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Factors Influencing the Purchase of Battery Electric Vehicles (BEVs): An Explorative Study Based on the Analysis of New Registrations and Expert Interviews in Germany

Johannes Hoffmann, Verena Szkudlarek, Daniela Ludin, Norbert Schreier*, Erika Mueller, Wanja Wellbrock

Abstract: This research aims to identify the key factors influencing the new registrations of battery electric vehicles (BEVs) in Germany. Focusing the topics economy, mobility change and climate sustainability a mixed-methods approach was used combining a regression analysis based on public databases and qualitative interviews with experts, represented by vehicle testing organizations, BEV leasing companies, car dealerships and automotive magazines. The study revealed similarities as well as discrepancies between expert opinions and the regression analysis results in the fields of real GDP, education rate, the average range of BEVs, the real estate price index, charging infrastructure and political conviction. Regarding practical implications, the results of this study help BEV manufacturers to enhance their marketing and product strategies. The findings of this study could help decision-makers to better understand the mind set of BEV customers.

Keywords: Battery Electric Vehicle (BEV); change in mobility; climate change; sustainable mobility

1 INTRODUCTION

Electro mobility has become increasingly important in recent years due to the reduction of Carbon Dioxide (CO_2) emissions in road traffic. The transport sector in Germany is a significant source of CO_2 emissions, to which road traffic contributes in particular. In 2018, road traffic accounted for around 18% of total CO_2 emissions in Germany [1]. Global warming, primarily caused by the greenhouse gas CO_2, is progressing at an increasing rate and is therefore one of the greatest challenges. In 2015, 195 countries including Germany agreed at the international climate conference in Paris to limit the temperature increase to a maximum of two degrees Celsius [2]. The proportion of BEVs (battery electric vehicles) in Germany is still low compared to conventional passenger cars with combustion engines. The research aim of this study is identifying measurable, socio-cultural influencing factors, which increase the number of new registrations of BEVs.

To better understand factors that influence new registrations of BEVs in contrast to combustion engines and to promote new registrations through this understanding, in this study a comprehensive analysis was carried out. The study consists of two parts, which are composed of a regression analysis with six variables as influencing factors and expert interviews with the aid of a supplementary questionnaire. The aim is to develop a statistical model and to identify and evaluate various influencing factors. The retrieved data is compared with the experts' interviews. The database used for this study is derived from a panel from 2018 to 2022 for the 16 German federal states.

2 LITERATURE REVIEW

Looking at the change of mobility towards electro mobility it quickly becomes clear how comprehensive this field is. To gain a complete and esteemed understanding of the existing literature, a systematic review based on the framework proposed by Zawacki-Richter (2019) [3].

2.1 Sustainability and Climate Change

The results show, that in Germany, the field of sustainability and climate change, especially in connection with electro mobility, has proven to be an extremely diverse and dynamic area that has become increasingly important in recent years [4]. With its ambitious climate targets and strong emphasis on sustainability in public policy and debate, Germany gives an example of how to deal with sustainability and climate change. The government has set itself the goal of being almost climate-neutral by 2050, which requires a drastic reduction in greenhouse gas emissions. This goal is manifested in a variety of political measures and initiatives to reduce emissions in various sectors of the economy [5]. However, other studies indicate that despite its ambitious climate targets, Germany will likely struggle to achieve them due to existing challenges and delays in implementing emission reduction measures. Implementing the necessary measures may require an increased political effort to achieve the targets set [6]. The German population's attitude towards these issues is generally positive and characterized by a high level of environmental awareness. This is reflected in the strong public support for renewable energies and the growing concern about the effects of climate change. Many Germans are willing to make personal changes to their lifestyle in order to live in a more environmentally friendly way, which is reflected in an increasing demand for sustainable products and services [7]. Contrary to this study, Klinger, Metag & Schäfer (2022) [8] emphasize scepticism about climate change and the demand for climate-neutral products and services, which is underlined by the statement that the spread of electro mobility in Germany is lagging behind the government's targets.

2.2 Change in Mobility

The transport sector contributes a significant share of total emissions in Germany, which is why the promotion of BEVs and the expansion of the corresponding infrastructure are key components of the country's sustainability strategy [5]. Although a high availability of an extensive repertoire of

technological expertise is available, Germany shows a very slow in-crease in the number of new registrations of BEVs, especially in international comparison with China [9]. In contrast to this, there is a slow growth in the acceptance and development of BEVs in Europe, also especially compared to China [10]. However, Germany is the largest and most advanced market in Europe [9].

In order to decelerate climate change, research and development has made considerable progress in Germany in the field of electro mobility. These range from improving battery technology and increasing the energy efficiency of electric vehicles all the way to developing sustainable production processes, which could increase BEV acceptance in Germany [11]. German car manufacturers and suppliers, supported by government funding programs and research initiatives, are investing heavily in this sector [12]. The willingness of the German population to switch to BEVs is encouraged by tax incentives, purchase premiums and exemption from vehicle tax. Cooperation between stakeholders from the public and private sectors is also crucial to debunking myths about electric mobility and raising awareness of its benefits [13]. Despite many benefits, incentives and subsidies on offer, acquisition costs remain high, which is holding back potential buyers in some cases and range anxiety is also a limiting factor for the purchase of a BEV [14, 15].

The development of a strong domestic market for electro mobility is seen in Germany as an impulse for the transformation to a green economy. Replacing the combustion engine with alternative drive systems can trigger a variety of macroeconomic effects. In addition, a scenario is considered that predicts six million electric vehicles by 2030, which shows that negative effects on vehicle production can be offset by positive effects in the production of energy technologies [16]. A further study emphasizes that the environmental benefits of electric vehicles depend on whether their additional electricity consumption is covered by renewable energy sources [17]. Furthermore, challenges for electro mobility in Germany are identified in the adaptation of vehicle technology, the value chain, the load on the electricity grid, electricity generation for the drive system, transportation and the charging infrastructure [18]. It has been shown that slow progress in the expansion of charging infrastructure is slowing down the transformation to a sustainable transport sector [19]. It is also illustrated that although BEVs have already been offered, promising economic incentives such as purchase premiums by the government [20], economic disadvantages are currently still preventing the widespread use of BEVs [21].

The change in mobility in Germany, increasingly characterized by the transition to electro mobility, is part of a comprehensive strategy to reduce CO_2 emissions and promote sustainable transport solutions. However, the introduction of BEVs meets with different reactions within the population [8]. While some citizens appreciate the advantages such as lower operating costs and environmental friendliness [15], there are concerns about charging times and the short range for BEVs [11, 22]. However, these can be overcome by the integration of charging stations in public areas, residential areas and workplaces [18]. The acceptance of BEVs is higher in urban areas in particular, as shorter driving distances and a better charging infra-structure prevail here [23]. Nevertheless, another study emphasizes that the integration of charging infrastructure in existing rural structures and areas, in particular can still be significantly expanded in order to generate a change in mobility and promote the acceptance of BEVs [24]. Among other things, the development of fast charging stations along the main transport axes is also underway to improve the long-distance suitability of BEVs [10]. It is emphasized that battery capacity and a well-developed charging infrastructure are decisive for long-distance suitability and thus for the acceptance of BEVs [22, 25]. Husarek et al. (2021) also address the importance of differences between urban and rural areas, charging demand on highways and the impact of energy demand and battery size on charging infrastructure [23]. In addition, an increasing average range of the vehicles increases their usability for longer distances, which can open up new customer groups [26, 27]. Following this, it is emphasized that the economic viability of electric cars depends largely on battery technology [28] and that the environmental benefits of electric cars can only be fully exploited if the electricity comes from renew-able sources [29]. Literature offers a few options for this. One is a combination of BEVs and private photovoltaic systems for private households, which is profitable above a mileage of 13,000 km per year [30].

2.3 Socio-economic Factors

The role of environmental awareness in the context of socio-economic factors reflects another commonality. Studies by Krause et al. (2016) [31], Mock et al. (2009) [32] and Letmathe & Suares (2020) [25] show that increased environmental awareness and macroeconomic conditions, such as an increase in gross domestic product, can often increase the willingness to buy BEVs. Sustainable mobility solutions play a relevant role in satisfying the need to reduce greenhouse gases and protect the environment [11]. It is also emphasized that educated groups of people tend to better understand the long-term economic benefits and environmental impacts [33, 34]. However, the relevance of individual influencing factors is not portrayed consistently in the literature. Some highlight the influence of education levels and attitudes as important factors for the acceptance of BEVs [34]. Others focus on charging infrastructure or product-related components [35], while Stockkamp et al. (2021) [36] present a whole range of influencing factors from product, politics and education to social influence and in-come as relevant. The spectrum is expanded by looking at specific areas of application and challenges [35, 37].

Here, the acceptance of BEVs in company fleets is examined, emphasizing the importance of product-related factors and environmental concerns [35]. In contrast, Hildermeier & Jahn (2021) [37] focus on the grid integration of electric mobility in Europe. In particular, they examine incentives for smart charging, which can reduce costs for consumers and promote the integration of renewable energies. The need for an integrated approach is further emphasized.

2.4 Research Gap

Overall, the literature review shows that the acceptance of BEVs is a complex interplay of various factors, ranging from technical and infrastructural aspects, environmental awareness and socio-economic conditions to education levels and safety concerns. An interesting observation is the lack of studies that directly address the influence of the real estate price index and the influence of the political orientation of buyers on the decision to purchase an electric vehicle. Although there are a number of studies that examine factors such as purchase price, range, environmental awareness, charging infrastructure and social influences on BEV purchase decisions, the specific role of the real estate price index and the political orientation of buyers remains largely unexplored. It is not clearly defined in literature whether and to what extent the real estate price index, which can be an indicator of the economic situation of an individual or a region, influences the decision to purchase an electric vehicle. In addition, there is also a lack of studies that investigate if support for or membership in a "green party" influences the propensity to purchase an electric vehicle.

These gaps in literature indicate that there is untapped potential to examine specific factors and to develop a more comprehensive understanding of the determinants behind the purchase of BEVs. Based on this research gaps the following research objectives and research questions emerge (Tab. 1).

RO1 analyses the main factors that influence the purchase of electric cars. Hereby, RQ1 looks at these factors in more detail. This is essential to understand the purchasing behaviour of BEV buyers. The research shows that socio-economic characteristics, attitudes, preferences, availability of charging infrastructure and energy costs all play a role [38]. Financial incentives, information about electric cars, convenience and environmental awareness also influence consumer attitudes and purchase intentions [39]. The availability of publicly accessible charging infrastructure and the visibility of electric cars are a further important factor [40]. RQ2 determines the relationship between individual variables and the acceptance of electric cars. Government measures such as financial incentives, traffic regulatory support and the expansion of charging infrastructure play a key role in promoting BEV acceptance [13]. In addition, studies also show that financial incentives and suitable business models can promote acceptance [41, 22].

RO2 examines the relationship between individual variables and their impact on BEV acceptance. With RQ3 the extent to which environmental awareness, as measured by green participation in the state government, has an influence on the decision in favour of BEVs will be investigated. It is shown that the acceptance of BEVs is related to individual differences in mobility needs and the acceptance of range extensions [43], which highlights the significance of environmental awareness and political orientation in shaping consumer preferences.

RQ4 focuses on the property price index and is based on the expectation that higher property prices are usually found in cities, not in rural areas. Generally, there are also more charging stations and services for BEVs in cities. This raises the question of whether this has an impact on the acceptance of BEVs. RQ5 focuses on the impact of the average range of BEVs as its influence on the purchase decision. Investigating whether longer ranges contribute to increased population acceptance, another study suggests that direct experience with BEVs can change evaluation and psychological factors influencing behavioural intention, potentially boosting acceptance [44].

Table 1 Research Objectives & Research Questions

	Research Objectives	Research Questions
Socio-economic Factors	1. Determine which of the factors analyzed are most relevant when purchasing BEVs. (RO1)	1. Which of the factors analyzed is the one, which most strongly promotes the registration of new BEVs? (RQ1)
		2. Which factors must governments pay attention to if they want to influence the mobility shift towards electro mobility? (RQ2)
Sustainability & Climate	2. Understand the relationship between individual variables and the extent of sustainable influence on these variables. (RO2)	3. Does environmental awareness, as measured by green participation in the state government; influence the decision in favor of BEVs? (RQ3)
		4. Does the property price index influence the population's willingness to buy BEVs? (RQ4)
		5. To what extent does the average range of BEVs influence purchasing decisions? (RQ5)
Change in mobility	3. Find out how electro mobility can be integrated in everyday life in various areas of society in order to achieve broad social acceptance. (RO3)	6. To what extent is the level of prosperity relevant to influence a mobility transformation with regard to electro mobility positively? (RQ6)
		7. What factors influence customer behavior of BEVs and how can these findings be used to improve their suitability for everyday use? (RQ7)

RO3 examines how electro mobility can be effectively integrated into society. RQ6 concerns the importance of domestic purchasing power in order to be able to achieve a change in mobility as a country, especially against the backdrop of even more expensive BEVs. It is examined to which factor the level of prosperity influences the purchase of a BEV. It is shown that socio-economic characteristics and attitudes vary considerably among BEV users, with early adopters having a higher average income, a higher level of education and more cars per household [33]. Further, it is shown, that suburban multi-person households are likely to be early adopters of BEVs. The study emphasizes that occupation, place of residence, and household size are considered socio-demographic purchase factors [45].

RQ7 focuses on factors influencing user behaviour in connection with BEVs and their impact on acceptance. Key factors such as symbolic attitudes, perceived barriers, mobility needs, personal norms and experiences with BEVs were identified [34]. Subjective norms and perceived behavioural control are also essential for users' intentions towards sustainable BEV consumption [46].

3 METHODOLOGY

A mixed-methods approach was chosen to conduct this study in order to collect both quantitative and qualitative data

and provide a more comprehensive perspective on the research questions [47, 48, 49]. For this purpose, a regression analysis was carried out in a panel as part of the quantitative research and qualitative expert interviews were conducted with specialists from the automotive industry. Article and the authenticity of information and statements written in the article.

3.1 Regression Analysis

The quantitative data on which this statistic is based was obtained from government-published analyses and surveys. These include publications by the Kraftfahrtbundesamt, the Bundesnetzagentur, the German Education Monitor Initiative Neue Soziale Marktwirtschaft (ISNM) and the statistical offices of the federal states. This ensures the sovereignty of the data. In order to provide a representative analysis with $n > 30$ [50] the methodology of a panel was applied. Consequently, the data collection for this study covered a period of five years (2018 to 2022) in each of the sixteen German Federal States ($n = 16*5 = 80$).

In this context, it was ensured that absolute figures were adjusted, making it possible to compare the data. The independent *Y* variable represents the starting point of the statistical analysis with the percentage of new BEV registrations compared to total new registrations. Respectively listed *X* variables are evaluated with *Y* by means of a correlation and regression analysis with regard to their relationship to each other. The variables of the underlying analysis are as follows:

Table 2 Variables

Variables	Importance of the variables
Y: New registrations of BEV passenger cars	Initial variable of the research topic.
X1: Real GDP	B have a higher price than conventional combustion engines. The study focuses on the potential purchasing power [51].
X2: Real charging infrastructure	Charging requires more time, which must be planned. The real charging infrastructure is crucial for evaluating concerns about the range of BEVs [14, 52].
X3: Average range of BEVs	The range of BEVs is steadily increasing. This variable influences the universal suitability of vehicles for customers [53].
X4: Education level	The level of education influences the attitudes and values of the population. A higher level of education can lead to greater awareness of environmental issues and innovative technologies [34].
X5: Real estate price index	Considering different infrastructural conditions and financial differences between cities and rural regions, a price gap can be identified, and possible conclusions can be drawn about new BEV registrations [45].
X6: Green participation in the state government	Green participation in the state government implies sustainability. It is questionable to what extent this is reflected in the purchase of new BEVs [43].

A correlation analysis carried out beforehand evaluates how strong the influence of one characteristic is on another characteristic [54]. The variables to be compared are treated equally. If two characteristics *X*, *Y* are at least interval-scaled, the correlation coefficient *r* is used to measure the strength of the linear relationship between the variables [54]. *r* is defined within the interpretation range of $-1 \leq r \leq +1$, where *r* must not be greater than 0.8 in order to avoid a linear correlation and thus an overlap in significance.

The final evaluation is carried out using a regression analysis created in Excel.

3.2 Interview

The second component involves conducting interviews with experts in the automotive industry in order to gain in-depth insights into the influence on the purchase of BEVs. Here, emphasis was placed on a broad knowledge and experience base among the selected experts, especially in customer contact. The interview partners (IPs) are presented below.

As managing director of a BEV leasing company, IP 1 has in-depth knowledge of a company that offers a wide range of leasing solutions for BEVs, thermal vehicles, hydrogen vehicles and bicycles. Under his leadership, the company focuses on the implementation of government programs for electric mobility in cooperation with federal ministries in order to facilitate customers' access to funding. The knowledge of the managing director is therefore of crucial importance for the investigation of the various factors influencing the approval of a BEV vehicle.

A large car dealership is used as an additional IP 2 for evaluating the factors influencing the purchase of BEVs. The car dealer-ship provides direct insights into customer preferences and purchasing decisions. As a sales point for various car models, including many different electric models, the car dealership generates valuable data on the various factors that influence why customers decide to buy an electric car. In particular, this information is based on practical aspects such as range and charging options. In addition, the dealership has experience with customer questions about BEVs and can identify trends and changes in demand over time, which is highly relevant for research into the boost of BEV purchases.

As an editor of an automotive magazine and in particular as a test driver, a high amount of vehicles passes through the desk of IP 3. The magazine is consumer-oriented and includes driving reports and vehicle evaluations. Trends must therefore be recognized at an early stage and customer wishes must be expressed. His expertise helps to make customer wishes even more explicit, especially concerning BEVs.

An expert from a vehicle testing organization will provide in-depth insights into several layers of the analysis as IP 4. On the one hand, through the certification of charging infrastructure in Germany and the subsequent current challenges and approaches to solutions, and on the other hand in the context of the frequency of new registrations, which must be approved by corresponding organizations. In addition, insights into possible concerns or progress in connection with electric vehicle batteries can be provided.
Before the interviews are carried out, a detailed guideline with relevant questions and criteria is prepared to ensure systematic coverage of the factors. The investigative process commences with questions of a general nature concerning the interviewee's professional background, including their role and relevance to BEV distribution. Subsequently, a specific

discussion of the variables mentioned above, evaluating their connection to the registration numbers. In addition, this research seeks to delineate strategic adjustments to the factors, which can increase the number of new BEV registrations. Where possible, the interviews will be conducted in person; if not virtually, for example utilizing platforms such as Microsoft Teams, recorded and transcribed to enable a precise evaluation afterwards.

After transcribing the interviews, recurring topics are identified as part of the analysis and, if possible, assigned to the *X* variables, otherwise additional categories are formed [55]. The key statements of the experts are summarized and categorized as described. This is followed by an analysis of the agreement between the experts' statements. In a subsequent section, the summarized statements are linked with the results of the regression. After combining both parts, an evaluation of the similarities and differences between the statements follows, thus answering the research objectives and questions with the existing database. It also examines whether and to what extent factors are justified or substantiated by the experts' statements.

4 RESULTS

The evaluation of the regression analysis (Tab. 3) shows that not all values are significant and can therefore be extended to the overall population. If the *P*-value exceeds the factor 0.1, the maximum significance level is exceeded. The coefficient indicates the strength and direction of the relationship between the independent *Y*-variable and dependent *X*-variables. The coefficient can be positive for a positive relationship or negative for a negative relationship. In this table, a positive or negative correlation can be recognized for each variable examined, which are defined below in their respective statements.

Table 3 Results regression analysis

	Coefficient	Standard error	St-statistics	*P*-Value	Upper 95%	Lower 95%
X1: Real GDP	–0,00149407	0,000902756	–1,6550165	0,10221458	–0,00329326	0,00030511
X2: Real charging infrastructure	–1,56301E–05	8,49914E–06	–1,8390206	0,06997898	–3,25689E–05	1,3087E–06
X3: Average range of BEVs	0,000720499	4,04615E–05	17,8070029	2,7942E–28	0,000639859	0,00080114
X4: Education level	–0,00115202	0,000442733	–2,6020781	0,0112139	–0,00203439	–0,0002697
X5: Real estate price index	6,81898E–06	4,34248E–06	1,57029788	0,12067048	–1,83556E–06	1,5474E–05
X6: Green participation in the state government	0,004164318	0,007032797	0,5921283	0,55559426	–0,00985202	0,01818066

The values obtained from the regression analysis reveal remarkable discrepancies between the experts' opinions and the empirical findings, especially in the context of new registrations of BEVs. It shows that GDP and the education rate do not have a significant influence on BEV registrations, which contradicts the results of some studies. The significant influence of the average range of BEVs and the property price index on registration figures should be emphasized, which clearly underlines the importance of technical developments and economic factors. Another particular observation is the divergence between the assessment of the charging infrastructure and the partial agreement regarding political participation, which reflects the complexity of the influence of socio-structural characteristics on the acceptance of BEVs.

Table 4 Consistency between the regression and expert interviews

Variables	Regression Analysis	Expert Interview	Consistency
X1: Real GDP	Increase in GDP has **no influence** on new BEV registrations (not significant)	Level of prosperity **influences** purchasing power	No
X2: Real charging infrastructure	Charging infrastructure has **no influence** on new BEV registrations (significant)	**Has an impact** on new BEV registrations	No
X3: Average range of electric vehicles	Range has an **influence** on new BEV registrations (significant)	Range has an **influence** on new BEV registrations	Yes
X4: Education level	Level of education has **no influence** on new BEV registrations (significant)	Level of education has **no influence** on new BEV registrations	Yes
X5: Real estate price index	Real estate prices have an **influence** on new BEV registrations (not significant)	Real estate prices have an **influence** on new BEV registrations	Yes
X6: Green participation in the state government	Tendency yes. **No clear statement** possible due to too high significance level	**No influence**. Possible connection due to high environmental awareness	Partially

4.1 Results Socio-economic Factors

Following the research questions (cf. Chapter 1.4) two factors can be identified based on the analysis carried out, which con-tribute essentially to the broadening of BEVs. These factors are:

- X3: Average range of BEVs
- X5: Real estate price index.

The results of the regression analysis and the overall opinion of experts matched for both variables examined. The high significance with regard to the range shows that the investigation can be clearly extended to the population as a whole. By confirming the high influence of the real estate price index through the expert survey, the corresponding variable can also be extended to the entirety. The disregard of variable 4 (education level) is due to the fact that this factor also produces a uniform result, but has no influence on new registrations.

In particular, the expansion of the range reduces the so-called range anxiety among buyers of BEVs, which leads to a significantly higher feeling of reliability. According to expert opinions, range is currently the decisive argument of BEV critics against buying an electric vehicle, which would

become progressively less important with the expansion. Despite the fact that charging times can be easily planned, there is a basic fear of uncertainty among the public regarding the range.

With regard to the real estate price index, less attention is paid to the difference between urban and rural areas, but even more to the type of housing, as measured by the real estate price index. The residential location plays a role with regard to the availability of a private charging space with a wall box, which is the case in a detached house compared to an apartment without a permanent parking space, which significantly increases the suitability of a BEV for everyday use. In addition, better living conditions imply increased purchasing power for BEVs that are even more expensive; however, there are also contrary opinions that the general level of prosperity has no influence on new registrations, which is discussed in more detail below.

One expert also refers to the reduction of the aforementioned range anxiety in cities, as the expansion of the charging infrastructure is usually better developed due to the higher population in cities and this subconsciously reduces range anxiety. This will be discussed in more detail below. Based on the analysis above, the German government must therefore significantly promote the technical expansion and development of batteries in order to increase new registrations. A state-subsidized combination of charging facilities in one's own home or in shared homes is also recommended in order to reduce the "exclusivity" of charging.

4.2 Results Sustainability and Climate Change

The scientific analysis of the factors influencing the registration of BEVs reveals a clear discrepancy between the results of the regression analysis and the expert opinions regarding green participation in the state government. This discrepancy manifests itself in particular in the inability of the regression analysis to make a definitive statement about the influence of green participation in the state government on BEV registrations due to an excessively high significance level. It underlines the need for a more careful consideration of the political dimensions and their potential influence on the acceptance and promotion of environmentally friendly technologies.

Experts, on the other hand, tend to assume that this political participation has no direct influence on BEV registrations. However, they suspect that there could be an indirect correlation due to increased environmental awareness in regions with stronger green participation in the state government. These differences of opinion and the only partial agreement in the results illustrate how complex and influenced by numerous factors the acceptance and the spread of BEVs is. They emphasize the need for an integrative view that includes both quantitative and qualitative perspectives in order to gain a more comprehensive understanding of the factors driving BEV adoption.

When asked about the influence of green participation in the state government on the purchase of a BEV, the experts' arguments suggest that this political variable has no direct influence. The experts argue that the decision to buy a BEV depends less on the state government and more on the long-term interest of the population who vote green. Another expert emphasizes that the purchase of BEVs is influenced more by decisions made by the federal government than by an individual party. These assessments illustrate that the promotion of BEVs is more strongly influenced by overarching national guidelines and the general environmental awareness of the population than by the specific involvement of a political party at state level.

For the X5 (Real estate price index) variable, the significance of property prices for new registrations of BEVs was examined. The regression analysis carried out indicates that property prices have an influence on new registrations of BEVs, but this influence is not statistically significant. This means that there is a correlation, but it is not strong enough to be considered decisive. In contrast, expert opinions confirm the high relevance of real estate prices for new BEV registrations, but experts offer contrary views. One expert argues that it is not the distinction between urban and rural locations that is decisive, but rather factors such as the type of housing, the size of the property and an affluent residential area. These factors could be more influential as they are directly linked to the financial capacity and lifestyle of residents. Other experts, however, emphasize the importance of urban residential locations, especially due to the denser charging infrastructure, which increases the acceptance and use of BEVs in urban areas. These insights underline the importance of socio-economic aspects in the purchase of BEVs. This consistency between the experts' opinions and the results of the regression analysis, despite the statistical non-significance, emphasizes the need to consider and further explore the influence of economic factors on BEV adoption.

The results of both the regression analysis and the expert opinions indicate a significant influence of the range of battery BEVs on their new registrations. The regression analysis identifies range as a significant factor, indicating its importance for user acceptance and the practical applicability of BEVs. Thus, this result confirms that an increased average range increases the acceptance of BEVs.

Experts confirm this finding and emphasize the importance of range for potential buyers of BEVs. The agreement in both analysis methods underlines the central role of vehicle range in the context of BEV adoption.

The expert statements regarding the range increase of BEVs emphasize the high relevance of this factor. Range anxiety is identified as a key factor that prevents potential buyers from purchasing a BEV. According to the experts, technological advances that increase the range can reduce this critical approach. Furthermore, range is a well-known argument used by BEV critics. Experts emphasize that the attractiveness of BEVs can be increased not only by technological improvements, but also by factors such as purchase price, vehicle selection and the expansion of the charging infrastructure. An interesting approach is the "store and charge" concept explained by one expert, which enables charging during other activities. These assessments make it clear that range plays a significant role in the market acceptance of BEVs compared to other factors. However, according to the experts, the factors mentioned, such as vehicle selection, must also be extended further, since with a

lower range, at least the charging infrastructure must be sufficiently available, according to another expert.

4.3 Results Change in Mobility

In terms of purchasing power, the GDP of Germany is used as the factor examined. According to the statistical survey, no influence of the level of prosperity on the number of new registrations of BEVs compared to conventional combustion vehicles can be identified. Due to the excessively high significance level, which is only just above 0.1, the statement is not significant, but can be considered generally valid in a general context. Accordingly, the analysis shows that purchasing power in the country has no effect. The negative coefficient supports this. This differs from the experts' statements. They cite the still very high price of BEVs, which in some cases is 50% higher than the price of combustion engines despite cheaper Chinese variants. A distinction must be made between private purchases and company cars. Expert opinions emphasize that the price of company cars, in contrast to a higher required level of prosperity in the private sector, plays barely any role. It is also emphasized that the current high inflation in Germany and cancelled subsidies have a negative impact on new registrations. According to the experts, the general level of prosperity is therefore relevant due to the available purchasing power.

As described, user behaviour is influenced to a greater or lesser extent by many factors. What is outstanding is the fact that, according to regression and experts, the level of education has no influence on the promotion of new registrations and can therefore be left out of further measures. Users still need to be introduced to BEVs. Many factors have a positive influence on achieving this. Systems and strategies, which are explained in more detail in Chapter 5, can sustainably and permanently increase behaviour and adoption. It can be said in advance that it will take a combination of several factors to achieve this development.

5 CONCLUSION

5.1 Summary

The analysis of factors influencing BEV registrations identifies two key factors: the range of the vehicles and the real estate price index. These significantly influence the acceptance and new registrations of BEVs. Extending the range reduces range anxiety and strengthens confidence in BEVs. It also shows that green participation in the state government does not have a direct influence on BEV registrations, but has an underlying indirect influence due to increased environmental awareness.

The real estate price index influences the suitability of BEVs for everyday use, as it indicates the availability of private charging stations and shows increased purchasing power for the purchase of BEVs. Germany's GDP has no direct influence on new BEV registrations, but the price of BEVs plays a decisive role, especially in the private sector.
Finally, the analysis of user behaviour shows that the education level has no influence on new BEV registrations. Instead, introducing potential users to BEVs through the development of various factors is crucial.

5.2 Discussion of the Results

As already mentioned, the results reveal significant discrepancies between the literature review and the empirical findings. What stands out is the fact that, according to the regression analysis and the expert interviews, the level of education has no influence on the promotion of new registrations, although educational measures were cited as relevant in the literature review. This shows the need to investigate the role of educational initiatives and the general level of education in the context of BEV adoption in more depth. Green participation in the state government is also a questionable factor. The connection here with more sustainable approaches is understandable, but the question arises as to whether more can be created from this context in terms of broad acceptance. The study shows that some factors have a greater or less influence on the acceptance of BEVs; a combination of technological improvements, an expansion of the charging infrastructure and political and economic measures is seen as the key to promoting BEV adoption.

5.3 Limitations and Practical Implication

There are also limitations to the research approach used. As the topic of electro mobility is growing rapidly, but is still quite new, some data sets are not yet mature enough to achieve workable results, as the comparative analysis of combustion engines, BEVs and the associated infrastructure is still too small. With regard to expert opinions, it must also be mentioned that such opinions are always subjective and experts do not necessarily answer purely objectively despite their extensive knowledge of the relevant sector.

With regard to practical implications, experts already provide relevant insights into measures that can be integrated into the German system for promoting BEVs. These generally include the promotion of technological progress with regard to battery development and the expansion of the charging infrastructure, but also area planning concepts for BEV suitability in everyday life, such as "store and charge" concepts at charging stations. New registrations are also expected to rise as the availability and variety of BEVs increases.

6 REFERENCES

[1] Umweltbundesamt (Hrsg.) (2020). Klimaschutz durch Tempolimit. Wirkung eines generellen Tempolimits auf Bundesautobahnen auf die Treibhausgasemissionen. https://www.umweltbundesamt.de/sites/default/files/medien/1410/publikationen/2020-06-15_texte_38-2020_wirkung-tempolimit_bf.pdf (in German)

[2] Bergk, F., Knörr, W. & Lambrecht, U. (2017). Klimaschutz im Verkehr: Neuer Handlungsbedarf nach dem Pariser Klimaschutzabkommen. https://www.umweltbundesamt.de/sites/default/files/medien/1410/publikationen/2017-07-18_texte_45-2017_paris-papier-verkehr_v2.pdf (Accessed on 23.11.2023) (in German)

[3] Zawacki-Richter, O., Kerres, M., Bedenlier, S., Buntins, K. & Bond, M. (Eds.) (2019). *Systematic Reviews in Educational Research: Methodology and Applications*. Springer VS, Wiesbaden. https://doi.org/10.1007/978-3-658-27602-7

[4] Bringezu, S., Distelkamp, M., Lutz, C., Wimmer, F., Schaldach, R., Hennenberg, K., Böttcher, H. & Egenolf, V.

(2021). Environmental and socioeconomic footprints of the German bioeconomy. *Nature Sustainability, 4*, 775-783. https://doi.org/10.1038/s41893-021-00725-3

[5] Heimann, D. (2018). Unternehmensnetzwerke für nachhaltige Gewerbegebiete. *Standort, 42*, 223-228. (in German) https://doi.org/10.1007/s00548-018-0557-6

[6] Buchmann, M., Kusznir, J. & Brunekreeft, G. (2019). Assessment of the drafted German integrated National Energy and Climate Plan. *Economics and Policy of Energy and the Environment, 1*, 85-96. https://doi.org/10.3280/efe2019-001006

[7] Haas, T. (2020). From Green Energy to the Green Car State? The Political Economy of Ecological Modernisation in German. *New Political Economy, 26*(4), 660-673. https://doi.org/10.1080/13563467.2020.1816949

[8] Klinger, K., Metag, J. & Schäfer, M. (2022). Global Warming's Five Germanys – Revisited and Framed in an International Context. *Environmental Communication, 16*(8), 1108-1126. https://doi.org/10.1080/17524032.2022.2153897

[9] Zhao, Q. (2018). Electromobility research in Germany and China: structural differences. *Scientometrics, 117*, 473-493. https://doi.org/10.1007/S11192-018-2873-9

[10] Hecht, C., Figgener, J. & Sauer, D. (2022). Analysis of electric vehicle charging station usage and profitability in Germany based on empirical data. *iScience, 25*(12), 105634. https://doi.org/10.1016/j.isci.2022.105634

[11] Weigelt, M., Mayr, A., Böhm, R., Kühl, A. & Franke, J. (2018). Quo vehis, Elektromobilität?: Aktuelle Treiber und Hindernisse der Mobilitätswende in Deutschland. *Zeitschrift für wirtschaftlichen Fabrikbetrieb, 113*(1-2), 59-63. (in German) https://doi.org/10.3139/104.111863

[12] Ahmad, A., Khan, Z., Alam, M. & Khateeb, S. (2018). A Review of the Electric Vehicle Charging Techniques, Standards, Progression and Evolution of EV Technologies in Germany. *Smart Science, 6*(1), 36-53. https://doi.org/10.1080/23080477.2017.1420132

[13] Rietmann, N. & Lieven, T. (2019). How policy measures succeeded to promote electric mobility – Worldwide review and out-look. *Journal of Cleaner Production, 206*, 66-75. https://doi.org/10.1016/j.jclepro.2018.09.121

[14] Neubauer, J. & Wood, E. (2014). The impact of range anxiety and home, workplace, and public charging infrastructure on simulated battery electric vehicle lifetime utility. *Journal of Power Sources, 257*, 12-20. https://doi.org/10.1016/j.jpowsour.2014.01.075

[15] Weiss, M., Zerfass, A. & Helmers, E. (2019). Fully electric and plug-in hybrid cars - An analysis of learning rates, user costs, and costs for mitigating CO_2 and air pollutant emissions. *Journal of Cleaner Production, 212*, 1478-1489. https://doi.org/10.1016/j.jclepro.2018.12.019

[16] Ulrich, P. & Lehr, U. (2020). Economic effects of an E-mobility scenario – input structure and energy consumption. *Economic Systems Research, 32*(1), 84-97. https://doi.org/10.1080/09535314.2019.1619522

[17] Tena, D. L. de & Pregger, T. (2018). Impact of electric vehicles on a future renewable energy-based power system in Europe with a focus on Germany. *International Journal of Energy Research, 42*(8), 2670-2685. https://doi.org/10.1002/er.4056

[18] Burkert, A., Fechtner, H. & Schmuelling, B. (2021). Interdisciplinary Analysis of Social Acceptance Regarding Electric Vehicles with a Focus on Charging Infrastructure and Driving Range in Germany. *World Electric Vehicle Journal, 12*(1), *e*010025. https://doi.org/10.3390/wevj12010025

[19] Anderson, J., Lehne, M. & Hardinghaus, M. (2018). What electric vehicle users want: Real-world preferences for public charging infrastructure. *International Journal of Sustainable Transportation, 12*(5), 341-352, https://doi.org/10.1080/15568318.2017.1372538

[20] Vilchez, J., Smyth, A., Kelleher, L., Lu, H., Rohr, C., Harrison, G. & Thiel, C. (2019). Electric Car Purchase Price as a Factor Determining Consumers' Choice and their Views on Incentives in Europe. *Sustainability, 12*(22), *e*226357. https://doi.org/10.3390/su11226357

[21] Fournier, G., Baumann, M., Gasde, J. & Kilian-Yasin, K. (2018). Innovative mobility in rural areas - the case of the Black Forest. *International Journal of Automotive Technology and Management*, 18(3), 247-269. https://doi.org/10.1504/IJATM.2018.10013851

[22] Halbey, J., Kowalewski, S. & Ziefle, M. (2015). Going on a Road-Trip with My Electric Car: Acceptance Criteria for Long-Distance-Use of Electric Vehicles, Marcus, A. (Ed.) *Design, User Experience, and Usability: Interactive Experience Design*, DUXU 2015. Lecture Notes in Computer Science, 9188, 473-484, Springer, Cham. https://doi.org/10.1007/978-3-319-20889-3_44

[23] Husarek, D., Salapic, V., Paulus, S., Metzger, M. & Niessen, S. (2021). Modeling the Impact of Electric Vehicle Charging Infrastructure on Regional Energy Systems: Fields of Action for an Improved e-Mobility Integration, *Energies, 14*(23), *e*237992. https://doi.org/10.3390/en14237992

[24] Elangovan, P., Lust, D., Gökdemir, E., Silberer, J., Pietruschka, D. & Mrso, M. (2021). Smart2charge: smart grid enabled BEV charging infrastructure for rural areas. *The 5th E-Mobility Power System Integration Symposium*, 169-174. https://doi.org/10.1049/icp.2021.2520

[25] Letmathe, P. & Suares, M. (2020). Understanding the impact that potential driving bans on conventional vehicles and the total cost of ownership have on electric vehicle choice in Germany. *Sustainable Futures, 2*, *e*100018, https://doi.org/10.1016/j.sftr.2020.100018

[26] Zeng, Y., Schmitz, H. & Madlener, R. (2018). An Econometric Analysis of the Determinants of Passenger Vehicle Sales in Germany. *FCN Working Papers, 6*. https://doi.org/10.2139/ssrn.3239373

[27] Kölbl, R., Bauer, D. & Rudloff, C. (2013). Travel behavior and Electric Mobility in Germany. *Transportation Research Record, 2385*(1), 45-52. https://doi.org/10.3141/2385-06

[28] Ajanovic, A. & Glatt, A. (2020). Wirtschaftliche und ökologische Aspekte der Elektromobilität. *Elektrotechnik und Informationstechnik, 137*, 136-146. https://doi.org/10.1007/s00502-020-00812-x

[29] Pons-Seres de Brauwer, C. (2022). The Politics of Market Change towards Sustainability: Revisiting Germany's Policy Support Framework for Renewables. *Energies, 15*(11), *e*113898. https://doi.org/10.3390/en15113898

[30] Berndorfer, J. M. & Neudorfer, H. (2023). Simulation und Wirtschaftlichkeitsbewertung von Photovoltaikanlagen in Kombination mit Elektrofahrzeugen. *Elektrotechnik und Informationstechnik, 140*, 407-414. https://doi.org/10.1007/s00502-023-01140-6

[31] Krause, J., Small, M., Haas, A., & Jaeger, C. (2016). An expert-based bayesian assessment of 2030 German new vehicle CO_2 emissions and related costs. *Transport Policy, 52*, 197-208. https://doi.org/10.1016/j.tranpol.2016.08.005

[32] Mock, P., Hülsebusch, D., Ungethüm, J. & Schmid, S. (2009). Electric vehicles - A model based assessment of future market prospects and environmental impacts. *World Electric Vehicle Journal, 3*(1), 172-185. https://doi.org/10.3390/wevj3010172

[33] Trommer, S., Jarass, J. & Kolarova, V. (2015). Early adopters of electric vehicles in Germany unveiled. *World Electric Vehicle Journal, 7*(4), 722-732. https://doi.org/10.3390/wevj7040722

[34] Haustein, S. & Jensen, A. (2018). Factors of electric vehicle adoption: A comparison of conventional and electric car users based on an extended theory of planned behaviour.

International Journal of Sustainable Transportation, 12(7), 484-496. https://doi.org/10.1080/15568318.2017.1398790
[35] Roemer, E. & Henseler, J. (2019). The dynamics of electric vehicle acceptance in corporate fleets: Evidence from Germany. *Technology in Society, 68*, *e*101938. https://doi.org/10.1016/j.techsoc.2022.101938
[36] Stockkamp, C., Schäfer, J., Millemann, J. A. & Heidenreich, S. (2021). Identifying Factors Associated with Consumers' Adoption of e-Mobility-A Systematic Literature Review. *Sustainability, 13*(19). *e*10975. https://doi.org/10.3390/su131910975
[37] Hildermeier, J. & Jahn, A. (2021). Regulierungsansätze zwischen Markt und Staat bei der Netzintegration von Elektromobilität in Europa. *WSI Mitteilungen*, *74* (3), 226-233. https://doi.org/10.5771/034230020213226
[38] Nazari, F., Rahimi, E. & Mohammadian, A. (2019). Simultaneous estimation of battery electric vehicle adoption with endogenous willingness to pay. *eTransportation, 6*, *e*100088. https://doi.org/10.1016/j.etran.2019.100008
[39] Wang, X., Cao, Y. & Zhang, N. (2021). The influences of incentive policy perceptions and consumer social attributes on battery electric vehicle purchase intentions. *Energy Policy, 151*, *e*112163. https://doi.org/10.1016/j.enpol.2021.112163
[40] Silvia, C. & Krause, R. (2016). Assessing the impact of policy interventions on the adoption of plug-in electric vehicles: An agent-based model. *Energy Policy, 96*, 105-118. https://doi.org/10.1016/j.enpol.2016.05.039
[41] Breetz, H. & Salon, D. (2018). Do electric vehicles need subsidies? Ownership costs for conventional, hybrid, and electric vehicles in 14 U.S. cities. *Energy Policy, 2*, 238-249. https://doi.org/10.1016/j.enpol.2018.05.038
[42] Hagman, J., Ritzén, S., Stier, J. & Susilo, Y. (2016). Total cost of ownership and its potential implications for battery electric vehicle diffusion. Re*search in transportation business and management, 18*, 11-17. https://doi.org/10.1016/j.rtbm.2016.01.003
[43] Schneidereit, T., Franke, T., Günther, M. & Krems, J. (2015). Does range matter? Exploring perceptions of electric vehicles with and without a range extender among potential early adopters in Germany. *Energy research and social science, 8*, 198-206. https://doi.org/10.1016/j.erss.2015.06.001
[44] Schmalfuß, F., Mühl, K. & Krems, J., 2017. Direct experience with battery electric vehicles (BEVs) matters when evaluating vehicle attributes, attitude and purchase intention. *Transportation Research Part F: Traffic Psychology and Behaviour, 46*, 47-69. https://doi.org/10.1016/j.trf.2017.01.004
[45] Plötz, P., Schneider, U., Globisch, J. & Dütschke, E. (2014). Who will buy electric vehicles? Identifying early adopters in Germany. *Transportation Research Part - Policy and Practice, 67*, 96-109. https://doi.org/10.1016/j.tra.2014.06.006
[46] Dutta, B. & Hwang, H. (2021). Consumers Purchase Intentions of Green Electric Vehicles: The Influence of Consumers Technological and Environmental Considerations. *Sustainability, 13*(21), *e*12025. https://doi.org/10.3390/su132112025
[47] Fielding, N. G. (2012). Triangulation and Mixed Methods Designs: Data Integration with New Research Technologies. *Journal of Mixed Methods Research*, 6(2), 124-136. https://doi.org/10.1177/1558689812437101
[48] Timans, R., Wouters, P. & Heilbron, J. (2019). Mixed methods research: what it is and what it could be. *Theory and Society*, 48, 193-216. https://doi.org/10.1007/s11186-019-09345-5
[49] Wibisono, E. (2022). The Expansion of Qualitative Research Methods in Innovation Policy Studies, *STI Policy and Management Journal, 7*(1), 63-75. https://doi.org/10.14203/STIPM.2022.322
[50] Koh, K. & Ahad, N., 2020. Normality for Non-Normal Distributions. *Journal of Science and Mathemathics Letters, 8*(2), 51-60. https://doi.org/10.37134/jsml.vol8.2.7.2020
[51] Koengkan, M., Fuinhas, J. A., Belucio, M., Alavijeh, N. K., Salehnia, N., Machado, D., Silva, V. & Dehdar, F. (2022). The Impact of Battery-Electric Vehicles on Energy Consumption: A Macroeconomic Evidence from 29 European Countries. *World Electric Vehicle Journal, 13*(2), 36. https://doi.org/10.3390/wevj13020036
[52] Neaimeh, M., Salisbury, S., Hill, G., Blythe, P., Scoffield, D., & Francfort, J. (2017). Analysing the usage and evidencing the importance of fast chargers for the adoption of battery electric vehicles. *Energy Policy*, 108, 474-486, https://doi.org/10.1016/j.enpol.2017.06.033
[53] Barter, G., Tamor, M., Manley, D. & West, T. (2015). Implications of Modeling Range and Infrastructure Barriers to Adoption of Battery Electric Vehicles. *Transportation Research Record, 2502*(1), 80-88. https://doi.org/10.3141/2502-10
[54] Bourier, G. (2022). *Beschreibende Statistik*. Springer Gabler, Wiesbaden. https://doi.org/10.1007/978-3-658-05916-3
[55] Clarke, S., Sushil, S., Dennis, K., Lee, U., Gomoll, A. & Gates, Z. (2023). Developing Shared Ways of Seeing Data: The Perils and Possibilities of Achieving Intercoder Agreement. *International Journal of Qualitative Methods, 22*, *e*160973, https://doi.org/10.1177/16094069231160973

Authors' contacts:

Hoffmann Johannes, B.Sc.
Heilbronn University of Applied Sciences,
Faculty of Economics,
Bildungscampus, 74076 Heilbronn, Germany
johannes.hoffmann@hsgbr.com

Verena Szkudlarek, B.Sc.
Heilbronn University of Applied Sciences,
Faculty of Economics,
Bildungscampus, 74076 Heilbronn, Germany
vreni.szkudlarek@gmail.com

Daniela Ludin, Prof. Dr.
Heilbronn University of Applied Sciences,
Faculty of Economics,
Bildungscampus, 74076 Heilbronn, Germany
daniela.ludin@hs-heilbronn.de

Norbert Schreier, Prof. Dr.
(Corresponding author)
Esslingen University of Applied Sciences,
Faculty of Mobility and Technic,
Kanalstrasse 33, 73728 Esslingen, Germany
norbert.schreier@hs-esslingen.de

Erika Mueller, M.Sc.
Heilbronn University of Applied Sciences,
Sustainability Department,
Bildungscampus, 74076 Heilbronn, Germany
erika.mueller@hs-heilbronn.de

Wanja Wellbrock, Prof. Dr.
Heilbronn University of Applied Sciences,
Faculty of Economics,
Bildungscampus, 74076 Heilbronn, Germany
wanja.wellbrock@hs-heilbronn.de