability, environmental impact, policy and incentives, knowledge, familiarity), are divided into two comparison groups using a median split (≤ median vs. > median). The categorical aspects are also divided into two groups based on content-related considerations. Table 75 illustrates the selected cut-off values for all moderators of the specific structural equation models that were used in the context of testing the respective moderator hypotheses (J. F. Hair et al., 2017, p. 21 ff.; R. B. Kline, 2023, p. 419 ff.).

Table 75: Selected cut-off values for all moderators

Moderator	M = 0	M = 1
Age	18 -54 years	55 years or older
Gender	Male	Female
Education	No school-leaving certificate; Secondary school certificate; Secondary school leaving certificate; intermediate school leaving certificate or equivalent; Completed apprenticeship; vocational baccalaureate diploma; entrance qualification for studies at a university of applied sciences; A levels; university entrance qualification	Technician's or master's certificate; Degree from a university of applied sciences or university, Doctorate/postdoctoral qualification
Daily travel demand	Up to 50 km	51 km or more
Occupation/Job	Pensioner; Currently unemployed	Employed; Pupil, trainee, student or similar; Family carer
EV driving expereince	No	Yes, I am not certain
Household size	Up to 2 persons	More than 2 persons
Household income	Up to 2500 EUR	More than 2500 EUR
Number of vehicles in household	Up to 1 car	2 or more cars
Types of vehciles in household	No car or vehicle with combustion engine only	Hybrid vehicle or battery electric vehicle
Charging Opportunity	Neither at home nor at work	Either at work or a home
Individualism	≤ 4.0	> 4.00
Masculinity	≤ 3.5	> 3,50
Motor Power	≤ 4.33	> 4.33
Driving Range	≤ 4.33	> 4.33
Charging Time	≤ 4.33	> 4.33
Market Availability	≤ 4.33	> 4.33
Charging Availability	≤ 4.33	> 4.33
Environmental Impact	≤ 4.33	> 4.33
Policy & Incentives	≤ 4.33	> 4.33
Knowledge	≤ 4.33	> 4.33
Familiarity	≤ 4.50	> 4.50

Source: Own illustration

Table 76 shows examples of the moderating effects of the age characteristic (coded as 0 = "younger" [18-54 years] and 1 = "older" [≥ 55 years]) on the respective path relationships in the structural equation model.

The column "M = 0" indicates the regression coefficient β for the reference group (younger respondents). The "Difference M = 1" column shows the difference in the effect between the groups, i.e. the extent to which the regression path changes for the older reference group. The "Significance" column indicates whether this difference effect is statistically significant and thus whether there is a moderating influence of the age characteristic.

The "Effect" column interprets the direction of the moderating effect.

- A positive value in the difference column (+) indicates that the effect in group 1 is stronger.
- A negative value (-) indicates a weakening.
- If there is a significant change in the direction of the sign, this is labelled with (±) (e.g. from positive to negative). This indicates an inverted moderation effect.

In this table, a significant moderation effect can only be detected for the costs (Co) → use behaviour (UB), a significant moderation effect by age can be detected ($p < .05$). The effect is positive for younger people, but turns negative for older people, resulting in a significant inverse moderation effect.

Table 76: Moderating effects of the individual characteristic age

Moderating effects through **Age**				
Path	**M = 0: Weight (β)**	**Difference for M = 1 (β)**	**Significant (Moderation)**	**Effect** (relevant when significant)
AtET -> BI	+0.00	+0.05	n.s.	
CA -> BI	+0.18	-0.09	n.s.	
CA -> TI	+0.45	-0.13	n.s.	
Co -> BI	+0.05	-0.10	n.s.	
Co -> UB	+0.22	-0.20	*	(±)
Com -> BI	+0.10	-0.04	n.s.	
Com -> UB	-0.20	+0.04	n.s.	
EE -> BI	-0.06	-0.01	n.s.	
EE -> TI	+0.07	-0.05	n.s.	
FC -> BI	-0.03	+0.01	n.s.	
FC -> TI	-0.10	+0.02	n.s.	
FC -> UB	+0.29	-0.15	n.s.	
Ha -> BI	+0.33	-0.05	n.s.	
Ha -> UB	+0.10	+0.11	n.s.	
HM -> BI	-0.01	+0.15	n.s.	
PE -> BI	+0.10	-0.02	n.s.	
PE -> TI	-0.04	+0.06	n.s.	
PIn -> BI	+0.16	+0.02	n.s.	
PIn -> UB	+0.02	-0.05	n.s.	
PV -> BI	+0.02	+0.16	n.s.	
Re -> BI	+0.12	-0.08	n.s.	
Re -> TI	+0.48	-0.05	n.s.	
SA -> TI	+0.05	+0.14	n.s.	
SI -> BI	+0.08	+0.02	n.s.	

*Significance level: * 5%; ** 1%; *** 0.1%; n.s. = not significant*

x (+) Significant positive moderation effect

x (±) Significant change in direction (inverted effect)

x (-) Significant negative moderation effect

Source: Own illustration

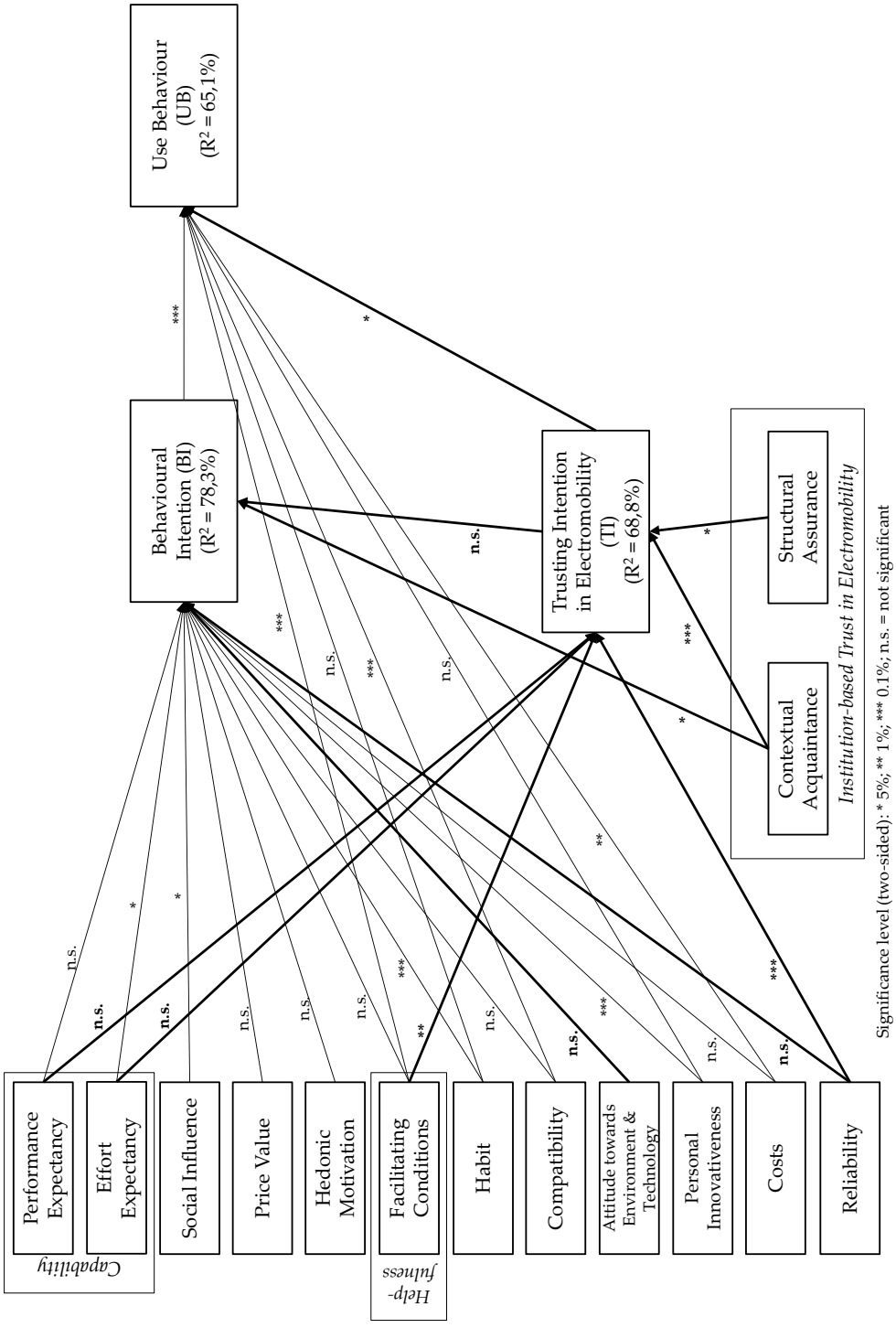
The other moderation results can be found in the appendix. The hypothesis test and discussion of the significant moderating effects are carried out in Chapter 5.7.3.

5.7 SUMMARY OF THE RESULTS

The research model was empirically examined in the previous chapters using the structural equation modelling method. The theoretical causal relationships between independent variables and dependent variables were analysed at two levels for Model I. At the level of the measurement model, the reliability of the indicators and constructs was first analysed and the content and construct validity was checked. In this review, five out of 50 indicators were excluded as insufficiently reliable. The further empirical investigation was continued with 45 indicators and seventeen constructs. The measurement model study was followed by the structural model test, which aims to confirm or reject the research hypotheses. Figure 43 displays the validation results, including the corresponding significance levels of the path connections and the coefficients of determination (R^2) for the latent endogenous variables.[27] This is followed by the evaluation (confirmation or rejection) of the research hypotheses based on the empirical validation in tabular form, which relates to Model I. The following chapters provide an overall assessment of the model fit and explanatory power of Model I as well as a discussion of the effect relationships of the constructs in Model I.

[27] As this is Model I, the results of the moderator variables are not shown here.

Figure 43: Results of the empirical validation of the structural equation model (Model I)



Source: Own illustration

Table 77: Confirmation or rejection of the research hypotheses of the empirical study for Model I

Hypothesis	Independent variable	Effect	Dependent variable	Confirmation ☑	Rejection ☒
				Model I	
H1	Perfromance Expectancy	Positive	Behavioural Intention		☒
H2	Perfromance Expectancy	Positive	Trusting Intention in Electromobility		☒
H3	Effort Expectancy	Positive	Behavioural Intention	☑	
H4	Effort Expectancy	Positive	Trusting Intention in Electromobility		☒
H5	Social Influence	Positive	Behavioural Intention	☑	
H6	Price Value	Positive	Behavioural Intention		☒
H7	Hedonic Motivation	Positive	Behavioural Intention		☒
H8	Faciliating Conditions	Positive	Behavioural Intention		☒
H9	Faciliating Conditions	Positive	Use Behaviour	☑	
H10	Faciliating Conditions	Positive	Trusting Intention in Electromobility	☑	
H11	Habit	Positive	Behavioural Intention	☑	
H12	Habit	Positive	Use Behaviour		☒
H13	Compatibility	Positive	Behavioural Intention		☒
H14	Compatibility	Positive	Use Behaviour	☑	
H15	Attitude towards Environment & Technology	Positive	Behavioural Intention		☒
H16	Personal Innovativeness	Positive	Behavioural Intention	☑	
H17	Personal Innovativeness	Positive	Use Behaviour		☒
H18	Costs	Negative	Behavioural Intention		☒
H19	Costs	Negative	Use Behaviour	☑	
H20	Reliability	Positive	Behavioural Intention		☒
H21	Reliability	Positive	Trusting Intention in Electromobility	☑	
H22	Contextual Acquaintance	Positive	Behavioural Intention	☑	
H23	Contextual Acquaintance	Positive	Trusting Intention in Electromobility	☑	
H24	Structural Assurance	Positive	Trusting Intention in Electromobility	☑	
H25	Trusting Intention in Electromobility	Positive	Behavioural Intention		☒
H26	Trusting Intention in Electromobility	Positive	Use Behaviour	☑	
H27	Behavioural Intention	Positive	Use Behaviour	☑	

☑ Confirmation of the hypothesis

☒ Rejection of the hypothesis

Source: Own illustration

5.7.1 Model quality: Model fit and explanatory power of Model I

The assessment of the general model quality forms the basis for the further interpretation of the hypothesis-testing and path analyses. The quality of the model was assessed as part of the PLS-SEM using common indicators, such as the coefficient of determination (R^2), effect sizes (f^2), and the significance and direction of the path coefficients (β). In addition, the model fit was assessed using the SRMR.

According to Henseler et al. (2014), an SRMR value of less than 0.08 is considered an indicator of good model fit.

Regarding the explanatory power of the central target constructs, the model demonstrates excellent overall explanatory power for the central dependent variables. The adjusted coefficients of determination of the three central endogenous constructs of use behaviour (UB), trusting intention in electromobility (TI) and behavioural intention (BI) are all above the critical threshold ofR2= 0.50, which corresponds to at least a moderate explanatory value (J. Hair et al., 2022, p. 190 ff.). BI ($R^2 = 0.783$) and TI ($R^2 = 0.688$) in particular achieve a substantial degree of explanation, which indicates a high predictive power of the exogenous predictors. The actual behaviour (use behaviour) is also explained very reliably with an R^2 of 0.651 (Chin, 1998; Henseler et al., 2009; F. Huber et al., 2007; Hulland, 1999). The predictive relevance of the model was also assessed using the Q^2 values of the target constructs, which consistently yielded positive results. This is supported by the assumption of substantial predictive relevance according to Hair et al. (2022) (J. Hair et al., 2022, p. 190 ff.).

In this context, the high model complexity should be emphasised in particular: The research model integrates seventeen constructs with a total of 50 manifest indicators. Despite the high complexity of the models, very good explanatory values are achieved for all target constructs. This indicates a high theoretical accuracy of fit and good empirical modelling. Compared to the results of previous studies, this result can be rated as above-average. The frequently cited meta-analysis by Venkatesh et al. (2003) shows that classic technology acceptance models such as TAM or UTAUT typically achieve coefficients of determination in the range of $R^2 \approx 0.40$ (Venkatesh et al., 2003). The results of the meta-analysis by Blut et al. (2022) are also clearly surpassed here. In view of this, the present model exhibits significant explanatory power (Blut et al., 2022, p. 106).

Additionally, it was ensured that there was no problematic multicollinearity among the predictors. The analysis showed that all values were below the threshold value of 0.8 (Backhaus et al., 2021, p. 121; Klarmann, 2008, p. 192).

In addition to the coefficients of determination, the path coefficients of the significant relationships also exhibit a high statistical robustness. It was found that

a significant proportion of the evaluated paths are significant at the level of $p < 0.001$ or $p < 0.05$ (Backhaus et al., 2021, p. 36 ff.; Bühner, 2006, p. 117).

The model fulfils the usual quality criteria in terms of explanatory content, validity and relevance of central mechanisms of action and expands existing acceptance models to include contextual and trust-based factors. In particular, the inclusion of use behaviour as an actual behavioural variable, rather than just intentions, represents a substantial further development of existing models (Ajzen & Fishbein, 1980; Venkatesh et al., 2003).

In summary, it can be stated that Theoretical Model I both fulfils the methodological requirements for structural equation models and exhibits above-average explanatory power in empirical comparison. This statement applies to both the established benchmarks of model quality (Chin, 1998; J. F. Hair et al., 2019) and to comparisons with existing empirical studies on the acceptance of electromobility. This illustrates the high relevance and theoretical foundation of the selected model structure (Blut et al., 2022, p. 109; Chin, 1998; J. F. Hair et al., 2019; Venkatesh et al., 2003, p. 446, 2012, p. 74 ff.).

5.7.2 Discussion of causal relationships and constructs

The path analysis of the extended acceptance model provides reliable findings on key factors influencing the use and acceptance of EVs. Particular attention should be drawn to the significant relationship between behavioural intention (BI) and use behaviour (UB), which, with a path coefficient of $\beta = 0.59$, is both theoretically consistent and statistically highly robust. This result confirms the basic assumption of the UTAUT model that behavioural intentions play a central role as a mediating variable between psychological constructs and actual behaviour (Azman Ong et al., 2023, p. 2 f.; Venkatesh et al., 2003, p. 425 ff.; M. Zhou et al., 2021, p. 137). The influence of BI on UB is considered one of the most robust correlations in technology acceptance research and has been confirmed in numerous empirical studies and meta-analyses (Blut et al., 2022, p. 109).

In addition, a significant, albeit weak, correlation between effort expectancy (EE) and behavioural intention ($\beta<0.10$) was shown. Although the path is statistically significant, the effect strength according to Cohen (1988) can be

categorised as low (Backhaus et al., 2021, p. 36 ff.; Bühner, 2006, p. 117; Cohen, 1988). The perceived ease of use of EVs is thus becoming a secondary influencing criterion, as potential users are becoming increasingly familiar with this technology. This development could lead to a kind of "baseline competence" in which users implicitly expect simplicity and no longer actively evaluate it (F. D. Davis, 1989; Fazel, 2014). Some exceptions with formally significant but weak effect sizes($\beta<0.10$) should be considered in a differentiated manner and further investigated in future studies, as they may indicate context-specific characteristics or latent moderation effects (Blut et al., 2022, p. 9; Cohen, 1988; A.-C. Teo et al., 2015, p. 321 ff.).

In contrast, the influence of social norms is considered to be significantly stronger. The present study concludes that there is a significant positive relationship between social influence (SI) and behavioural intention (BI). This result underpins the significance of social influences in the adoption process of new technologies, as already presented in theoretical form by Ajzen (1991), Venkatesh et al. (2003) or Kotler and Keller (2016) (Ajzen, 1991; Kotler & Keller, 2016; Venkatesh et al., 2003). The relevance of social comparison processes and the influence of the social environment on technological decisions is particularly evident in the case of visible innovations such as EVs (Almansour, 2022; Fedorko et al., 2021; Kumar Jain et al., 2022; Tsu Wei et al., 2009; Venkatesh et al., 2012).

Furthermore, the significant influence of personal innovativeness (PIn) on BI becomes clear. This pair relationship captures the individual tendency to try out new technologies at an early stage and has already proven to be a relevant predictor of adoption decisions in previous studies (Agarwal & Prasad, 1998; Jansson, 2011; Kuo & Yen, 2009; Kwon et al., 2007; Meuter et al., 2005; Parasuraman, 2000). This study concludes that PIn makes a significant contribution to explaining BI. The lack of significance of PE is striking, as this variable is one of the central predictors in classic acceptance models such as UTAUT. One possible explanation lies in the growing self-perception of technological benefits among user groups with a affinity for technology. It can therefore be deduced that an affinity for technology in individuals aligns a behavioural intention less with a rational benefit calculation and more with their openness to technological innovations.

The habit (Ha) construct shows a further significant result. The positive path relationship with behavioural intention (BI) indicates that previous (usage) experience with EVs promotes the intention to use them in the future. This result confirms H11, which posits that habitual behavioural patterns are relevant predictors of the acceptance of technological innovations (Azman Ong et al., 2023; Venkatesh, Thong, et al., 2016; M. Zhou et al., 2021). However, Habit has no significant effect on actual use behaviour (UB), so that H12 cannot be confirmed. This could indicate that habit tends to generate motivation, but does not automatically lead to behaviour (Limayem et al., 2007, p. 705 ff.)

While the construct of performance expectancy (PE) surprisingly shows no relevance, contextual influencing factors emerge particularly clearly. The paths from contextual acquaintance (CA) to both trusting intention (TI) and BI are significant and convincing in their effect size (Gefen et al., 2003; D. McKnight & Chervany, 2002; Sovacool et al., 2018, p. 86 ff.). It can be stated that positive contextual experiences (such as test drives or exchanges with e-car users) play a significant role in building trust and generating intentions. This empirical finding confirms considerations by McKnight (2009), Sovacool et al. (2018), as well as the research results of Dudenhöffer (2015), which emphasise the importance of experience-related influencing factors in the adoption process (K. Dudenhöffer, 2015; H. McKnight et al., 2009; Sovacool et al., 2018).

The relationship between TI and the target constructs BI and UB shows an interesting effect. The path from TI to BI is not significant, while there is a significant effect on UB. This difference indicates a direct, non-cognitively mediated influence of trust on behaviour. Following McKnight et al. (2009), trust in a technology can reduce uncertainty and trigger immediate behaviour, even without an explicit intention to act (Gefen et al., 2003; D. McKnight & Chervany, 2002; H. McKnight et al., 2009).

A significant result is shown for the construct of compatibility (Com). The negative effect of Com on UB (β= -0.19, $p< 0.001$) contradicts the assumptions of classical acceptance models. One possible explanation for this discrepancy could be cognitive dissonance. It is assumed that users perceive EVs as compatible with their values and goals in principle, but experience practical discrepancies in everyday life, for example, when charging or planning routes. This can lead to a

negative reaction at the behavioural level, even though the technology is subjectively perceived as suitable. Alternatively, it could be a mediating or moderating effect, which should be analysed in greater depth in further studies (Venkatesh et al., 2003, p. 425 ff.).

The hypotheses regarding the paths from hedonic motivation (HM), PE and AtET to BI were not confirmed. These results contradict the UTAUT2 logic (Venkatesh et al., 2012), according to which pleasure-oriented and benefit-related motives drive the user as central points of behavioural intention. One possible interpretation is that consumers' adoption decisions in the field of electromobility are increasingly rational and risk-based. This in turn means that trust and contextual factors override affective and utilitarian motives, especially if the target group is technologically experienced (Blut et al., 2022, p. 9; Cohen, 1988; Fazel, 2014, p. 286; Han et al., 2017; Kapser & Abdelrahman, 2020; J. Liu et al., 2024; A.-C. Teo et al., 2015, p. 321 ff.; Venkatesh et al., 2012).

One of the central predictors in the UTAUT literature is price value (PV). Given that PV shows no significant effect on behavioural intention in this study, this result is surprising in that price-performance considerations usually play an important role for consumers in the purchase decision process. Possible reasons could be that users perceive the prices of EVs differently from those of vehicles with a combustion engine, or that consumers consider the perceived benefits of a vehicle to be more important than its price. Furthermore, a subjectively perceived cost neutrality status could compensate for a differentiation based on price advantages (Adnan et al., 2017; Bockarjova & Steg, 2014; Dodds et al., 1991; Goldsmith et al., 2005; Han et al., 2017; Kapser & Abdelrahman, 2020; Kumar Jain et al., 2022).

A different picture emerges with regard to the effect of costs. While the path of costs on BI remains insignificant, there is a significant influence on UB. This finding suggests that cost aspects in the decision-making process become relevant only in specific action situations, which is consistent with action theory models (Heckhausen & Gollwitzer, 1987; Shuhaiber & Mashal, 2019; J.-H. Wu & Wang, 2005).

The following differentiation can be made regarding the facilitating conditions (FC), whereby the paths to UB and TI are significant, whereas the

influence on BI is not. According to studies, supportive framework conditions, such as charging infrastructure or service offerings, tend to promote actual use or trust in the technology, but not necessarily the formation of an intention to use it. This distinction is in line with earlier findings on the role of external framework factors in UTAUT theory (Kumar Jain et al., 2022; D. McKnight & Chervany, 2002; H. McKnight et al., 2009; Venkatesh et al., 2003).

Finally, the constructs of reliability and structural assurance, both confidence-building dimensions, show a significantly positive influence on TI. Reliability refers to perceived technical reliability, whereas structural assurance manifests institutional trust, which is represented by guarantees or regulatory standards, for example. This finding emphasises the multidimensionality of trust in electromobility and underlines the need to fulfil both the technical and structural safety expectations of customers (Gefen et al., 2003; Hilale & Chakor, 2024; B. Kim & Han, 2011; H. McKnight et al., 2009; Wicki et al., 2022; Wixom & Todd, 2005).

Overall, the results of Model I show that trust, technological openness, social influences and contextual experience are among the most important predictors for the acceptance of electromobility. In contrast, classic benefit and fun components lose explanatory power. This indicates a shift in the cognitive evaluation structure of sustainable mobility solutions, with far-reaching implications for the design of research-based innovation strategies, target group-specific communication and effective funding policies in the field of sustainable mobility.

5.7.3 Discussion of moderator effects (Model II)

In this chapter, the significant effects of the postulated moderating influences are discussed. Six moderator groups (individual characteristics, situational determinants, national culture, technical determinants, contextual determinants, and experience) were derived based on theory and corresponding hypotheses formulated (cf. Chapter 3.3.4).

Moderating effects of individual characteristics

Hypotheses H28-H30 examine the moderating influences of individual characteristics (age, gender, education, daily driving needs, occupation/employment and EV driving experience) on the central dependent

constructs behavioural intention (BI), trusting intention (TI) and use behaviour (UB). The result of the hypothesis test for the influences of the moderating group of individual characteristics is illustrated in Table 78:

Table 78: Significant moderating effects of individual characteristics

Hypothesis	Independent variable	Dependent variable	Effect	Moderator Group Individual Characteristics						Confirmation ☑	Rejection ☒
				Age	Gender	Education	Daily travel demand (km)	Occupation / Job	EV driving experience	Model II	
H28	Performance Expectancy	Behavioural Intention	moderated by				x (+)			☑	
	Effort Expectancy		moderated by								
	Social Influence		moderated by								
	Price Value		moderated by								
	Hedonic Motivation		moderated by								
	Facilitating Conditions		moderated by								
	Habit		moderated by								
	Compatibility		moderated by								
	Attitude towards Environment & Technology		moderated by								
	Personal Innovativeness		moderated by								
	Costs		moderated by								
	Contextual Acquaintance		moderated by								
	Reliability		moderated by					x (±)	x (±)		
H29	Performance Expectancy	Trusting Intention in Electromobility	moderated by				x (-)		x (±)	☑	
	Effort Expectancy		moderated by								
	Facilitating Conditions		moderated by				x (±)				
	Reliability		moderated by						x (-)		
	Contextual Acquaintance		moderated by								
	Structural Assurance		moderated by								
H30	Facilitating Conditions	Use Behaviour	moderated by					x (+)	x (+)	☑	
	Habit		moderated by			x (±)					
	Compatibility		moderated by								
	Personal Innovativeness		moderated by								
	Costs		moderated by	x (±)							

x (+) Significant positive moderation effect

x (±) Significant change in direction (inverted effect)

x (-) Significant negative moderation effect

☑ Confirmation of the hypothesis

☒ Rejection of the hypothesis

Source: Own illustration

It is clear that a total of eleven moderating effects were identified across the three latent constructs, although not every moderator variable (see gender) has a moderating effect. This means that the three hypotheses H28, H29 and H30 can be confirmed. For further details, see Appendix 10. The scientific interpretation of the

effects and a discussion of their significance in the context of the research question follow.

The effect of costs (Co) on use behaviour shows a significant moderation effect due to age. The positive correlation between perceived costs and usage behaviour is evident in younger people, although this correlation turns negative in older people, resulting in a significant inverse moderation effect. This suggests that younger users benefit more from more favourable usage costs, while older users may be more likely to face hidden or unexpected costs. The implication is that cost arguments should be prepared for specific target groups, as older target groups in particular require transparent and reliable cost information (Shuhaiber & Mashal, 2019; Sovacool et al., 2018; Z. Wang et al., 2017; J.-H. Wu & Wang, 2005).

The effect of habit on use behaviour is significantly moderated by the level of education. While people with a lower level of education tend to use electromobility more out of habit, this correlation is weaker or even negative for more highly educated users. This suggests that more highly educated people make more reflective decisions and rely less on routine behaviour. It can be implied that intervention strategies to promote electromobility via habitual use should be prioritised for target groups that are less educated (Azman Ong et al., 2023; Sovacool et al., 2018; M. Zhou et al., 2021).

There is a significant moderating effect on the path from facilitating conditions to trusting intention, depending on the daily driving requirement. Users with a higher daily driving requirement perceive a supportive infrastructure (e.g. charging infrastructure) as more conducive to trust than users with a lower driving requirement. This allows the implication that trust in electromobility can be sustainably strengthened, especially among frequent drivers, by expanding the infrastructure (Kumar Jain et al., 2022; H. McKnight et al., 2009; Sovacool et al., 2018; Venkatesh et al., 2012).

The moderating role of the need to travel is also evident in the path from performance expectancy to behavioural intention. Perceived performance has a significant influence on the intention to use a car, particularly for individuals with high daily mobility requirements. This implies that frequent travellers focus on functional added value. This should be taken into account accordingly in the

communication design (Kapser & Abdelrahman, 2020; Kumar Jain et al., 2022; Sovacool et al., 2018; Venkatesh et al., 2003).

The daily driving requirement also moderates the relationship between performance expectancy and trusting intention. While the expectation of functional benefits plays no role for drivers with low mobility needs, it has a negative effect on trust among frequent drivers. This can be interpreted as meaning that users with high expectations of performance are more susceptible to disappointment during intensive use. The implication is that effective expectation management is essential to ensure the long-term trust of frequent users (D. McKnight et al., 2002; Sovacool et al., 2018; Venkatesh et al., 2012).

The path from facilitating conditions to use behaviour is significantly moderated by employment status. This means that employed users react more strongly to structural support measures than non-employed users. This implies that the expansion of charging infrastructure close to the workplace or targeted information services for commuters could significantly increase the use of EVs (Azman Ong et al., 2023; Kumar Jain et al., 2022; H. McKnight et al., 2009; Sovacool et al., 2018).

The path relationship between reliability and behavioural intention is also significantly moderated by employment status. For employed persons, the perceived reliability of the vehicle is a much stronger influencing factor on the intention to use the vehicle than for non-employed persons. This leads to the implication that the reliability of EVs should be explicitly communicated and advertised for working people, for example, through (mobility) guarantees or reliability tests (B. Kim & Han, 2011; H. McKnight et al., 2009; Wixom & Todd, 2005).

A further significant influence can be observed for "reliability" on "behavioural intention" at the different levels of experience with EVs. The effect varies significantly between the two groups, so that people with more experience rate technical reliability more critically. The implication is that for this group, communication regarding quality should be more data-driven, transparent, and fact-oriented (Blut et al., 2022; B. Kim & Han, 2011; Wicki et al., 2022).

The influence of reliability on trusting intention varies in intensity among user groups with varying experience in EV driving. Without personal experience

with EVs, the perceived reliability has a stronger trust-promoting effect, but this effect is relativised for people with EV driving experience. It can be implied that trust is particularly sensitive among newcomers, which is why they represent a central target group for quality seals or test drive programmes (Gefen et al., 2003; D. McKnight & Chervany, 2002; Wixom & Todd, 2005).

The path relationship from performance expectancy to trusting intention is also significantly moderated by EV driving experience. The effect is negative without driving experience, but it reverses to positive with more experienced users, representing a significant inverse moderation effect. One interpretation could be that people without personal experience may perceive high-performance expectations as critical or exaggerated, while experienced users confirm them and have a corresponding level of confidence. The implication is that trust in the performance characteristics of EVs can be strengthened through testimonials, test drives, and experience reports for individuals with little or no prior experience (Kapser & Abdelrahman, 2020; H. McKnight et al., 2009; Venkatesh et al., 2012).

An equally significant moderation effect can be seen in the path between the facilitating conditions and the use behaviour, which is moderated by the driving experience with EVs. Users with experience in EVs react much more sensitively to perceived facilitating conditions than those without such experience. It can be deduced from this that practical experience with the use of EVs appears to heighten sensitivity to infrastructural and organisational support. This implies that positive charging and usage experiences should be actively communicated in order to reduce uncertainty among those who are not yet users (Azman Ong et al., 2023; Kumar Jain et al., 2022; H. McKnight et al., 2009; Sovacool et al., 2018; Venkatesh et al., 2012).

Moderating effects of situational determinants

Hypotheses H31-H33 examine the moderating influences of situational determinants (household size, household income, number of vehicles per household, types of vehicles in the household, charging opportunity) on the central dependent constructs of behavioural intention (BI), trusting intention (TI), and use behaviour (UB). The result of the hypothesis test for the influences of the moderating group of situational determinants is illustrated in Table 79:

Table 79: Significant moderating effects of situational determinants

Hypothesis	Independent variable	Dependent variable	Effect	Moderator Group Situational determinants					Confirmation ☑	Rejection ☒
				Household size	Household income	Number of vehicles in household	Types of vehicles in household	Charging Opportunity	Model II	
H31	Performance Expectancy	Behavioural Intention	moderated by						☑	
	Effort Expectancy		moderated by							
	Social Influence		moderated by			x (±)	x (±)			
	Price Value		moderated by							
	Hedonic Motivation		moderated by			x (+)	x (±)			
	Facilitating Conditions		moderated by							
	Habit		moderated by			x (±)	x (±)			
	Compatibility		moderated by							
	Attitude towards Environment &		moderated by							
	Personal Innovativeness		moderated by					x (+)		
	Costs		moderated by							
	Contextual Acquaintance		moderated by							
	Reliability		moderated by				x (+)			
H32	Performance Expectancy	Trusting Intention in Electromobility	moderated by						☑	
	Effort Expectancy		moderated by							
	Facilitating Conditions		moderated by							
	Reliability		moderated by					x (±)		
	Contextual Acquaintance		moderated by							
	Structural Assurance		moderated by							
H33	Facilitating Conditions	Use Behaviour	moderated by					x (+)	☑	
	Habit		moderated by							
	Compatibility		moderated by				x (±)			
	Personal Innovativeness		moderated by				x (±)			
	Costs		moderated by	x (+)			x (±)			

x (+) Significant positive moderation effect

x (±) Significant change in direction (inverted effe

x (-) Significant negative moderation effect

☑ Confirmation of the hypothesis

☒ Rejection of the hypothesis

Source: Own illustration

A total of fourteen moderating effects were identified across the three latent constructs, although not every moderator variable (see household income) has a moderating effect. This means that the three hypotheses H31, H32 and H33 can be confirmed. For further details, see Appendix 11. The scientific interpretation of the effects and a discussion of their significance in the context of the research question follow.

A significant positive moderation effect is evident in the path from costs to usage behaviour, which is dependent on household size. This means that the larger the household, the stronger the impact of cost perception on actual usage behaviour. This implies that cost effects due to shared journeys or budgets play a central role in multi-person households, making costs particularly relevant for family-oriented mobility solutions (Y.-F. Liu et al., 2018; R. Wang et al., 2021; Wicki et al., 2022).

At the same time, the effect of costs on usage behaviour is significantly moderated by the type of vehicles available in the household. This means that the relative cost advantage of e-vehicles could be perceived differently or relativised for certain vehicle types (e.g. combustion engine vs. hybrid). This leads to the implication that the positioning of e-mobility should be more focused on fleet combinations (Göthlich, 2009; Shuhaiber & Mashal, 2019; S. Wang et al., 2017; J.-H. Wu & Wang, 2005).

The relationship between compatibility and usage behaviour is significantly reversed depending on the number of vehicles in the household. The corresponding interpretation is: depending on the vehicle stock, e-mobility is perceived as a break rather than an extension of the previous mobility logic. This leads to the implication that counselling approaches should be tailored to the technical and social suitability in the respective household (Jansson, 2011; Meuter et al., 2005; G. C. Moore & Benbasat, 1991).

It is also clear that, depending on the type of vehicle in the household, there is a significant inverse effect in the path from personal innovativeness to use behaviour. This suggests that actual use is influenced by contextual factors, even in the case of innovative individuals, who are aware of possible alternatives from the EV market (Agarwal & Prasad, 1998; Parasuraman, 2000; M. Zhou et al., 2021).

In addition, there is a highly significant positive moderation effect in the relationship between the facilitating conditions and use behaviour, which is influenced by the availability of charging facilities. This leads to the conclusion that the availability of infrastructure is a critical factor for the actual use of e-vehicles (Helveston et al., 2015; Herndler, 2024; Jaiswal, Kaushal, et al., 2022).

There is a significant inverse effect in the path from Reliability to Trusting Intention. This can be interpreted as meaning that the influence of reliability on

trust is relativised when charging options are available, as the reality of use becomes more tangible. This means that trust is based more on personal usage experiences than on technical expectations (B. Kim & Han, 2011; H. McKnight et al., 2009; Wixom & Todd, 2005).

Furthermore, there is a significant inverse moderation effect due to the number of vehicles in the household for the influence of habit on behavioural intention. This suggests that with multiple vehicles, habitual behaviour tends to be influenced by selection decisions. This means that intervention logics on usage behaviour are less effective in households with multiple vehicles (Azman Ong et al., 2023; Venkatesh et al., 2012; M. Zhou et al., 2021).

Another inverse effect of habit on behavioural intention can be observed in the variation of vehicle types within households. This implies that usage routines are irritated or relativised by heterogeneity in the vehicle population (Egbue & Long, 2012; Sovacool et al., 2018).

In households with several vehicles, hedonic motivation has a significantly stronger effect on behavioural intention. This means that in more flexible mobility environments, fun and driving pleasure play a greater role in the decision in favour of electromobility (Azman Ong et al., 2023; Han et al., 2017; M. Zhou et al., 2021).

Depending on the vehicle mix, however, the direction of the effect of hedonic motivation on behavioural intention is significantly reversed. It can be implied that emotional motivations appear to be influenced by the perceived comparison with conventional vehicles (Sovacool et al., 2018; Venkatesh et al., 2012).

If charging facilities are available, the effect of personal innovativeness on behavioural intention is significantly stronger. This implies that innovative individuals can be additionally activated by infrastructural conditions (Agarwal & Karahanna, 2000; Kwon et al., 2007; Meuter et al., 2005).

A significant positive effect can be observed with certain vehicle constellations in the household, indicating that reliability has a stronger impact on behavioural intention. This implies that the importance of technical reliability is growing in comparison to tried-and-tested, conventional vehicle types (Gefen et al., 2003; B. Kim & Han, 2011; H. McKnight et al., 2009).

An inverse moderation effect can be seen in the influence of social norms on behavioural intention when a certain number of vehicles are present in the

household. This means that social influence loses its effect when households have a high degree of autonomy and freedom of choice (Fedorko et al., 2021; Tsu Wei et al., 2009; Venkatesh et al., 2003).

A significant change in direction can also be seen in the path of social influence on behavioural intention, which is moderated by different vehicle types in the household. This can be interpreted to mean that in technologically mixed households, social comparison appears to be less relevant or even leads to the opposite behavioural impulses (Almansour, 2022; Kumar Jain et al., 2022; Venkatesh et al., 2012).

Moderating effects of national Culture

Hypotheses H34-H36 examine the moderating influences of national culture (individualism, masculinity) on the central dependent constructs of behavioural intention (BI), trusting intention (TI) and use behaviour (UB). The result of the hypothesis test for the influences of the moderating group of national culture is illustrated in Table 80:

Table 80: Significant moderating effects of National Culture

Hypothesis	Independent variable	Dependent variable	Effect	Moderator Group National Culture		Confirmation ☑	Rejection ☒
				Individualism	Masculinity	Model II	
H34	Performance Expectancy	Behavioural Intention	moderated by		x (±)	☑	
	Effort Expectancy		moderated by				
	Social Influence		moderated by				
	Price Value		moderated by				
	Hedonic Motivation		moderated by				
	Facilitating Conditions		moderated by				
	Habit		moderated by				
	Compatibility		moderated by				
	Attitude towards Environment &		moderated by				
	Personal Innovativeness		moderated by		x (+)		
	Costs		moderated by				
	Contextual Acquaintance		moderated by		x (±)		
	Reliability		moderated by				
H35	Performance Expectancy	Trusting Intention in Electromobility	moderated by			☑	
	Effort Expectancy		moderated by		x (+)		
	Facilitating Conditions		moderated by				
	Reliability		moderated by		x (+)		
	Contextual Acquaintance		moderated by		x (±)		
	Structural Assurance		moderated by				
H36	Facilitating Conditions	Use Behaviour	moderated by	x (+)	x (+)	☑	
	Habit		moderated by				
	Compatibility		moderated by				
	Personal Innovativeness		moderated by				
	Costs		moderated by		x (+)		

x (+) Significant positive moderation effect

x (±) Significant change in direction (inverted effe

x (-) Significant negative moderation effect

☑ Confirmation of the hypothesis

☒ Rejection of the hypothesis

Source: Own illustration

A total of nine moderating effects were identified across the three latent constructs. This means that the three hypotheses H34, H35 and H36 can be confirmed. For further details, see Appendix 12. The scientific interpretation of the

effects and a discussion of their significance in the context of the research question follow.

Individualism shows a significant moderating effect in the facilitating conditions path on use behaviour. According to this, people with a pronounced individualism use EVs more if they perceive supportive conditions such as infrastructure or technical support. This suggests that in contexts characterised by individualism, a higher degree of personal responsibility for technology decisions is expected when there are supporting measures. The implication is that political measures or marketing strategies should specifically emphasise the self-efficacy aspect and highlight functional framework conditions (Ayyash et al., 2022; Goularte & Zilber, 2019; Srite & Karahanna, 2006; Yuniaristanto et al., 2024).

In contrast, numerous significant moderation effects were found for the moderator variable masculinity. These emphasise the central importance of performance-oriented, rational and status-related value patterns for the acceptance of electromobility in Germany. A total of eight paths are significantly influenced by masculinity:

The paths from contextual acquaintance to behavioural intention and from contextual acquaintance to trusting intention each show an inverted effect. This means that contextual awareness influences behaviour in masculine groups. The effect of costs on usage behaviour is also significantly increased, so that more favourable usage in masculine contexts appears to be particularly important as a rational advantage. Similarly, facilitating conditions have a stronger effect on actual usage behaviour in highly masculine contexts. The path from performance expectancy to behavioural intention shows a significant reversal of direction. This indicates a differentiated assessment of performance expectations, for example, concerning the need for control or scepticism towards innovations. Personal innovativeness also has a stronger effect on the behavioural intention of people with pronounced masculinity, which suggests a higher status consciousness or interest in technology. Finally, effort expectancy and reliability strengthen the effect on trust in electromobility. These paths suggest that the summarising implication is that electric mobility is more strongly accepted in masculine cultures due to its functional, performance-oriented, and status-related characteristics. This leads to the recommendation that communication strategies should therefore

specifically emphasise value propositions, technical robustness and individual benefits, while social or cooperative aspects are less central (Ayyash et al., 2022; Blut et al., 2022; Goularte & Zilber, 2019; Srite & Karahanna, 2006; Yuniaristanto et al., 2024).

Moderating effects of technical determinants

Hypotheses H37-H39 examine the moderating influences of technical determinants (motor power, driving range and charging time) on the central dependent constructs of behavioural intention (BI), trusting intention (TI) and use behaviour (UB). The result of the hypothesis test for the influences of the moderating group of technical determinants is illustrated in Table 81:

Table 81: Significant moderating effects of Technical determinants

Hypothesis	Independent variable	Dependent variable	Effect	Moderator Group Technical determinants			Confirmation ☑	Rejection ☒
				Motor Power	Driving Range	Charging Time	Model II	
H37	Performance Expectancy	Behavioural Intention	moderated by				☑	
	Effort Expectancy		moderated by					
	Social Influence		moderated by					
	Price Value		moderated by					
	Hedonic Motivation		moderated by			x (±)		
	Facilitating Conditions		moderated by					
	Habit		moderated by					
	Compatibility		moderated by					
	Attitude towards Environment &		moderated by					
	Personal Innovativeness		moderated by					
	Costs		moderated by					
	Contextual Acquaintance		moderated by					
	Reliability		moderated by					
H38	Performance Expectancy	Trusting Intention in Electromobility	moderated by	x (±)			☑	
	Effort Expectancy		moderated by			x (±)		
	Facilitating Conditions		moderated by					
	Reliability		moderated by		x (+)			
	Contextual Acquaintance		moderated by		x (-)			
	Structural Assurance		moderated by					
H39	Facilitating Conditions	Use Behaviour	moderated by			x (+)	☑	
	Habit		moderated by					
	Compatibility		moderated by					
	Personal Innovativeness		moderated by					
	Costs		moderated by					

x (+) Significant positive moderation effect

x (±) Significant change in direction (inverted effe

x (-) Significant negative moderation effect

☑ Confirmation of the hypothesis

☒ Rejection of the hypothesis

Source: Own illustration

A total of six moderating effects were identified across the three latent constructs. This means that the three hypotheses H37, H38 and H39 can be confirmed. For further details, see Appendix 13. The scientific interpretation of the effects and a discussion of their significance in the context of the research question follow.

A significant inverted moderation effect is observed in the relationship between performance expectancy and trusting intention, as a function of motor performance. This can be interpreted as meaning that users with a low motor performance orientation attach less importance to the performance of an EV in terms of trust than performance-oriented people do in this context. The change of sign indicates that high-performance requirements can even undermine trust, for example, if the vehicles do not fulfil expectations. This implies that trust in e-mobility can only be built among users with an affinity for performance if high-performance promises are also fulfilled. Manufacturers and politicians should therefore take care to communicate realistic performance levels (Chang & Tung, 2008; Roca et al., 2006; Schmalfuß et al., 2017; Shin, 2009).

A significant negative effect was found for the path of contextual acquaintance on trusting intention. This suggests that individuals with a high reach requirement place less emphasis on contextual references when establishing trust. Apparently, mere familiarity with the technology is not enough if restrictions on reach are feared. For users with high range requirements, this implies that information campaigns are not sufficient to promote trust. What is needed instead are concrete product experiences or technology-supported test drives (Bockarjova & Steg, 2014; H. McKnight et al., 2009; Shin, 2009; R. Wang et al., 2021).

A significant positive effect shows that the range requirement increases the influence of reliability on trust. This can be interpreted to mean that for people with high range expectations, perceived reliability is central to trust. The implication of this is that manufacturers and service providers should specifically emphasise proof of technical stability (e.g. guarantees, test results) with this target group in order to intensify trust (Chang & Tung, 2008; Gefen et al., 2003; D. H. McKnight et al., 1998; Schmalfuß et al., 2017; Z. Wang et al., 2017).

In terms of charging time, there is a significant inverse effect on the path from effort expectancy to trusting intention in electromobility. This shows that people with a higher charging time expectation show more trust with a lower charging time. This could indicate that their expectations are already so low that they perceive small improvements as clearly positive. From this, it can be implied that in segments with a particularly sceptical attitude towards loading times, even moderate improvements can significantly increase trust. Expectation management

thus becomes a strategic lever (Hackbarth & Madlener, 2013; Hidrue et al., 2011; Kapser & Abdelrahman, 2020; Kumar Jain et al., 2022; H. McKnight et al., 2009).

There is also a significant positive effect on the facilitating conditions path on actual usage behaviour. This leads to the interpretation that someone who expects a shorter charging time reacts significantly more sensitively to facilitating conditions such as a good infrastructure and high charging availability. This implies that a high-quality charging infrastructure is a crucial factor in encouraging actual use, especially among tech-savvy users with charging optimism. This also emphasises the relevance of promoting public charging points (Azman Ong et al., 2023; Erick Ayapana, 2023; Kumar Jain et al., 2022; Schmalfuß et al., 2017).

There is also a significant inverted moderation effect for the path from hedonic motivation to behavioural intention. This can be interpreted to mean that people with long loading times are more likely to be motivated by fun and enjoyment, while this effect becomes less important for people with short loading expectations, as the focus may be more on functional aspects. This leads to the implication that for users who are sceptical about the loading time, communicative measures should focus more on experience values and lifestyle elements to address compensatory motives (Bockarjova & Steg, 2014; Han et al., 2017; Roca et al., 2006; M. Zhou et al., 2021).

Moderating effects of contextual determinants

Hypotheses H40-H42 examine the moderating influences of contextual determinants (market availability, charging availability, environmental impact and policy and incentives) on the central dependent constructs of behavioural intention (BI), trusting intention (TI) and use behaviour (UB). The result of the hypothesis test for the influences of the moderating group of contextual determinants is illustrated in Table 82:

Table 82: Significant moderating effects of contextual determinants

Hypothesis	Independent variable	Dependent variable	Effect	Moderator Group Contextual determinants				Confirmation ☑	Rejection ☒
				Market availability	Charging availability	Environmental impact	Policy & Incentives	Model II	
H40	Performance Expectancy	Behavioural Intention	moderated by		x (±)			☑	
	Effort Expectancy		moderated by						
	Social Influence		moderated by						
	Price Value		moderated by						
	Hedonic Motivation		moderated by						
	Facilitating Conditions		moderated by						
	Habit		moderated by						
	Compatibility		moderated by						
	Attitude towards Environment &		moderated by						
	Personal Innovativeness		moderated by		x (+)				
	Costs		moderated by				x (±)		
	Contextual Acquaintance		moderated by						
	Reliability		moderated by		x (+)				
H41	Performance Expectancy	Trusting Intention in Electromobility	moderated by					☑	
	Effort Expectancy		moderated by			x (±)	x (±)		
	Facilitating Conditions		moderated by						
	Reliability		moderated by						
	Contextual Acquaintance		moderated by	x (-)	x (-)		x (+)		
	Structural Assurance		moderated by		x (+)				
H42	Facilitating Conditions	Use Behaviour	moderated by	x (+)	x (+)		x (+)	☑	
	Habit		moderated by						
	Compatibility		moderated by						
	Personal Innovativeness		moderated by						
	Costs		moderated by		x (+)				

x (+) Significant positive moderation effect

x (±) Significant change in direction (inverted effe

x (-) Significant negative moderation effect

☑ Confirmation of the hypothesis

☒ Rejection of the hypothesis

Source: Own illustration

A total of fourteen moderating effects were identified across the three latent constructs. This means that the three hypotheses H40, H41 and H42 can be confirmed. For further details, see Appendix 14. The scientific interpretation of the effects and a discussion of their significance in the context of the research question follow.

The independent variable of contextual acquaintance has a weaker effect on the dependent variable of trusting intention when market availability is low. This

suggests that the significance of contextual acquaintance on trust in electromobility decreases significantly when market availability is limited. This leads to the implication that trust is not created by personal familiarity alone, but requires a realistic market offering (Gefen et al., 2003; Hasan, 2021; Kautish et al., 2024; D. McKnight & Chervany, 2002; Wicki et al., 2022).

Facilitating conditions influence use behaviour more strongly when market availability is high. This means that facilitating conditions have a greater effect when consumers assume a wide range of vehicles are available. This implies that investments in user support should be accompanied by the actual availability of EVs (Hasan, 2021; Kautish et al., 2024; Kumar Jain et al., 2022; Wicki et al., 2022).

Numerous significant moderation effects were found for the moderator variable charging availability. These emphasise the central importance of this moderator for the acceptance of electromobility in Germany. In total, the following seven paths are significantly influenced by charging availability:

- Contextual Acquaintance →Trusting Intention
- Costs → Use Behaviour
- Facilitating Conditions → Use Behaviour
- Personal Innovativeness → Behavioural Intention
- Performance Expectancy → Behavioural Intention
- Reliability → Behavioural Intention
- Structural Assurance → Trusting Intention

When charging availability is limited, the key factors influencing the acceptance and use of electromobility shift significantly. This means that hard facts such as costs, reliability and supportive framework conditions become more important, as users pay more attention to practical hurdles when charging infrastructure is scarce. At the same time, soft facts such as contextual acquaintance lose impact, as trust is no longer created through environmental experience, but through structural assurance. The altered effect of performance expectancy on behavioural intention is particularly critical: when charging availability is poor, the expected benefit is reversed, so that users evaluate high-performance expectations negatively. People with high personal innovativeness show stronger usage intentions with good charging availability, which indicates a positive leverage effect of infrastructural conditions on progressive target groups (Azman Ong et al.,

2023; Kapser & Abdelrahman, 2020; She et al., 2017; R. Wang et al., 2021; I.-L. Wu & Wu, 2005).

Charging availability is a central factor in the contextual determinants moderator group, which can moderate both the strength and the direction of the effect of central constructs. On the one hand, this results in the recommendation that structural safety factors such as guarantees or clear service processes should be emphasised and functional barriers removed in regions with poor charging availability. Furthermore, formal credibility should be established in these regions, and trust in electromobility should not be overstated. It should also be emphasised that innovative target groups particularly benefit from good charging availability, which is why infrastructure expansion is essential not only for the masses, but also to appeal to progressive users. In conclusion, it should be noted that performance expectancy clearly shows that high expectations of performance without functional implementation conditions can even have a deterrent effect on users, so that realistic expectation management is necessary here (Bockarjova & Steg, 2014; Han et al., 2017; D. McKnight & Chervany, 2002; H. McKnight et al., 2009; S. Wang et al., 2019).

Effort expectancy influences trusting and is inversely moderated by the environmental impact variable, meaning that a high level of environmental awareness weakens the significance of effort estimates for trust. The implication is that communication focusing on the environmental benefits of EVs can override the perceived effort involved in using an EV (Butt & Singh, 2023; Nguyen et al., 2024; Quy Nguyen-Phuoc et al., 2022; R. Wang et al., 2021).

Policy and incentives have a significant positive influence on the path from contextual acquaintance to trusting intention. This means that if political support measures are perceived as significant, familiarity with the technology increases and trust in electric mobility is also strengthened. The funding backdrop acts here as an amplifier for existing contextual knowledge. This implies that support measures should be accompanied by information campaigns that focus on building awareness and experience. The interaction of policy and acquaintance can effectively promote trust (D. McKnight & Chervany, 2002; H. McKnight et al., 2009; Singh et al., 2021; S. Wang et al., 2017).

The influence of costs on behavioural intention is significantly moderated by policy and incentives. This means that financial support measures relativise the significance of perceived costs for the intention to use, so that users tend to ignore monetary hurdles when state support is present. This implies that the subsidy policy acts as a psychological price buffer. The specific financial relief should therefore be emphasised in communication and made easy to understand (Bockarjova & Steg, 2014; Kautish et al., 2024; Y.-F. Liu et al., 2018; Venkatesh et al., 2012; J.-H. Wu & Wang, 2005).

If there is a strong perception of policy and incentives, facilitating conditions have a stronger influence on use behaviour. This means that facilitating conditions exert their behavioural influence above all when they are perceived in harmony with political measures. The political framework legitimises and reinforces their effect. The interlocking of political funding logic with concrete support measures, such as the provision of sufficient charging infrastructure or free counselling services, is therefore crucial. The leverage effect can only unfold through interaction (Adnan et al., 2017; Azman Ong et al., 2023; Singh et al., 2021; S. Wang et al., 2017; M. Zhou et al., 2021).

Policy and incentives moderate the influence of effort expectancy on trusting intention, significantly inverting the relationship. This suggests that the expected effort is no longer perceived as being so burdensome due to considerable political incentive systems, which in turn is beneficial for trust in electromobility. The funding therefore acts as a catalyst for user-friendliness. The implication of this is that support measures should not only be linked in monetary terms, but also with simple and accessible applications for users. Intuitive use (e.g. through apps or simple charging processes) strengthens trust, especially in the case of political support (Bockarjova & Steg, 2014; Kapser & Abdelrahman, 2020; Kautish et al., 2024; Kumar Jain et al., 2022; H. McKnight et al., 2009).

Moderating effects of experience

Hypotheses H43-H45 examine the moderating influences of experience (knowledge, familiarity) on the central dependent constructs of behavioural intention (BI), trusting intention (TI) and use behaviour (UB). The result of the hypothesis test for the influences of the moderating group of experience is illustrated in Table 83:

Table 83: Significant moderating effects of experience

Hypothesis	Independent variable	Dependent variable	Effect	Moderator Group Experience		Confirmation ☑	Rejection ☒
				Knowledge	Familiarity	Model II	
H40	Performance Expectancy	Behavioural Intention	moderated by			☑	
	Effort Expectancy		moderated by	x (±)			
	Social Influence		moderated by				
	Price Value		moderated by				
	Hedonic Motivation		moderated by				
	Facilitating Conditions		moderated by				
	Habit		moderated by				
	Compatibility		moderated by				
	Attitude towards Environment &		moderated by				
	Personal Innovativeness		moderated by		x (+)		
	Costs		moderated by				
	Contextual Acquaintance		moderated by				
	Reliability		moderated by				
H41	Performance Expectancy	Trusting Intention in Electromobility	moderated by				☒
	Effort Expectancy		moderated by				
	Facilitating Conditions		moderated by				
	Reliability		moderated by				
	Contextual Acquaintance		moderated by				
	Structural Assurance		moderated by				
H42	Facilitating Conditions	Use Behaviour	moderated by			☑	
	Habit		moderated by				
	Compatibility		moderated by				
	Personal Innovativeness		moderated by				
	Costs		moderated by	x (+)			

x (+) Significant positive moderation effect

x (±) Significant change in direction (inverted effect

x (-) Significant negative moderation effect

☑ Confirmation of the hypothesis

☒ Rejection of the hypothesis

Source: Own illustration

A total of three moderating effects were identified across the three latent constructs. This means that the three hypotheses H43 and H45 can be confirmed. Hypothesis H44 must be rejected, as no moderating influence was identified here. For further details, see Appendix 15. The scientific interpretation of the effects and a discussion of their significance in the context of the research question follow.

Knowledge moderates the influence of effort expectancy on behavioural intention. In relation to users, this means that the less knowledge they have about electromobility, the more important perceived effort expectancy is for their intention to use it. This implies that low-threshold entry aids and user-friendly offers should be provided especially for target groups with little prior knowledge (Meuter et al., 2005; Schmalfuß et al., 2017; Venkatesh et al., 2003; R. Wang et al., 2021).

If knowledge is high, this has a significant positive influence on the path from costs to usage behaviour. This means that users who are well informed about electromobility consider financial aspects to be important for their actual usage behaviour. Furthermore, this implies that economic aspects (e.g. TCO calculators[28]) should be specifically integrated into communication with informed target groups (Bennett & Vijaygopal, 2018; Jiang, 2023; Y.-F. Liu et al., 2018; Shuhaiber & Mashal, 2019; R. Wang et al., 2021).

The path from Personal Innovativeness to Behavioural Intention is significantly positively influenced by high familiarity. This means that when familiarity with electric mobility is high, innovativeness has a stronger effect on the intention to use. This implies that innovative target groups with practical EV experience are particularly receptive to pioneering product features and should therefore be addressed with innovative communication strategies (Jansson, 2011; Meuter et al., 2005; Parasuraman, 2000; Schmalfuß et al., 2017; S. Wang et al., 2019).

Conclusion of moderating effects

Table 84 summarises the hypotheses on the moderating influences in general. Seventeen out of eighteen hypotheses could be confirmed, which in turn emphasises the high relevance of moderating influences on the acceptance and use of electromobility. It can be deduced from this that the effect of classic acceptance factors is not universal but influenced by moderators (Blut et al., 2022, p. 76).

[28] TCO – total cost of ownership.

Table 84: Overview of the confirmation or rejection of the moderating hypothesis

Hypothesis	Dependent variable	Moderator Group	Confirmation ☑	Rejection ☒
H28	Behavioural Intention	Individual Characteristics	☑	
H29	Trusting Intention in Electromobility		☑	
H30	Use Behaviour		☑	
H31	Behavioural Intention	Situational determinants	☑	
H32	Trusting Intention in Electromobility		☑	
H33	Use Behaviour		☑	
H34	Behavioural Intention	National Culture	☑	
H35	Trusting Intention in Electromobility		☑	
H36	Use Behaviour		☑	
H37	Behavioural Intention	Technical determinants	☑	
H38	Trusting Intention in Electromobility		☑	
H39	Use Behaviour		☑	
H40	Behavioural Intention	Contextual determinants	☑	
H41	Trusting Intention in Electromobility		☑	
H42	Use Behaviour		☑	
H43	Behavioural Intention	Experience	☑	
H44	Trusting Intention in Electromobility			☒
H45	Use Behaviour		☑	

☑ Confirmation of the hypothesis

☒ Rejection of the hypothesis

Source: Own illustration

VI – DISCUSSION AND CONCLUSIONS

VI DISCUSSION AND CONCLUSIONS

This chapter summarises the key findings of this work and places them in an overarching context. Firstly, the original scientific contribution is outlined (Section 6.1). The practical implications for politics, business and society are derived (Section 6.2), and finally an outlook for further research is provided (Section 6.3).

6.1 RESEARCH CONTRIBUTION OF THIS WORK

The present study successfully closes a relevant research gap in the field of electric car acceptance research through an integrative research model. In addition to classic technology acceptance constructs, the model designed for this purpose also includes trust-based factors and a series of demographic, situational, cultural and technology-related moderators. This represents a novelty, as classic acceptance models primarily examine cognitive-benefit-oriented influencing variables, whereas this model incorporates behavioural, trust-based and context-based determinants into electromobility research. Building on the meta-analysis by Wicki et al. (2022) and the trust-based analyses by McKnight et al. (2009), the UTAUT 3 by Blut et al. (2022) was systematically expanded and an integrative research model was created. This work provides an integrative framework that captures both intention and actual usage behaviour, thereby closing the gap between hypothetical intentions and real behaviour. The need for this study was also due to the fact that previous studies on technology acceptance models usually only consider the intention to use, but not the actual behaviour. By combining PLS-SEM with validated scales for trust and moderators, causal relationships between trust, intention to use and actual behaviour could be empirically proven for the first time.

Based on UTAUT 3 by Blut et al. (2022), the model was expanded to include the trust-based influencing factors of contextual acquaintance, reliability and structural assurance. The empirical validation using SmartPLS shows that these have a significantly positive influence on the trusting intention in electromobility (TI) and thus increase the explanatory power of the classic UTAUT variables. It should also be emphasised that TI has a direct effect on user behaviour. This

emphasises the importance of trust as an independent mediating determinant above and beyond the intention level.

In contrast to previous studies, this research model also included the actual use behaviour (UB) as an endogenous variable. With anR2of 0.651 for UB, the model thus achieves above-average predictive power. Using contextual acquaintance and facilitating conditions, experiences from test drives, knowledge about the charging infrastructure, and supporting framework conditions (such as electric car subsidies) were taken into account and included in the explanation of acceptance. In contrast to previous research, these factors exhibited high effect sizes on TI and UB, thereby surpassing traditional benefit and enjoyment determinants as the primary drivers of acceptance explanations, such as performance expectancy (PE), price value (PV), or hedonic motivation (HM). This demonstrates that trust and contextual factors can predict not only intentions but also real behaviour. The lack of confirmation of the hypotheses defined for PE, PV and HM can be explained by the increasing familiarity of tech-savvy user groups, who prioritise rational and trust-based motives over affective aspects of enjoyment. Concerning compatibility, it can also be stated that subjective compatibility expectations in everyday life lead to behavioural barriers due to practical discrepancies (be it the charging process or route planning).

In addition to analysing direct effects, a comprehensive study of moderator effects was also carried out. For this purpose, six moderator groups (individual characteristics, situational determinants, national culture, technical determinants, contextual determinants and experience) were derived based on theory and empirically tested. For example, age has an inverse moderating effect on the path from costs to use behaviour, the level of education moderates the path from habit to use behaviour, and masculinity moderates both the effort expectancy and reliability effects on TI. As a result, seventeen out of eighteen hypotheses in the area of moderator effects were confirmed. These results also show that the mechanisms of action of classic acceptance factors do not apply universally, but depend to a large extent on the individual, social or cultural context.

With regard to the research questions formulated at the beginning and the objective, the following answer can be given to the question concerning which factors specifically influence or inhibit acceptance and how it can be increased:

- Significant influencing factors that affect the three endogenous constructs (TI, BI and UB) are effort expectancy, social influence, facilitating conditions, habit, personal innovativeness, costs, reliability, contextual acquaintance and structural assurance.
- High acquisition costs, range anxiety, long charging times and a lack of experience were identified as the main factors inhibiting acceptance.
- To increase acceptance, the expansion and reliability of the charging infrastructure, financial support measures, education and practical experiences for potential users, transparent cost visualisation and communication campaigns were identified.

Furthermore, the research question of whether trust is a suitable extension of the initial model (UTAUT 3) can be answered as follows:

- It can be said that trust and the associated constructs (reliability, contextual acquaintance, and Structural Assurance) increase the explanatory power of the model and show significant paths on usage intention, as well as usage behaviour.

The question of whether demographic and cultural moderators such as age, gender, individualism vs. collectivism) play a moderating role can also be answered as follows:

- The moderating influence of demographic but also cultural moderators (especially masculinity) could be confirmed (see in particular Section 5.7.3).

The question of other indirect factors that have a moderating influence on intention and usage behaviour can also be answered:

- Further indirect factors were postulated, empirically tested and shown to have a significant influence on direct path connections. These include political support and technical infrastructure, but also factors such as market availability, charging options, number and type of vehicles in the household and knowledge.

In comparison to existing research, it can be said that the variance explanation achieved for BI ($R^2 = 0.783$) and TI ($R^2 = 0.688$) and UB ($R^2 = 0.651$) is significantly higher than the average values of classic acceptance models (Blut et

al., 2022; Venkatesh et al., 2003, 2012). As a result, the accuracy of the developed model's fit can be confirmed both in terms of content and empirically, despite its high complexity with seventeen constructs, 50 indicators, and 27 direct path connections. As a result, this work represents one of the most comprehensive empirical studies of user acceptance of EVs in an established market, which manages to link the will to adopt more strongly to confidence-building and experience factors than to benefit or fun motives. This allows closing the research gap between purely technology-oriented acceptance models and multifactorial, real-world influencing variables as psychological, technological, social and cultural determinants and their interrelationships are taken into account.

Thus, this work not only contributes theoretically to the further development of technology acceptance models, but also provides a reliable basis by establishing trust and contextual influences as central components of acceptance models and emphasising the importance of moderators.

In conclusion, the following limitations can be noted, which will be taken up again in Chapter 6.3 on the need for further research. As only one measurement point in time was considered for the model developed, the causal relationships can be considered to be of limited reliability. Furthermore, an online survey always harbours the risk of social desirability effects, whereby respondents may be tempted to give answers that they assume are the desired responses to the questions posed. Finally, the focus of the study is limited to Germany, which means that it is not yet possible to derive any reliable, generalised results.

6.2 IMPLICATIONS FOR PRACTICE

The following recommendations for action can be derived from the empirical findings. These are also attributed to one of the following addressees: Car manufacturers/OEMs, infrastructure operators and energy suppliers, political decision-makers and funding institutions, as well as mobility service providers and fleet managers:

Promotion of trust

(Addressees: car manufacturers/OEMs; political decision-makers and funding organisations)

First, the promotion of trust in electromobility could be focused on. As TI exerts a direct influence on EMS, OEMs and politicians could utilise this and take measures to make technical and institutional reliability visible, thereby strengthening consumer confidence in electromobility. With regard to reliability, technical guarantees (e.g. on battery life), quality seals or transparent test reports could be communicated to users. In connection with variable structural assurance, on the other hand, guarantee and insurance concepts, as well as regulatory frameworks (e.g. EU standards or certified standards for the charging infrastructure) could be communicated to users (*Technischer Leitfaden ELEKTROMOBILITÄT LADEINFRASTRUKTUR - Version 4.1*, 2023)) should be emphasised to strengthen institutional trust.

Experience- and event-based marketing

(Addressees: car manufacturers/OEMs; mobility service providers)

In addition to strengthening trust, car manufacturers could also use experience- and event-based marketing. This involves creating a positive user context through test drives, trial periods, community events or user forums, for example, which in turn can build trust in electromobility. Testimonials or influencers can also be integrated here so that opinion leadership can be achieved in homogeneous groups, and EVs can be made tangible for potential users.

Segmented user approach

(Addressees: car manufacturers/OEMs; mobility service providers)

A segmented user approach is also suitable, as a one-size-fits-all campaign would not be effective for the different user groups. This becomes clear when considering the moderating effects of age, education, experience, and culture, as well as daily travel needs. Accordingly, clear, transparent cost information supplemented by comprehensible operating instructions and an unobtrusive customer approach are suitable for older users, for example. This contrasts with tech-savvy and innovative users who have a clear focus on new mobility features and networked systems and are therefore ideally suited to early adopter programmes. Another example is the masculine cultural segments, for whom arguments such as performance, status and technical robustness are suitable. Emphasising environmental benefits would in turn have a negative impact on their

adoption behaviour. On the other hand, there are young families for whom cost benefits are important, and who should therefore be receptive to car-sharing offers or leasing models, along with the associated higher environmental benefits. For this purpose, a TCO calculator could be provided, which, for example, recommends the best leasing tariff and shows the environmental benefits in addition to the cost benefits. For frequent drivers, who are particularly sensitive to facilitating conditions and performance expectations, a well-developed fast-charging network, as well as safety and reliability messages, could be persuasive arguments.

Concerning the sinus-mileus, the effects identified provide the following starting points for a targeted approach to specific target groups, for example (Calmbach & Hecht, 2024):

- Progressive performers with a high level of technology and environmental orientation are interested in an emotional presentation of sustainable mobility concepts, emphasising the latest range and charging technologies as well as CO2 benefits.
- The middle class is performance and order-oriented and therefore focuses on reliability through quality seals and warranty bundles as well as transparent service and maintenance packages.
- Adaptive pragmatists are price-benefit-oriented, which is why interactive tools such as TCO calculators and combined mobility concepts (e.g. electric car plus car-sharing) and the highlighting of cost benefits are suitable.
- Conservative-traditional customers tend to be risk-averse and status-conscious, so insurance and warranty offers, as well as practical test drives with a focus on simple operation and the presentation of services, are suitable here.

As a recommendation for action, it can be concluded that the communication channels should be adapted to address each milieu to maximise the relevance and acceptance of the messages. Social media is suitable for addressing progressive performers, whereas classic print or direct mailings should be used for the middle class. The same also applies in terms of tonality and visualisation. For progressive performers, the focus should be on terms relating to technology and innovation,

whereas the middle class looks for terms such as reliability and down-to-earth formulations (B. Barth et al., 2018; Calmbach et al., 2024).

Realistic performance promises

(Addressees: car manufacturers/OEMs)

At the same time, it makes sense for manufacturers to make realistic performance and range promises to avoid the risk of disappointment and loss of trust. Realistic simulations and practical demonstrations (e.g. roadshows) could be used to counter discrepancies between expectations and practice. In addition, manufacturers should clearly highlight even small improvements, such as reductions in charging time, to positively influence hedonic motivation and appeal to sceptical user segments.

Political support programmes and infrastructure measures

(Addressees: political decision-makers and funding institutions; infrastructure operators and energy suppliers)

In addition, political support programmes combined with information campaigns are also suitable for convincing undecided users. This is due to the fact that policy and incentives have a moderating effect on the costs, facilitating conditions, and effort expectancy on the endogenous variables, trusting intention in electromobility and actual user behaviour. For this reason, funding and information campaigns, for example, could be combined to highlight the financial incentives offered by electromobility and provide practical application tips. Furthermore, political support programmes and investment measures should not be limited to financial subsidies but should also promote the expansion of a nationwide, reliable and easily accessible infrastructure and communicate this to the public. Due to the not insignificant moderating influence of charging availability on a whole series of correlations between performance expectancy, costs, facilitating conditions, personal innovativeness, reliability and structural assurance and the latent variables, test drive events could also be linked to the opening of new charging parks. Particularly in regions where the charging infrastructure is still underdeveloped, this could help to convince users who are still undecided or unconvinced to switch to an EV. Of course, in areas with poorly

developed electric mobility infrastructure, additional institutional anchors of trust, such as government guarantees in a service network to ensure a reliable charging infrastructure, would be necessary to counter user concerns about range anxiety and increase motivation to purchase an EV. The latter is due to the fact that reliability has a significant effect on TI and is inversely moderated by range.

Promotion of habits and the influence on fleet management

(Addressees: mobility service providers and fleet managers; infrastructure operators and energy suppliers)

As habit has a significant impact on usage behaviour, a well-developed charging infrastructure at the workplace could ensure that company car fleets are converted to electrically powered vehicles more quickly, but also that employees without company cars can charge at these charging points free of charge (e.g. free charging vouchers). The installation of charging points at the workplace should be accompanied by state-subsidised training courses as well as the subsidisation of early adopter programmes to promote habitual use in the long term.

6.3 FURTHER RESEARCH DIRECTIONS

Despite the comprehensive model and the broad empirical basis, the opportunities for future research projects arising from the present research work are briefly discussed below.

Given that the postulated and empirically tested model provides only a snapshot of the present cross-sectional study on the acceptance of EVs, it could initially be confirmed through further empirical validation. On the one hand, the same study could be conducted with a significantly larger sample ($n \geq 10{,}000$) to evaluate all moderators in a multi-group analysis and thus obtain a greater depth of knowledge concerning measurement and structural variance, but also concerning target group segmentation (F. Huber et al., 2007, p. 118; Steenkamp & Baumgartner, 1998, p. 78 ff.). On the other hand, it would be interesting to investigate how the acceptance factors and moderating influences change over time due to technological progress in terms of range, charging speed or social trends. Longitudinal studies, with surveys conducted every 12-24 months, could illustrate

changes in trust, intention and behaviour after the introduction of new vehicle models or infrastructure measures and strengthen causal conclusions.

As this study focuses on the German market, it would also be beneficial to investigate whether the same mechanisms of action can be reproduced in other established or emerging markets. International comparisons could show which moderators have a universal influence and which are country-specific. Particularly against the background of the two national culture moderators of individualism and masculinity, it would be interesting to find out how these have a country-specific effect to derive global, regional, or local strategies.

In addition to further quantitative studies, qualitative approaches are also suitable for empirically testing the indirect impact paths and possible mediation or moderation mechanisms such as the test experience on the trusting intention. Field or laboratory experiments are suitable for this purpose. Against this background, it could also be investigated whether the direct effect of TI on UB can be achieved without mediation and whether trust is translated into behaviour independently, rather than via intention formation.

This could also be accompanied by phase-related studies based on the purchasing process, allowing for a comparison between pre- and post-adoption phases and gaining insights into when emotional and environmental motives play a role, particularly in different milieus (Calmbach & Hecht, 2024). The same also applies to the findings of performance expectancy and price value on behavioural intention, which were assessed as significant. Experimental study designs could also be used to investigate the conditions under which benefit and price arguments have a stronger effect on acceptance.

Interactions or influences of digital mobility services such as car-sharing, micromobility or ride-pooling could also be analysed[29] or ride-pooling[30] on trust

[29] Micromobility refers to the use of electrically powered micro-vehicles as an alternative to conventional means of transport. Examples include electric bicycles, e-scooters, and Segways.

[30] Ride pooling, also known as on-demand ridesharing, on-demand transport or mobility on demand (MOD), is a public transport system that responds to demand.

and user behaviour. The idea here is that new mobility business models also require a changed customer journey and consequently a separate acceptance analysis.

Furthermore, it also makes sense to further supplement and refine the analysed model. One possible line of investigation could be to further explore environmental awareness in order to determine whether affective environmental motives provide insight into green purchasing behaviour. In addition, the urban or rural residential location could be included as a further situational moderator. Other determinants that should be considered include the direction of data protection and the question of electricity source transparency during the charging process: Do drivers consciously choose to charge at charging stations whose electricity comes from a sustainable source?

Recommended next steps and outlook:

- An international panel design with annual surveys in at least five countries should be established.
  - Illustration of culture-comparative, milieu effects and longitudinal effects to test generalisability.
  - In addition, a longitudinal study offers the opportunity to analyse trust and contextual effects over the long term in the various phases of innovation diffusion.
- Conducting field experiments on trust-building measures (reliability, structural assurance)
  - Investigation of the effect of trust-building measures in a real user context.
  - Which causal impact paths of reliability and structural assurance affect trust?
  - Which paths of impact are suitable for supporting the acceptance of electromobility and thus its spread?

VII – BIBLIOGRAPHICAL REFERENCES

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VIII – APPENDIXES

VIII APPENDIXES

Appendix 1: Vehicle fleet 2019 - Passenger cars on 1st January 2020 according to selected fuel types

2019		
Fuel type	**Status 01.01.2020 (in pcs)**	**Share in %**
Petrol	31.464.680	65,94%
Diesel	15.111.382	31,67%
Liquefied petroleum gas (LPG)	371.472	0,78%
Compressed natural gas (CNG)	82.198	0,17%
HEV + PHEV	539.383	1,13%
only PHEV	102.175	0,21%
BEV	136.617	0,29%
FCV	507	0,0011%
Other fuels	9.738	0,02%
Total	**47.715.977**	**100,00%**
Cars with an alternative drive (PHEV + HEV + BEV + FCV)	**676.507**	**1,42%**

Source: Own illustration based on (Kraftfahrt-Bundesamt (KBA), 2020a)

Appendix 2: Vehicle fleet 2020 - Passenger cars on 1st January 2021 according to selected fuel types

2020		
Fuel type	**Status 01.01.2021 (in pcs)**	**Share in %**
Petrol	31.435.340	65,15%
Diesel	15.060.124	31,21%
Liquefied petroleum gas (LPG)	346.765	0,72%
Compressed natural gas (CNG)	83.067	0,17%
HEV + PHEV	1.004.089	2,08%
only PHEV	279.861	0,58%
BEV	309.083	0,64%
FCV	808	0,0017%
Other fuels	9.308	0,02%
Total	**48.248.584**	**100,00%**
Cars with an alternative drive (PHEV + HEV + BEV + FCV)	**1.313.980**	**2,72%**

Source: Own illustration based on (Kraftfahrt-Bundesamt (KBA), 2021a)

Appendix 3: Vehicle fleet 2021 - Passenger cars on 1st January 2022 according to selected fuel types

2021		
Fuel type	**Status 01.01.2022 (in pcs)**	**Share in %**
Petrol	31.005.134	63,87%
Diesel	14.824.262	30,54%
Liquefied petroleum gas (LPG)	331.481	0,68%
Compressed natural gas (CNG)	82.309	0,17%
HEV + PHEV	1.669.051	3,44%
only PHEV	565.956	1,17%
BEV	618.460	1,27%
FCV	1.211	0,0025%
Other fuels	8.970	0,02%
Total	**48.540.878**	**100,00%**
Cars with an alternative drive (PHEV + HEV + BEV + FCV)	**2.288.722**	**4,72%**

Source: Own illustration based on (Kraftfahrt-Bundesamt (KBA), 2022a)

Appendix 4: Vehicle fleet 2022 - Passenger cars on 1st January 2023 according to selected fuel types

2022		
Fuel type	**Status 01.01.2023 (in pcs)**	**Share in %**
Petrol	30.556.538	62,66%
Diesel	14.437.489	29,61%
Liquefied petroleum gas (LPG)	326.853	0,67%
Compressed natural gas (CNG)	80.630	0,17%
HEV + PHEV	2.337.897	4,79%
only PHEV	864.712	1,77%
BEV	1.013.009	2,08%
FCV	1.989	0,0041%
Other fuels	8.631	0,02%
Total	**48.763.036**	**100,00%**
Cars with an alternative drive (PHEV + HEV + BEV + FCV)	**3.352.895**	**6,88%**

Source: Own illustration based on (Kraftfahrt-Bundesamt (KBA), 2023c)

Appendix 5: Vehicle fleet 2023 - Passenger cars on 1st January 2024 according to selected fuel types

2023		
Fuel type	**Status 01.01.2024 (in pcs)**	**Share in %**
Petrol	30.235.032	61,58%
Diesel	14.142.184	28,80%
Liquefied petroleum gas (LPG)	313.723	0,64%
Compressed natural gas (CNG)	77.421	0,16%
HEV + PHEV	2.911.262	5,93%
only PHEV	921.886	1,88%
BEV	1.408.681	2,87%
FCV	2.116	0,0043%
Other fuels	8.266	0,02%
Total	**49.098.685**	**100,00%**
Cars with an alternative drive (PHEV + HEV + BEV + FCV)	**4.322.059**	**8,80%**

Source: Own illustration based on (Kraftfahrt-Bundesamt (KBA), 2024b)

Appendix 6: Vehicle fleet 2024 - Passenger cars on 1st January 2025 according to selected fuel types

2024		
Fuel type	**Status 01.01.2025 (in pcs)**	**Share in %**
Petrol	29.918.520	60,64%
Diesel	13.829.261	28,03%
Liquefied petroleum gas (LPG)	299.922	0,61%
Compressed natural gas (CNG)	73.123	0,15%
HEV + PHEV	3.556.956	7,21%
only PHEV	967.423	1,96%
BEV	1.651.643	3,35%
FCV	1.802	0,00%
Other fuels	7.939	0,02%
Total	**49.339.166**	**100,00%**
Cars with an alternative drive (PHEV + HEV + BEV + FCV)	**5.210.401**	**10,56%**

Source: Own illustration based on (Kraftfahrt-Bundesamt (KBA), 2025b)

Appendix 7: Raw data for "Share of passenger vehicle registrations by different drive systems from 2019 to 2024"

Drive system/ fuel source	2019	2020	2021	2022	2023	2024
Petrol	2.136.891	1.361.723	972.588	863.445	978.660	991.948
Diesel	1.152.733	819.896	524.446	472.274	486.581	483.261
Gas total	14.879	13.702	14.034	16.852	14.474	13.848
Liquefied petroleum gas (LPG)	7.256	6.543	10.118	15.006	13.147	13.711
Compressed natural gas (CNG)	7.623	7.159	3.916	1.846	1.327	137
HEV + PHEV	239.250	527.864	754.588	827.321	840.304	947.398
only PHEV	45.348	200.469	325.449	362.093	175.724	191.905
BEV	63.281	194.163	355.961	470.559	524.219	380.609
FCV	208	308	464	835	263	158
Others	16	22	51	71	108	109
Total	**3.607.258**	**2.917.678**	**2.622.132**	**2.651.357**	**2.844.609**	**2.817.331**

Drive system/ fuel source	2019	2020	2021	2022	2023	2024
Petrol	2.136.891	1.361.723	972.588	863.445	978.660	991.948
Diesel	1.152.733	819.896	524.446	472.274	486.581	483.261
Vehicles w/ ICE only	3.289.624	2.181.619	1.497.034	1.335.719	1.465.241	1.475.209
Vehicles w/ alt. Drive	317.634	736.059	1.125.098	1.315.638	1.379.368	1.342.122
Gas total	14.879	13.702	14.034	16.852	14.474	13.848
Liquefied petroleum gas (LPG)	7.256	6.543	10.118	15.006	13.147	13.711
Compressed natural gas (CNG)	7.623	7.159	3.916	1.846	1.327	137
HEV + PHEV	239.250	527.864	754.588	827.321	840.304	947.398
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BEV	63.281	194.163	355.961	470.559	524.219	380.609
FCV	208	308	464	835	263	158
Others	16	22	51	71	108	109
Total	**3.607.258**	**2.917.678**	**2.622.132**	**2.651.357**	**2.844.609**	**2.817.331**

Source: Own illustration based on (Kraftfahrt-Bundesamt (KBA), 2019, 2020c, 2021c, 2022c, 2023e, 2024c)

Appendix 8: Cover letter for the questionnaire (English version)

Dear participant,

Welcome to my survey!

As part of my doctorate, I am conducting a study on the acceptance of electric vehicles. The aim of this survey is to identify the **factors and barriers** that influence the **acceptance of electric vehicles (EVs)**.

An electric vehicle (EV) is a vehicle powered by an electric motor. This technology is increasingly seen as an environmentally friendly alternative to vehicles with internal combustion engines, but it also presents new challenges in terms of infrastructure, costs and use. In the context of this work, an electric vehicle is understood to mean both purely battery-electric and partially electric vehicles (so-called hybrid vehicles).

Please answer the questions from your personal point of view – regardless of whether you currently use an EV or not. If you do not yet use an EV, please answer based on your **expectations and perceptions**.

The survey will take about **12 minutes** to complete. It is important for the success of the study that you **completely fill out** the questionnaire.

Your participation in this study is **voluntary** and can be cancelled at any time. There are no right or wrong answers. The questions are mostly answered on a scale of **1 to 7**.

Your information will be **treated confidentially** and analysed exclusively in **anonymised form** for scientific research purposes. The data will not be passed on to third parties.

Thank you very much in advance for your support.

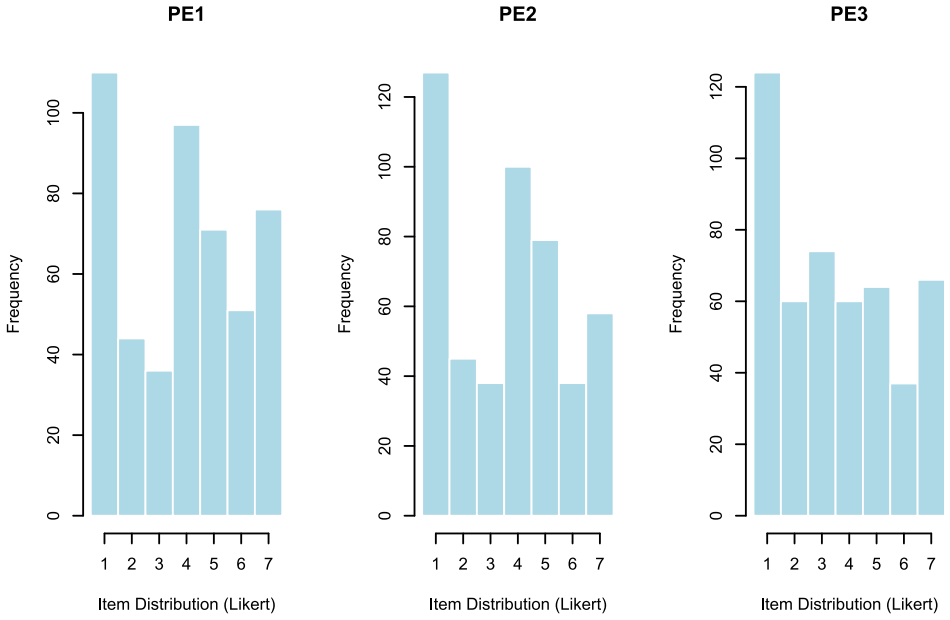
Kind regards,
Steffen Berg

P.S.: I would be very grateful if you would **forward this** to your colleagues, friends and family.

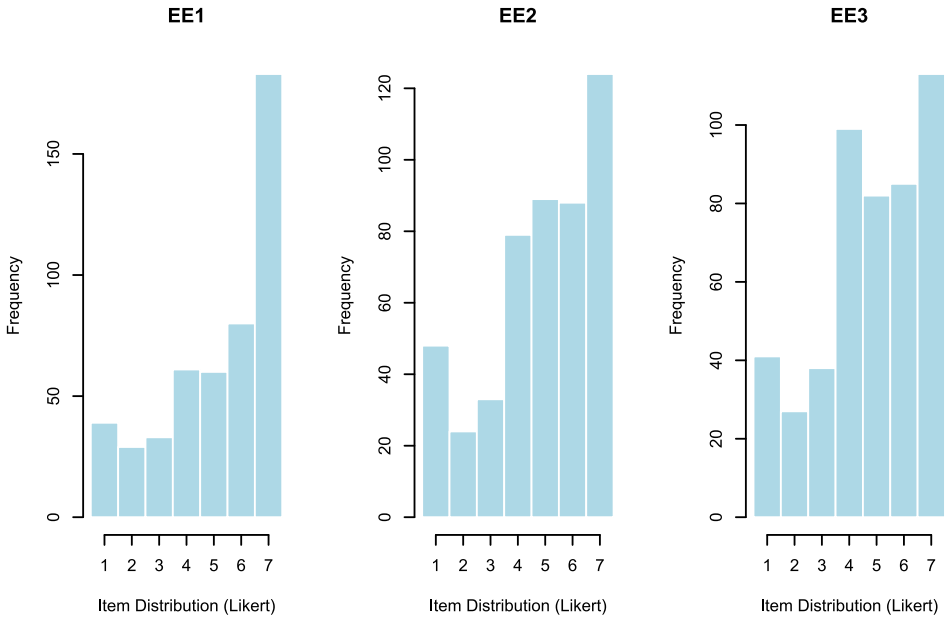
Source: Own illustration

Appendix 9: Graphical representation of item distributions using histograms

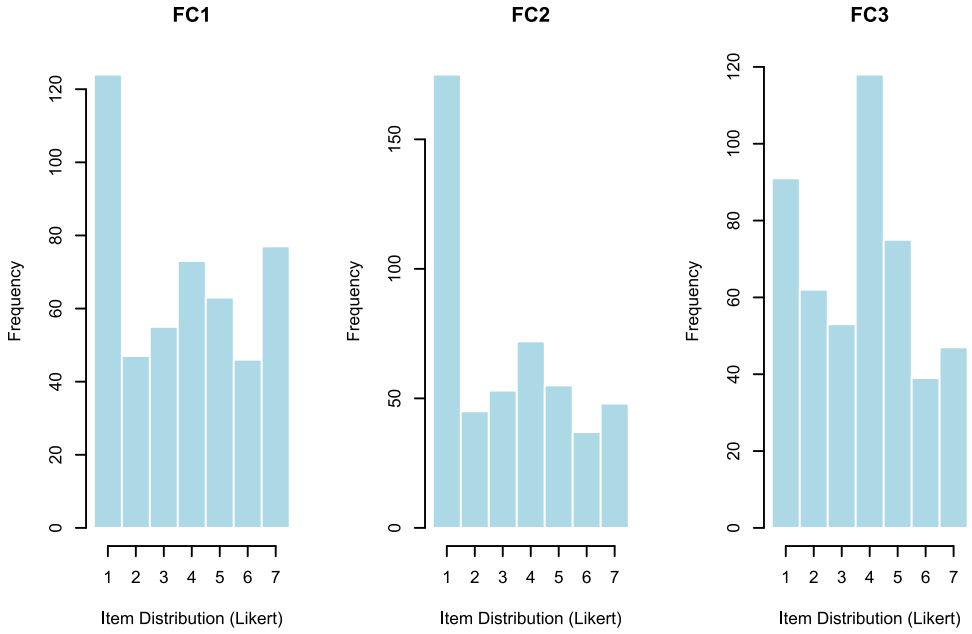
Performance Expectancy



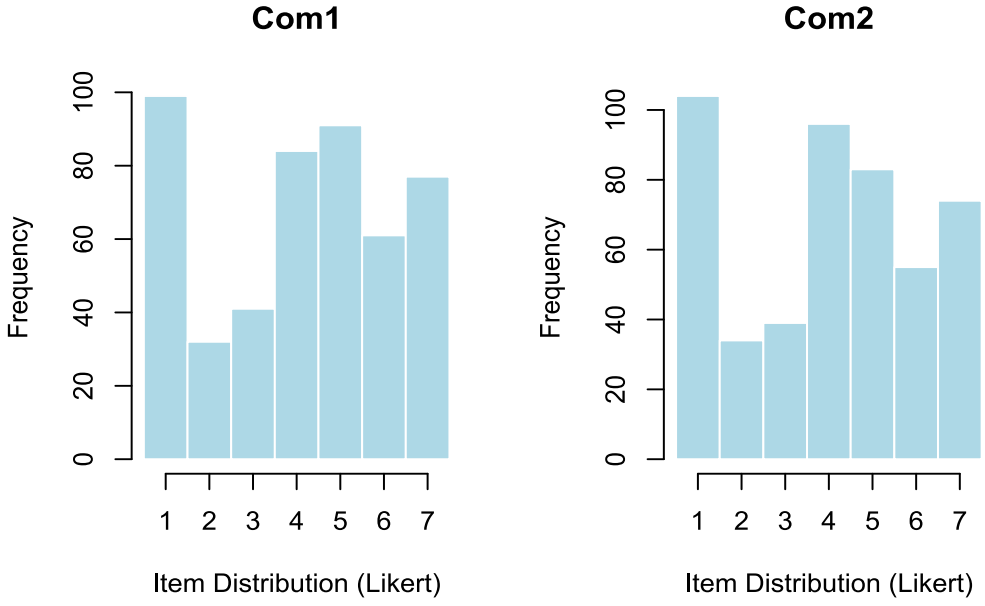
Effort Expectancy



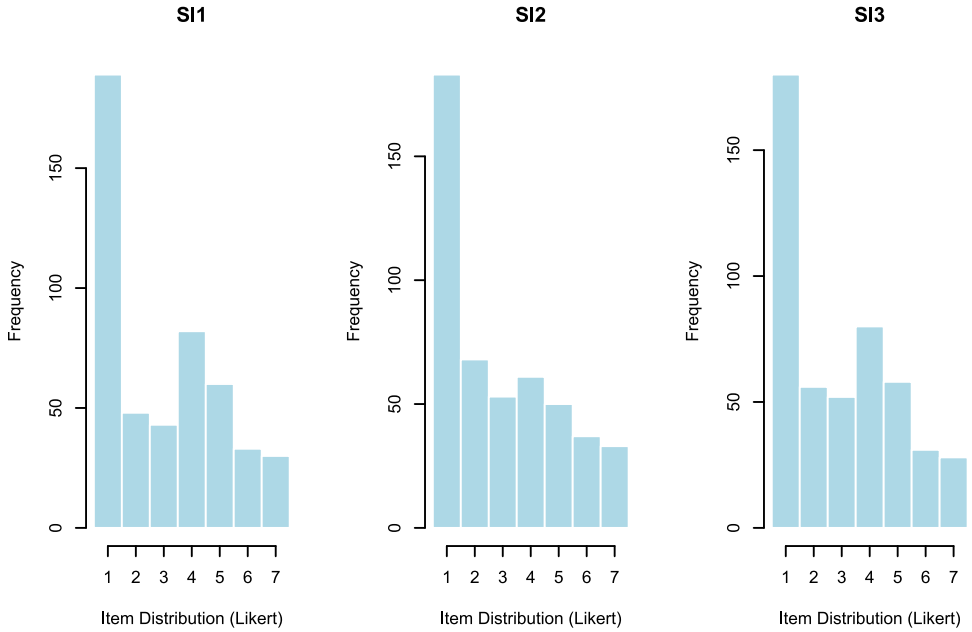
Facilitating Conditions



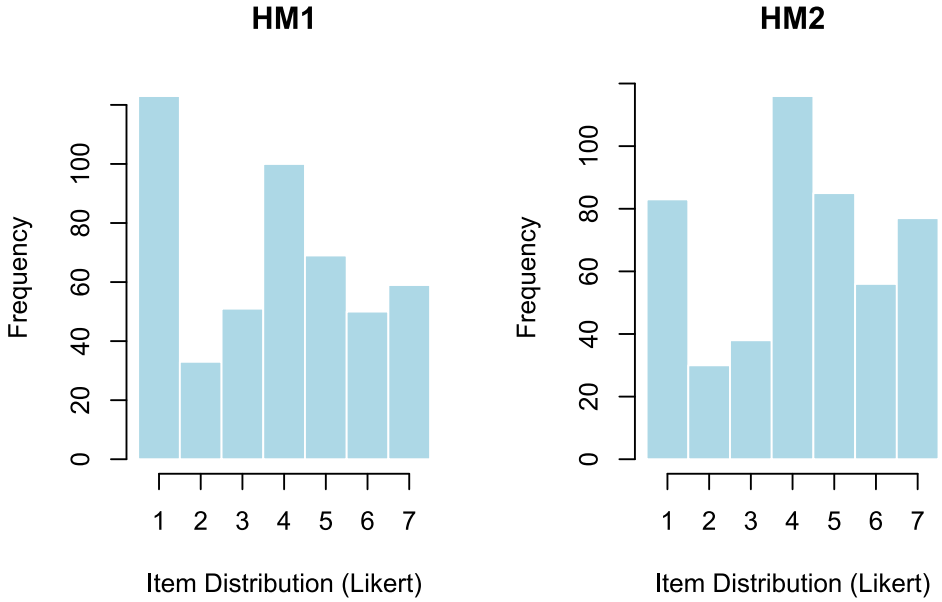
Compatibility



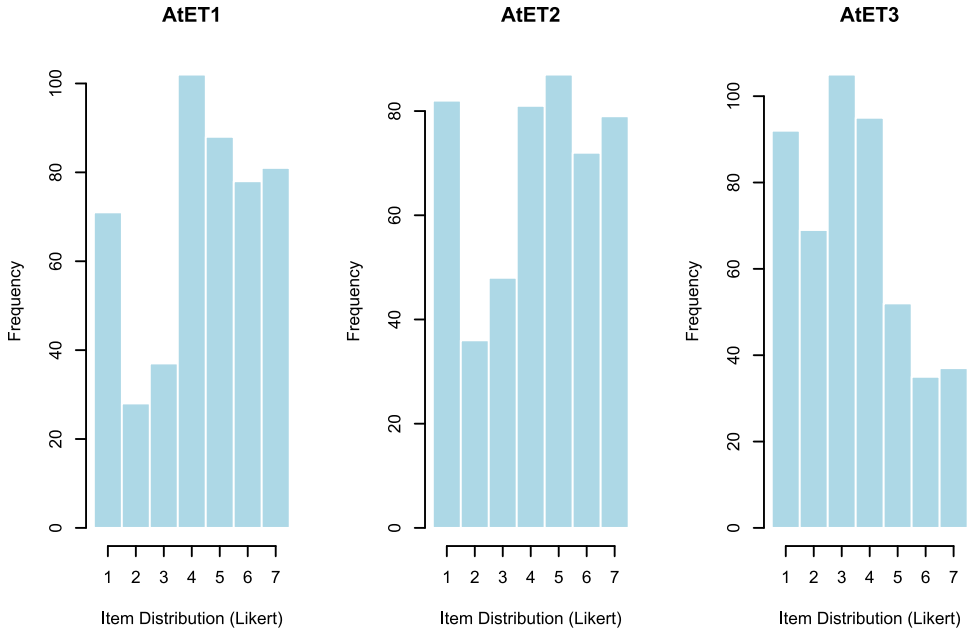
Social Influence



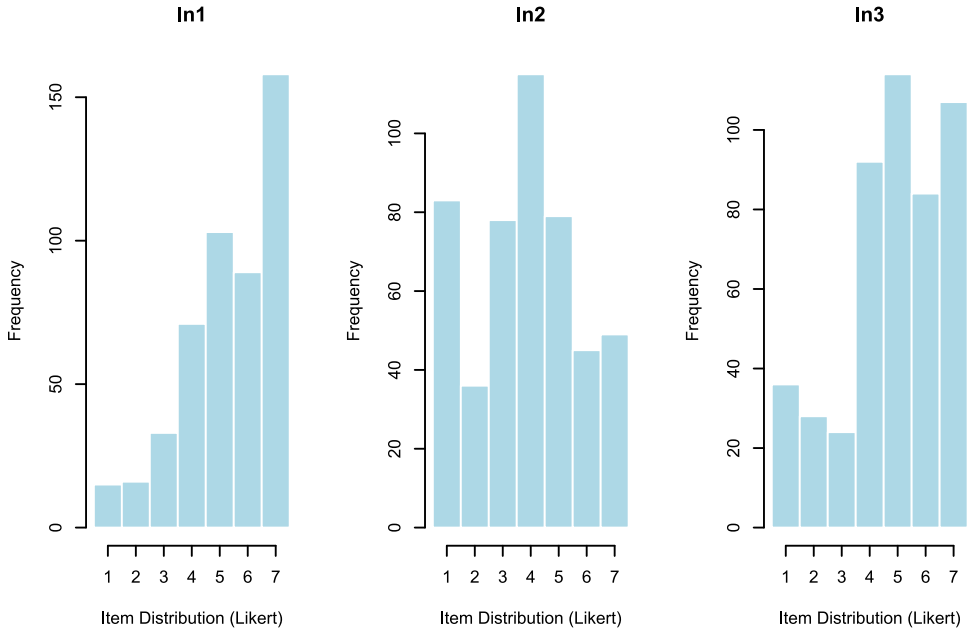
Hedonic Motivation



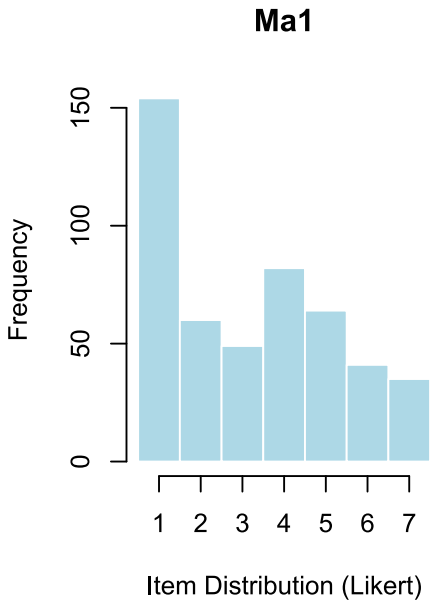
Attitude towards Environment & Technology

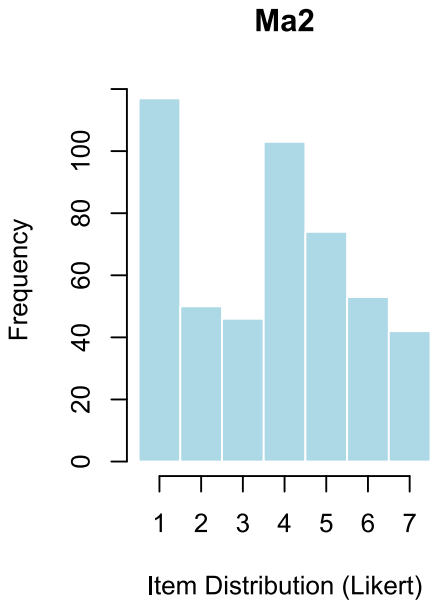


Individualism

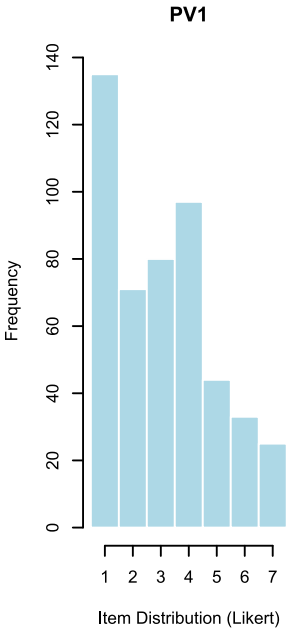


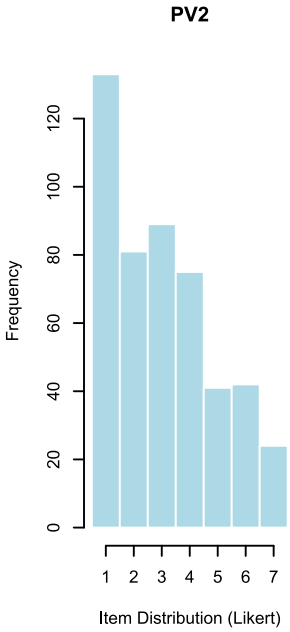
Masculinity

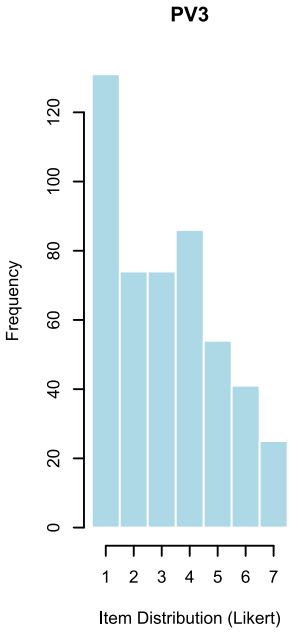




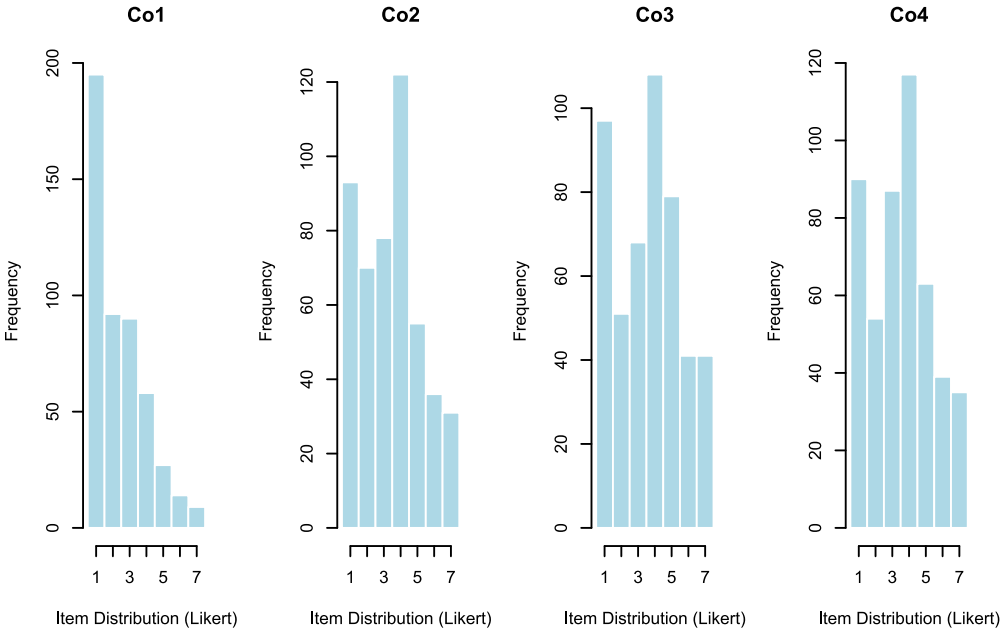
Price Value



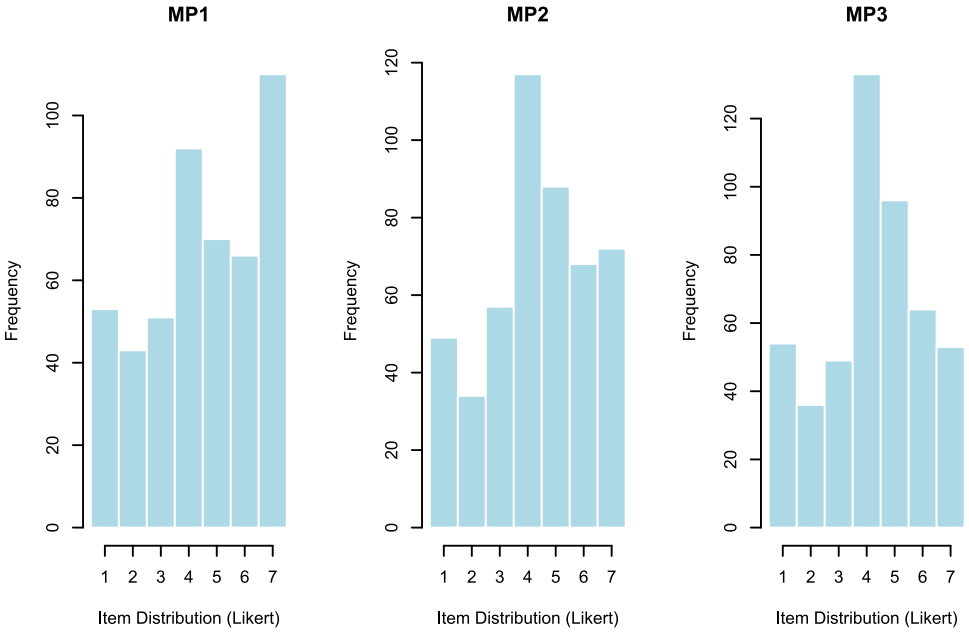




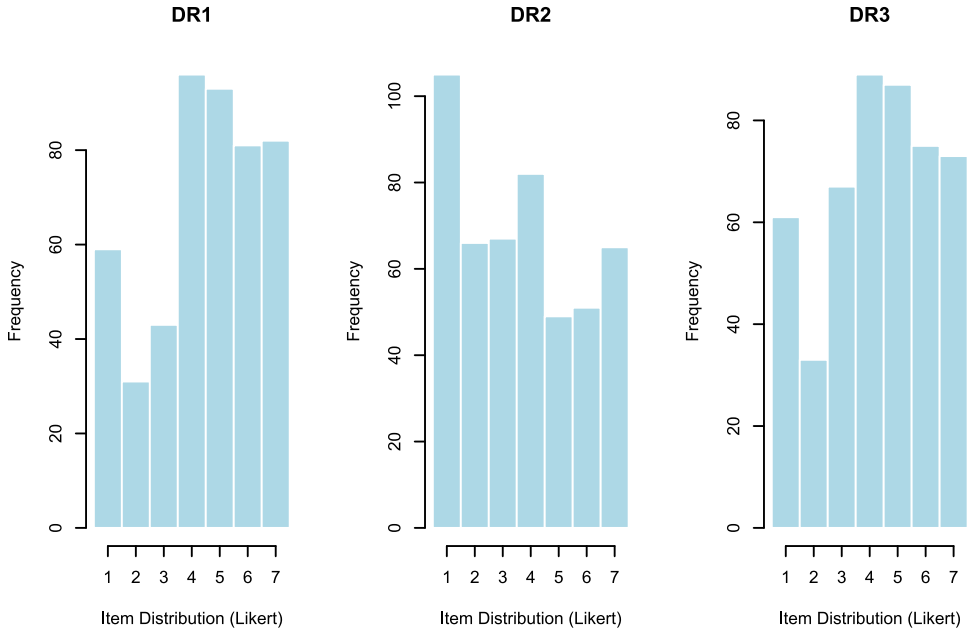
Costs



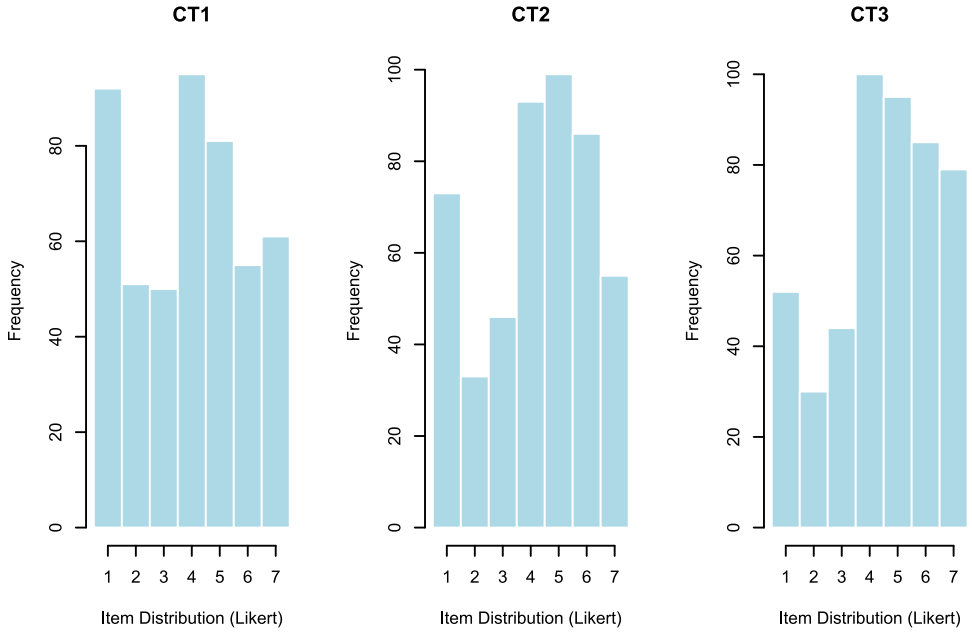
Motor Power



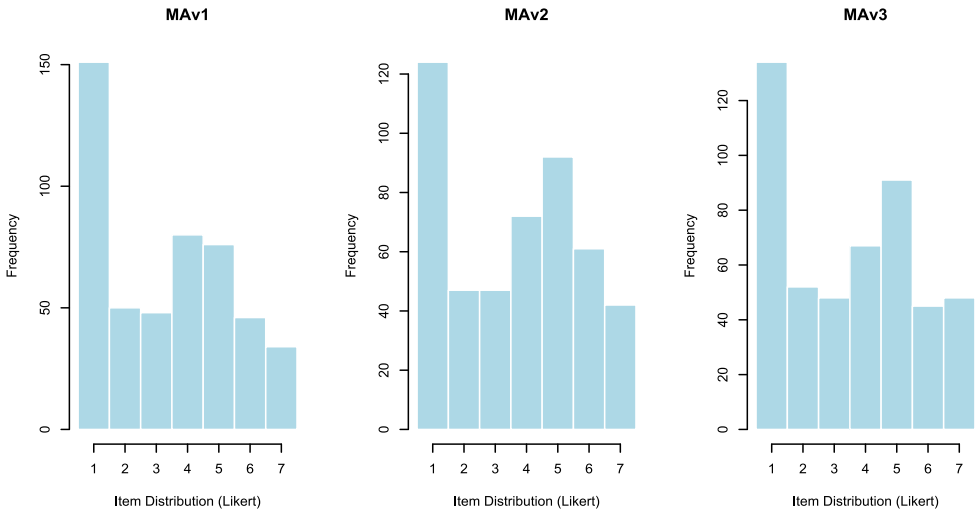
Driving Range



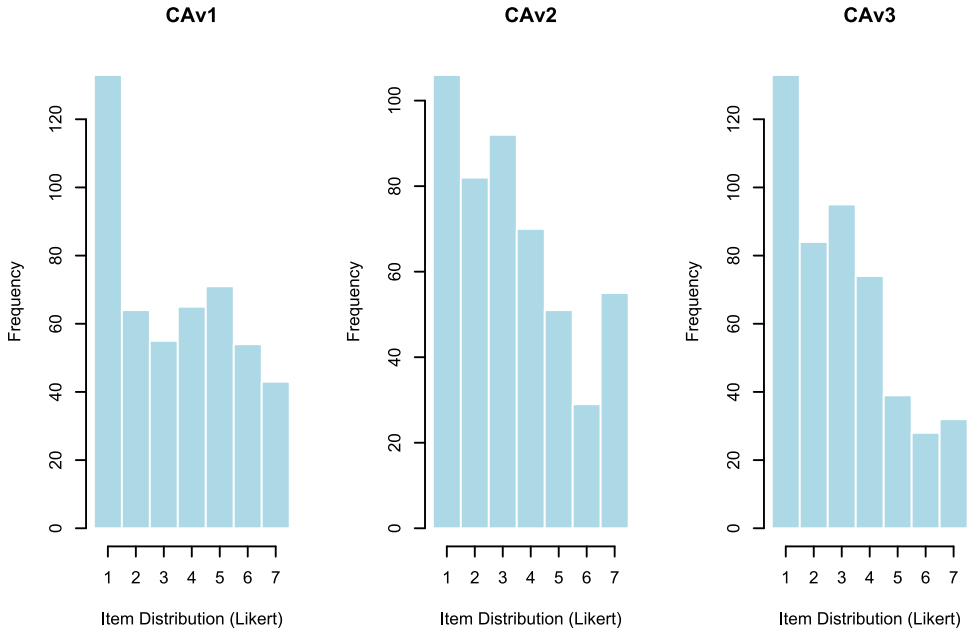
Charging time



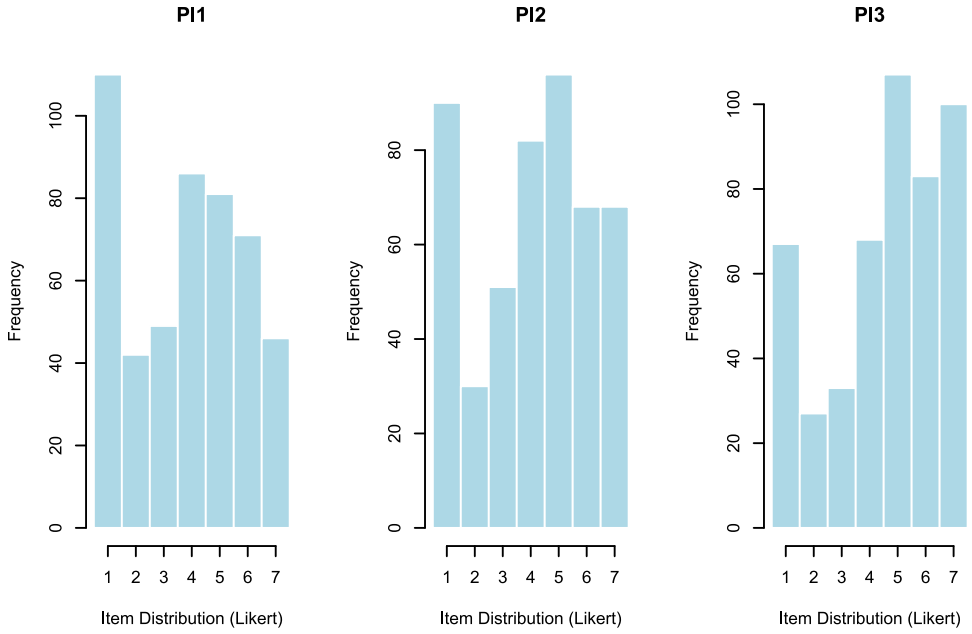
Market Availability



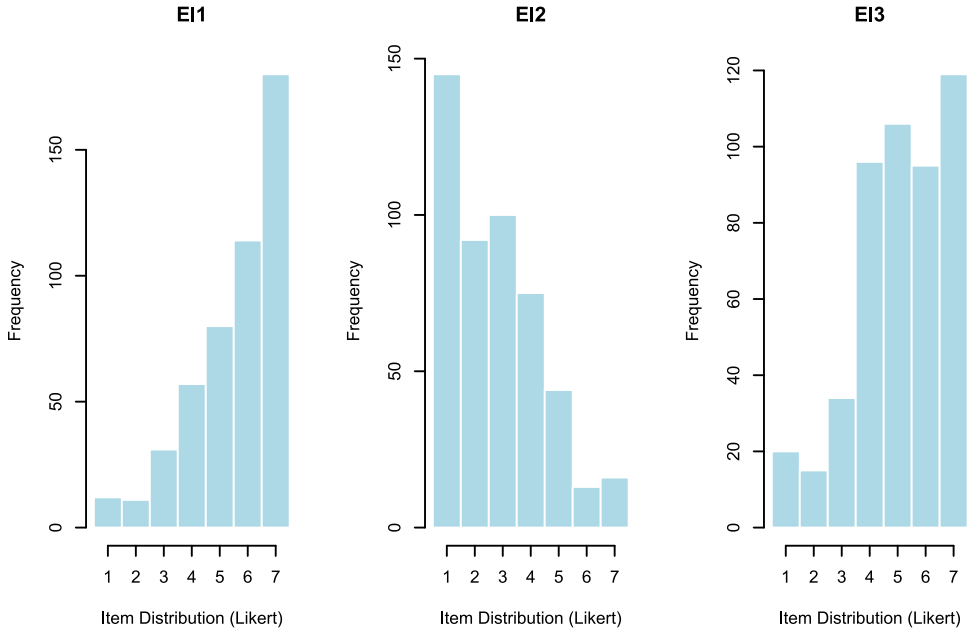
Charging Availability



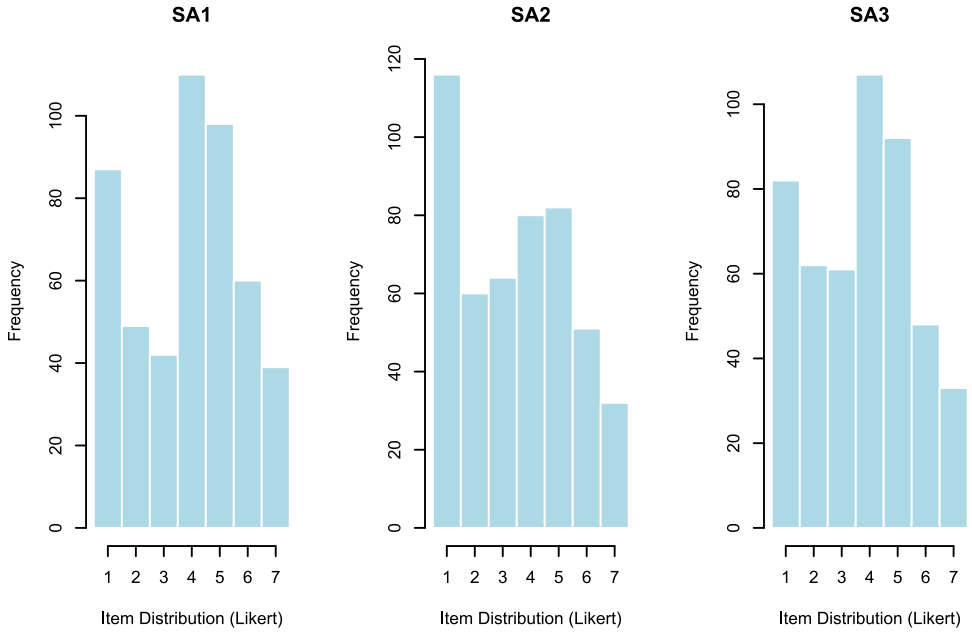
Policy & Incentives



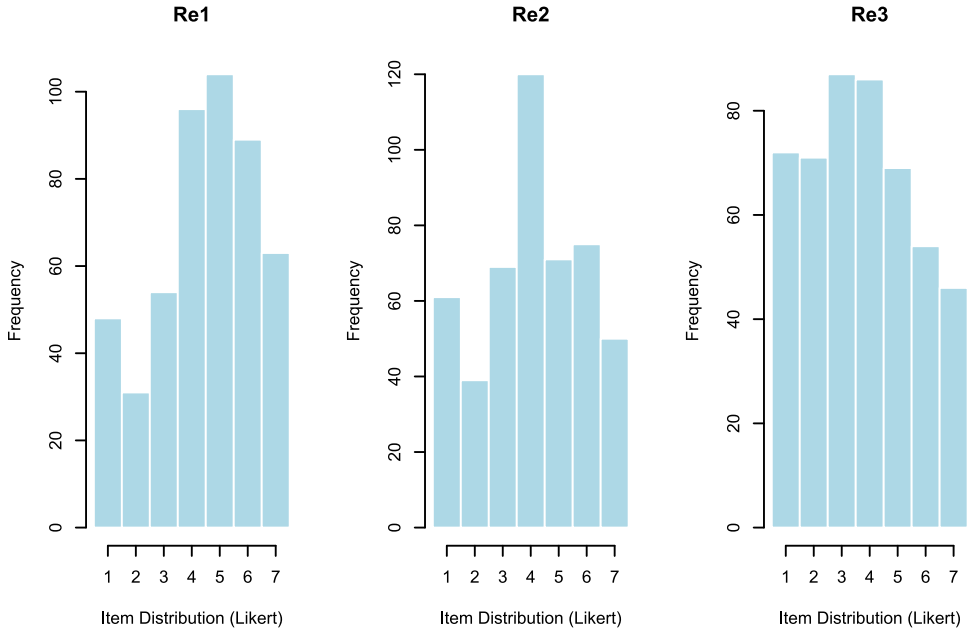
Environmental Impact



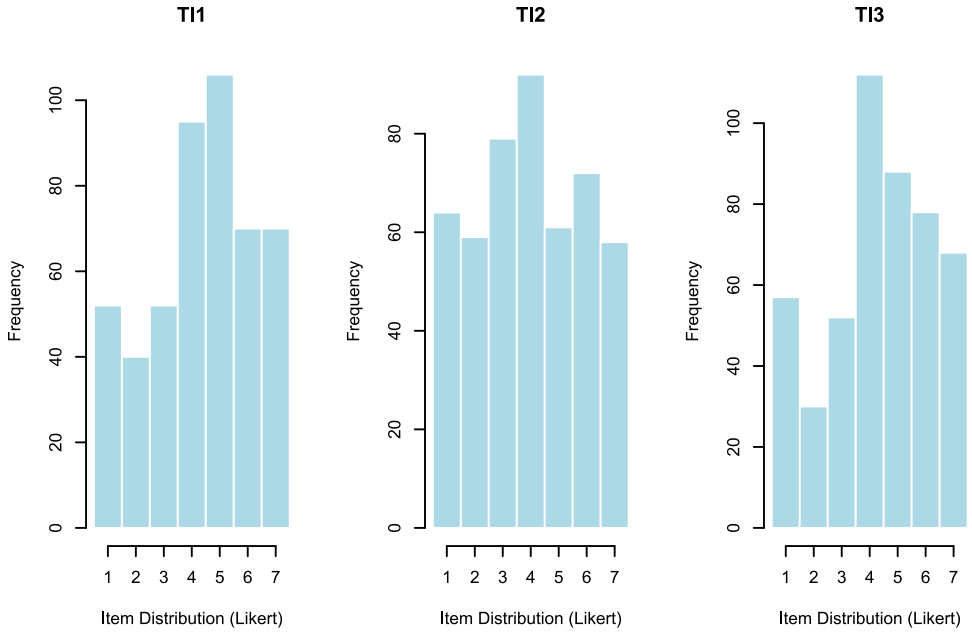
Structural Assurance



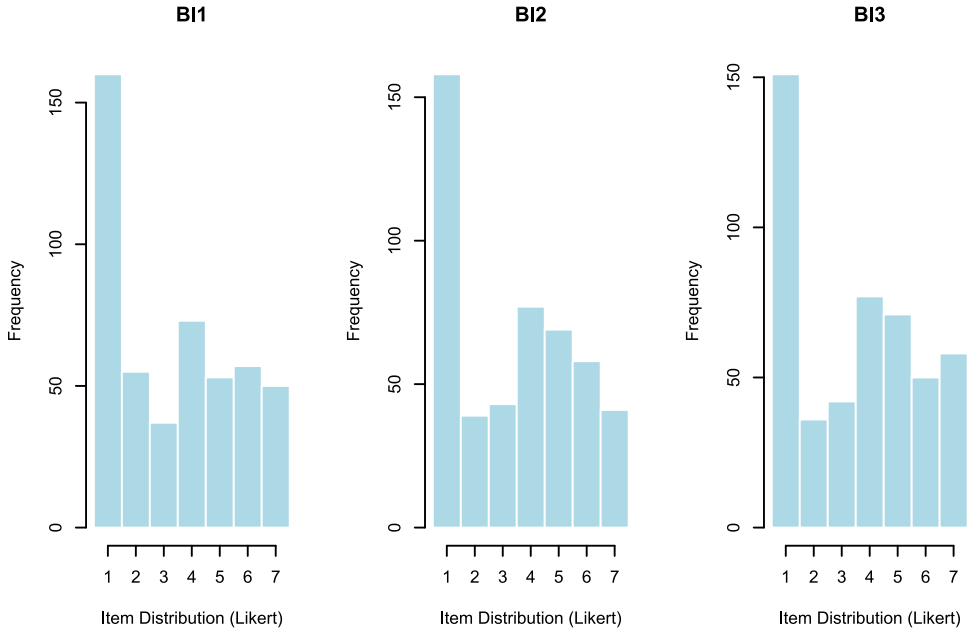
Reliability



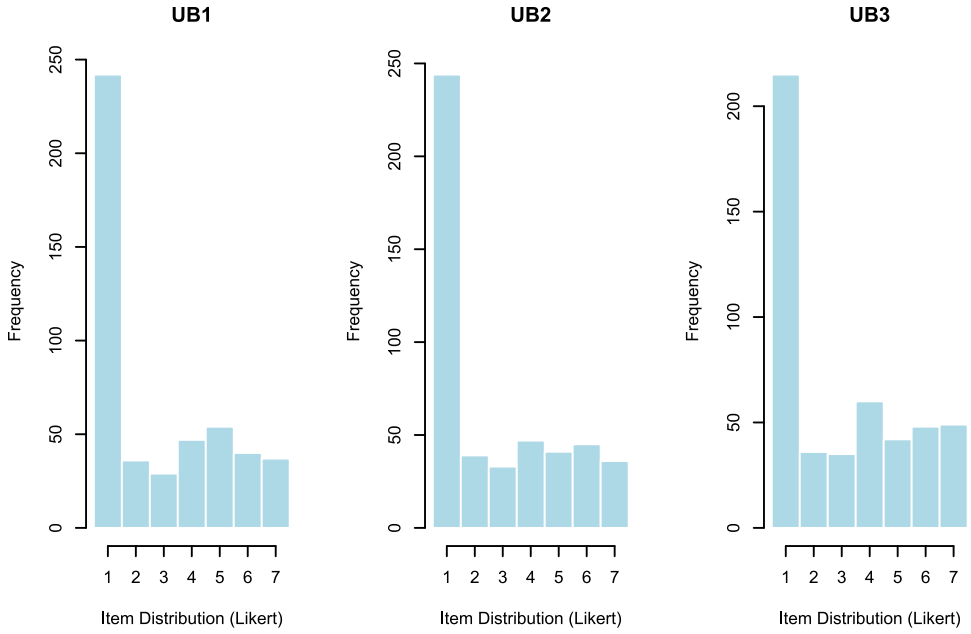
Trusting Intention in Electromobility



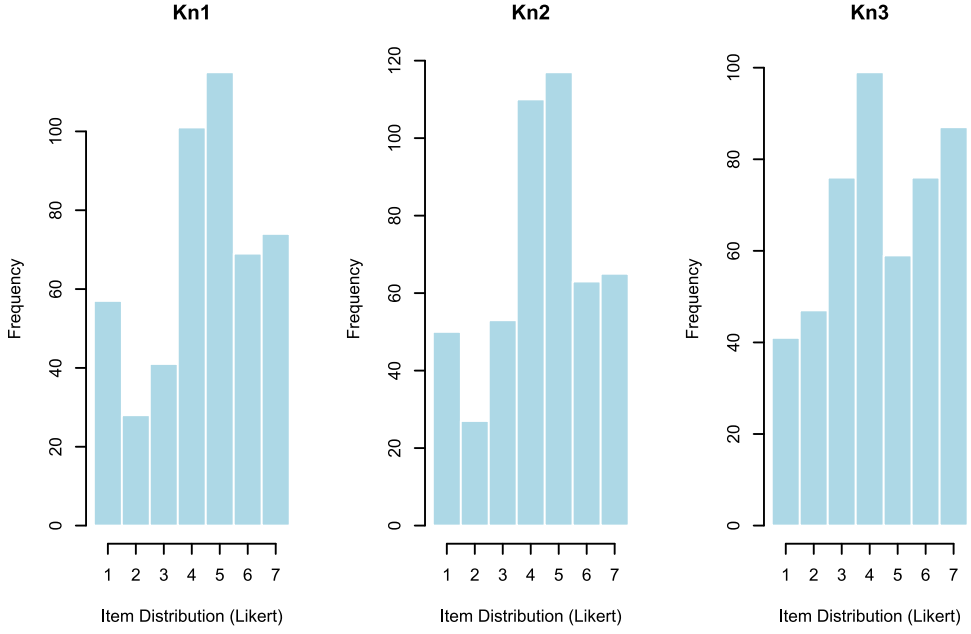
Behavioural Intention



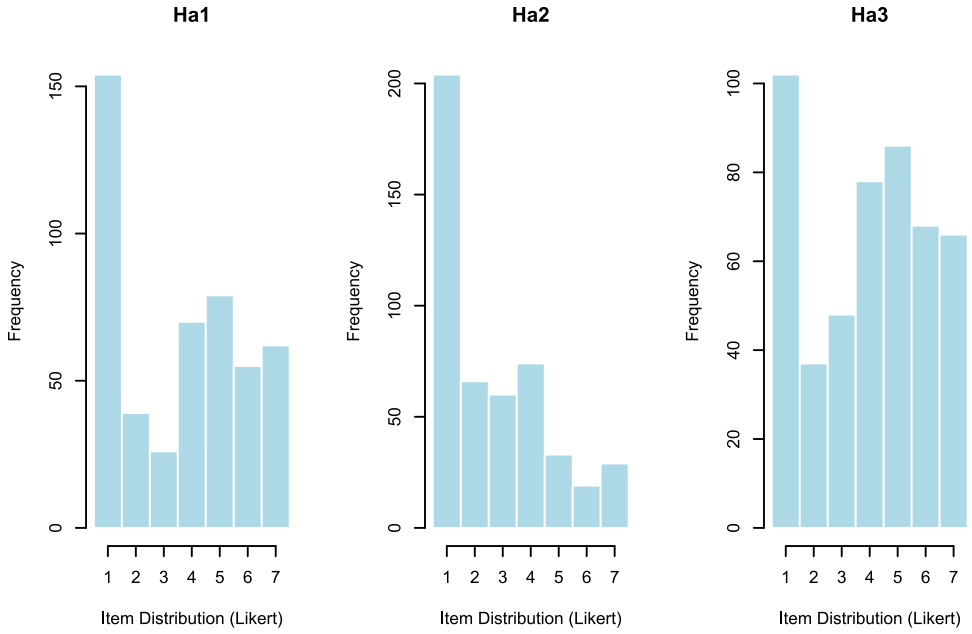
Use Behaviour



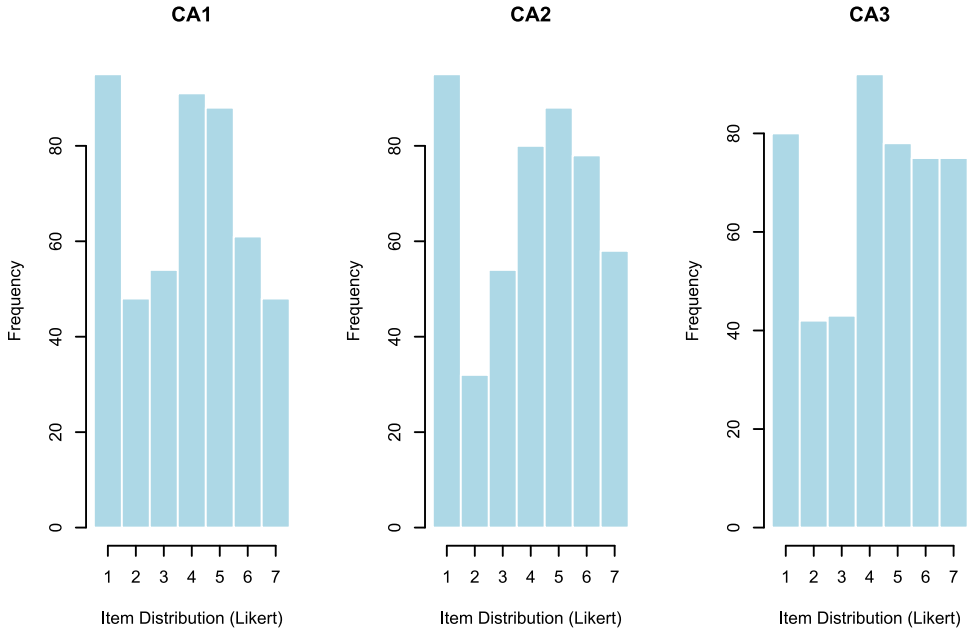
Knowledge



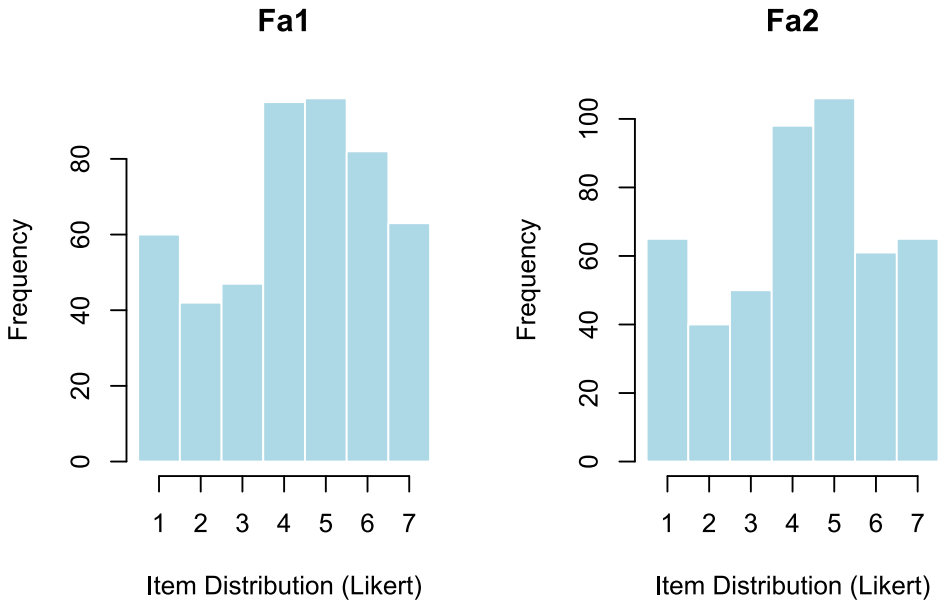
Habit



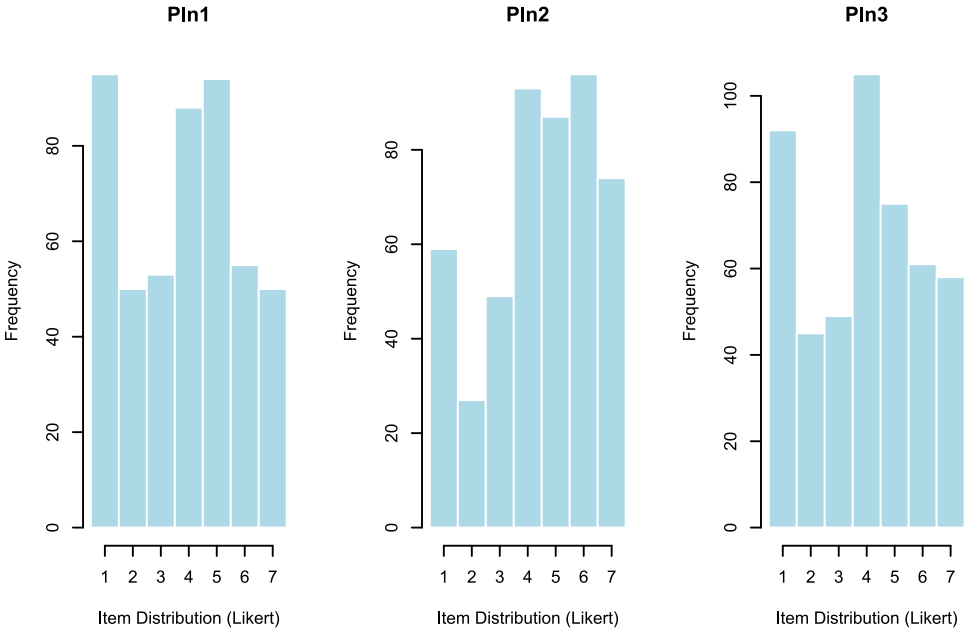
Contextual Acquaintance



Familiarity



Personal Innovativeness



Source: Own illustration

Appendix 10: Moderating effects of the Group Individual Characteristics

Age

Moderating effects through **Age**				
Path	**M = 0: Weight (β)**	**Difference for M = 1 (β)**	**Significant (Moderation)**	**Effect** (relevant when significant)
AtET -> BI	+0.00	+0.05	n.s.	
CA -> BI	+0.18	-0.09	n.s.	
CA -> TI	+0.45	-0.13	n.s.	
Co -> BI	+0.05	-0.10	n.s.	
Co -> UB	+0.22	-0.20	*	(±)
Com -> BI	+0.10	-0.04	n.s.	
Com -> UB	-0.20	+0.04	n.s.	
EE -> BI	-0.06	-0.01	n.s.	
EE -> TI	+0.07	-0.05	n.s.	
FC -> BI	-0.03	+0.01	n.s.	
FC -> TI	-0.10	+0.02	n.s.	
FC -> UB	+0.29	-0.15	n.s.	
Ha -> BI	+0.33	-0.05	n.s.	
Ha -> UB	+0.10	+0.11	n.s.	
HM -> BI	-0.01	+0.15	n.s.	
PE -> BI	+0.10	-0.02	n.s.	
PE -> TI	-0.04	+0.06	n.s.	
PIn -> BI	+0.16	+0.02	n.s.	
PIn -> UB	+0.02	-0.05	n.s.	
PV -> BI	+0.02	+0.16	n.s.	
Re -> BI	+0.12	-0.08	n.s.	
Re -> TI	+0.48	-0.05	n.s.	
SA -> TI	+0.05	+0.14	n.s.	
SI -> BI	+0.08	+0.02	n.s.	

*Significance level: * 5%; ** 1%; *** 0.1%; n.s. = not significant*

x (+) Significant positive moderation effect

x (±) Significant change in direction (inverted effect)

x (-) Significant negative moderation effect

Gender

Moderating effects through **Gender**				
Path	**M = 0: Weight (β)**	**Difference for M = 1 (β)**	**Significant (Moderation)**	**Effect** (relevant when significant)
AtET -> BI	+0.02	+0.02	n.s.	
CA -> BI	+0.15	-0.04	n.s.	
CA -> TI	+0.40	-0.06	n.s.	
Co -> BI	-0.03	+0.10	n.s.	
Co -> UB	+0.14	+0.05	n.s.	
Com -> BI	+0.12	-0.14	n.s.	
Com -> UB	-0.18	-0.01	n.s.	
EE -> BI	-0.12	+0.13	n.s.	
EE -> TI	+0.02	+0.06	n.s.	
FC -> BI	-0.07	+0.05	n.s.	
FC -> TI	-0.16	+0.07	n.s.	
FC -> UB	+0.18	+0.10	n.s.	
Ha -> BI	+0.38	-0.13	n.s.	
Ha -> UB	+0.17	-0.07	n.s.	
HM -> BI	+0.12	-0.12	n.s.	
PE -> BI	+0.03	+0.10	n.s.	
PE -> TI	+0.06	-0.14	n.s.	
PIn -> BI	+0.16	+0.05	n.s.	
PIn -> UB	-0.03	+0.04	n.s.	
PV -> BI	+0.16	-0.12	n.s.	
Re -> BI	+0.01	+0.14	n.s.	
Re -> TI	+0.52	-0.07	n.s.	
SA -> TI	+0.03	+0.13	n.s.	
SI -> BI	+0.07	+0.03	n.s.	

*Significance level: * 5%; ** 1%; *** 0.1%; n.s. = not significant*

x (+) Significant positive moderation effect

x (±) Significant change in direction (inverted effect)

x (-) Significant negative moderation effect

Education

Moderating effects through **Education**				
Path	**M = 0: Weight (β)**	**Difference for M = 1 (β)**	**Significant (Moderation)**	**Effect** (relevant when significant)
AtET -> BI	+0.00	+0.07	n.s.	
CA -> BI	+0.14	-0.04	n.s.	
CA -> TI	+0.37	+0.04	n.s.	
Co -> BI	-0.02	+0.12	n.s.	
Co -> UB	+0.12	+0.13	n.s.	
Com -> BI	+0.07	+0.03	n.s.	
Com -> UB	-0.22	+0.19	n.s.	
EE -> BI	-0.08	+0.04	n.s.	
EE -> TI	+0.03	+0.06	n.s.	
FC -> BI	-0.01	-0.16	n.s.	
FC -> TI	-0.12	+0.03	n.s.	
FC -> UB	+0.24	-0.03	n.s.	
Ha -> BI	+0.32	+0.03	n.s.	
Ha -> UB	+0.22	-0.26	*	(±)
HM -> BI	+0.06	-0.02	n.s.	
PE -> BI	+0.08	+0.01	n.s.	
PE -> TI	-0.01	-0.04	n.s.	
PIn-> BI	+0.16	+0.15	n.s.	
PIn -> UB	-0.03	+0.03	n.s.	
PV -> BI	+0.12	-0.11	n.s.	
Re -> BI	+0.11	-0.18	n.s.	
Re -> TI	+0.47	-0.02	n.s.	
SA -> TI	+0.11	-0.02	n.s.	
SI -> BI	+0.09	+0.03	n.s.	

*Significance level: * 5%; ** 1%; *** 0.1%; n.s. = not significant*

x (+) Significant positive moderation effect

x (±) Significant change in direction (inverted effect)

x (-) Significant negative moderation effect

Daily travel demand

Moderating effects through **Daily travel demand**				
Path	**M = 0: Weight (β)**	**Difference for M = 1 (β)**	**Significant (Moderation)**	**Effect** (relevant when significant)
AtET -> BI	+0.039	-0.19	n.s.	
CA -> BI	+0.12	-0.04	n.s.	
CA -> TI	+0.35	+0.30	n.s.	
Co -> BI	+0.00	-0.01	n.s.	
Co -> UB	+0.13	+0.12	n.s.	
Com -> BI	+0.08	-0.15	n.s.	
Com -> UB	-0.20	+0.17	n.s.	
EE -> BI	-0.06	-0.11	n.s.	
EE -> TI	+0.05	-0.22	n.s.	
FC -> BI	-0.05	+0.02	n.s.	
FC -> TI	-0.13	+0.31	*	(±)
FC -> UB	+0.22	+0.01	n.s.	
Ha -> BI	+0.32	-0.10	n.s.	
Ha -> B	+0.17	-0.34	n.s.	
HM -> BI	+0.07	+0.18	n.s.	
PE -> BI	+0.03	+0.46	*	(+)
PE -> TI	+0.00	-0.37	*	(-)
PIn -> BI	+0.21	-0.04	n.s.	
PIn -> UB	-0.02	+0.18	n.s.	
PV -> BI	+0.12	-0.06	n.s.	
Re -> BI	+0.06	-0.04	n.s.	
Re -> TI	+0.49	-0.14	n.s.	
SA -> TI	+0.12	-0.06	n.s.	
SI -> BI	+0.11	-0.14	n.s.	

*Significance level: * 5%; ** 1%; *** 0.1%; n.s. = not significant*

x (+) Significant positive moderation effect

x (±) Significant change in direction (inverted effect)

x (-) Significant negative moderation effect

Occupation/Job

Moderating effects through **Occupation/Job**				
Path	**M = 0: Weight (β)**	**Difference for M = 1 (β)**	**Significant (Moderation)**	**Effect** (relevant when significant)
AtET -> BI	+0.06	-0.05	n.s.	
CA -> BI	+0.08	+0.08	n.s.	
CA -> TI	+0.36	+0.03	n.s.	
Co -> BI	-0.04	+0.07	n.s.	
Co -> UB	+0.08	+0.10	n.s.	
Com -> BI	+0.11	-0.08	n.s.	
Com -> UB	-0.19	+0.04	n.s.	
EE -> BI	-0.06	+0.00	n.s.	
EE -> TI	+0.03	+0.02	n.s.	
FC -> BI	-0.07	+0.07	n.s.	
FC -> TI	-0.12	+0.05	n.s.	
FC -> UB	+0.11	+0.17	*	(+)
Ha -> BI	+0.30	+0.03	n.s.	
Ha -> UB	+0.20	-0.12	n.s.	
HM -> BI	+0.11	-0.08	n.s.	
PE -> BI	+0.06	+0.02	n.s.	
PE -> TI	+0.03	-0.08	n.s.	
PIn -> BI	+0.22	-0.08	n.s.	
PIn -> UB	-0.06	+0.10	n.s.	
PV -> BI	+0.11	-0.02	n.s.	
Re -> BI	-0.01	+0.16	*	(±)
Re -> TI	+0.43	+0.06	n.s.	
SA -> TI	+0.14	-0.05	n.s.	
SI -> BI	+0.16	-0.11	n.s.	

*Significance level: * 5%; ** 1%; *** 0.1%; n.s. = not significant*

x (+) Significant positive moderation effect

x (±) Significant change in direction (inverted effect)

x (-) Significant negative moderation effect

EV driving experience

Moderating effects through **EV driving experience**				
Path	**M = 0: Weight (β)**	**Difference for M = 1 (β)**	**Significant (Moderation)**	**Effect** (relevant when significant)
AtET -> BI	+0.05	-0.02	n.s.	
CA -> BI	+0.13	-0.01	n.s.	
CA -> TI	+0.35	+0.14	n.s.	
Co -> BI	-0.05	+0.11	n.s.	
Co -> UB	+0.09	+0.02	n.s.	
Com -> BI	+0.09	+0.02	n.s.	
Com -> UB	-0.21	+0.15	n.s.	
EE -> BI	-0.04	-0.14	n.s.	
EE -> TI	+0.05	+0.01	n.s.	
FC -> BI	-0.04	+0.03	n.s.	
FC -> TI	-0.12	-0.06	n.s.	
FC -> UB	+0.09	+0.20	*	(+)
Ha -> BI	+0.28	-0.03	n.s.	
Ha -> UB	+0.15	-0.04	n.s.	
HM -> BI	+0.05	+0.02	n.s.	
PE -> BI	+0.05	+0.00	n.s.	
PE -> TI	-0.08	+0.28	**	(±)
PIn -> BI	+0.19	-0.01	n.s.	
PIn -> UB	-0.03	+0.08	n.s.	
PV -> BI	+0.14	-0.12	n.s.	
Re -> BI	-0.01	+0.27	**	(±)
Re -> TI	+0.52	-0.27	*	(-)
SA -> TI	+0.14	-0.05	n.s.	
SI -> BI	+0.16	-0.14	n.s.	

*Significance level: * 5%; ** 1%; *** 0.1%; n.s. = not significant*

x (+) Significant positive moderation effect

x (±) Significant change in direction (inverted effect)

x (-) Significant negative moderation effect

Source: Own illustration

Appendix 11: Moderating effects of the Group Situational determinants

Household size

Moderating effects through **Household size**				
Path	**M = 0: Weight (β)**	**Difference for M = 1 (β)**	**Significant** (Moderation)	**Effect** (relevant when significant)
AtET -> BI	0.05	-0.11	n.s.	
CA -> BI	0.10	0.12	n.s.	
CA -> TI	0.34	0.06	n.s.	
Co -> BI	0.01	0.04	n.s.	
Co -> UB	0.09	0.21	*	(+)
Com -> BI	0.08	-0.03	n.s.	
Com -> UB	-0.20	0.07	n.s.	
EE -> BI	-0.07	0.03	n.s.	
EE -> TI	0.05	-0.02	n.s.	
FC -> BI	-0.05	0.00	n.s.	
FC -> TI	-0.09	0.01	n.s.	
FC -> UB	0.19	0.17	n.s.	
Ha -> BI	0.32	0.00	n.s.	
Ha -> UB	0.17	-0.10	n.s.	
HM -> BI	0.06	0.04	n.s.	
PE -> BI	0.04	0.13	n.s.	
PE -> TI	0.01	-0.11	n.s.	
PIn -> BI	0.22	-0.12	n.s.	
PIn -> UB	0.03	-0.17	n.s.	
PV -> BI	0.13	-0.14	n.s.	
Re -> BI	0.05	0.03	n.s.	
Re -> TI	0.49	-0.08	n.s.	
SA -> TI	0.10	0.03	n.s.	
SI -> BI	0.10	-0.04	n.s.	

*Significance level: * 5%; ** 1%; *** 0.1%; n.s. = not significant*

x (+) Significant positive moderation effect

x (±) Significant change in direction (inverted effect)

x (-) Significant negative moderation effect

Household income

Moderating effects through **Household income**				
Path	**M = 0: Weight (β)**	**Difference for M = 1 (β)**	**Significant** (Moderation)	**Effect** (relevant when significant)
AtET -> BI	-0.02	0.06	n.s.	
CA -> BI	0.10	0.02	n.s.	
CA -> TI	0.31	0.12	n.s.	
Co -> BI	-0.05	0.12	n.s.	
Co -> UB	0.12	0.06	n.s.	
Com -> BI	0.09	-0.03	n.s.	
Com -> UB	-0.20	0.02	n.s.	
EE -> BI	-0.04	-0.05	n.s.	
EE -> TI	0.07	-0.04	n.s.	
FC -> BI	-0.03	-0.05	n.s.	
FC -> TI	-0.14	0.04	n.s.	
FC -> UB	0.26	-0.04	n.s.	
Ha -> BI	0.34	-0.03	n.s.	
Ha -> UB	0.23	-0.15	n.s.	
HM -> BI	0.05	0.04	n.s.	
PE -> BI	0.09	0.00	n.s.	
PE -> TI	-0.03	0.04	n.s.	
PIn -> BI	0.18	0.05	n.s.	
PIn -> UB	-0.04	0.07	n.s.	
PV -> BI	0.19	-0.17	n.s.	
Re -> BI	0.09	-0.02	n.s.	
Re -> TI	0.53	-0.09	n.s.	
SA -> TI	0.13	-0.05	n.s.	
SI -> BI	0.08	0.04	n.s.	

*Significance level: * 5%; ** 1%; *** 0.1%; n.s. = not significant*

x (+) Significant positive moderation effect

x (±) Significant change in direction (inverted effect)

x (-) Significant negative moderation effect

Number of vehicles in household

Moderating effects through **Number of vehicles in household**				
Path	**M = 0: Weight (β)**	**Difference for M = 1 (β)**	**Significant** (Moderation)	**Effect** (relevant when significant)
AtET -> BI	0.06	-0.17	n.s.	
CA -> BI	0.09	0.12	n.s.	
CA -> TI	0.37	0.02	n.s.	
Co -> BI	-0.03	0.12	n.s.	
Co -> UB	0.17	-0.04	n.s.	
Com -> BI	0.09	-0.08	n.s.	
Com -> UB	-0.22	0.11	n.s.	
EE -> BI	-0.05	-0.10	n.s.	
EE -> TI	0.03	0.05	n.s.	
FC -> BI	-0.06	0.08	n.s.	
FC -> TI	-0.10	-0.01	n.s.	
FC -> UB	0.19	0.12	n.s.	
Ha -> BI	0.38	-0.27	*	(±)
Ha -> UB	0.12	0.03	n.s.	
HM -> BI	0.02	0.26	*	(+)
PE -> BI	0.04	0.21	n.s.	
PE -> TI	0.00	-0.09	n.s.	
PIn -> BI	0.20	0.03	n.s.	
PIn -> UB	0.02	-0.07	n.s.	
PV -> BI	0.12	-0.03	n.s.	
Re -> BI	0.06	-0.06	n.s.	
Re -> TI	0.49	-0.08	n.s.	
SA -> TI	0.10	0.03	n.s.	
SI -> BI	0.13	-0.17	*	(±)

*Significance level: * 5%; ** 1%; *** 0.1%; n.s. = not significant*

x (+) Significant positive moderation effect

x (±) Significant change in direction (inverted effect)

x (-) Significant negative moderation effect

Types of vehicles in household

Moderating effects through **Types of vehicles in household**				
Path	**M = 0: Weight (β)**	**Difference for M = 1 (β)**	**Significant** (Moderation)	**Effect** (relevant when significant)
AtET -> BI	0.04	-0.15	n.s.	
CA -> BI	0.12	0.16	n.s.	
CA -> TI	0.39	-0.08	n.s.	
Co -> BI	0.01	0.02	n.s.	
Co -> UB	0.17	-0.17	*	(±)
Com -> BI	0.07	-0.01	n.s.	
Com -> UB	-0.21	0.36	*	(±)
EE -> BI	-0.05	-0.03	n.s.	
EE -> TI	0.03	0.17	n.s.	
FC -> BI	-0.07	0.16	n.s.	
FC -> TI	-0.07	-0.23	n.s.	
FC -> UB	0.15	-0.06	n.s.	
Ha -> BI	0.32	-0.24	*	(±)
Ha -> UB	0.13	-0.06	n.s.	
HM -> BI	0.06	-0.15	*	(±)
PE -> BI	0.07	-0.11	n.s.	
PE -> TI	-0.03	0.11	n.s.	
PIn -> BI	0.18	0.12	n.s.	
PIn -> UB	-0.01	0.25	*	(±)
PV -> BI	0.08	-0.05	n.s.	
Re -> BI	0.04	0.33	*	(+)
Re -> TI	0.49	-0.20	n.s.	
SA -> TI	0.09	0.15	n.s.	
SI -> BI	0.16	-0.17	*	(±)

*Significance level: * 5%; ** 1%; *** 0.1%; n.s. = not significant*

x (+) Significant positive moderation effect

x (±) Significant change in direction (inverted effect)

x (-) Significant negative moderation effect

Charging opportunity

Moderating effects through **Charging opportunity**				
Path	**M = 0: Weight (β)**	**Difference for M = 1 (β)**	**Significant** (Moderation)	**Effect** (relevant when significant)
AtET -> BI	0.04	0.01	n.s.	
CA -> BI	0.10	0.06	n.s.	
CA -> TI	0.27	0.23	n.s.	
Co -> BI	0.02	0.03	n.s.	
Co -> UB	0.18	-0.03	n.s.	
Com -> BI	0.13	-0.09	n.s.	
Com -> UB	-0.18	0.02	n.s.	
EE -> BI	-0.02	-0.09	n.s.	
EE -> TI	0.03	0.04	n.s.	
FC -> BI	-0.07	0.03	n.s.	
FC -> TI	-0.05	-0.09	n.s.	
FC -> UB	0.08	0.24	**	(+)
Ha -> BI	0.22	0.14	n.s.	
Ha -> UB	0.15	0.02	n.s.	
HM -> BI	-0.02	0.11	n.s.	
PE -> BI	0.17	-0.17	n.s.	
PE -> TI	-0.03	0.03	n.s.	
PIn -> BI	0.06	0.22	**	(+)
PIn -> UB	-0.04	0.08	n.s.	
PV -> BI	0.19	-0.17	n.s.	
Re -> BI	0.02	0.06	n.s.	
Re -> TI	0.58	-0.24	*	(±)
SA -> TI	0.10	0.01	n.s.	
SI -> BI	0.12	-0.02	n.s.	

*Significance level: * 5%; ** 1%; *** 0.1%; n.s. = not significant*

x (+) Significant positive moderation effect

x (±) Significant change in direction (inverted effect)

x (-) Significant negative moderation effect

Source: Own illustration

Appendix 12: Moderating effects of the Group National Culture

Individualism

Moderating effects through **Individualism**				
Path	**M = 0: Weight (β)**	**Difference for M = 1 (β)**	**Significant** (Moderation)	**Effect** (relevant when significant)
AtET -> BI	0.07	-0.10	n.s.	
CA -> BI	0.10	0.03	n.s.	
CA -> TI	0.46	-0.12	n.s.	
Co -> BI	0.03	-0.02	n.s.	
Co -> UB	0.12	0.08	n.s.	
Com -> BI	0.12	-0.11	n.s.	
Com -> UB	-0.19	0.05	n.s.	
EE -> BI	-0.07	0.00	n.s.	
EE -> TI	0.04	0.02	n.s.	
FC -> BI	-0.12	0.15	n.s.	
FC -> TI	-0.08	-0.06	n.s.	
FC -> UB	0.13	0.19	*	(+)
Ha -> BI	0.33	0.00	n.s.	
Ha -> UB	0.16	-0.03	n.s.	
HM -> BI	-0.02	0.11	n.s.	
PE -> BI	0.02	0.11	n.s.	
PE -> TI	-0.03	0.05	n.s.	
PIn -> BI	0.26	-0.06	n.s.	
PIn -> UB	-0.02	-0.02	n.s.	
PV -> BI	0.06	0.00	n.s.	
Re -> BI	0.00	0.17	n.s.	
Re -> TI	0.46	0.01	n.s.	
SA -> TI	0.07	0.09	n.s.	
SI -> BI	0.14	-0.04	n.s.	

*Significance level: * 5%; ** 1%; *** 0.1%; n.s. = not significant*

x (+) Significant positive moderation effect

x (±) Significant change in direction (inverted effect)

x (-) Significant negative moderation effect

Masculinity

Moderating effects through **Masculinity**				
Path	**M = 0: Weight (β)**	**Difference for M = 1 (β)**	**Significant** (Moderation)	**Effect** (relevant when significant)
AtET -> BI	0.07	-0.15	n.s.	
CA -> BI	-0.01	0.30	**	(±)
CA -> TI	0.47	-0.31	**	(±)
Co -> BI	0.04	-0.06	n.s.	
Co -> UB	0.04	0.25	**	(+)
Com -> BI	0.09	0.00	n.s.	
Com -> UB	-0.09	-0.19	n.s.	
EE -> BI	-0.05	-0.04	n.s.	
EE -> TI	0.00	0.18	*	(+)
FC -> BI	-0.02	0.01	n.s.	
FC -> TI	-0.08	-0.06	n.s.	
FC -> UB	0.19	0.06	*	(+)
Ha -> BI	0.26	0.12	n.s.	
Ha -> UB	0.14	0.00	n.s.	
HM -> BI	0.11	-0.03	n.s.	
PE -> BI	0.15	-0.22	*	(±)
PE -> TI	0.04	-0.13	n.s.	
PIn -> BI	0.11	0.18	*	(+)
PIn -> UB	-0.05	0.12	n.s.	
PV -> BI	0.11	-0.07	n.s.	
Re -> BI	0.02	0.04	n.s.	
Re -> TI	0.38	0.26	**	(+)
SA -> TI	0.09	0.07	n.s.	
SI -> BI	0.12	-0.06	n.s.	

*Significance level: * 5%; ** 1%; *** 0.1%; n.s. = not significant*

x (+) Significant positive moderation effect

x (±) Significant change in direction (inverted effect)

x (-) Significant negative moderation effect

Source: Own illustration

Appendix 13: Moderating effects of the Group Technical determinants

Motor Power

Moderating effects through **Motor Power**				
Path	**M = 0: Weight (β)**	**Difference for M = 1 (β)**	**Significant** (Moderation)	**Effect** (relevant when significant)
AtET -> BI	0.08	-0.13	n.s.	
CA -> BI	0.15	-0.07	n.s.	
CA -> TI	0.37	0.00	n.s.	
Co -> BI	0.04	-0.07	n.s.	
Co -> UB	0.18	-0.05	n.s.	
Com -> BI	0.09	-0.02	n.s.	
Com -> UB	-0.15	-0.05	n.s.	
EE -> BI	-0.04	-0.05	n.s.	
EE -> TI	0.05	-0.04	n.s.	
FC -> BI	-0.04	0.00	n.s.	
FC -> TI	-0.05	-0.13	n.s.	
FC -> UB	0.26	-0.03	n.s.	
Ha -> BI	0.29	0.04	n.s.	
Ha -> UB	0.14	-0.02	n.s.	
HM -> BI	0.11	-0.04	n.s.	
PE -> BI	0.04	0.10	n.s.	
PE -> TI	-0.12	0.22	**	+-
PIn -> BI	0.13	0.14	n.s.	
PIn -> UB	-0.05	0.12	n.s.	
PV -> BI	0.05	0.07	n.s.	
Re -> BI	0.05	0.09	n.s.	
Re -> TI	0.45	0.00	n.s.	
SA -> TI	0.19	-0.14	n.s.	
SI -> BI	0.06	0.07	n.s.	

*Significance level: * 5%; ** 1%; *** 0.1%; n.s. = not significant*

x (+) Significant positive moderation effect

x (±) Significant change in direction (inverted effect)

x (-) Significant negative moderation effect

Driving Range

Moderating effects through **Driving Range**				
Path	**M = 0: Weight (β)**	**Difference for M = 1 (β)**	**Significant** (Moderation)	**Effect** (relevant when significant)
AtET -> BI	0.02	-0.03	n.s.	
CA -> BI	0.09	0.10	n.s.	
CA -> TI	0.46	-0.26	*	-
Co -> BI	0.03	-0.04	n.s.	
Co -> UB	0.09	0.15	n.s.	
Com -> BI	0.04	0.04	n.s.	
Com -> UB	-0.17	-0.02	n.s.	
EE -> BI	-0.03	-0.09	n.s.	
EE -> TI	0.04	0.02	n.s.	
FC -> BI	-0.06	0.06	n.s.	
FC -> TI	-0.13	0.04	n.s.	
FC -> UB	0.19	0.12	n.s.	
Ha -> BI	0.30	0.03	n.s.	
Ha -> UB	0.23	-0.22	n.s.	
HM -> BI	0.01	0.12	n.s.	
PE -> BI	0.10	-0.05	n.s.	
PE -> TI	-0.04	0.03	n.s.	
PIn -> BI	0.17	0.07	n.s.	
PIn -> UB	-0.02	0.02	n.s.	
PV -> BI	0.13	-0.09	n.s.	
Re -> BI	0.07	-0.01	n.s.	
Re -> TI	0.39	0.20	*	+
SA -> TI	0.08	0.03	n.s.	
SI -> BI	0.13	-0.04	n.s.	

*Significance level: * 5%; ** 1%; *** 0.1%; n.s. = not significant*

x (+) Significant positive moderation effect

x (±) Significant change in direction (inverted effect)

x (-) Significant negative moderation effect

Charging Time

Moderating effects through **Charging time**				
Path	**M = 0: Weight (β)**	**Difference for M = 1 (β)**	**Significant** (Moderation)	**Effect** (relevant when significant)
AtET -> BI	0.02	0.01	n.s.	
CA -> BI	0.11	0.01	n.s.	
CA -> TI	0.40	-0.05	n.s.	
Co -> BI	0.07	-0.08	n.s.	
Co -> UB	0.14	0.04	n.s.	
Com -> BI	0.07	-0.04	n.s.	
Com -> UB	-0.13	-0.10	n.s.	
EE -> BI	-0.05	-0.03	n.s.	
EE -> TI	-0.01	0.20	**	+-
FC -> BI	-0.03	-0.01	n.s.	
FC -> TI	-0.06	-0.10	n.s.	
FC -> UB	0.14	0.19	*	+
Ha -> BI	0.22	0.19	n.s.	
Ha -> UB	0.12	0.11	n.s.	
HM -> BI	-0.07	0.25	*	+-
PE -> BI	0.11	-0.03	n.s.	
PE -> TI	0.00	-0.09	n.s.	
PIn -> BI	0.13	0.12	n.s.	
PIn -> UB	-0.03	0.05	n.s.	
PV -> BI	0.19	-0.19	n.s.	
Re -> BI	0.03	0.05	n.s.	
Re -> TI	0.47	0.00	n.s.	
SA -> TI	0.06	0.06	n.s.	
SI -> BI	0.14	-0.02	n.s.	

*Significance level: * 5%; ** 1%; *** 0.1%; n.s. = not significant*

x (+) Significant positive moderation effect

x (±) Significant change in direction (inverted effect)

x (-) Significant negative moderation effect

Source: Own illustration

Appendix 14: Moderating effects of the Group Contextual determinants

Market availability

Moderating effects through **Market availability**				
Path	**M = 0: Weight (β)**	**Difference for M = 1 (β)**	**Significant** (Moderation)	**Effect** (relevant when significant)
AtET -> BI	0.03	-0.02	n.s.	
CA -> BI	0.09	0.06	n.s.	
CA -> TI	0.49	-0.28	*	-
Co -> BI	0.04	-0.01	n.s.	
Co -> UB	0.10	0.10	n.s.	
Com -> BI	0.08	0.03	n.s.	
Com -> UB	-0.11	-0.15	n.s.	
EE -> BI	-0.07	-0.02	n.s.	
EE -> TI	0.02	0.06	n.s.	
FC -> BI	-0.02	-0.07	n.s.	
FC -> TI	-0.10	-0.02	n.s.	
FC -> UB	0.09	0.27	**	+
Ha -> BI	0.28	0.07	n.s.	
Ha -> UB	0.12	0.09	n.s.	
HM -> BI	0.03	0.05	n.s.	
PE -> BI	0.08	0.03	n.s.	
PE -> TI	-0.09	0.18	n.s.	
PIn -> BI	0.13	0.14	n.s.	
PIn -> UB	-0.02	0.04	n.s.	
PV -> BI	0.09	-0.06	n.s.	
Re -> BI	0.07	-0.03	n.s.	
Re -> TI	0.46	0.02	n.s.	
SA -> TI	0.11	0.02	n.s.	
SI -> BI	0.02	0.06	n.s.	

*Significance level: * 5%; ** 1%; *** 0.1%; n.s. = not significant*

x (+) Significant positive moderation effect

x (±) Significant change in direction (inverted effect)

x (-) Significant negative moderation effect

Charging availability

Moderating effects through **Charging availability**				
Path	**M = 0: Weight (β)**	**Difference for M = 1 (β)**	**Significant** (Moderation)	**Effect** (relevant when significant)
AtET -> BI	0.00	-0.07	n.s.	
CA -> BI	0.09	0.06	n.s.	
CA -> TI	0.36	-0.17	**	-
Co -> BI	0.01	-0.05	n.s.	
Co -> UB	0.15	0.09	*	+
Com -> BI	0.06	0.06	n.s.	
Com -> UB	-0.19	-0.06	n.s.	
EE -> BI	-0.06	-0.01	n.s.	
EE -> TI	0.05	0.00	n.s.	
FC -> BI	-0.03	-0.05	n.s.	
FC -> TI	-0.12	0.01	n.s.	
FC -> UB	0.25	0.04	**	+
Ha -> BI	0.33	0.06	n.s.	
Ha -> UB	0.13	-0.08	n.s.	
HM -> BI	0.08	0.02	n.s.	
PE -> BI	0.09	-0.21	***	+-
PE -> TI	-0.02	-0.06	n.s.	
PIn -> BI	0.18	0.09	*	+
PIn -> UB	0.00	0.06	n.s.	
PV -> BI	0.08	-0.01	n.s.	
Re -> BI	0.11	0.09	*	+
Re -> TI	0.47	0.08	n.s.	
SA -> TI	0.10	0.15	**	+
SI -> BI	0.11	0.02	n.s.	

*Significance level: * 5%; ** 1%; *** 0.1%; n.s. = not significant*

x (+) Significant positive moderation effect

x (±) Significant change in direction (inverted effect)

x (-) Significant negative moderation effect

Environmental impact

Moderating effects through **Environmental impact**				
Path	**M = 0: Weight (β)**	**Difference for M = 1 (β)**	**Significant** (Moderation)	**Effect** (relevant when significant)
AtET -> BI	-0.05	0.10	n.s.	
CA -> BI	0.20	-0.11	n.s.	
CA -> TI	0.34	0.09	n.s.	
Co -> BI	0.10	-0.18	n.s.	
Co -> UB	0.16	-0.01	n.s.	
Com -> BI	0.07	0.00	n.s.	
Com -> UB	-0.14	-0.08	n.s.	
EE -> BI	-0.05	-0.01	n.s.	
EE -> TI	0.14	-0.18	*	+-
FC -> BI	-0.11	0.11	n.s.	
FC -> TI	-0.17	0.09	n.s.	
FC -> UB	0.18	0.08	n.s.	
Ha -> BI	0.34	-0.05	n.s.	
Ha -> UB	0.10	0.08	n.s.	
HM -> BI	0.08	-0.02	n.s.	
PE -> BI	0.04	0.09	n.s.	
PE -> TI	0.03	-0.10	n.s.	
PIn -> BI	0.23	-0.05	n.s.	
PIn -> UB	0.05	-0.08	n.s.	
PV -> BI	0.05	0.08	n.s.	
Re -> BI	0.03	0.07	n.s.	
Re -> TI	0.52	-0.08	n.s.	
SA -> TI	0.03	0.15	n.s.	
SI -> BI	0.12	-0.03	n.s.	

*Significance level: * 5%; ** 1%; *** 0.1%; n.s. = not significant*

x (+) Significant positive moderation effect

x (±) Significant change in direction (inverted effect)

x (-) Significant negative moderation effect

Policy & Incentives

Moderating effects through **Policy & Incentives**				
Path	**M = 0: Weight (β)**	**Difference for M = 1 (β)**	**Significant** (Moderation)	**Effect** (relevant when significant)
AtET -> BI	-0.02	0.06	n.s.	
CA -> BI	0.05	0.23	n.s.	
CA -> TI	0.52	-0.38	**	+
Co -> BI	0.16	-0.28	**	+-
Co -> UB	0.11	0.09	n.s.	
Com -> BI	0.05	0.02	n.s.	
Com -> UB	-0.10	-0.14	n.s.	
EE -> BI	-0.03	-0.05	n.s.	
EE -> TI	0.02	0.06	*	+-
FC -> BI	-0.07	0.06	n.s.	
FC -> TI	-0.09	-0.03	n.s.	
FC -> UB	0.15	0.16	*	+
Ha -> BI	0.31	0.01	n.s.	
Ha -> UB	0.12	0.04	n.s.	
HM -> BI	-0.01	0.03	n.s.	
PE -> BI	0.07	0.03	n.s.	
PE -> TI	0.00	0.00	n.s.	
PIn -> BI	0.13	0.06	n.s.	
PIn -> UB	-0.06	0.12	n.s.	
PV -> BI	0.02	0.15	n.s.	
Re -> BI	0.04	-0.04	n.s.	
Re -> TI	0.42	0.18	n.s.	
SA -> TI	0.03	0.16	n.s.	
SI -> BI	0.18	-0.16	*	-

*Significance level: * 5%; ** 1%; *** 0.1%; n.s. = not significant*

x (+) Significant positive moderation effect

x (±) Significant change in direction (inverted effect)

x (-) Significant negative moderation effect

Source: Own illustration

Appendix 15: Moderating effects of the Group Experience

Knowledge

Moderating effects through **Knowledge**				
Path	**M = 0: Weight (β)**	**Difference for M = 1 (β)**	**Significant** (Moderation)	**Effect** (relevant when significant)
AtET -> BI	-0.05	0.10	n.s.	
CA -> BI	0.10	0.07	n.s.	
CA -> TI	0.32	0.12	n.s.	
Co -> BI	0.06	-0.08	n.s.	
Co -> UB	0.04	0.21	**	+
Com -> BI	0.05	0.03	n.s.	
Com -> UB	-0.18	-0.01	n.s.	
EE -> BI	0.00	-0.14	*	+-
EE -> TI	0.06	-0.02	n.s.	
FC -> BI	-0.03	-0.04	n.s.	
FC -> TI	-0.12	0.00	n.s.	
FC -> UB	0.24	0.00	n.s.	
Ha -> BI	0.34	-0.06	n.s.	
Ha -> UB	0.14	-0.01	n.s.	
HM -> BI	0.05	0.06	n.s.	
PE -> BI	0.00	0.17	n.s.	
PE -> TI	-0.06	0.08	n.s.	
PIn -> BI	0.22	-0.01	n.s.	
PIn -> UB	0.08	-0.14	n.s.	
PV -> BI	0.03	0.11	n.s.	
Re -> BI	0.12	-0.09	n.s.	
Re -> TI	0.49	-0.05	n.s.	
SA -> TI	0.12	-0.05	n.s.	
SI -> BI	0.15	-0.10	n.s.	

*Significance level: * 5%; ** 1%; *** 0.1%; n.s. = not significant*

x (+) Significant positive moderation effect

x (±) Significant change in direction (inverted effect)

x (-) Significant negative moderation effect

Familiarity

Moderating effects through **Familiarity**				
Path	**M = 0: Weight (β)**	**Difference for M = 1 (β)**	**Significant** (Moderation)	**Effect** (relevant when significant)
AtET -> BI	0.04	-0.08	n.s.	
CA -> BI	0.18	-0.10	n.s.	
CA -> TI	0.38	0.02	n.s.	
Co -> BI	0.01	0.01	n.s.	
Co -> UB	0.17	-0.01	n.s.	
Com -> BI	0.01	0.12	n.s.	
Com -> UB	-0.12	-0.13	n.s.	
EE -> BI	-0.04	-0.05	n.s.	
EE -> TI	0.04	0.03	n.s.	
FC -> BI	-0.02	-0.06	n.s.	
FC -> TI	-0.09	-0.03	n.s.	
FC -> UB	0.20	0.06	n.s.	
Ha -> BI	0.38	-0.12	n.s.	
Ha -> UB	0.03	0.20	n.s.	
HM -> BI	0.01	0.08	n.s.	
PE -> BI	0.09	0.00	n.s.	
PE -> TI	-0.07	0.09	n.s.	
PIn -> BI	0.09	0.23	**	+
PIn -> UB	-0.06	0.09	n.s.	
PV -> BI	0.02	0.10	n.s.	
Re -> BI	0.04	0.08	n.s.	
Re -> TI	0.49	-0.05	n.s.	
SA -> TI	0.10	0.00	n.s.	
SI -> BI	0.16	-0.08	n.s.	

*Significance level: * 5%; ** 1%; *** 0.1%; n.s. = not significant*

x (+) Significant positive moderation effect

x (±) Significant change in direction (inverted effect)

x (-) Significant negative moderation effect

Source: Own illustration