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PROSPECTS OF THE EU ELECTRIC CAR MARKET*

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Abstract. The electrification of the transport sector is pivotal in achieving the European Union's climate neutrality objectives, given its substantial contribution to greenhouse gas emissions within the region. Furthermore, this initiative aligns with the broader Sustainable Development Goals (SDGs) 9 and 11, which underscore the critical importance of fostering sustainable transport systems. However, there is a pressing need for a comprehensive index that robustly correlates with advancements toward the SDGs in general, and more specifically, the electrification of transport. Such an index would facilitate a nuanced analysis of these processes. This article introduces the Sustainable Development Green Index (SDGI), a multifaceted analytical tool that encompasses educational, economic, political, societal, and environmental dimensions. The findings presented in this study support the efficacy of the SDGI and demonstrate its significant potential for analyzing current trends while emphasizing its strong correlation with progress in transport electrification within European Union member states.

Keywords: electric car; sustainable development; green economy; SDGs

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1. Introduction

The notion of sustainable development gained significant prominence in the latter part of the 20th century, propelled by a growing awareness of the interrelatedness among economic, social, and environmental dimensions. This holistic approach to development was notably influenced by the 1987 Brundtland Report, which articulated sustainable development as the capacity to fulfill present needs without undermining the ability of future generations to satisfy their own needs (Mitra, 2016). The report served as a catalyst for global dialogue, underscoring that economic growth should not occur at the cost of environmental degradation, thereby

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establishing the foundation for what subsequently developed into the Sustainable Development Goals (SDGs) endorsed by the United Nations in 2015 (Gracia-de-Rentería et al., 2023; Dobson, 2024).

The European Union's dedication to the SDGs exemplifies a wider movement toward sustainable economic policies that emphasize social equity and environmental sustainability alongside economic growth (Ricciolini, 2023). The EU's sustainable development strategy is fundamentally based on its international commitments as outlined in the SDGs. A significant initiative in this regard at the EU level is the European Green Deal (EGD) (Kielczewski, 2021; Gołaszka, 2023; Gomez-Olmedo et al., 2024). To actualize the principles of the EGD, the European Commission has aimed to reduce net greenhouse gas emissions by at least 55% by 2030, with a target for the European economy to achieve climate neutrality by 2050 (European Commission, 2021).

Threats such as noise pollution, air pollution, traffic congestion, stress, etc., pose serious risks to the environment and human health. About 75% of air pollution in cities globally is attributable to transportation activities, primarily emanating from vehicular emissions (Meydani et al., 2023). In response to this issue, the transport sector has implemented significant measures, most notably the adoption of electric vehicles as a viable alternative to traditional gasoline-powered cars. Electric vehicle is considered as a promising solution to reduce pollutant emission (Victor et al., 2019; Zhang et al., 2023; Subbotin et al., 2023), increase risks to human health (Nieuwenhuijsen, 2018; Sisani et al., 2022; Golinucci et al., 2023), save fuel consumption (Mazur et al., 2023; Roca-Puigròs et al., 2023). Research indicates that the extensive implementation of electric cars can substantially mitigate urban air pollution and decrease greenhouse gas emissions (Hofbauer & Maier, 2022; Kurc, et al., 2024; Jędrzejczak-Gas, 2024).

In 2020, global EC sales saw an increase of 43% compared to 2019, with the market share for electric cars reaching a record 4.6%. The following year, 2021, marked a significant milestone in ECs sales, which doubled from the previous year to total 6.75 million units. Remarkably, the number of electric vehicles sold within a single week in 2021 surpassed the total sales recorded for the entire year of 2012. The year 2022 continued this upward trajectory, setting new records as electric vehicle sales exceeded 10 million units, representing 14% of all new car sales – an increase from 9% in 2021 and below 5% in 2020. This growth resulted in over 26 million electric vehicles on the roads worldwide by 2022, reflecting a 60% increase from the previous year (Virta, 2024).

The most visible benefit of using electric cars is the absence of exhaust fumes in cities and a reduction in the amount of exhaust fumes globally. The argument often put forward that drawing energy from the grid produces the same amount of carbon dioxide is pure demagoguery. First of all, EC has greater efficiency – it doesn't waste energy to generate large amounts of heat, doesn't have a lot of moving parts, and implements regenerative braking. Secondly, the energy can come from various power plants, including nuclear, hydroelectric, wind, etc., which certainly can't power combustion cars. Third, most of the energy consumed by ECs in the future will come from wind turbines (Abdelrahim et al., 2022), water (Kubiak-Wójcicka et al., 2022) and photovoltaic panels (Vu et al., 2022). In recent years, electrification has emerged as a progressively vital component in numerous transportation modes. This is influenced by the increase in economic competitiveness, technological advancement and model availability of electric cars (Al-Saadi et al., 2022; REN21, 2022, 2024; Dirma et al., 2024).

Various indices have been developed to measure progress in this area, reflecting the multifaceted nature of green growth. This interest has precipitated the development of various indices designed to assess advancement toward this objective, alongside the realization of the SDGs. These indices integrate an array of factors that encapsulate the complex interrelationships between economic growth, ecological integrity, and social equity, thereby providing a multifaceted tool for evaluating progress within this paradigm.

2. Literature review

A variety of indices exist to evaluate the progress made toward establishing a green economy and achieving the SDGs. These indexes integrate an array of factors that encapsulate the complex interrelationships between economic growth, ecological integrity, and social equity, thereby providing a multifaceted tool for evaluating

progress within this paradigm. In the context of the increasing urgency to transition towards sustainable development, Ryszawska (2015) work on green economy indicators is particularly significant. Ryszawska (2015) research contributes to the understanding of how indicators can be utilized to measure the progress and effectiveness of green economy initiatives. This comprehensive analysis not only delineates the theoretical underpinnings of green economy indicators but also provides practical frameworks for their implementation across various sectors and regions. The researcher's work begins by establishing a clear definition of what constitutes a green economy. The author asserts that a green economy is characterized by enhancements in human well-being and social equity, coupled with a substantial reduction in environmental risks and ecological scarcity. This definition is in harmony with the overarching discourse surrounding sustainable development, which underscores the necessity for economic growth that does not jeopardize planetary health or the welfare of future generations. Ryszawska's Green Economy Index encompasses various elements, including natural capital (biodiversity and ecosystems), economic factors (waste, pollution, emissions, and resource consumption), political dimensions (policies and environmental strategies), and social considerations (social inequalities and poverty). By framing green economy indicators within this context, Ryszawska underscores their role as essential tools for measuring progress towards sustainability (Ryszawska, 2015).

Kasztelan (2017; 2018) employed the methodology established by the Organization for Economic Cooperation and Development (OECD, 2017) as a foundation, utilizing its Green Growth Indicators. These indicators encompass various metrics such as low-income levels, GDP per capita, inequality, material productivity, environmentally adjusted multi-factor productivity, CO2 productivity, environmentally related innovation and taxation, and exposure to air pollution (Organization for Economic Co-operation and Development, 2017).

Kasztelan's work on the Hellwig's Pattern Model serves as a methodological framework for assessing green growth across OECD nations. This model facilitates the evaluation of various indicators that reflect the interplay between economic performance and environmental sustainability (Kasztelan, 2017; Kasztelan, 2018). By employing such models, researchers can identify the effectiveness of green growth strategies and their impact on sustainable development. By employing such models, researchers can identify the effectiveness of green growth strategies and their influence on sustainable development. The integration of natural capital into economic development processes is crucial, as it provides an extensive understanding of the role that environmental assets play in fostering economic prosperity (Kasztelan, 2021).

Another important enhancement to the evaluation of progress in the green economy is the Green Economy Index (GEI). The index includes more than 20 detailed indicators covering environmental quality, resource efficiency, and social equity. Godlewska and Sidorczuk-Pietraszko (2019) highlight that such composite indices are instrumental in assessing the transition to a green economy across different regions, including Poland. As nations continue to grapple with pressing environmental challenges, the GEI will play a crucial role in guiding policy decisions and fostering a more sustainable and equitable global economy (Godlewska & Sidorczuk-Pietraszko, 2019). Alekna and Kazlauskienė (2020) highlight that the GEI incorporates a range of indicators, including environmental quality, resource efficiency, and social equity, providing a holistic view of green economic development. This comprehensive approach is essential for understanding the multifaceted nature of sustainability and the interconnections between economic, environmental, and social dimensions.

Within the framework of Germany's transition toward a green economy, Lutz et al. (2017) emphasize the necessity of a multi-dimensional framework that incorporates natural resource use, environmental quality of life, and institutional measures. This approach is crucial for effective policymaking and resource allocation, as it enables an in-depth understanding of sustainability allows for a comprehensive understanding of sustainability. The integration of various dimensions of sustainability into the assessment process is essential for addressing tackling the complex challenges associated with environmental degradation and resource depletion. Wagner et al. (2017) note that while environmental issues are often discussed politically, their perceived importance among the populace may not align with the urgency of the situation, particularly in regions where past environmental crises have been mitigated.

All these researches in assessing the transition to a green economy has represented essential milestones in the development of analytical frameworks for assessing the green economy within the paradigm of sustainable development, recognized by both researchers and policymakers. However, the indices referenced previously do not capture the full range of sustainable development dimensions, and their frameworks have not been employed to evaluate their relationship with progress on the SDGs, particularly in the European Union. At this background, this paper proposes the implementation of a new Sustainable Development Green Index (SDGI), developed by the authors, which includes educational, economic, political, societal and environmental dimensions of sustainability (Lavrinenko et al., 2022; Rybalkin, 2022). SDGI is based on the quintuple helix model of sustainable development. This model consists of five subsystems: economy, policy, society, education, and environment. Each subsystem consists of 10 indicators (see Annex 1). The EEPSE index effectively correlates with various SDGs, thereby providing a comprehensive framework for evaluating the performance of different countries in their transition to a green economy. This index is particularly useful as it allows for a nuanced understanding of how specific policies and initiatives align with broader sustainability objectives. Shao et al. further elaborate on the importance of monitoring progress over time, arguing that static composite indices may not adequately capture the dynamic nature of green development (Shao et al., 2022).

The research aim of the paper is to examine the relationship between electric car adoption and sustainable development in EU countries. It focuses on analyzing how the SDGI correlates with the growth of the electric car market, providing insights to enhance policies for sustainable transportation. The research questions of the paper include:

- How does the SDGI correlate with electric vehicle adoption across EU countries?
- What role do economic, educational, and environmental dimensions play in influencing electric car market growth?
- How can policymakers leverage sustainability metrics to enhance electric vehicle infrastructure and incentives?
- What regional differences exist in electric vehicle adoption within the EU, and what factors contribute to these variations?

3. Materials and Methods

The sales of electric car cannot be regarded merely as an economic factor, given that the electrification of transportation is a complex phenomenon. Moreover, electric cars continue to exhibit significantly higher costs in comparison to traditional alternatives (even though there are positive developments in this respect). Therefore, in order to enhance their adoption, it is essential to implement subsidies and state support (political subsystem), such as tax discounts, low-interest loans, and benefits related to road usage and parking. Additionally, it is imperative to establish the necessary infrastructure, including charging stations. Besides that, electric cars sales are obviously stimulated by high level of ecological awareness (societal subsystem) and developed green education (educational subsystem) (Ginavičienė & Sprogytė, 2021; Zamfir et al., 2022).

The abovementioned considerations necessitate the integration of economic, educational, environmental, societal, and political factors into the analysis, thereby establishing the foundation for employing the Quintuple Helix model in this research (Rybalkin, 2022). The Quintuple Helix model is characterized by both interdisciplinary and transdisciplinary aspects, as the complexity inherent in the five-spiral framework demands ongoing engagement from the entire spectrum of academic disciplines, spanning from the Natural Sciences (due to the inclusion of the natural environment) to the Social Sciences and Humanities. This collaboration fosters the visualization and promotion of a system interlinking knowledge, expertise, and innovation for sustainable development (Carayannis et al., 2012). A visual representation of the model is illustrated in Figure 1. As indicated in the figure, the Quintuple Helix model comprises five helices: the educational system (represented by academic and higher education institutions), the economic system (including industries, banks, and services), the political system (comprising public authorities along with their plans, laws, and ideologies), the media and cultural sectors, and the natural environment (Grundel & Dahlström, 2016). These five helices function as subsystems facilitating the circular movement of knowledge among them.

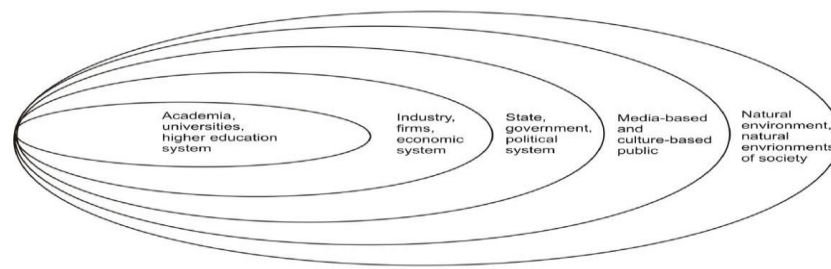


Figure 1. The subsystems of the Quintuple Helix model.

Source: Carayannis et al. (2012), as modified from Etzkowitz, Leydesdorff (2000)

Moreover, the implementation of the Quintuple Helix Innovation Model in the context of sustainable development, and specifically the Sustainable Development Goals (SDGs), has already been undertaken (Barcellos-Paula, 2021). The role of institutional differences among countries in achieving the SDGs is underscored by Maya, who notes that effective governance and the promotion of knowledge transfer between universities and businesses are critical for fostering social innovation (Maya, 2022). The Quintuple Helix model supports this by encouraging collaboration among multiple stakeholders, thereby enhancing the capacity for innovative solutions that address sustainability challenges.

The environment subsystem encompasses the status of environmental conditions and resources, including indicators such as changes in forest cover and levels of water and air pollution. The educational subsystem pertains to the degree of ecological education and research and development activities. The economic subsystem focuses on the proportion of renewable energy sources and per capita CO₂ emissions. The political subsystem examines governmental incentives for the advancement of a green economy and international partnerships addressing climate change. The societal subsystem addresses issues of social and gender inequality as well as community engagement in matters related to the green economy. Now that the basis for the proposed Index (i.e., the Quintuple Helix Model) has been defined, to make necessary calculations of SDGI an equal number of indicators (Grundel & Dahlström, 2016) were assigned to each of the subsystems (Kasztelan, 2018), 50 indicators in total (see Annex 1). All indicators were standardized. The average values of the (SDGI were calculated as the arithmetic means of the respective indicators. The composite SDGI was derived as the arithmetic mean of the values of five subsystems.

4. Research results

The Sustainable Development Green Index, including its subsystems, was computed utilizing data from European Union member states. The subsequent analysis was conducted using SPSS software.

According the results, Sweden leads the SDGI index with a score of 58.97, benefiting from its strong performance across the educational (57.39), economic (64.58), and societal (58.45) dimensions, indicating a balanced approach to sustainable development. Denmark follows closely with an overall SDGI score of 57.75, marked by strong educational (55.42) and political (61.73) subsystems, though lower performance in the economic sector (55.42). Germany demonstrates a notable strength in the educational subsystem (69.28), but has lower scores in economic (51.72) and societal (51.28) dimensions, suggesting a potential area for improvement despite its high SDGI index rank – 56.42 (Table 1).

Table 1. Sustainable Development Green Index calculated for the EU countries in 2020

Country	Sustainable Development Green Index subsystems					SDGI
	Educational	Economic	Political	Societal	Environmental	
Sweden	57.39	64.58	59.59	58.45	54.83	58.97
Denmark	55.42	59.56	61.73	56.65	55.38	57.75
Germany	69.28	51.72	54.71	51.28	55.09	56.42
Finland	53.08	56.02	60.92	57.32	52.73	56.02
France	63.88	51.41	54.06	50.47	53.64	54.69
Netherlands	58.33	51.71	56.45	53.86	51.55	54.38
Austria	52.37	52.67	51.22	50.35	54.48	52.22

Luxembourg	44.93	51.78	53.31	55.92	54.77	52.14
Spain	57.32	48.43	47.83	51.36	51.90	51.37
Estonia	44.28	52.62	51.21	54.42	52.83	51.07
Italy	56.68	50.12	50.19	47.16	49.96	50.82
Belgium	52.84	46.91	52.60	52.54	47.85	50.55
Ireland	46.19	51.91	48.77	55.59	47.92	50.08
Slovenia	45.63	47.89	49.50	47.36	52.58	48.59
Portugal	47.67	49.08	53.73	51.35	40.53	48.47
Latvia	40.90	52.23	51.79	48.16	48.37	48.29
Lithuania	41.58	51.32	47.93	48.68	49.61	47.82
Greece	47.26	42.15	48.31	51.88	48.40	47.60
Czech Republic	45.63	47.89	49.50	47.36	52.58	48.59
Slovakia	42.33	46.92	45.58	44.98	49.93	45.95
Croatia	42.32	49.50	45.24	40.85	49.76	45.53
Malta	42.52	49.82	43.70	47.28	43.98	45.46
Romania	42.17	49.09	43.06	42.91	49.02	45.25
Hungary	45.15	45.42	43.57	42.76	47.83	44.94
Cyprus	42.52	40.34	43.57	51.63	39.42	43.50
Bulgaria	42.24	43.40	42.14	42.67	46.85	43.46
Poland	47.55	40.72	37.50	44.68	45.61	43.21

Source: authors' calculations in SPSS software using statistical data

This group with higher values of the SDGI includes following countries as Finland (56.02), France (54.69), Netherlands (54.38), Austria (52.22), Luxemburg (52.14), Spain (51.37), Estonia (51.07), Italy (50.82), Belgium (50.55), Ireland (50.08). A lower level of values of the SDGI characterized other countries – Slovenia (48.59), Portugal (48.47), Latvia (48.29), Lithuania (47.82), Greece (47.60), Czech Republic (48.59), Slovakia (45.95), Croatia (45.53), Malta (45.46), Romania (45.25), Hungary (44.94), Cyprus (43.50), Bulgaria (43.46), Poland (43.21) (Table 1).

Statistic data show that Sweden leads the way with 46.0%, indicating a significant shift towards electric cars. Denmark and Finland also show high registered electric car rates at 34.5% and 31.8%, respectively, suggesting a growing preference for sustainable transport solutions in these countries as well. Countries like Germany (26.9%), Netherlands (29.7%), and France (17.6%) fall in the mid-range category. These are significant markets in the EU, and their shift towards electric cars can be a strong indicator of future trends. Eastern and Southern European countries tend to have lower adoption rates. Estonia, Slovakia, and Cyprus show the lowest percentages with 3.2%, 2.1%, and 0.8%. This might reflect economic factors, infrastructure challenges, or a slower policy push towards electrification (Table 2). Overall, the data points to a significant variation across the EU in electric car adoption, highlighting both the successes of certain regions and the opportunities for growth and development in others.

Table 2. Sustainable Development Green Index, newly registered electric cars and GDP per capita in the EU countries

Country	SDGI	Newly registered electric cars (% of all cars registered)	GDP, euro per capita, 2021
Sweden	58.97	46.0	44820.0
Denmark	57.75	34.5	50010.0
Germany	56.42	26.9	35480.0
Finland	56.02	31.8	37280.0
France	54.69	17.6	32530.0
Netherlands	54.38	29.7	41860.0
Austria	52.22	20.0	36950.0
Luxembourg	52.14	21.5	84490.0
Spain	51.37	5.7	23450.0
Estonia	51.07	3.2	15750.0
Italy	50.82	9.3	26710.0
Belgium	50.55	19.6	35960.0
Ireland	50.08	16.0	70530.0
Slovenia	48.59	4.3	21310.0
Portugal	48.47	19.9	18050.0
Latvia	48.29	3.9	12970.0

Lithuania	47.82	5.0	14820.0
Greece	47.60	6.9	17610.0
Czech Republic	48.59	3.2	18020.0
Slovakia	45.95	2.1	15920.0
Croatia	45.53	4.3	13780.0
Malta	45.46	20.5	22300.0
Romania	45.25	7.6	9550.0
Hungary	44.94	7.0	13690.0
Cyprus	43.50	0.8	25480.0
Bulgaria	43.46	4.4	6950.0
Poland	43.21	3.6	13760.0

Source: authors' calculations according to statistical data (European Environment Agency, 2022; Rybalkin, 2022).

Analyzing the provided table showing GDP (per capita in euros) for various European countries in 2021 reveals several observations regarding economic performance and disparities among countries. **Luxembourg** stands out with an exceptionally high GDP per capita (84.490), which is significantly above all other countries listed. Next follows **Ireland** with (70.530). **Denmark** (50.010), **Germany** (35.480), and **Netherlands** (41.860) are within the high range of income. **Bulgaria** (6.950) and **Romania** (9.550) show the lowest GDP per capita figures (Table 2).

Now that the SGDI has been defined for the EU member-states, it is suggested to test empirically its correlation with new registrations of electric cars in these countries and in a broader sense – with SDGs 9 and 11, which imply promoting sustainable transport (European Statistical Agency, 2022). Previously a strong correlation between SDGI and Plug-in Electric Car Share of Market in the EU countries has been revealed (Rybalkin, 2022). Recently new data have been published, showing a significant increase in the uptake of electric cars and vans in the EU-27 (European Environment Agency, 2022). Further, it appears necessary to find out if there is a correlation between the new data and SDGI, and to compare it to the correlation with such conventional metrics as GDP per capita.

To test this hypothesis and find out, which interrelation is stronger, a correlation analysis was performed with SPSS software. The results were as follows (Table 3).

Table 3. Results of Pearson correlation analysis between new electric cars registrations and SDGI, GDP per capita.

	SDGI	GDP per capita
Electric cars registration	0.824**	0.624**
	0.000	0.001
	27	27

**. Correlation is significant at the 0.01 level (2-tailed).

The correlation analyses show the strong positive correlation between newly registered electric cars (as percentage of all cars registered) and SDGI (0.824), which suggests countries with high sustainable development scores (as captured by the SDGI) are more likely to promote new electric cars registrations. This could be due to different factors (Table 3).

The correlation coefficient between electric car registrations and GDP per capita is 0.624. This value suggests a moderate positive correlation, meaning that as GDP per capita increases, the number of new electric car registrations tends to increase as well (Table 3).

5. Discussion and conclusions

Traditionally electric cars are seen as one of pillars for transition towards green economy (International Energy Agency, 2021). At the same time, still there is a big field for studying the electrification as one of the strategies for promotion sustainability in the transport sector.

The objective of this study to investigate the relationship between the adoption of electric car and sustainable development in European Union countries was achieved. It emphasized the analysis of how SDGI is associated with the expansion of the electric car market, offering insights to inform and improve policies related to sustainable transportation.

The results of the Pearson correlation analysis emphasize a strong, statistically significant relationship between electric car registrations and the SGDI in the EU countries. This finding highlights the importance of sustainability efforts in promoting electric car adoption. Policymakers and stakeholders should take these correlations into account when designing strategies to improve both the sustainability profile of their regions and the transition to electric mobility. Further research could explore the causal mechanisms behind this relationship and assess the impact of specific policies on electric cars uptake. The Pearson correlation analysis results presented indicate a significant relationship between new electric car registrations and GDP per capita in EU countries. Other research results also show that a strong economy stimulates demand for electric vehicles and supports the development of charging infrastructure (Shao & Mišić, 2023).

While the correlation suggests a positive relationship, it is important to note that higher GDP per capita does not automatically guarantee higher electric vehicle registrations. Researchers mention different factors such as regional policies, availability of electric car models, consumer preferences, and cultural attitudes toward electric cars and even cost of electricity (Hofbauer, 2021) also play critical roles. Hidayati underlines that public perceptions play a significant role in the adoption of electric cars. Research indicates that positive public perceptions can enhance ridership and support for sustainable transport policies (Hidayati, 2023). Scientists Qiu and Bindhya indicate that while there is a growing interest in electric cars, challenges such as range anxiety and the availability of charging infrastructure continue to represent considerable impediments to the widespread adoption of electric cars (Qiu, 2024; Bindhya, 2024); Hofbauer, Vylegzanin (2022) and Schvartz et. al. (2024) survey findings also reveal that factors such as accessibility of charging infrastructure and maintenance considerations are primary determinants that influence the purchasing decisions regarding electric cars. Government initiatives aimed at promoting electric cars through incentives and subsidies are crucial in addressing these concerns and enhancing consumer confidence (Budiono, 2024).

The novelty of the findings lies in its use of the SDGI to analyze the impact of sustainability efforts on electric car adoption across EU countries. This approach provides a unique perspective on how different dimensions of sustainability – economic, educational, environmental, societal, and political – influence the growth of the electric car market. By linking SDGI scores to electric car registrations, the study offers valuable insights for policymakers aiming to foster sustainable transportation solutions.

The practical implications of the article are significant for advancing electric car adoption in the EU. It provides guidance for policymakers on creating effective incentives and infrastructure plans. The study highlights the necessity of expanding charging networks, emphasizing the importance of robust infrastructure to support increased electric car usage. Economic incentives such as tax breaks and subsidies are recommended to make electric vehicles more affordable and attractive to consumers. Additionally, the paper underscores the significance of raising public awareness about the benefits of sustainable transportation and suggests that tailored solutions should be implemented to address specific challenges and opportunities in different EU regions.

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Annex 1

Indicators used for each of the subsystems of the Quintuple Helix

Subsystem 1. Education:

- S_1_1 Research institutions prominence 0–100 (best) (Global competitiveness report (further – GCR) 2019);
- S_1_2 Scientific publications score (GCR, 2019);
- S_1_3 Gross expenditure on R&D, % of GDP (Global Innovation Index, 2020);
- S_1_4 Total number of documents in Scopus, Environmental science, cumulative, 1996 – 2019 (SJR — SCImago, 2021);
- S_1_5 Citable documents, 1996 – 2019 (SJR — SCImago, 2021);
- S_1_6 Citations (SJR — SCImago, 2021);
- S_1_7 Self-citations (SJR — SCImago, 2021);
- S_1_8 Citations per document (SJR — SCImago, 2021);
- S_1_9 h-index, (SJR — SCImago, 2021);
- S_1_10 Patents by origin/bn PPP\$ GDP (Global Innovation Index Report, 2020);

Subsystem 2. Economic aspects:

- S_2_1 GDP per unit of energy use (Global Innovation Index Report, 2020);
- S_2_2 ISO 14001 environmental certificates per bn PPP\$ GDP (Global Innovation Index Report, 2020);
- S_2_3 Resource efficiency index (The global sustainable competitiveness index, 2020);
- S_2_4 Greenhouse gas emissions score (Climate Change Performance Index, 2021);
- S_2_5 Share of renewable energy in gross final energy consumption by sector, % (Eurostat, 2019)
- S_2_6 The global sustainable competitiveness index (2020);
- S_2_7 Circular material use rate, % of material input for domestic use (Eurostat, 2019);
- S_2_8 Efficiency sectors (Global Competitiveness Report, 2019);
- S_2_9 growth of innovative companies 1–7 (best) (Global Competitiveness Report, 2019);
- S_2_10 Energy transition index (Energy transition index 2020 by World Economic Forum);

Subsystem 3. Political system:

- S_3_1 Stringency of environmental regulations, index (Travel and Tourism Competitiveness Report, 2019);
- S_3_2 Enforcement of environmental regulations, index (Travel and Tourism Competitiveness Report, 2019);
- S_3_3 Environment-related treaties in force count (out of 29 possible) (Global Competitiveness Report, 2019);
- S_3_4 Climate policy, index – covers both national and international climate policy performance (Climate change performance index, 2021);
- S_3_5 Climate Change Performance Index (Climate change performance index, 2021);
- S_3_6 Environmental performance, index (Global Innovation Index, 2020);
- S_3_7 Environmental tax revenues, % of GDP (Eurostat, 2018);
- S_3_8 Intellectual property protection 1–7 (best) (Global Competitiveness Report, 2019);

S_3_9 population covered by the Covenant of Mayors for Climate & Energy signatories – percentage of total population (Eurostat, 2019, for the UK – 2018);

S_3_10 Renewable energy regulation 0–100 (best) (Global Competitiveness Report, 2019).

Subsystem 4. Civil society:

S_4_1 Attitude of European citizens towards the environment – percentage of population who consider environmental issues to be important (Eurobarometer, 2017);

S_4_2 World Press Freedom Index (Reporters without borders, 2020)*;

S_4_3 Democracy index (The Economist Intelligence Unit, 2020);

S_4_4 Civil liberties (The Economist Intelligence Unit, 2020);

S_4_5 Social Capital Index (The global sustainable competitiveness index, 2020);

S_4_6 Incidence of corruption 0–100 (best), (Global Competitiveness Report 2019);

S_4_7 Internet users % of adult population, (Global Competitiveness Report, 2019).

S_4_8 People at risk of poverty or social exclusion, Eurostat (2019), except for Ireland, Italy, the UK (2018);

S_4_9 Share of busses and trains in total passenger transport, % of total inland passenger-km (Eurostat, 2018);

S_4_10 Females employed with advanced degrees, % (Global Innovation Index, 2020).

Subsystem 5. Natural environment:

S_5_1 Environmental performance index (Environmental performance index report, 2020);

S_5_2 Air quality (Environmental performance index report, 2020);

S_5_3 Water resources (Environmental performance index report, 2020);

S_5_4 Biodiversity and habitat (Environmental performance index report, 2020);

S_5_5 Forest cover change, % (The Travel & Tourism Competitiveness Report, 2019)*;

S_5_6 Wastewater treatment, % of total (The Travel & Tourism Competitiveness Report, 2019);

S_5_7 Total protected areas, % of territory (The Travel & Tourism Competitiveness Report, 2019);

S_5_8 Natural capital (The Global Sustainable Competitiveness Index, 2020);

S_5_9 Ecological sustainability, index (Global Innovation Index Report, 2020);

S_5_10 Agriculture (Environmental performance index report, 2020);

* a negative indicator (inverse relationship with sustainable development).

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