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Trends, main economic determinants of the e-mobility in the EU: Additional evidence and verification

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Abstract
The adoption of e-mobility in the countries of the European Union shows significant differences in terms of dynamics of electric car sales and in terms of differences in the share of electric cars in the total fleet of passenger cars in individual Member states. Despite the common European policy of transition to less emission-intensive car drives, the economic performance of countries, as well as other determinants, turn out to be the key drivers of differences in the sales and shares of electric cars on the car fleet within individual countries. In light of these findings, the paper contributes to the existing discussion and knowledge with additional recent findings and how intensive main consensual factors cause differences in the recent electric cars market shares in the EU countries.

Keywords
E-mobility, electrically-chargeable vehicles, living standards of the population, fiscal support tools, infrastructure.

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Introduction

E-mobility is a concentrated community response to a fundamental transformation of transport in the EU, as well as the economic impacts and externalities associated with the development of living standards, the increasing mobility of people, goods, and services in EU countries, and global climate change. The European Commission adopted a key policy document, "A European Strategy for Low Emission Mobility" (European Commission, 2016) already in 2016, in which the EU responds to the long-term risks of depletion of traditional fossil energies and to the risks of rising prices associated with the mining, transportation, and use of traditional power units in the growing sector of transportation.

This document can be considered one of the key initiatives and strategies towards a low carbon circular economy and ensuring that Europe remains competitive and is able to respond to the growing needs for the mobility of people and goods in the long term and perspective. The aim was to reduce the EU's dependence on oil import, which accounted for 94% of its power consumption when the strategy was adopted, and to explore the opportunity to accelerate the use of advanced biofuels, electricity, hydrogen, and renewable synthetic fuels. Subsequently, by providing strong incentives and policies, the aim was to increase the demand for advanced energies in transportation to replace around 15-17% of the initial demand for petroleum products in transport by 2030.

The main pillars of that strategy were:

- increasing the efficiency of the transport system by using digital technologies and promoting a shift to lower-emission transport modes,
- accelerating the deployment of low-emission alternative energy in transportation, such as advanced biofuels, renewable electricity, and renewable synthetic fuels, and removing barriers to the electrification of transportation, as already mentioned,
- using zero-emission vehicles, accelerating the transition to low and zero-emission vehicles,
- continuing incentives at the city and municipal level for low-emission alternative energies and vehicles, for a shift to active travel (cycling and walking), to public transport and/or shared mobility systems such as bicycles, to car sharing to reduce congestion and pollution,
- Europe's commitment to continue global efforts to control emissions from international aviation and maritime transport.

The strategy responded to the increasing emissions, air deterioration, and climate change affecting the growth of transport performance as well as other related externalities. Toxic tailpipe emissions and road noise are becoming an increasing threat to life in urban areas for their impact on the health of the population. According to (EEA, 2018), road transportation is a major source of air pollution, and the upper emission limits for the most harmful - oxides of nitrogen (NO_x), ground-level ozone (O_3), and particulate matter have been significantly exceeded. The EU estimates that 100 million people have been affected by harmful noise levels above 55 dB during the day and 60 million people above 50 dB at night. Road traffic was assessed to be the dominant source of noise; according to the (EEA, 2017) report, noise has caused ill health and even avoidable deaths in part of the population.

Despite the turbulent economic developments during the Global Pandemic Crisis and the subsequent energy crisis, the EU and its Member States implement the underlying objectives of this strategy as a broader strategic concept in their policies. The EU aims to become the first climate-neutral[1] continent in 2050, underlying the Green Deal. This target (European Parliament, 2023) became legally binding following the adoption of the Climate Act by the European Parliament and the Council in 2021. The EU's interim target of a 40% reduction by 2030 has also been updated to a more ambitious target of 55%. The EU is currently revising old legislation and adopting new legislation that will help achieve the 55% reduction target by 2030. The package of legislation is known as "Fit for 55" and includes, among other goals, emissions trading rules, national reduction targets, carbon removal in the land use sector, emissions from transport, or other emissions-intensive sectors of the economy.

According to several authors, the transport sector was one of the largest consumers of oil out of the total oil consumption and contributed significantly to the total final energy consumption[2]. According to forecasts (Climate Action, 2023) (Rokicki, Koszela, et al., 2021), road transport is directly responsible for 20% of Europe's CO_2 emissions. Therefore, the emergence and development of E-mobility are considered to be one of the supporting strategies for carbon neutrality. That encompasses the wide cycle from production and trade, mainly the use of low to zero-emission passenger vehicles to the end of its life cycle.

[1] Carbon neutrality means striking a balance between carbon emissions and their removal from the atmosphere into so-called carbon sinks. Carbon sinks are any natural or man-made systems that absorb more carbon than they produce. For example, soils, forests and oceans. According to the EU, these natural sinks absorb between 9.5 and 11 gigatonnes of CO_2 per year, which is not enough to absorb all the emissions that humanity puts into the atmosphere each year, with 37.8 gigatonnes emitted in 2021

[2] According to (Iea, 2018) transport sector in 2018 one of the largest consumers of oil consumption (cc. 64%) of global oil consumption, and around 29% of total final energy consumption.

Based on a review of scientific and expert studies, the paper aims to contribute to the debate and the current knowledge on the adaptation of EU economies to E-mobility with some of the latest findings from currently available data.

Main determinants and trends of the development of E-mobility in Europe

According to (Buekers et al., 2014), zero tailpipe emissions from electric vehicles and zero engine noise positively impact local air quality and living conditions. Depending on the energy source used, emissions in the energy supply chain, both in production and use, can be very low or even equal to zero. Public charging stations supply electricity from renewable energy sources such as hydro, solar, wind, and nuclear power in many countries, which production is considered by the IEA[3] to be the second lowest source of emissions in power generation. Electric cars can be defined as zero-emission vehicles in this case. Despite the use of non-emitting clean energies in the electric vehicles (EVs) traffic, i.e., Battery electric vehicle (BEV), Plug-in hybrid vehicle (PHEV), electrically-chargeable vehicles (ECV), Hybrid electric vehicle (HEV)[4], some studies estimate that the overall environmental impact of vehicles powered by electricity generated from coal is better than of vehicles with an internal combustion engine (Messagie et al., 2017, Eltayeb, 2010). Electric vehicles are also considered a potential for storage capacity for variable renewable energy generation, optimizing the use of tariffs and electricity consumption times, and transient storage.

Electrification, automation, robotization, artificial intelligence, and additional breakthrough technologies are prerequisites for the entire circular economy of the automotive industry to become comprehensively more sustainable in terms of economic and environmental aspects.

Likewise, the popularization of the population's desire to resist the negative environmental aspects of transportation and economic development is often the reason for the public's acceptance of the increased interest in the use of electric vehicles as one of the paths to sustainable and rapid growth, and not only in economically developed countries (Liao et al., 2016), (Ling et al., 2021), (Rokicki, Perkowska, et al., 2021), (Iea 2023).

As will be stated below, the composition of the car fleet and the penetration of EVs varies from country to country in Europe, as well as studies that address either the potential drivers of BEV and HEV sales or purchases in different countries or research and explanation of the existing differences in the representation of personal electric vehicles in the car fleet.

Trends and economic factors in the adaptation of EU countries to E-mobility

The purchase price of EVs and the population's income level are generally accepted as the dominant economic factors for E-mobility development, either in individual countries or due to income differentials within countries. The average prices of EVs are much more expensive than their petrol equivalents, around €35,000 (Euractive, 2023), and in many non-European countries, these prices are 2 to 2.5 times higher than comparable conventionally powered vehicles (Sriram et al., 2022). Tesla company announced price cuts of up to 20% in Europe and the US in early January this year, quickly followed by similar price cuts by Ford, which could add significantly to the downward pressure on the price of EVs in the EU. As (Euractive, 2023) further reports, German analyst Matthias Schmidt also introduces that manufacturers in Europe could follow a similar path in order to gain market share and meet increasingly stringent European CO_2 emission standards. Manufacturers could also respond to the fact that Chinese manufacturers are increasing production and plan to produce in Europe at a lower price. Smaller and cheaper models are also expected to come onto the market in the next few years.

For many drivers, electric cars are beyond their financial budget despite high subsidies. According to (Iea, 2023), demand incentives are therefore increasingly successful in persuading consumers to buy electric vehicles. However, as the transition progresses, governments should not suddenly change existing incentive structures. Incentives or subsidies should gradually shift to more targeted and financially sustainable instruments. The following figure illustrates the dynamics of EV sales in Europe[5].

[3] https://www.iea.org/reports/nuclear-power-in-a-clean-energy-system

[4] https://www.acea.auto/fact/electric-vehicles/

[5] According to (ACEA, 2023), BEV registrations in the EU increased by 14.3% to 14.8% of the market in September 2023. In Germany significant 28.6% decrease was noted, positive results were achieved by the Netherlands (+70.8%), Sweden (+60.7%) and France (+34.2%). In September, registrations of new HEVs in the EU increased by 30.5, new PHEVs were relatively stable (+0.4%). Registrations of petrol cars increased by 5.5%, its market share fell from 35.3% to 34.1% compared to last September. The EU diesel car market continued to decline in September (-12.5%).

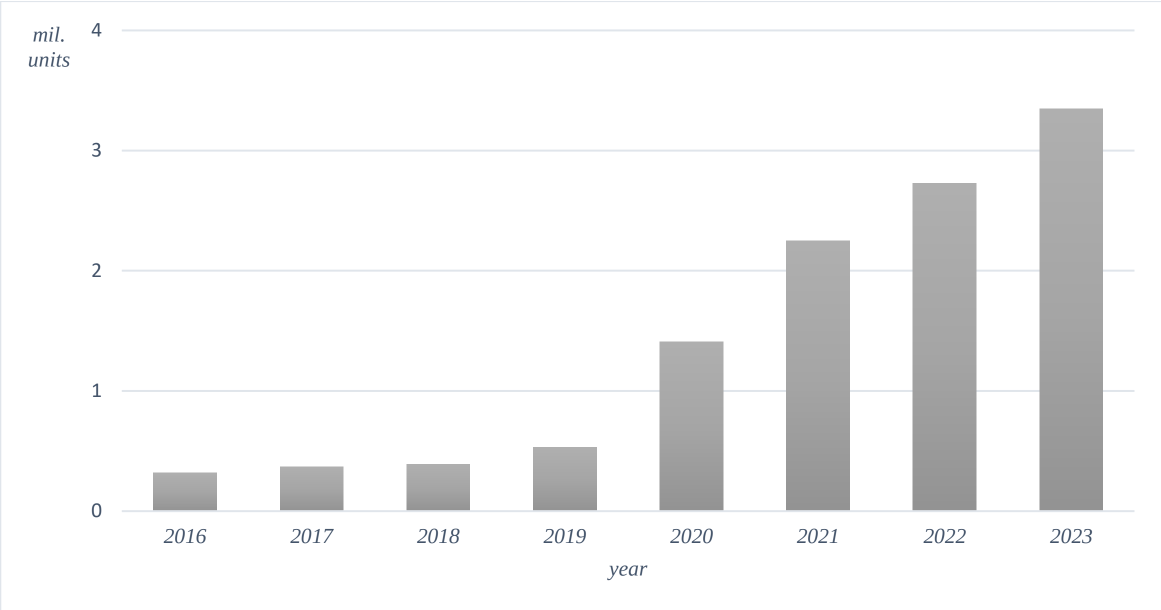

Fig. 1. Growth of EV sales in Europe in million units. SOURCE: IEA, Electric car sales, 2016-2023, IEA, Paris https://www.iea.org/data-and-statistics/charts/electric-car-sales-2016-2023, IEA. License: CC BY 4.0

The stated dynamic is mainly driven by sales in economically developed countries and higher incomes of the population. Countries from Western Europe and the most economically developed ones belong to the leader in E-mobility development. This conclusion was convinced by empirical evidence, for instance (Rokicki, Bórawski, et al., 2022), by using a Lorenz concentration curve (Fig. 2). This finding has been valid since 2011, with Germany, the UK, France, the Netherlands, and Sweden ranking as the top five countries with the highest share of total EVs in the EU in 2020. In the top ten countries, 92% of this type of car was located, with only Western European countries covered in this group. This is despite the fact that there is a gradual shift in the Lorenz curve, i.e., a softening of the concentration of sales in the leading countries.

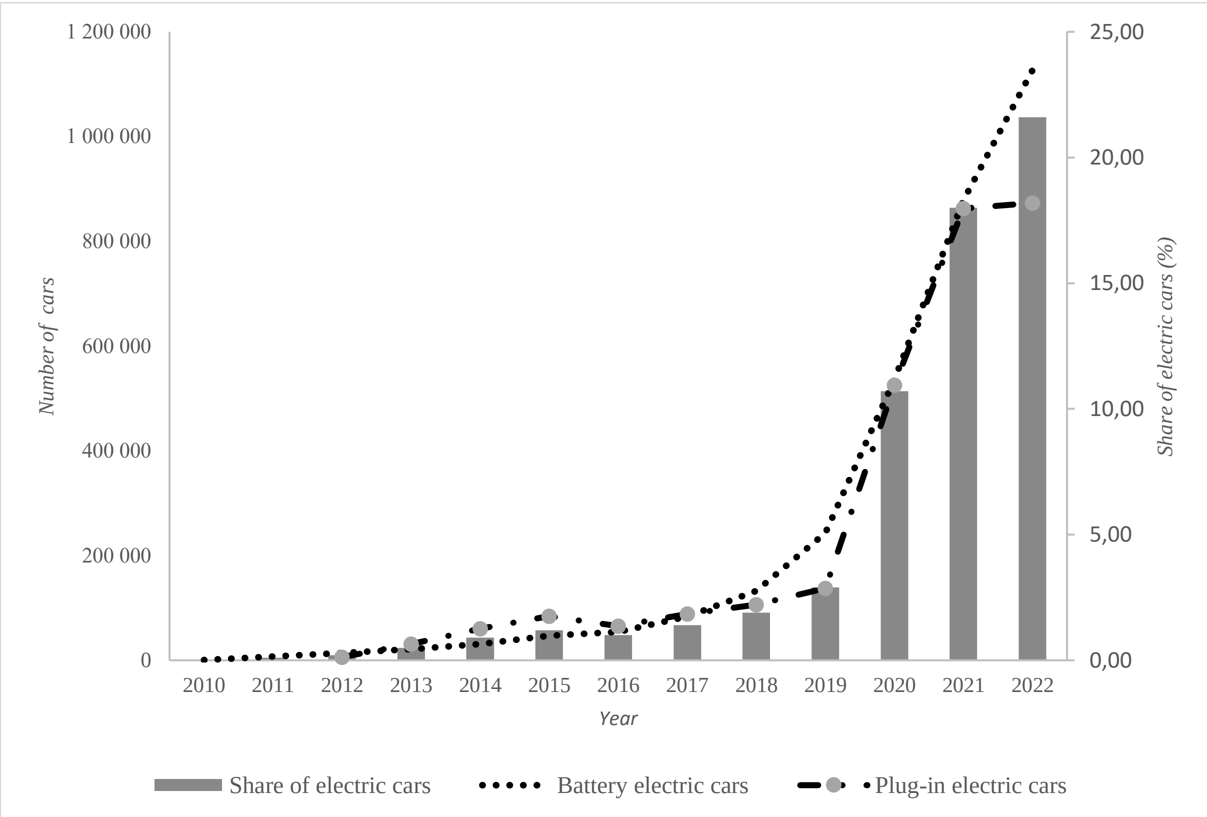

Fig. 2. Growth of new BEV and PHEV registrations and their share of the car fleet in Europe. SOURCE: https://www.eea.europa.eu/data-and-maps/daviz/new-electric-vehicles-in-eu-3#tab-chart_3

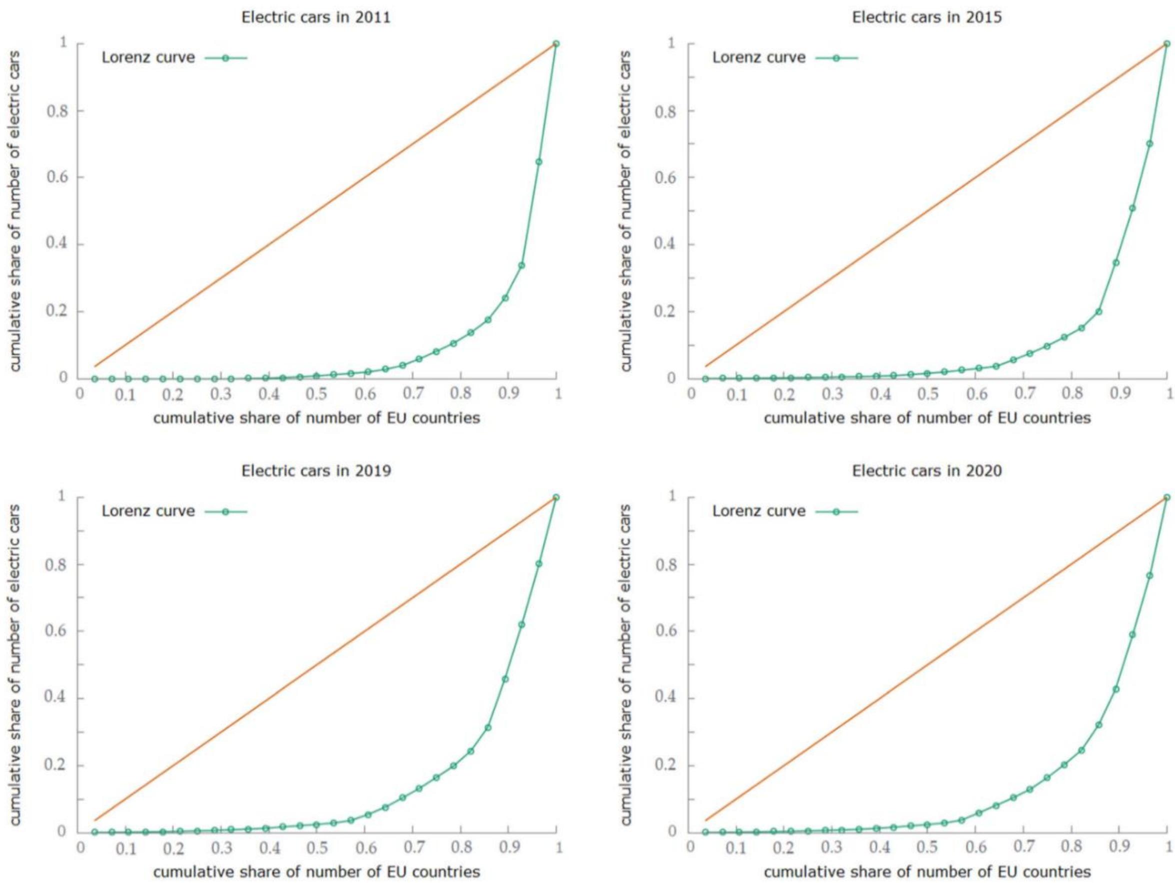

Fig. 3. Concentration of EV sales in Europe. SOURCE: https://www.researchgate.net/publication/357247800_Development_of_Electromobility_in_European_Union_Countries_under_COVID-19_Conditions/figures?lo=1

In addition, the income level of countries also determines the age structure of car fleets, as well as the development of services and technologies for vehicle maintenance and vehicle lifetime. According to ACEA, the average age of vehicles in EU countries is 12 years. Greece and Estonia have the oldest fleets, with vehicles that are almost 17 years old. Luxembourg has the youngest car fleet (7.6 years).

According to (Rokicki, Bórawski, et al., 2022), not only the purchase price but also price concerns for the total cost of the EV, i.e., unknown or not estimated maintenance and operating costs, or the cost of the EV battery and its lifetime, are the main motivations factors or barriers for purchasing an EV to consumers. Some consumers consider buying an EV when they reach the same price as an internal combustion engine (ICE) vehicle or do not consider buying one yet because they assume that the price will drop in the future. The study confirmed the findings of (Noel et al., 2020) that the key factor in consumer purchase is the knowledge of the price of the electric vehicle and battery.

Behavioral factors and other determinants of EU citizen's adaptation to E-mobility penetration

Several empirical studies in the scientific literature and studies by consulting and worldwide marketing companies try to verify which determinants represent the crank barriers or motivations for consumers to purchase an electric vehicle. The study (Javanmardi et al., 2023) identified the aforementioned economic price or financial barriers as a common factor. The authors consider high acquisition costs and limited driving ranges to be the main barriers to mass EV adoption. Consumer characteristics such as age, gender, and education are also important in EV purchase intention and EV awareness. The authors conclude that socio-demographic and psychological factors positively impact the prediction of consumer adoption of EVs. However, contextual factors, including supportive policies and "nondeveloped/developed" charging infrastructure directly influence consumers' intention to purchase EVs, and therefore, the study considers charging infrastructure and supportive tools as another important factor in determining EV adoption rates.

The starting point of the study (Kovárnik and Staňková, 2021) on the penetration of E-mobility was the identification of several groups (clusters) within the 31 EU countries using cluster analysis. Seven socio-economic, technical, and environmental variables were used as a basis for comparison: sales of battery electric vehicles per capita, sales of internal combustion engine vehicles per capita, GDP per capita, average annual income per capita, number of charging stations per capita, happiness index and CO_2 value per capita.

When researching the impact of vehicle performance factors on potential buyers, consumers are particularly interested in the maximum range offered by electric vehicles per charge and charging time. A significant influence is the consideration that they are concerned about running out of charge when driving an EV, and they also have to plan their journeys carefully, leading more to consider buying and using EVs only for short-distance journeys, with frequent and repeated charging of EVs appearing impractical and limiting when compared to ICEs and with frequent use.

Inadequate or adequate charging infrastructure or the unavailability of charging facilities at home properties or on motorways is a significant factor in not buying an electric vehicle. Lack of charging facilities, whether for overnight charging or along highways, causes inconvenience in using electric vehicles (Noel et al., 2020). A consequence of this limitation may be that EV purchase is motivated by frequent daily driving over short distances and is more intense in more densely populated agglomerations. Also, at the EU country level, the relationship and clear correlation of whether the number of charging stations is a determinant of EV purchase or vice versa has not been sufficiently investigated. Also, according to (ACEA, 2022), almost 42% of all EV charging points in 2022 were concentrated in just two EU countries: the Netherlands (111,821 charging points) and Germany (87,674). Together, these two countries account for less than 10% of the EU's total land area. The remaining chargers are scattered over the remaining 90% of the region. The Netherlands, the country with the highest share of infrastructure, has almost 70 times more charging points than Romania (1 658), which is roughly seven times larger.

Environmental concern, or the consumer's belief that by driving an electric vehicle, they would express their awareness of environmental protection, is another factor persuading the consumers to buy a vehicle. According to (Sriram et al., 2022), a portion of the population believes that purchasing a vehicle, regardless of price and using it, would contribute to reducing the consumption of natural resources, thereby contributing positively to climate change. The growing environmental awareness around consumers is influenced by their peers, family or society to consider the environment when purchasing an electric vehicle. When driving electric vehicles, owners feel socially responsible, and awareness of electric vehicles also plays a role in the acceptance of electric vehicles as a source of use and advancement in technology.

Although it is not supported by a scientific study or empirical evidence (Energy 5, 2023), it provides an inspiring source on the definition of potential factors, which can be considered critical for the further development of E-mobility, including the EU territory. These include technology policy and perceptions of factors shaping the future of EVs, the EV revolution as an understanding of other key factors driving or hindering EV adoption, overcoming challenges and factors that need to be addressed so that EVs can "take off", pathway factors to widespread adoption and influencing EV ownership. There is also the current conundrum about EVs, i.e., what factors will influence the future of the automotive industry and the emergence of EVs.

According to (Makena et al., 2016), EV's have been relatively recently reintroduced to the global automotive market over their predecessors, and this is a permanent improvement in performance and electric range. Most government targets for adoption have not been met yet. The authors identified several important knowledge gaps. First, there is mixed evidence on the effectiveness of government incentives in promoting EV uptake and, in particular, little knowledge of timing and scale issues. They confirmed that public charging infrastructure is an important driver of EV usage distribution and that the direction of causality is not yet obvious. The study sought to provide compelling evidence that actual EV purchases/sales are much lower than reported consumer preferences.

Regarding the future development of E-mobility, the fear of failure remains one of the main factors that may discourage drivers from switching to electric vehicles. Also, the range of most cars is limited to a few hundred kilometers, and recharging can take from twenty minutes to several hours, depending on the terminal. Sufficient development of a network of fast and accessible charging terminals is key to making these cars viable for longer trips. According to a report by consultancy firm McKinsey, the EU will need 3.4 million charging points with updated energy networks by 2030. In total, this could represent a cost of around €240 billion, with a number of companies increasing investment in charging station networks.

The safety of the supply of critical minerals is also a concern for both the EU and the US. According to the International Energy Agency (IEA)[6], "clean energy technologies are becoming the fastest growing demand segment" for critical minerals. With the given world goals to meet the Paris Agreement, the IEA estimates that demand for copper and rare earth elements in this sector will grow by more than 40% in the next two decades, more than 60% for nickel and cobalt, and almost 90% for lithium. In particular, the expansion of the battery industry may put pressure on the material supply chain. Governments will need to establish clear policy frameworks and encourage international cooperation to ensure that all required investments are made in a timely, environmentally, and socially sustainable manner to secure a growing electric vehicle industry. Without a steady supply of energy, the energy transition risks slowing down. "The data shows a looming mismatch between the

[6] https://www.energymonitor.ai/transport/as-ev-sales-are-rising-recyclers-are-getting-ready-for-spent-batteries/?cf-view&cf-closed

world's strengthened climate ambitions and the availability of critical minerals that are essential to realizing those ambitions," IEA Executive Director Fatih Birol said in a May 2021 statement. "These potential vulnerabilities could make global progress towards a clean energy future slower and more costly."

Main economic determinants, hypothesis formulation and methodology

When formulating the determinants and hypotheses, we proceed from an overview of studies on the sale of electric cars and on the adaptation of EU countries to electric mobility. In addition, discussion and feedback from participants of the TOP 2023 conference from the academic community and the Association of the Automotive Industry of the Slovak Republic were also used.

Formulation of the research questions

Based on a review of studies of EV sales in the EU, it is possible to conclude their common penetration in three main (non-price and non-behavioral) determinants that influence differences in EU countries' adaptation to EV penetration - economic maturity, charging station network density, and government support incentives. For the purposes of the paper, this will also involve the identification of three research questions:

(Q1) the importance and significance role of adaptation to E-mobility is determined by the economic development of the countries,

(Q2) the importance and significance role of public charging station infrastructure, including their density, has influenced the country's adaptation to E-mobility,

(Q3) the importance and significance role of government incentives and support has influenced the adaptation of countries to E-mobility

Data and methodology

In contrast to most known popular studies, we will take the real expenditures of countries by purchasing power parity of currency per capita (REI_{ppp}) as an indicator of the economic development of countries according to Eurostat data. In addition to the traditionally used GDP per capita or average income, these also take into account price and, for some EU countries, exchange rate differences (non-euro area members) across countries.

In the case of charger network density, the postponed number of charging stations per 100 km (ChD)[7] , as well as the absolute number of charging stations, will be used as a key comparative indicator, which, compared to the indicator of the number of charging stations per capita, but also implies differences in population density and the openness of economies, which may influence the consumer's decision to purchase an EV due to shorter distance trips or higher adaptation of these economies to the E-mobility.

We aggregate government support incentives by an index of the intensity of government support for E-mobility (IIG), the construction of which is based on the ACEA (Kovárnik and Staňková, 2021) survey and 2022 data. We construct the IIG index as an aggregated expert assessment of the level of E-mobility support in a country for 3 sub-indicators (SI) of taxation (of the tax benefits TB type) and one of the purchase incentives type:

- SI_1 acquisition (type TB),
- SI_2 ownership (type TB),
- SI_3 company cars (type TB),
- SI_4 purchase incentiveness (type PI).

Using the multi-criteria variant evaluation method (for country *j*), each co-author compiles an index IIG_j, which is a weighted sum of the country's score according to the level of individual support (criteria):

$$IIG_{s,j} = \sum_{s=1}^{4} SI_{s,i,j}, v_i \tag{1}$$

The weights v_i were determined by the authors of this paper expertly assigning weights with values $v_1 = 0.141$, $v_2 = 0.154$, $v_3 = 0.205$, $v_4 = 0.5$, while the authors agreed on the share of weights of sales promotion and cumulative tax promotion instruments with the same weight of 0.5. The level of support for subindicators $SI_{s,i,j}$ are determined by a holistic expert method where each co-author s rates each sub-indicator i for country j with a value of $SI_{i,j,s}$ in the interval 1-100.

The arithmetic average of the value of the $IIG_{s,j}$ is set to determine the value of the E-mobility support indicator in country *j* as:

[7] https://www.acea.auto/press-release/electric-cars-10-eu-countries-do-not-have-a-single-charging-point-per-100km-of-road/

$$SIG_j = \left(\sum_{s=1}^{4} IIG_{s,j} \right)/4 \qquad (2)$$

Due to the inhomogeneity of the current unavailability of some data (Bulgaria, Malta), but again, the availability of some of the most up-to-date data on the promotion of E-mobility, the research aimed to validate the three research questions. Namely, the dependence of the market share of electric vehicles (ECVs) in EU countries in 2022 on the real expenditure in purchasing power parity of currency per capita (RECpps) in 2022, on the cumulative stock of charging stations (CHD) as well as on the index of E-mobility support tools (SIG) available for 2022. Based on a correlation analysis, we evaluate the correlation between the share of electric vehicles in the car fleet of EU countries using cross-sectional data and between the main determinants (indicators) of adaptation to E-mobility in the EU countries defined by us.

Empirical conclusions

The cumulative penetration of E-mobility in 2022 confirms that Sweden has the highest market share of ECVs (56.1%), which in 2022 exceeded more than half of the ECV sales in its market, with a 24% increase in ECVs compared to 2020. Sweden is followed by Denmark, Finland, the Netherlands, Germany, Belgium, Luxembourg, Austria and France. In line with the long-term trend, the converging CEE and V4 countries are at the bottom of the ranking.

Tab. 1. Market shares of ECVs in 2022 (%)[8]

Country	SIG	Country	SIG	Country	SIG
Austria	*22,1*	*Germany*	*31,4*	*Poland*	*5,0*
Belgium	*26,5*	*Greece*	*7,9*	*Portugal*	*21,7*
Croatia	*5,0*	*Hungary*	*8,6*	*Romania*	*9,0*
Cyprus	*5,4*	*Ireland*	*22,2*	*Slovakia*	*3,7*
Czech Republic	*3,9*	*Italy*	*8,7*	*Slovenia*	*6,2*
Denmark	*38,6*	*Latvia*	*8,1*	*Spain*	*9,6*
Estonia	*5,4*	*Lithuania*	*7,9*	*Sweden*	*56,1*
Finland	*37,6*	*Luxembourg*	*24,3*		
France	*21,5*	*Netherlands*	*34,5*		

SOURCE: Own processing based on EUROSTAT data

The countries with the highest E-mobility penetration in 2022 were also among the group of countries with the highest levels of real per capita spending in purchasing power parity currency terms.

Tab. 2. Real expenditure per capita (in PPS) in 2022

Country	RECpps	Country	RECpps	Country	RECpps
Austria	*27 400*	*Germany*	*27 500*	*Poland*	*19 800*
Belgium	*26 700*	*Greece*	*18 100*	*Portugal*	*19 600*
Croatia	*17 400*	*Hungary*	*16 700*	*Romania*	*20 400*
Cyprus	*22 600*	*Ireland*	*20 100*	*Slovakia*	*16 800*
Czech Republic	*19 200*	*Italy*	*23 000*	*Slovenia*	*20 800*
Denmark	*25 700*	*Latvia*	*18 400*	*Spain*	*19 700*
Estonia	*18 300*	*Lithuania*	*21 900*	*Sweden*	*25 000*
Finland	*25 300*	*Luxembourg*	*32 000*		
France	*25 200*	*Netherlands*	*26 900*		

SOURCE: Own processing based on EUROSTAT data

The correlation coefficient of 0.69 confirms that there is a strong link between the market share of ECVs and the economic maturity of European countries in 2022.

When examining the effects of the density of the charging station network on the market share of ECVs, the situation is not so clear. In terms of charging station density per 100 km, the Netherlands, Luxembourg, Germany,

[8] https://www.iea.org/commentaries/electric-cars-fend-off-supply-challenges-to-more-than-double-global-sales

and Portugal dominated significantly, with the Nordic countries and Denmark lagging relatively behind the leading group of countries in this indicator. In terms of the number of charging stations, the Netherlands and Germany dominated in 2022.

Tab. 3. Charging network in EU countries in 2022 (number)

Country	CHD	Country	CHD	Country	CHD
Austria	*22874*	*Germany*	*87674*	*Poland*	*3952*
Belgium	*24159*	*Greece*	*1021*	*Portugal*	*7716*
Croatia	*1285*	*Hungary*	*3622*	*Romania*	*1658*
Cyprus	*69*	*Ireland*	*2535*	*Slovakia*	*2713*
Czech Republic	*3962*	*Italy*	*37186*	*Slovenia*	*1893*
Denmark	*11055*	*Latvia*	*660*	*Spain*	*34380*
Estonia	*300*	*Lithuania*	*477*	*Sweden*	*25464*
Finland	*6121*	*Luxembourg*	*2367*		
France	*83317*	*Netherlands*	*111821*		

SOURCE: Own processing based on EUROSTAT data

The low correlation between the market share of ECVs in 2022 and the number of charging nodes in 2022, with a correlation coefficient value of 0.43, and the similarly low correlation coefficient value of 0.44 between the market share of ECVs in 2022 and the density of charging nodes per 100 km in 2020 do not provide a clear argument, that charging node infrastructure can be one of the drivers of E-mobility penetration.

The resulting assessment of the country *j*'s level of E-mobility support by the constructed SIG_j index for 2022 is presented in Table 4 below. Austria, France, Hungary, Germany, Finland, the Netherlands, Ireland, Belgium, and Sweden were evaluated as the countries with the highest government support for E-mobility (above average SIG value).

Tab. 4. EU Electromobility Support Index 2022

Country	*SIG*	Country	*SIG*	Country	*SIG*
Austria	*83,61*	*Germany*	*64,76*	*Poland*	*25,00*
Belgium	*58,80*	*Greece*	*28,30*	*Portugal*	*48,43*
Croatia	*23,81*	*Hungary*	*67,74*	*Romania*	*21,26*
Cyprus	*22,80*	*Ireland*	*59,13*	*Slovakia*	*13,39*
Czech Republic	*18,39*	*Italy*	*43,32*	*Slovenia*	*6,68*
Denmark	*17,81*	*Latvia*	*13,26*	*Spain*	*27,73*
Estonia	*0,00*	*Lithuania*	*32,85*	*Sweden*	*55,89*
Finland	*62,67*	*Luxembourg*	*45,82*		
France	*77,05*	*Netherlands*	*61,85*		

SOURCE: Own processing based on EUROSTAT data

The value of the correlation coefficient of 0.57 between the market share of ECVs in 2022 and the 2022 EU-25 E-mobility Support Index makes it possible to conclude a rather positive sale of the fiscal incentives supporting the sale of ECVs in individual countries.

Discussion and conclusion

The dynamic penetration and support of the European E-mobility policy in individual European states appears to be irreversible despite the turbulent economic development. Especially in the Nordic countries, Benelux and Germany, the market share of ECV sales reached more than a third in 2022, and in Sweden, it has already gained the majority market share. At the opposite end of the scale in the adaptation of the economy to E-mobility are the ECE countries, even though countries such as Romania and Hungary have already made significant progress. This "two-speed" situation between the old and new EU member countries is and will be the source of different approaches to the fulfillment of the overall European goals in the penetration of E-mobility and the acceptance of the overall regulatory instruments of the EC.

If we disregard behavioral factors, possibly also ESG policy and its acceptance in individual countries, the two-speed penetration of E-mobility has and will have its source in the findings of this contribution. Those for 2022 confirm that the main driving forces for E-mobility penetration are the standard of living and the "power" of supporting tax and subsidy schemes in individual EU countries. The density of the public infrastructure of recharging nodes turns out to be less decisive when the inhabitants of the respective country decide to buy an electric car.

The acceleration of sales and the transition to the structure of vehicle sales in EU countries in adaptation to E-mobility towards the level of countries at the top of the European ranking will obviously depend on the growth of living standards, performance, and the ability of countries to converge to the most advanced EU countries. This ability is becoming questionable, especially for the countries of Central and Eastern Europe, where there are signs of a slowdown in convergence due to the consequences of the pandemic and energy crisis or the consequences of the military conflict in Ukraine.

Likewise, the slowdown in economic growth and the growth of gross public debts, or their consolidation, not only in CEE countries but especially in them, limit the more massive use of fiscal instruments to support the sale of electric cars in the EU countries for the next few years. Already, the support for the sale of electric vehicles for individual EU countries for the year 2022, which we approximated with an aggregated support index, signals not only the intensity of support linked to the development of countries but also the current expenditure and income fiscal restrictions, as well as the ability to use EU resources and programs to support the development of E-mobility in individual EU member states.

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