INVESTIGATION OF POSSIBLE INFLUENCES ON THE DIFFERENT DEVELOPMENT OF REGISTRATION NUMBERS OF ELECTRIC VEHICLES WITHIN EUROPE

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Abstract: In Europe and other regions of the world, climate policy targets and concrete measures for the reduction of climate-damaging greenhouse gases have been defined in recent years, partly as a result of the Paris UN Framework Agreement, partly as binding and legally anchored, partly as more or less non-binding target formulations. In this context, the electrification of individual transport is seen as a central element of decarbonisation in the transport sector. Linked to this are political support measures that vary greatly in terms of type and extent at national and regional level. The automotive industry has also oriented itself towards e-mobility in recent years with considerable investments and an adapted brand and model policy. The significant increase in registrations in the main sales markets seems to confirm the success of electrically powered vehicles. Nevertheless, considerable differences between individual regions and countries can still be observed, even within economic clubs such as the European Union (EU). This paper deals with the question of which factors fundamentally influence the success or failure of e-vehicles on the automotive market and to what extent these influencing factors contribute in their impact to the regionally pronounced differences on the e-vehicle market. For this purpose, selected papers and studies were systematically analysed within the framework of a literature search and their results were evaluated in relation to the questions of this paper. The focus was on the European region, but not limited to it. The literature research was accompanied and supplemented by an analysis of selected data from the European region with the aim of identifying possible statistically significant correlations between the E shares in the vehicle market and certain demographic, social and economic conditions. One result of this study is that the success of e-vehicles on national markets can depend on a whole range of different factors, some of them regionally determined, and their combination. On the other hand, however, consumer behaviour as a whole is particularly influenced by certain factors or factor groups of an economic, political and socio-economic nature.

Keywords: Electromobility, mobility transition, consumer behaviour, charging infrastructure, political support measures

JEL Classification: G18, R40, O18

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1. Introduction

After steady growth in recent years, driven in particular by the Chinese market, the international automotive industry has had to cope with significant market declines in many parts of the world since 2018/2019. Global trade conflicts, national financial and economic crises, the Corona pandemic and its effects on purchasing behaviour and supply chains, and even the consequences of the Russia-Ukraine war in 2022 have all had a negative impact on the automotive industry, especially in the main sales markets of China, Europe and the USA. While the number of new registrations of light vehicles, essentially consisting of private vehicles, could recover in China and the USA in 2021, the European market will remain subdued in 2021 (cf. Table 1).

Tab. 1 Sales of light vehicles in million units; percent of registrations of electric vehicles

Region		2019	+/- %	2020	+/- %	2021	+/- %
Europe total	total	15,806	1	11,958	-24	11,775	-2
(EU, EFTA, UK)	Electro Vehicles		3,6		12,4		19,2
USA	total	16,953	-2	14,466	-15	14,921	3
	Electro Vehicles		1,9		2,1		4,1
China	total	21,073	-9	19,790	-6	21,101	7
	Electro Vehicles		5,2		6,3		15,8
world	total	79,964	-5	68,206	-15	71,317	5
	Electro Vehicles		3,4		6,42		11,8

Source: www.vda.de

Contrary to the general trend, e-vehicles (hybrids and BEVs) recorded dynamic growth in the most important sales markets. The European market saw a real sales boom in 2020 and 2021, driven primarily by the growth in battery electric vehicles (BEVs). Within two years, the share of new registrations increased from 3.6% in 2019 to 19.2% in 2021. In China, the share of e-vehicles in new registrations also jumped again in 2021, from 6.3% in 2020 to 15.8% in 2021. In total, about 3.3 million e-vehicles were newly registered in China in 2021, an increase of 168% year-on-year. The US car market, which has so far been rather reserved with regard to e-mobility, recorded almost a doubling of registrations in 2021 compared to the previous year. In the USA and China, the growth in e-vehicles will continue unabated in 2022, while in Europe they are currently stagnating after the "breakthrough" in 2020. The German industry association VDA attributes the "electric boom" in Europe mainly to the tightening of limit value regulations for GHG and CO2 emissions within Europe and the massive subsidy measures for e-cars in many European countries. In this context, however, the association also points to the wide range and the large differences between European countries and also sees the, in its view, hesitant expansion of the charging infrastructure in many parts of Europe as the main risk factor for a further spread of e-vehicles. In Norway, for example, the share of e-vehicles in new registrations in 2019 was around 86%, in Sweden around 44%, in Austria and Portugal 20%, while in Spain it was below 8% and in the Czech Republic only just above 3%. While the market for e-vehicles has developed into a series market in the more northern and western countries of the EU, it remains in a niche in the eastern and some southern states of the EU. This means that development in these countries falls far short of the expectations formulated by the EU in its climate targets. Overall, according to the VDA, "major efforts" are still needed to implement the mobility turnaround towards climate neutrality. (VDA Economic Barometer 09/2022, VDA Economic Barometer 02/2022, VDA Analyses of the Automotive Economy 2020).

In a study published in 2022, the Boston Consulting Group (BCG) assumes that e-vehicles will dominate the global market with a market share of about 80% by 2030. The authors of the study attribute the significant increase in production and sales of e-vehicles primarily to the recent political course-setting, combined with clear target quotas for emission-free drives. With regard to Europe, the EU's announcement to ban the sale of internal combustion engine vehicles (ICEVs) by 2035 is described as a "game changer". The EU is planning a statutory ban on the sale of internal combustion engines from 2035 in the member states, with the passenger car fleet to be emission-free by 2050. With accompanying investments in public transport and other low-emission mobility alternatives, the EU is trying to achieve its defined goal of reducing transport-related CO2 emissions by 45-50% by 2030 (based on 2005 levels). The Chinese government has set itself the goal of a "zero-emissions fleet" by 2060. To achieve this, 40% of cars sold are to be purely electric by 2030. And in the USA, too, the political goal has been formulated to sell only e-vehicles by 2030. However, the BCG analysts also see risks for a pervasive, sustainable market success of e-vehicles and thus for the achievement of the political targets. This mainly concerns battery production, supply chains and the supply of battery raw materials, on the other hand the required number of public charging points. (Niese et al., 2022).

The current state of research on possible factors influencing the market success of e-vehicles is summarised in the following section 1.2. From this, the research gap, questions and hypothesis of the thesis are derived in section 1.3.

1.2 Analysis of the state of research

In recent years, numerous studies and papers have been published on the topic of e-mobility. The following studies deal with the influence of social and demographic characteristics as well as technical and economic conditions on consumer decisions regarding the possible purchase of an e-vehicle. Regional differences are also taken into account. Many of the studies are limited to specific countries or regions, while some establish overarching correlations or comparisons. The methodologies and procedures used differ, but are often based on existing market, user and traffic data, which are analysed and evaluated using descriptive or combinatorial statistics. The behaviour of specific groups of people or households as well as regionally specific user groups are examined. While the works published before 2018/2019 mainly deal with the conditions on "early adopter markets", more recent studies increasingly turn to the rapidly developing serial market and consider possible scenarios and risks for future market developments in this context. Contributions on technical and scientific developments at manufacturers and in research, e.g. on technical innovations in battery and charging technology, are not part of the research. The most important results of the literature research are summarised below, grouped according to certain main topics.

On the benefits of e-vehicles for climate and health

Consistently, many of the studies considered point to the positive contribution of electrification to reducing global transport emissions, especially CO_2 emissions. The United Nations Framework Convention on Climate Change, known as the Paris Agreement, which has been ratified by almost 200 countries, defines the overarching climate goal as limiting anthropogenic global warming caused by the greenhouse effect to 1.5 °C (starting value: average value from the pre-industrial period of the years 1850-1900, final value year 2100). To achieve this goal, greenhouse gas emissions (GHG), in particular CO_2 , are to be reduced as completely as possible by the year 2050. Various studies point out that many of the national and international climate protection targets for CO_2 reduction can only be achieved if e-vehicles become much more established on the markets than is currently the case in many regions of the world despite all the market successes (Brückmann et al. , 2020). With a share of well over 20%, the transport sector is one of the largest emitters of carbon dioxide. The majority of this is generated in road traffic (Velten et al., 2019). The electrification of road vehicles can therefore make a significant contribution to decarbonisation and thus to climate protection (Degirmenci et al. , 2017; Velten et al., 2019). This is particularly true when renewable, CO_2-neutral energies are used to cover the electricity demand of electrically powered vehicles (Schmalfuß et al. , 2017). A clear and recognised benefit for the environment, as a contribution to climate protection, also helps to increase the acceptance of e-vehicles among consumers. According to Brückmann et al. (2021). it is not sufficiently demonstrable whether this factor plays a significant role in purchasing decisions. In other studies, the environmental benefits of e-cars are definitely assigned a significant influence on consumer decisions. Based on survey data, Degirmenci et al. (2017) assess the "environmental performance" of electric vehicles (BEV) as a stronger criterion than the purchase price and the range, the latter two nevertheless important, significant drivers.

On the influence of costs for e-vehicles

From the consumer's point of view, the costs of purchasing and operating a vehicle play an important role in purchasing decisions. Electric vehicles are more expensive to purchase than comparable vehicles with conventional drives. The driving force here is the cost of the vehicle battery. On the other hand, there are possible savings in operation, fuel, maintenance and repair. Scorrano et al. (2020) refer to various studies that assess the total cost of ownership of BEVs compared to internal combustion engines as limited and only competitive under certain, limited conditions. The high purchase price in combination with high value losses due to faster "ageing rates" of existing technologies are often determining variables in cost analyses to the disadvantage of electric vehicles. Many studies of the last few years conclude that electric vehicles are not or only to a limited extent competitive in terms of consumer costs without political subsidies. However, given the highly dynamic nature of the market, combined with continuous technical, economic and political changes, the meaningfulness of operating cost determinations for BEVs may well be limited in time. Lower purchase costs due to increased competition and production effects, policy incentives, technological advances and competitive charging costs can significantly shift operating cost advantages. Scorrano et al. (2020) evaluate the total cost of ownership (TCO) as an alternative feature in the purchase decision of rationally deciding consumers, which can potentially compensate for the disadvantages of the higher acquisition costs of BEVs. In their cost modelling for the Italian car market, the authors consider three "consumer factors", among others: The possibility to charge with cheaper night electricity, the share of urban trips where conventional drives (ICEVs) lose consumption efficiency and the distance travelled (in km/year). The model calculations lead to the conclusion that for the Italian region considered, "home charging" and urban transport are the determining cost determinants for the operating costs in favour of BEVs. The annual mileage and the possibility of home charging exert the greatest influence on the TCO. BEV models in the small and compact car segment in predominantly urban traffic with comparatively low overall traffic performance and a high proportion of night or home charging are competitive from a cost perspective. However, although BEV's could already show cost advantages for an estimated over 11% of car owners in Italy within the considered study area today, the market share of e-vehicles at the time of the study is around 1% of new registrations. Assuming rational consumer decisions, cost aspects alone cannot be the main criterion for the decision in favour or against BEVs. He et al. (2017) also point to the economic advantages of home charging and the associated attractiveness from the user's perspective. According to this comprehensive cost and consumer analysis based on data from China, the USA and Germany, around 98% of EV users take advantage of home charging or charging at work. Dumortier et al. (2015) use survey data among US consumers to investigate whether and to what extent transparent information on operating costs influences e-vehicle purchase decisions. According to their findings, consumers' preference for small and medium-sized e-vehicles increases when transparent information on total cost of ownership is available, despite higher purchase prices compared to conventional drives. In contrast, an effect of information on fuel and electricity prices and consumption on purchase preferences was not statistically verifiable in the USA. The study also concludes that preferences for e-vehicles decrease with age and that knowledge about local charging options significantly influences the purchase of an e-vehicle. Raustad (2017) reports on the results of a research project at the University of Central Florida (UCF), according to which the economic viability of e-vehicles is decisively co-determined by traffic performance and usage profiles, but in the case of popular vehicles in the smaller vehicle segment, there is also an overall economic viability across different driving profiles, even when government subsidies are neglected. In this context, Raustad (2017) refers to the possibilities of low-cost self-energy generation and use, e.g. through PV systems. In the long term, falling battery costs would shift economic considerations directly in favour of e-vehicles. The study by Tamor et al. (2015), which is based on the analysis of US data, shows that the use of smaller e-vehicles with shorter ranges in multi-vehicle households is an economically sensible alternative. Any range bottlenecks, for example triggered by spontaneous trips, could be compensated for by alternative vehicles. Jakobsson et al. (2016) focus explicitly on the characteristic "single or multi-car households" and evaluate travel and consumer data from Germany and Sweden for this purpose. According to this, BEVs as second cars, combined with a lower mileage used, prove to be significantly more attractive in both countries than in the context of a first or single car use, both from a technical point of view (keyword range limitation) and from an economic point of view in terms of operating costs. However, differences can be found in the comparison of the economic efficiency between the two countries, possibly justifiable by different economic framework conditions and subsidy approaches. Letmathe & Suares (2017) analyse the total cost of ownership of e-vehicles (BEV and HEV) compared to vehicles with combustion engines for the German market. According to this, fully electric vehicles are more interesting from an economic point of view for smaller vehicle types, lower mileages and thus usually also lower ranges, e.g. in urban traffic. Hybrid drive systems can also offer economic advantages in the premium segment with higher mileages and ranges. Subsidies improve economic efficiency, but cannot compensate for economic disadvantages for all use cases, especially in view of high acquisition costs in the hybrid sector. Charging costs represent an important part of the operating costs for electric vehicles. In this context, Guo & Chan (2015) complain about the lack of a global, holistic approach to "intelligent charging management" in order to improve the overall economic efficiency of electric vehicles. Optimised charging management could avoid peak loads in the local, regional or national electricity grid, while making optimal use of phases of low load. Under these conditions, electricity could be purchased at marginal cost. By smoothing the load curves, wind energy in particular can be used more efficiently and thus the overall benefit of renewable energies can be increased. Junquera et al. (2016) point out the hurdle of a high purchase price of e-vehicles. Despite possible net savings in the total cost of ownership in the perception of consumers negatively influence the willingness to buy. This may be due to financing options or it may "deter" consumers as they cannot, at least subjectively, see any countervailing added value or benefit for themselves that compensates for the high purchase Limited lifetime combined with high costs may "deter" consumers. Attractive battery warranties, battery replacement programmes or battery leasing offers can help reduce concerns about battery replacement costs or battery life. A wider range of offers for cheaper model series, especially for younger consumers, can also contribute to better affordability of an e-car. For younger consumers, other forms of mobility are also interesting and attractive, e.g. car sharing. Corresponding offers could be expanded to promote e-mobility. Liao et al. (2019) also assess the high purchase price as a major obstacle on the way to market definition of e-vehicles and in this context see alternative, specifically oriented business models as a possible contribution to sustainable commercialisation success. Uncertainties regarding, for example, battery life, maintenance and residual values represent significant purchase risks from the perspective of many consumers, especially in combination with high acquisition costs, and argue against the Classic Model of "paying the full purchase price in exchange for acquiring full ownership" from a consumer perspective. Based on a multi-stage consumer survey of around 1,000 people in the Netherlands, three other variants of business models are evaluated: vehicle leasing, battery leasing for fully electric vehicles (BEVs) and the mobility guarantee model, i.e. the provision of suitable replacement vehicles for long journeys. In summary, the study shows that vehicle leasing in connection with the BEV vehicle type is a significant preference. Battery leasing as a special form of vehicle leasing, on the other hand, cannot be assigned a major effect on consumer behaviour. In short, the preferences for vehicle leasing are generally more pronounced among younger, higher-earning and more educated people, while those for mobility guarantees and battery leasing are lower.

Influence of political interventions and guidelines

The expansion of electric mobility is assigned a central role in the reduction of transport-related emissions within the framework of climate protection policy in many industrialised countries. The interest and commitment of politicians to measures that support the expansion of e-mobility is correspondingly high. However, the promotion policy differs considerably in some cases, certainly also depending on specific political framework conditions such as budget possibilities or different programmes of the respective government officials. A study conducted by the Ecologic Institute on behalf of Greenpeace e.V. in 2019 examines the effectiveness of political support measures on the expansion of e-mobility from a cost-benefit perspective. The study looks at various measures or packages of measures, ranging from a ban on combustion engines to quotas or limits on emissions and other governmental measures. emissions and other government regulations (e.g. the regulation of fleet consumption) to incentives for the purchase and use of e-vehicles (in the form of premiums, tax benefits, free parking and charging, etc.) and indirect subsidies, e.g. through the subsidisation of charging infrastructure. (Velten et al., 2019). Apart from the direct effect of bans and limits, a (temporally) coordinated, adapted to the market development, i.e. dynamic promotion strategy in the form of bundles of measures, from purchase assistance to bans/regulations, is considered effective.

Financial incentives are judged to be particularly effective if they are coupled with disincentives for combustion engines (bonus-malus system). In this context, reference is made to the examples of Norway and France. The promotion of the charging infrastructure, including the associated technical standardisation, is named as one of the essential individual success factors for the expansion of e-mobility.

Brückmann & Bernauer (2020) also address the question of the effectiveness of political measures to promote electromobility, pointing to the major influence of political interventions on the spread of e-mobility, in the form of both positive and negative incentives, as described in many publications. The findings of scientific studies on political market interventions indicate that incentive-based measures such as subsidies (pull measures) generally meet with more acceptance in the public perception than restrictive or deterrent regulatory and prohibitive measures (push measures). Voluntariness is perceived more positively than coercion. Brückmann et. al (2020) confirm in their study using the example of Switzerland, a country that has hardly any state intervention policy with regard to electromobility, on the one hand that incentive-based interventions receive significantly more support than restrictive measures, and on the other hand that the degree of acceptance does not change statistically significantly even for investment-intensive measures such as state investments in the charging infrastructure if the financing requirements are disclosed.

In an extensive paper by Bohnsack et al. (2015), the influence of political interventions on technology development is examined, historically and with regard to low-emission vehicle technology (LEV). In doing so, it points to the major influence of political framework conditions and decisions on the innovation management of vehicle manufacturers and thus on certain technology fields through guiding and promoting measures, which has been proven by numerous studies. Bohnsack et al. (2015) see politics as the driving social force behind the development of alternative, low-emission vehicles, starting in California in the 1970s and continuing until today. The political objective of reducing harmful pollutants such as hydrocarbons or nitrogen oxides is increasingly supplemented in the 2000s by the basic direction of CO2 reduction as a climate-damaging emission. In the historical context, the authors see the period 2006 to 2010 as a "revival of electrics", marked by the search for alternative, climate-friendly drives, advances in battery technology, the introduction of plug-in technology and the growth in hybrid drives. Bohnsack et al. (2015) see a political initial effect in the Kyoto Protocol adopted in 1997, which formalised climate policy measures at a broad international level under international law and was included in numerous national programmes. In sum, the authors assess political programmes with corresponding international, cross-border diffusion power as an important influence or driver of LEV development as a whole and refer in this context to the Californian ZEV (Zero Emission Vehicle) of 1990, which envisaged a certain proportion of emission-free vehicles and developed a broad international impact with influence on political initiatives outside California and the United States, for example in Japan and Germany. In their literature and study comparisons, Brückmann et al. (2021) point out that the factors influencing market penetration in regions with strong policy interventions and those with weaker ones tend to be the same or at least similar, e.g. home ownership, education, density, environmental protection efforts and income, but vary significantly in their manifestation or effects, and can have a stronger impact in regions with pronounced subsidy policies, as shown e.g. by developments in the Netherlands, Norway, Denmark and Germany.

The influence of charging infrastructure, charging management and range limitation

Jakobsson et al. (2016) point out that the available studies from different countries and regions are rather indifferent with regard to the question of the essential framework conditions and criteria for the use of e-vehicles and do not allow any uniform, universally valid conclusions, but many study results, especially from the USA, point to the range limitation as an important argument for or against the purchase of e-vehicles. According to Jakobsson et al. (2016), an expansion of the charging infrastructure that enables convenient and economically attractive charging from the user's perspective could lead to a significantly increased benefit of BEVs compared to conventional vehicles. Hardman et al. (2018) deal with various studies on charging infrastructure and the question of how a corresponding infrastructure should be designed in order to effectively support the market penetration of EVs and focus on preferences from the consumer's perspective. Although the charging infrastructure is identified as a "general" success factor for e-vehicles, the specific design of this infrastructure is considered crucial. On the one hand, it must be oriented towards existing consumer and user profiles, and on the other hand, it must be designed in such a way that local and regional electricity grids are not impaired. In addition to the requirements for charging time, the authors see location, accessibility, number and handling as well as the payment system as the main criteria for a consumer-friendly and supply-optimised design. The study concludes that location is the most influential criterion in terms of infrastructure. Research shows that by far the most frequently used charging location is the home, followed by charging stations at the workplace. Public locations and corridors, on the other hand, are used less frequently. In addition to location, transparency and universality play a role in the payment system and, of course, the cost of charging overall. The number of charging options close to home is highest in Norway and California, but low in the Netherlands and China. In terms of charging management, regulating charging rates and times, Hardman et al. (2018) see different approaches, e.g. electricity price incentives for certain time windows when the public grid is hardly or less loaded. The authors see charging infrastructure as one component of an overall policy strategy that should be considered for an efficient promotion of the e-vehicle market. Charging options close to home, transparent payment systems that are as standardised as possible and intelligent charging management are mentioned as potential success factors in this context. In addition to the acquisition costs, Junquera et al. (2016) identify the shortening of charging times and the increase in autonomy (range) as significant influences on consumer behaviour among Spanish vehicle users. Technological advances in terms of charging and battery technology, charging management, standardisation and charging infrastructure are seen by the authors as important starting points for investment. With regard to investments in charging infrastructure, a classic dilemma emerges: investments in charging infrastructure are essential for increasing the share of E-vehicles; on the other hand, a low number of E-vehicles hinders the willingness to invest in infrastructure. Political intervention is therefore described as almost essential. The issue of "range anxiety" in connection with EV purchase considerations in an "early adopter market" is also addressed by Schneidereit et al. (2015), who referred to "range extender technology" in this context as a way to counteract corresponding consumer concerns. The main drive in range extender vehicles (EREVs) is electric and is enabled by lower-cost batteries of medium or smaller capacity. A smaller internal combustion engine is available as a "bypass", which can be used when the electric range is exceeded and with which the vehicle can be operated independently. The authors see great potential in such hybrid concepts to overcome purchase barriers caused by consumers' range anxiety and thus to accelerate the electrification of vehicle fleets. Users with corresponding range requirements see the hybrid solution of the EREV as an acceptable solution to their demand profiles.

The influence of factor combinations

For a market without strong political influence on e-mobility, Brückmann et al. (2021) examine possible driver factors for the market growth of e-vehicles, taking Switzerland as an example. According to the authors, the market acceptance necessary for the implementation of the political climate targets is still not given, at least not across countries or regions. This particularly affects regions that largely do without accompanying political support measures to promote e-mobility. Brückmann, Willibald and Blanco assess the market penetration of e-vehicles as highly location-dependent, also depending on local or national demand-side subsidies and political guidelines. Using Switzerland as an example, they examine the influence of socio-economic, demographic and political influences such as education level, income, housing structures, multi-car influence, car sharing possibilities, charging infrastructure as well as the influence of political preferences and technology affinity of consumers. Despite high GDP and an environmentally sensitive population - factors that can potentially have a positive impact on market growth - the share of e-vehicles in Switzerland remains strikingly low at 1.7% new registrations in 2018. From the study, significant, positive correlations emerge in this context between BEV ownership on the one hand and income, multi-car households, home ownership, car-sharing options, a strong environmental policy conviction and an affinity for technology on the other.

However, the effects are most pronounced for home ownership. Households that own their own homes are much more likely to use BEV vehicles than households that do not own their own homes - an effect that is attributed to the possibility of home charging. Home charging is identified as a key to success that should guide policy decisions. A significant correlation between population density and public charging infrastructure, but also with regard to the level of education, was not found. The significant influence of income is also attributed to the lack of support measures for the purchase of e-cars. The low level of subsidies in combination with a relatively small share of home owners in Switzerland could, in the authors' view, be one of the explanations for the low market penetration in Switzerland. Javid & Nejat (2017) investigate possible influences on the market penetration (vehicle density) of BEVs and plug-in hybrids in a total of 58 Californian counties. From a total of 17 investigated parameters or possible influences, the authors identify infrastructural influences such as charging station density (in relation to inhabitants), car sharing, socio-economic parameters such as education level, annual income as well as traded petrol prices as statistically significant influencing factors on the purchase of PEVs. Influences of demographic parameters such as age, gender and employment on purchase decisions are not found in the study. Likewise, characteristics such as home ownership, housing type, number of household members and vehicles, PEV manufacturer density, population density and the price of electricity are not found to be statistically significant. The fact that an effect of travel time (mileage) is not detectable is described as "surprising". In summary, the authors see public infrastructure investments as a major lever for the diffusion of PEV vehicles in California. In their model analysis, which is also based on data from the USA, Nazari et al. (2018) assign a co-determining influence to certain socio-economic factors. According to this analysis, the probability of purchasing PEVs increases significantly for households with higher incomes and educational qualifications.

Berkeley et al. (2018) look at possible market barriers or obstacles, i.e. negative influences on the acceptance of e-vehicles, using the example of Great Britain, the second largest car market in Europe. The authors refer to the still low overall market shares in the e-vehicle sector measured against the total market, with the "exception of Norway". In total, 19 characteristic factors are identified and evaluated as barriers to e-car purchase decisions from the drivers' perspective, categorised into "economic uncertainties" and "socio-technical factors". The high purchase costs and the question of the availability of charging stations emerge as those barriers that are judged to be "pronounced" or "really serious". Overall, according to Jarvis and Jones, financial concerns are more prevalent, such as high acquisition costs, operating costs and resale value. Questions about battery technology and maintenance infrastructure are other uncertainties that are increasingly mentioned in connection with the purchase of e-vehicles. Classic technology factors such as reliability and more personal preferences regarding designs and aesthetics, on the other hand, are far less pronounced, at least as negative characteristics. Berkeley et al. (2018) see a lack of information and education with regard to charging options, but also with regard to existing economic uncertainties, in order to counteract any lack of transparency. For Great Britain, the authors find a statistically significant correlation between age structures and economic concerns as well as a clear difference between the populations of the metropolitan region of London and the more rural areas. Economic concerns are significantly more pronounced among older consumers in rural Britain than among younger Londoners. The authors conclude that it is not individual factors that determine non-purchase of an e-vehicle, but rather a combination of different deterrents, real or hypothetical, that lead to purchase rejection. The development of consumer awareness in the context of a growing share of e-vehicles is addressed by Long et al. (2019). Comparing two Canadian consumer surveys on the knowledge of key attributes of plug-in vehicles (PEVs) from 2013 and 2017 from different provinces, Long et al. show that consumer knowledge has not demonstrably increased over this period, despite dynamic technological developments and the broadening of models and market shares over this period. The increasing variety of models and poor quality of advice from retailers are cited as possible reasons for this. Long et al. (2019) assess the stagnating awareness and the still lacking consumer understanding as an important barrier to market success. A study by Schmalfuß et al. (2017) from Germany investigates the possible influence of existing market experience with BEVs on the purchase decision process. Experience-oriented attributes such as noise emissions, smooth running and acceleration behaviour could have a positive effect on interested consumers and thus contribute to the purchase decision in favour of e-vehicles, while other attributes that previously had negative connotations could be relativised or eliminated over time. This is not confirmed by the results of the survey study. In summary, the study does not show any significant effect of experience effects on consumers' purchase intentions, at least not with decisive criteria. In an analysis of the current state of research with a focus on early adopter studies, Coffman et al. (2017) find that purchase costs and range, and in connection with this the charging infrastructure, are the dominant factors for purchase preferences with regard to e-vehicles. On the influence of individual consumer characteristics, the study paints an indifferent picture. Coffman et al. (2017) point to different study results on the influence of socio-economic and demographic characteristics on e-vehicle purchase preferences, for example in relation to the factors income and education. While several studies identify a positive correlation of these factors, others conclude that there are no significant effect relationships. Furthermore, the authors found the effect of incentive policy measures to be ambiguous and referred in this context to the influence of regionally and locally different framework conditions and to the varying attractiveness of incentives, e.g. the respective level of purchase premiums.

Comparative studies

Ajanovic & Haas (2016) analyse the market development of EVs in various metropolises with the aim of evaluating influencing parameters and boundary conditions for market developments in metropolitan areas. Against this background, the authors also refer to the continuously increasing urbanisation trends worldwide and the associated transport and climate policy challenges. Growing transport performance and vehicle densities, increasing urbanisation worldwide and rising prosperity in industrialised countries in recent years counteract a trend reversal in the transport sector towards a sustainable reduction of emissions, especially of CO_2 . Private and publicly used e-vehicles can play an important, if not key role in a sustainable urban transport policy, especially in conjunction with the expansion and use of renewable energies. In this context, the degree of penetration of electrification determines the potential savings in emissions. Based on these considerations, there is almost no alternative to converting the vehicle population to BEVs as quickly as possible as the only marketable variant for emission-free drives, at least while maintaining the existing degree of mobility. Urban metropolises offer favourable conditions for alternative transport concepts. The daily distances travelled are rather low in the inner city but also in the suburbs. The connections to public transport are usually already well developed. There are sufficient users for mobility on demand and sharing systems. The average age in urban regions is generally lower than in rural regions, and the level of education and affinity with technology is higher. Despite comparable basic conditions, the study reveals considerable differences in the use and efficiency of e-mobility when looking at different metropolises. By far the highest share of e-vehicles in the stock is in Oslo (Nor), followed by Portland (US), Amsterdam, Rotterdam (both NL) and Los Angelos (US). The analysis shows some significant differences in the charging infrastructure, home charging options, fuel and electricity costs, the energy mix for electricity generation, but also in the economic strength of the individual metropolises. All in all, these factors lead to a very differentiated picture with regard to the market penetration of e-vehicles and the climate and health benefits. Regardless of the above-mentioned factors, the political packages of measures and strategies are emphasised as a co-determining factor, which vary greatly at both national and local level. They range from essentially nationally determined tax benefits and incentives, such as exemption from car tax, to purchase premiums for vehicles and charging stations, to benefits for the use of transport networks. The Norwegian capital Oslo offers a variety of national and local, monetary and non-monetary benefits. Fuel prices are high in comparison, electricity prices rather low, investments in public charging infrastructure are ambitious, the share of renewable energy in electricity generation is high. The share of private cars in the transport mix is approx. 35% and thus rather in the middle range, the daily transport performance of 30 km/person is also rather in the middle range of the city comparison, the charging density is high, the economic power as well. All in all, Oslo offers much more favourable conditions for the spread of BEVs than the other metropolises considered. According to Ajanovic & Haas (2016), however, one should refrain from establishing generally applicable rules with regard to the spread of e-mobility, as local circumstances and conditions are often too different. Portland and LA, for example, have a significantly higher share of passenger cars than New York, for example. The study concludes that expensive political support measures for private vehicles in metropolitan areas should be very carefully considered and that other transport policy measures may have a more environmentally sustainable effect, e.g. the expansion and electrification of public transport. In any case, however, sustainable power generation from renewable sources is a basic prerequisite for e-strategies that are efficient in terms of climate policy. From such a perspective, the expansion of renewable energies and e-mobility must go hand in hand. A comprehensive comparative study of different European countries by Costa et al. (2017) on the economic and environmental benefits of EVs compared to ICEVs based on TCO and GHG emissions shows large differences in the economic viability and climate benefits of EVs, even when comparing countries. The benefit is expressed and evaluated by a payback in km performance, depending on the respective mobility profiles considered. The authors of the study attribute the regional differences in economic efficiency and environmental benefits to different energy mixes, among other factors. While most countries show an ecological payback of less than 60,000 km, the model calculations for Estonia and Poland are over 100,000 km. For Poland, where coal plays a central role in energy supply, the payback is as high as 190,000 km. With regard to the economic payback, based on a selection of representative vehicle types, various country-specific differences lead to very different economies. For example, different costs for fuel and electricity, expenses for insurance and tax and differences in the acquisition costs of a vehicle play an important role. Different government subsidies but also differences in the pricing policies of manufacturers lead to different amortisations. While consumers in Iceland and Denmark, for example, could generate an immediate economic benefit, BEV's are not yet economically competitive in other countries. For example, large differences between BEV and ICEV costs combined with "unfavourable" mobility profiles in individual countries such as Poland, Slovakia and the Czech Republic, lead to very high paybacks. In addition, high acquisition costs in countries with lower GDP lead to greater inhibitions or problems with financing. The ratio of "differential cost of acquisition" to GDP is unfavourable from a consumer perspective, especially in Eastern European countries. Costa et al. (2017) recommend, in view of the large differences between European countries in terms of the respective benefits of e-vehicles, a targeted coordination of political support measures and fiscal regulations that is oriented in such a way that the widespread diffusion of e-vehicles can be promoted so that both economic and environmental benefits can be generated.

Summary

In principle, many of the scientific publications analysed point to the climate policy necessities and the political framework conditions that make a rapid and sustainable spread of e-vehicles necessary and promote it. In contrast, there are barriers and risks that can at least delay such a spread of e-mobility. Overall, it can be deduced from the analysis of the literature sources considered that the variables that contribute to the market success or failure of e-vehicles are quite diverse and their effects depend to a large extent on the user profile and regional conditions as well as certain constellations of impact factors. Despite the diversity of influences, the "central variables" are a) costs from the consumer's point of view, b) factors that could influence the user behaviour and profile, and c) certain socio-economic variables such as income or household circumstances such as home ownership or second vehicle use. It should be added here that the characteristics from the consumer perspective are primarily negative characteristics. Promoting the purchase of EVs is thus often about relativising or completely removing concerns, barriers or obstacles to purchase. For the sake of clarity, most of the influencing factors examined can be categorised as technical, political, socio-economic or demographic. A social-cultural component could also be added. Certainly, it is also due to this variety of influencing factors that market successes of EVs differ so clearly. However, economic reasons (acquisition costs and operating costs), charging options and the respective political support measures can be named as dominant.

1.3 Research gap, research question and thesis

Despite all the understandable regional and national differences, the large differences in the market development of e-vehicles within certain economic areas such as the USA or the EU, important sales markets in the automotive sector, are striking. From the author's point of view, the previous state of research on the market development of e-vehicles often focuses on certain factors and locally limited markets. The author is not aware of any work that specifically examines social, economic, demographic and political influences on the market expansion of e-vehicles within the entire EU. Such a work, which looks at the entire economic and political club and analyses the possible reasons for the very different developments within the EU across the board and is not limited to a comparison of individual, few countries or regions, could contribute to a better understanding of the topic "spread of electric mobility". The present study is intended to contribute to closing this gap. Derived from this, the guiding questions of the thesis are: "Which factors, conditions and influences contribute significantly to the observed, large differences in the market success of e-vehicles in the individual countries of the EU? Can overarching central success factors and conditions for e-vehicles be identified within the EU that differ regionally?" In view of the expectations associated with the spread of e-vehicles, both politically and economically, these and related questions are, in the author's view, of interest not only to academia, but also to business and politics.

The focus of the work is on the analysis of societal, social, demographic and economic factors. Based on the current state of research, the following theses are derived and verified within the framework of the work:

H1: E-vehicles are seen as premium goods by consumers, the vehicle users. Their purchase depends on the economic circumstances and possibilities of the consumers. Purchases are supported by political incentives

H2: E-vehicles are seen as new technology by consumers. Affinity for technology and openness to new technologies play an important role in the purchase decision

H3: A major barrier to the purchase of EVs can be the charging infrastructure, coupled with charging management. Potential e-vehicle users want convenient and comfortable charging, without restrictions on specific usage requirements and profiles.

The methodology and procedure described below serve to address, possibly answer and verify the questions and the theses formulated.

2. METHODOLOGY

A mixed-method approach was chosen as the methodological approach:

- By applying an SLR to the current state of research, key variables influencing market developments in the e-vehicle sector are to be identified and assessed.
- Through a targeted selection and evaluation of existing economic, sociological and demographic data from different countries of the EU, the results from the literature analysis will be verified and possible causal relationships in the form of correlations of individual factors with country-specific market developments in the e-vehicle sector will be evaluated on the basis of statistical significances.

The combined application of literature research and descriptive statistics is intended to ensure the largest possible information base, which is to be verified and evaluated in a second step through the evaluation of existing data and information derived from reliable sources. In this way, the work should do justice to the complexity of the topic and enable a fact-oriented, scientifically sound answer to the formulated questions. The influence of political measures is only assessed qualitatively in paragraphs 3 and 4. For this purpose, the current status of political measures in the individual EU countries will be compared with the respective spread of e-vehicles.

2.1 Structured literature search

In a first step, international scientific publications were searched for key terms and defined time periods using common platforms such as Web of Science (WoS) and Google Scholar. As a temporal selection factor, the publication year was limited to the period 2014-2021. Both German-language and English-language scientific articles and also evaluated independent studies were used. Initially, the articles were not focused on the European region. In the course of the research, it was found that factors influencing e-mobility in the USA (predominantly California) have already been extensively studied and evaluated. The approaches from this were used as a basis for further research and data analysis for the European area. Following Rowley & Slack (2004), a mind map was created on possible influences on the market development of e-mobility. The method of the mind map is intended to support the derivation of suitable, narrowing down search terms and to contribute to a better understanding of the most diverse interrelationships. To identify the research gap and specify the research questions, 62 articles were first selected and analysed with regard to a research gap and divided into categories using a matrix. As a result, around 41 articles and studies were shortlisted from a total of 62. From these, 25 articles were selected which, from the author's point of view, contained the most comprehensive information with regard to the questions and theses posed.

2.2 Data analyses:

For the data analysis, existing data from the portals "Statista" and "Eurostat" were used. The basis for this is formed by data reports from the national and international data collection centres, for Germany for example the Federal Motor Transport Authority from the period 2018-2021. Possible correlations with the registration shares of e-vehicles (BEV and HEV) in the EU countries under consideration were examined. The following were tested for statistical significance: 1) data on the degree of urbanisation: population density (inhabitants per m2), population share in urban and rural areas, 2) data on demographics: population shares according to specific age groups, 3) social and economic data: average income per employee, gross domestic product per inhabitant, expenditure on R&D, the level of digitalisation based on the DSI (digitalisation index), proportion of the population with higher educational qualifications (tertiary level) and 4) data on infrastructure such as number of charging points per inhabitant, density of fast charging points per km of long-distance transport network. The data series were country-specific and separated into fully electric drives (BEV) and hybrid drives (PHEV) as well as total electric drives (EV). The correlations of individual data sets were evaluated for statistical significance according to Pearson using linear regression. The calculation was carried out using the statistical programme SAS 9.4 (SAS Institute, Cary, NC, USA). Significance of correlations was assumed at a level of $p < 0.05$. For a first assessment of the influence of political support measures, current registration shares from the year 2021 were qualitatively compared with the current political support programmes. For this purpose, data from the Association of European Automobile Manufacturers was used.

3. RESULTS

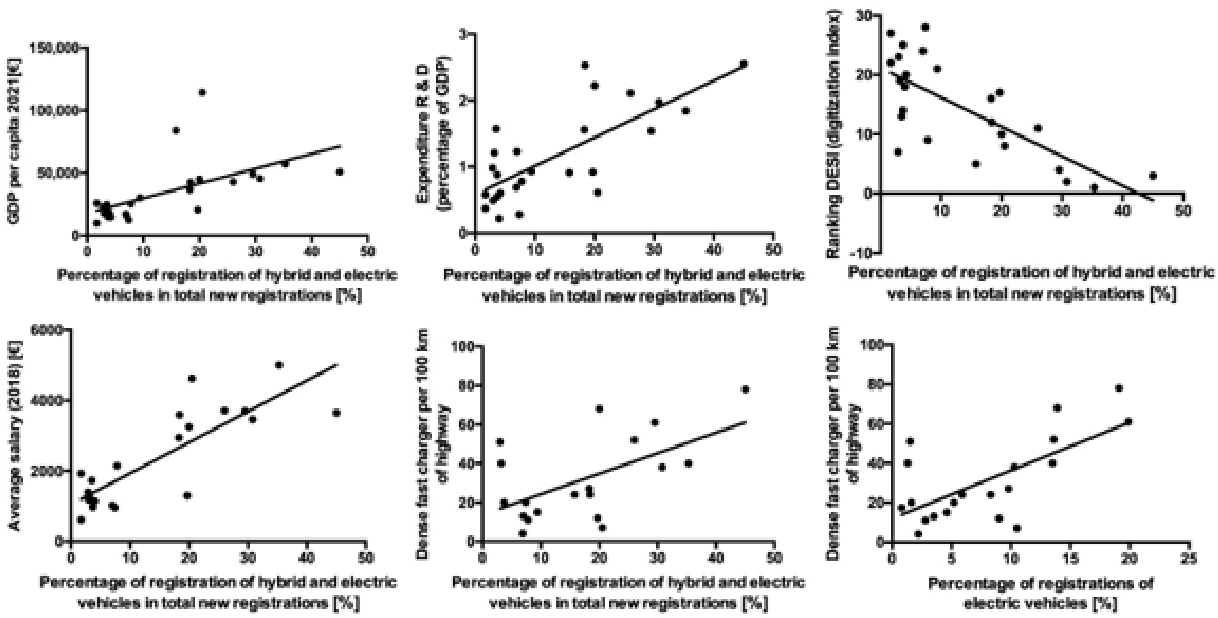
The main results of the systematised literature review are summarised in section 1.2, section 4.1 contains the main conclusions. Table 2 and the following plots summarise the main results of the statistical data analysis according to Pearson. The characteristic values in Table 2 refer in each case to the sum of e-vehicles (BEVs and PHEVs). Separate presentations of the results for each drive type are included in the appendix. In the comparison of the two drive variants BEV and PHEV, no noticeable differences in the results are discernible, with one exception. Overall, the results of the statistical evaluation show a stable and coherent picture. The registration shares of EVs in the EU countries considered clearly correlate with the average income of the population. The correlations are highly significant ($\rho=0.83$, $p<0.0001$). The GDP in € per person ($\rho=0.6$, $p=0.0013$) correlates less markedly, but still significantly, with the registration shares. Both variables, income and GDP, are indicators of wealth. A clear correlation can also be derived for research and development expenditure, especially in relation to inhabitants ($\rho=0.88$, $p<0.0001$). Likewise, the country rankings on digitisation in the form of the DESI (Digital Economy and Society Index) correlate significantly with the approval shares (ρ=0.6, p<0.0001). The variables digitisation index and expenditure on R&D could, in addition to the general level of research and development, also index technology affinity of a country and its population. The results of the data analysis suggest that the e-vehicle market is more likely to be promoted in countries with more pronounced research and development activities, which also tend to be associated with greater technological progress. A direct correlation between the proportion of the population with a higher level of education (tertiary level) and the spread of e-vehicles, on the other hand, cannot be determined or evaluated as significant.

With regard to age structures and population shares in rural and urban regions and population density as a whole, no significant correlations are discernible either. An influence of demographic structures and urbanisation distributions can therefore not be derived from the available data. An assumed dependency of e-registrations on charging point density does exist, but the correlation is significantly weaker than for other significant influences. This applies both to the total density of charging stations (ρ=0.57, p=0.0025) and to the density of fast charging stations in the long-distance network (ρ=0.58, p=0.0092). However, the analysis according to electric drive types yields a differentiated picture. For all-electric drives (BEV), significantly more significant correlations can be seen (ρ=0.73/p<0.0001; ρ=0.66/p=0.002) than for hybrid drives (ρ=0.38/0.44 for fast charging points). The result is also not surprising from a technical perspective. Hybrid vehicles are not only electrically powered, the dependence on the charging network is generally lower. The significant correlations described are also easily recognisable graphically.

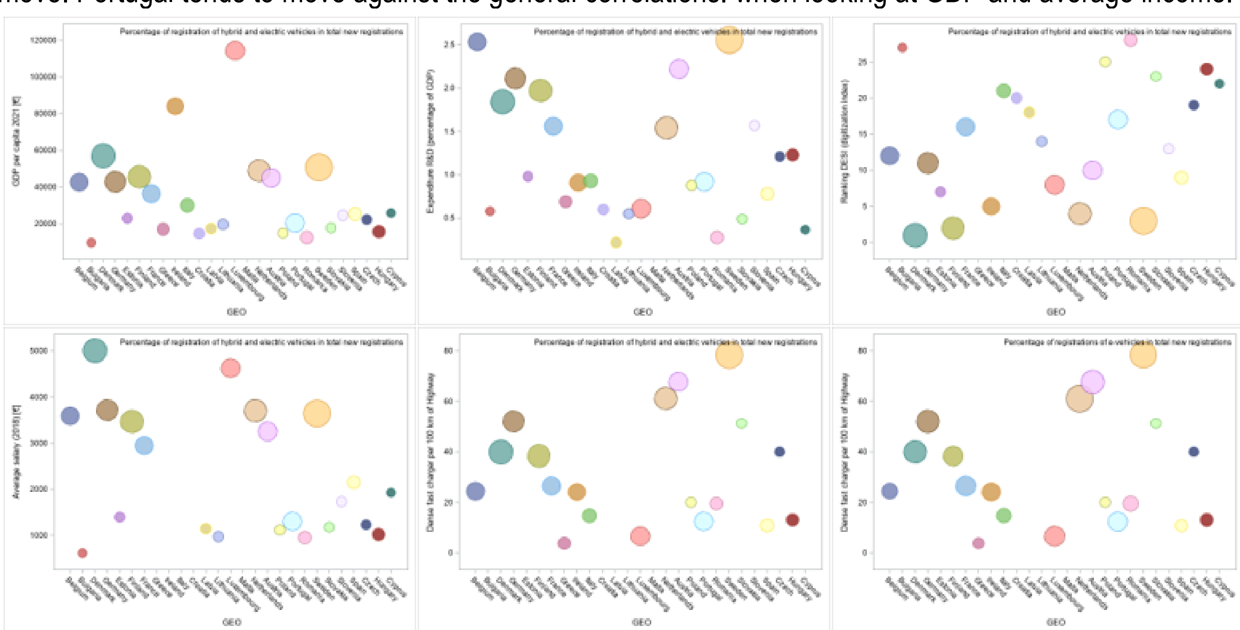
Tab. 2 Country-specific conditions and the correlation with the percentage of e-vehicle registrations

											Registration percentage of electric vehicles	
Variable	N	Mean	Std Dev	Median	Q1	Q3	Skewness	Kurtosis	Min	Max	Rho	p-value
Average salary (€; 2018)	22	2297	1321	1926	1146	3592	0.565745	-0.99375	617	5005	0.83271	<0.0001
GDP per capita (€, 2019)	26	33640	23426	25410	17480	4504	1.991082	4.76102	9850	114370	0.59692	0.0013
Expenditure RaD (€ per inhabitant)	26	397.7889	367.8024	198.9	97.5	709.7	0.777827	-0.92569	31.30000	1175	0.88451	<0.0001
Expenditure RaD (% of GDP)	26	1.13148	0.69750	0.92	0.58	1.57	0.702058	-0.63061	0.22000	2.55000	0.73916	<0.0001
Ranking DESI	25	14.03846	8.21940	13.5	7	21	0.063999	-1.21133	1.00000	28.00000	-0.73570	<0.0001
Value DESI (graphically estimated)	25	52.11538	9.54399	52.5	45	59	-0.11043	-0.47609	32.00000	70.00000	0.74003	<0.0001
Charging station per 1000_per	26	0.48740	0.76754						0.02567	3.81479	0.56666	0.0025
Fast charger per 100 km highway	19	31.85263	21.82337	24.45	13.07	51.24	0.705422	-0.49501	3.86000	78.38000	0.58044	0.0092
Education Tertiary sector	24	30.56667	7.34756	31.4	24.65	36.85	-0.27398	-0.902	16.20000	42.80000	0.31746	0.1306
Population density (per/sqm, 2019)	26	182.12593	302.34310	106.1	71.9	138.5	4.260723	19.83224	18.20000	1595	0.28539	0.1576
Age structure 15-64 years (%)	26	64.88519	1.87897	64.7	63.7	65.9	0.57607	0.291931	61.70000	69.50000	-0.32215	0.1085
Proportion 65 years +	26	19.61481	2.18644	19.9	18.9	21	-0.88124	0.82679	14.40000	23.20000	0.07479	0.7165
Urban population (%)	26	39.55926	14.51848	37.2	30.3	44.8	1.55628	4.05901	19.10000	88.80000	0.03172	0.8778
Population Small town, suburb (%)	26	30.37407	10.81056	31	23.4	35.7	0.10597	0.24661	9.30000	54.80000	0.41042	0.0373
Population Country (%)	26	30.08148	11.37734	32.3	19.6	38.1	-0.80692	0.27132	0.20000	44.90000	-0.46128	0.0177

Source: own Representation



The following plots provide a visual impression of the respective country-specific characteristics. The size and diameter of the bubbles represent the share of e-vehicles in the respective EU country. Only correlating variables are shown; the overall evaluation is part of the appendix. The distribution of the individual "country elements" elements show clear systematics. Interesting cases represent the "outliers", e.g. Portugal tends to move. Portugal tends to move against the general correlations. when looking at GDP and average income.



Politically initiated support measures for e-vehicles vary widely across Europe in terms of type, form and duration. In principle, subsidies can include bans and incentives or a combination of both. The national governments in Europe still predominantly rely on the instrument of incentive policy. Classic incentives are purchase bonuses, tax benefits, e.g. in relation to vehicle tax or charging current, or advantages in transport use such as exemption from tolls, etc. Government investments in the charging infrastructure can also be important incentives. Bans or negative incentives primarily concern the registration of combustion vehicles or locally restricted driving bans as well as tax burdens on combustion vehicles. A future ban on the sale of combustion vehicles is being discussed throughout the EU, cf. also para. 1.1. In Denmark, regulatory measures are under discussion such as tax reductions for e-vehicle owners or charging electricity, on the other hand, tax increases for combustion vehicles or linking the vehicle tax to CO2 emissions. State investments of around €10 million are currently flowing into the expansion of the charging infrastructure. In Poland, too, the charging infrastructure is considered one of the main obstacles to the spread of e-mobility. The number of publicly accessible charging points is comparatively low; so far, representatives of the automotive industry have demanded corresponding subsidies from politicians. In the Czech Republic, the high purchase price of new cars is often seen as an obstacle in view of low average wages. The purchase price of e-vehicles is higher, and state subsidies are limited. Since 2021, however, tolls for e-vehicles on motorways have been waived, and the Czech state has announced billions in subsidies for the next few years. Austria, on the other hand, is already massively promoting the purchase of e-vehicles in the form of state purchase bonuses. It also promotes the installation of charging stations. France massively promotes the expansion of the charging infrastructure, for example through energy-saving certificates for companies. Furthermore, purchase and scrapping premiums for old cars with combustion engines are budgeted for by the state. A purchase premium has also been introduced in Luxembourg. The government's target of 49% e-vehicles by 2030 is still a long way off at currently less than 2%. However, the Belgian state also relies on restrictive measures. The ban on combustion vehicles, including hybrid drives, for company vehicles is to apply from 2026. In Holland, purchase premiums apply. The vast majority of EU countries combine purchase premiums with tax benefits for e-vehicles as an exemption or staggered according to CO2 limits. However, the benefits differ significantly in terms of amount and design. Bulgaria, Denmark, Slovakia, Latvia and Malta do without purchase premiums and limit themselves to tax incentives. Only Estonia has so far dispensed almost completely with state subsidies. Apart from Denmark, one of the countries with the highest share of registrations of e-vehicles, the countries mentioned also show low shares of e-vehicles, ranging from 1.7% to 4.0% in 2021. Sweden records the largest share of registrations in 2021 with around 45%. Sweden continues to promote the purchase of e-vehicles in the form of high purchase incentives and tax breaks. A comparison between France, Germany and Italy is interesting. France and Germany implement a similar incentive policy, but Germany, with around 26%, has significantly higher rates than France with 18.3%. The subsidy policy in Italy, on the other hand, can be described as rather restrained compared to the other two countries. The share of registrations in Italy for e-vehicles amounts to 9.4% in 2021. (Overview - Electric Vehicles: Tax Benefits & Purchase Incentives in the European Union (2022), 2022), (Köstlinger, 2022)

4. DISCUSSION

4.1 Conclusion

From a climate policy perspective, the electrification of road vehicles is expected to make a significant contribution to CO_2 reduction in the transport sector in the coming years. This climate policy objective is strengthened by the current developments on the most important vehicle markets, which point to sustainable market growth of e-vehicles in the coming years. On the other hand, market developments also vary greatly from region to region in terms of speed and penetration. This is particularly true within the EU. Despite a uniform economic area, significant differences can be observed. The bundle of factors "political support measures", "consumer costs and economic uncertainties" as well as "charging infrastructure and charging management" could be identified in the literature analysis as the main influences that, in combination with national framework conditions, can also lead to different purchasing behaviour within the EU and thus to different market successes in individual countries. This led to research questions and theses for the present study. A correlation of registration shares with economic conditions in the individual countries, primarily shown by the GDP per inhabitant and the average income, could be evaluated as significant within the framework of the data analysis. It can be assumed that richer economies tend to have higher budgets for research and development and for infrastructure measures, which also include the charging infrastructure, and this is at least shown in an examination of the individual data series. Within the scope of the analysis, the correlations between registration shares on the one hand and R&D expenditure in relation to GDP and per inhabitant on the other hand prove to be statistically significant, as does the digitalisation index DSI. R&D expenditure and the state of digitisation can be understood as indicators of the state of modern technology in a country. These patterns indicate a demonstrable connection between prosperity and market penetration and, from the author's point of view, allow a confirmation of the working hypotheses H1 and H2, taking into account the limitations under 4.2. The formulated thesis H3 (charging infrastructure and charging management as a possible major barrier to the purchase of e-vehicles) can be confirmed on the basis of the present data evaluation, at least with regard to the purchase of fully electric vehicles. Albeit not with the significance level of the aforementioned correlation. Significant correlations of market shares with demographic variables such as the degree of urbanisation, age structures and the proportion of the population with higher educational qualifications cannot be proven in the appendix to the present data analyses. With regard to the influence of political promotion measures, the current state of research clearly suggests an influence of political incentive or prohibition measures on market penetration. The qualitative comparison carried out in the context of this work in para. 3 does not provide a clear picture. Overall, however, the tendency is also evident here that more ambitious political subsidy measures promote the purchase of e-vehicles. The subsidy policy may also be related to the respective budget possibilities. Richer countries such as Germany, France, Austria or the Netherlands tend to use massive incentives for the purchase of e-vehicles. If we compare countries whose economies are more or less convergent, such as Italy and France, considerable differences in subsidy policies, but also in registrations, can be observed. On the other hand, countries such as Denmark show that despite a restrained subsidy policy, the registration figures are clearly above average and in Hungary, for example, the registration figures remain at a low level despite a portfolio of subsidy measures. It is possible that more political measures have a delayed effect. However, there is still no sign of a jointly coordinated strategic approach within the EU Investments in infrastructure have been announced and planned in many EU countries, but a uniform political line or approach is not discernible in this context either. A Europe-wide coordinated and possibly also partially financed funding policy could possibly help to implement the goal of reducing emissions more quickly, especially since CO_2 emissions have a cross-border effect on the climate. In sum, economic differences or a lack of economic convergence within the EU area seem to be the determining factors for different market shares for EVs. The cost issue is a main criterion for consumers even after analysing the state of research, especially the high purchase costs compared to conventional vehicles, but also further uncertainties regarding operating costs and resale values. Consumers with higher incomes, who certainly also tend to own second vehicles in multi-person households and have greater home charging options, are more willing and able to decide to purchase an e-vehicle despite economic uncertainties.

As a result of the literature research and analysis, it can also be stated that not individual criteria, which could possibly be regulated quickly and autonomously, but rather a holistic, systematic approach would be necessary to further promote the market success of e-drives. In this context, various studies also refer to the possibility of bundling and concentrating measures in relation to a specific market segment. Targeted market policy measures on the part of manufacturers, suppliers and policymakers aimed at specific segments could increase market penetration in the short term. Such measures could focus on specific regions and locations, on specific consumer groups or infrastructures. A comparable political strategy is not yet discernible within the EU. The EU Commission's programme to promote e-mobility could contribute to such a strategic EU-wide orientation, for example in the development of a "nationwide" charging infrastructure and standardised charging management. Overall, it also remains to be noted that the decision-making process in the purchase of e-vehicles is still increasingly influenced by the perception of disadvantages, which is not unusual in the "introduction of new technologies". Price, battery technology and costs, ranges, etc. are seen as negatives, as barriers to purchase. Industrial policy decisions should also aim to eliminate or at least significantly reduce these concerns as soon as possible, for example through increased information transparency and targeted education (Carley et al. , 2013). Charging convenience is not only determined by the existing infrastructure and the business models of the providers, but of course also by advances in battery and charging technology. Due to the transition to the series market in combination with volume effects in manufacturing costs and increased competitive pressure, but also due to further innovations, prices should fall in the coming years. Manufacturers such as Mercedes, VW, BMW, Renault, Volvo, Toyoto and Ford, as well as numerous start-ups from China and the USA, are placing massive emphasis on the "E-card" as the drive system of the future and are pushing the corresponding expansion of their model ranges, also in the lower price segment. The success of their models is thus also decisive for the success of the companies in the coming years. This means that from the point of view of the car industry, or at least large parts of it, a penetrating market success of e-vehicles is indispensable. The industry's interest thus coincides with climate policy goals and measures. This is a good prerequisite for the sustainable success of the technology. As the number of e-vehicles increases, the supply on the used car market will also grow. This in turn can promote the spread of e-vehicles in countries with lower household incomes in the coming years.

All in all, the prospects of a broad base of consumers being able to afford the purchase of EVs, and thus the spread of EVs within Europe, are good. The biggest challenge may be an expansion of the charging infrastructure that can keep up with a rapid growth of vehicles, including the provision of "green energy". On the other hand, many technical potentials have not yet been exhausted, at least this is clearly indicated by the current state of research on this topic. In view of the described interrelationships, a shift in state subsidies away from purchase premiums towards investments in charging infrastructure and charging management might be an efficient way to strengthen electrification. (Gerbert et al., 2018; Climate Pathways Transport 2030 (n.d.), 2022; Climate Pathways 2.0 An Economic Programme for Climate and the Future. (n.d.), 2022)

4.2 Limitations and Discussion

The amount of data used for this paper is comparatively small. The data represent more or less a snapshot from a very dynamically developing market whose framework conditions and mechanisms are sometimes subject to rapid changes. Overall, this leads to limitations in the informative value of this study. The evaluation of long-term surveys could provide more precise results in this context. Furthermore, the limitation to the EU member states does not allow for any generalisations. The results are not transferable to other regions of the world. Extending the data collection to other markets outside the EU is an approach for further studies. On the other hand, an extensive literature analysis was carried out within the framework of the work, which confirms the main statements from the data analysis. Furthermore, the significances determined are clear and the static results are coherent, so that from the author's point of view the conclusions from 4.1 are robust. With regard to the degree of urbanisation, e.g. expressed by population density, no significant correlations could be established within the framework of the work. Sweden, with the highest share of e-vehicles of over 45%, has around 25 people/sqm, with Finland the lowest population density. A counterexample to this is Italy with a population density of > 200 and a registration rate of less than 10%. However, the state of research also includes studies that come to different conclusions in this regard. Distinct urban structures can make the use of EVs more attractive. Urban transport often offers suitable usage profiles for an attractive use of e-vehicles. The present study only refers to country comparisons. In order to examine the influence of urban structures within the EU in more detail, country-specific analyses on the specific distribution of e-vehicles could be included or initiated.

On the question of whether the level of education and in connection with it possibly a higher affinity for technology does play a significant role, a further differentiation into predominantly technical and humanities education would be an approach for further work. Advances in battery technology and charging technology in general could lead to decreasing costs and more confidence among consumers. These aspects were hardly considered in the context of the work. However, current issues such as raw material shortages and price increases, which could have a lasting impact on battery production and prices, are also rated as "risks" for

the success of e-vehicles. Securing the supply chains, including the supply of raw materials, is an aspect that may become a co-determining factor in the expansion of e-mobility in the coming years, certainly also of interest in the context of scientific work. The contribution of e-mobility to the reduction of climate-damaging CO2 is also highly dependent on the design of the energy mix, the shares of sustainable, renewable energy sources. In this respect, too, considerable differences can be seen within Europe. This important aspect of climate and environmental policy was only dealt with as a marginal topic in the present study.
While the electrification of private transport is one of the key elements for the future success of the car industry, it is only one part of the transformation of mobility as a whole, which can change society and industry to a greater extent than the switch from combustion engines to electric engines. (Canzler et al., 2017) The number of private vehicles and the density of vehicles per inhabitant have increased significantly in recent years. The drivers of this development were economically prosperous countries and regions in Asia and South America, but also in parts of Southern or Eastern Europe. At the same time, the trend towards urbanisation continues unabated. The world's most important metropolitan regions are growing continuously. These developments present societies and politics with ever-growing challenges. A significant increase in private transport in densely populated regions, further limited road and parking space with high traffic density and low average vehicle utilisation rates, increasing emissions of noise and gases and particles that are harmful to health and the climate, pose immense challenges for future concepts for individual mobility as an important characteristic of modern industrial societies. The electrification of means of transport is an important but not exclusively light and probably not the determining component of future mobility. Future mobility will possibly be determined and characterised by a greater range and broader spectrum of transport options and a change in usage behaviour. (Canzler, 2018)
The digitalisation of society, industry and technology combined with systems for artificial intelligence, driving autonomy and digital networking of systems and road users, as well as the integration of information, alternative means of transport and socialised usage concepts, is the determining factor of the mobility concepts of the future. (Canzler, 2018).

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