Article

Modeling and Evaluation of Market Incentives for Battery Electric Vehicles

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Abstract: Electric mobility has great potential to help achieve global climate change mitigation goals. Within the domain of electric vehicles (EVs), battery electric vehicles (BEVs) have the largest advantage over conventional internal combustion engine technology. However, their penetration depends on many factors. Several studies have investigated the different policy incentives supporting the EV market, but less analytical research has been conducted to evaluate the different incentives. This study investigates the wide range of incentives that were adopted across 15 countries between 2010 and 2018, and their effectiveness in the market amidst other factors, using a generalized linear model. The results of the statistical analysis identified the availability of local BEV production facility, income, accessibility to fast charging infrastructure, and value-added tax exemptions as positive and statistically significant factors to the market share of BEVs across the years, while positive significant correlations were not identified for the other factors and incentives investigated. This emphasizes the impact of economic performance, technological certainty, and the presence of charging infrastructure with fast charging solutions in BEV adoption decision making, and could be an indication to policymakers of the limited impact of other factors when considered over a length of time.

Keywords: battery electric vehicles; electric mobility; incentives; sustainability

1. Introduction

With increased urbanization and economic growth, there has been a corresponding increase in the global demand for passenger and freight transportation free of unwanted carbon emissions. Urban transport has been particularly problematic due to the heavy dependence of society on automobiles powered by fossil fuels for daily activities. However, the adverse effects of these carbon emissions on human health, biodiversity, and the environment have made it vital to decarbonize the transport sector. Different policy actions themed around transition to a more transport-efficient society, more energy-efficient and less polluting vehicles, and an accelerated shift from non-renewable energy to renewable energy sources have thus been formulated and implemented across the globe [1,2]. The electric vehicles (EVs) and, among them, battery electric vehicles (BEVs) may be best for tackling local air pollution and carbon-dioxide emissions [3–8]. The development and deployment of alternative-fueled vehicles have a critical role in this transition [9].

The fueling network is part of the chicken-and-egg problem of electric mobility, and the changes in supply and demand may hinder each other through their cross effects. Anyway, market experiences show that the deployment of alternative fuel infrastructure plays a substantial role in increasing the adoption ratios, aiming at sustainable transportation.

Another substantial barrier in further market development is the technological conditions (range, refueling time), where BEVs still have disadvantages compared to the internal
combustion engine vehicles (ICEVs). Furthermore, there are remarkable gaps in purchase prices of these two technologies, favoring ICEVs [3,10–12].

This study builds on the authors’ former research findings on incentives and disincentives in electric mobility based on market evidence. The previous research identified and categorized the existing factors according to their main attributes as financial incentives (purchase incentives, value-added tax exemption, vehicle registration tax benefits, ownership tax benefits, discounted/free parking, and toll road exemptions), non-financial incentives (charging infrastructure development and access to restricted traffic lanes), and disincentives with respect to conventional vehicles [3]. The study proved that there are positive impacts and interactions of market incentives, but defining their extent needs further quantitative analysis.

This phase of the research aims to identify the effective market influencing factors with statistical analysis. It investigates a wide range of measures adopted by various countries, incorporating local socio-demographic and socio-economic factors that may influence the factors’ market effects. In this paper, a comprehensive statistical analysis and modeling, including a sophisticated qualification of market incentives across the most prominent countries, are presented and discussed. It adopts regression analysis, a research approach that has, over time, become the top priority statistical tool to find the relationship between EV adoptions and factors [13]. In accordance with the aim of the study, the generalized linear model sub-method of regression analysis was used, as the model provides a measure of the importance of each independent variable as a predictor of the dependent variable. While this approach has previously been successfully applied to investigate the factors and incentives supporting the EV market for a single case in a particular year, and a single case over a span of years or multiple cases over a year [14–18], we extended the application from a data perspective by compiling a dataset with data of the different factors and incentives influencing the BEV market across fifteen European countries between 2010 and 2018. The findings support the set of policy measures to be applied by countries in the future. Due to their market-distorting effects, the authors consciously neglect the recent pandemic years (starting from 2019) in the research.

2. Materials and Methods

This section describes how BEV adoption rates across selected countries were analyzed using a set of technological, socio-economic and socio-demographic variables together with available incentives including financial, non-financial and disincentives using SPSS software.

2.1. Data Collection

Data were collected across 15 countries in Europe between 2010–2018 from different sources, as provided in Table 1. The covered countries, which have well-developed BEV markets due to the presence of strategies and policy instruments to incentivize the growth of the electric vehicle market, include: Norway, Germany, the United Kingdom, France, Sweden, Belgium, Netherlands, Switzerland, Spain, Austria, Italy, Portugal, Finland, Hungary and Poland. The study period was limited to this period, as data about some of the intended variables were not available prior to this period. This is to be expected, as socio-technical transitions occur gradually over time after the availability of new sustainable technologies. The delayed transition offers time for new value chains to be established, the alignment of institutional arrangements to new sector structures, and the development of business models of utilities and consumer usage patterns [19,20]. This equally justifies why a large span of time was selected for the study, as this increases the probability of creating a realistic and more reliable model. However, the timeline of the analysis neglects the recent pandemic years, due to their market-distorting effects.
Table 1. Description of data and source.

| Data                | Description                                                                 | Source                                      |
|---------------------|-----------------------------------------------------------------------------|---------------------------------------------|
| BEVs market         | Number of BEVs for selected countries (2010–2018)                           | EAFO \(^1\) [21], ACEA \(^2\) [22]         |
| AFV market          | Number of alternative fuel vehicles for selected countries (2010–2018)      | EAFO [21], ACEA [22]                       |
| Passenger car market| Total number of passenger cars for each of the studied countries (2010–2018) | ACEA [22]                                  |
| AC charger ≤ 22 kw   | Number of slow charging points for selected countries (2010–2018)           | EAFO [21]                                  |
| DC charger > 22 kw   | Number of fast charging points for selected countries (2010–2018)           | EAFO [21]                                  |
| DC charger/100 km   | Number of public fast charging points per 100 km of the highway (2010–2018) | EAFO [21]                                  |
| V/C ratio           | The ratio of vehicles per total number of charging points                    | EAFO [21]                                  |
| GDP                 | Per capita GDP for the selected countries (2010–2018)                       | Eurostat [23]                              |
| % Employment        | Employment ratio as a percentage of total population (2010–2018)           | OECD \(^3\) [24]                           |
| Gasoline prices     | Gasoline pump price (EUR/lit)                                               | WB \(^4\) [25], European Commission [26]   |
| Electricity prices  | Annual electricity prices in EUR                                             | Statista [27]                              |
| Incentives          | Availability of financial and non-financial incentives                       | EAFO [21], ACEA [22]                       |
| Urban population    | Population living in the urbanized area                                      | WB [25], Demographia \(^5\) [28]           |
| Urban area          | The urbanized area of the selected countries                                 | WB [25], Demographia [28]                  |

\(^1\) European Alternative Fuel Observatory. \(^2\) European Automobile Manufacturers Association. \(^3\) Organization for Economic Cooperation and Development. \(^4\) The World Bank. \(^5\) Demographia World Urban Areas.

Data for the following were collected and used to develop the variables used in this study: socio-economic and socio-demographic factors including income (per capita GDP), employment ratio, gasoline prices, electricity prices in the urban population, and urban land area (used as an input to compute the urban density); and technological factors including availability of charging infrastructure (number of fast, slow charging points) and vehicles per charging point. In addition, information about the availability of financial incentives (purchase incentives, value-added tax exemption, vehicle registration tax benefits, ownership tax benefits, discounted/free parking, and toll road exemptions) and non-financial incentives (charging infrastructure development and access to restricted traffic lanes), were also collected.

For infrastructure, while the majority of previous studies considered the number of charging points as one variable to investigate its impact on the PEVs, this study took this a step further by categorizing it into two separate components. We considered the number of fast (DC) charging points and number of normal (AC) charging points separately, while correcting both per 100,000 urban population. We did this to investigate the effectiveness of fast charging infrastructure in quelling the range anxiety of adopters.

In contrast with other studies [14,15,29,30], the financial and non-financial incentives were treated as dummy variables, represented as 1 when available and 0 when unavailable, regardless of the cost associated with the incentive on the part of the government or the benefits derived by the potential user or early adopter of the BEVs. For grants or subsidies given by the government for charging infrastructure development, however, they were assigned the value of 1 provided the government incentives covered at least 50% more than the installation cost for companies, public entities and residential buildings.
2.2. Generalized Linear Model

The generalized linear model (GLM) is a flexible generalization of ordinary linear regression, allowing the response variables with error distribution models but not a normal distribution. The GLM generalizes the linear regression by allowing the linear model to be related to the response variable by a connection function and by allowing the magnitude of the variance of each measurement to be a function of its predicted value.

A preliminary correlation analysis on the individual variables revealed some dynamics that otherwise would not have been evident in the generalized linear model. One of the observed patterns was that many of the variables were significantly correlated. The correlation analysis and the significant relation between some independent variables made a reconfiguration in the data necessary, as it was designed to check the comprehensive effect of infrastructure on the number of BEVs per year. However, after the correlation analysis, it was clear that there was a significant relationship between the number of fast charging points, the number of slow charging points, and the number of fast charging points per 100 km of highway. At this point, the number of fast charging points was normalized per 100,000 urban population (FCUP), while the effect of normal charging points and fast charging points were considered together as a single variable (Fast&Norm).

The variables considered in this research are listed in Table 2, and were analyzed by the generalized linear model using SPSS software. The final model specification is given as:

$$ BEVs_{MSi} = \alpha + \beta_1 \text{Fast&Norm}_i + \beta_2 \text{FCUP}_i + \beta_3 \left( \frac{V}{C} \right)_i + \beta_4 \text{GDP}_i + \beta_5 \text{Emp}_i + \beta_6 \text{Elec}_i + \beta_7 \text{Gas}_i + \beta_8 \text{Urban Density}_i + \beta_9 \text{Purchase}_i + \beta_{10} \text{Reg}_i + \beta_{11} \text{Own}_i + \beta_{12} \text{Comp}_i + \beta_{13} \text{VAT}_i + \beta_{14} \text{Other}_i + \beta_{15} \text{Prod}_i + \beta_{16} \text{Infra}_i + \beta_{17} \text{Local}_i + \epsilon_i $$

where the subscript \((i)\) signifies the country, and \((\epsilon)\) is the error value.

### Table 2. Variables and their description.

| Variable           | Description                                                                 |
|--------------------|-----------------------------------------------------------------------------|
| BEVsMS             | Market share of BEVs per year                                              |
| Fast&Norm          | Total number of the charging points (fast charger + normal charger)         |
| FCUP               | Number of the fast charging points per 100,000 urban population             |
| V/C                | BEVs per total number of the charging point                                 |
| GDP                | Per capita GDP                                                              |
| Emp                | Employment ratio as a percentage of the total population                    |
| Elec               | Annual electricity prices in EUR                                            |
| Gas                | Gasoline pump prices (EUR/lit)                                             |
| Urban Density      | Urban population per km² of urban land area                                 |
| Purchase           | (yes/no) Monetary subsidy given to the buyer during first purchase of a BEV |
| Reg                | (yes/no) Registration tax benefit for the potential buyer of BEVs          |
| Own                | (yes/no) Ownership or circulation tax benefit for the BEV users             |
| Comp               | (yes/no) Company tax benefit for the BEV users                              |
| VAT                | (yes/no) Value-added tax benefit for the BEV buyers                         |
| Other              | (yes/no) Other benefits for BEV users                                       |
| Prod               | (yes/no) Availability of local BEV production facility                      |
| Infra              | (yes/no) Government fiscal incentive for the installation of the charging point |
| Local              | (yes/no) Local incentives such as free parking, access to the bus lane, toll fees, free charging, access to the restricted area |

The empirical values that were used for the statistical analysis and the Pearson’s correlation coefficient \((r)\) and statistical significance between the variables are presented in Tables S1 and S2 of the Supplementary Materials, respectively.

3. Modeling the BEV Market

Two models were investigated in this study. The purpose was to check which one of them would show a greater response in the case of correlation between the dependent variable (BEVs market share) and the independent variables, including the technological, socio-economic, socio-demographic factors and incentive policies as given in (1). The difference between the two models was that, in the first model, the dependent variable,
the market share of BEVs (BEVsMS) was calculated as a percentage of BEV sales per the alternative fuel vehicle AFV sales per year, as shown in (2), while in the second model, the market share was calculated as a percentage of BEV sales per total passenger car sales per year, as shown in (3).

\[
\text{BEVsMS}_i = \frac{\text{BEV market}}{\text{AFV market}} \times 100\% \quad (2)
\]

\[
\text{BEVsMS}_i = \frac{\text{BEV market}}{\text{Passenger car market}} \times 100\% \quad (3)
\]

The goodness of fit calculated showed that the second model (BEV/passenger cars) was more responsive to the independent variables based on the goodness of fit criteria for each model. As shown in Table 3, the Akaike’s Information Criterion (AIC) and the Bayesian Information Criterion (BIC) of the second model were lower than that of the first model. The lower the values, the better the model; hence, Model 2 was selected for further analysis in the study.

Table 3. Goodness of fit \(^{a}\) of Model 1 and Model 2.

| Criteria                          | Model 1 \(^{c}\)       | Model 2 \(^{d}\)       |
|----------------------------------|------------------------|------------------------|
| Deviance                         | 33,759.311             | 4798.546               |
| Observations                     | 135                    | 135                    |
| Log Likelihood \(^{b}\)          | −564.274               | −432.585               |
| Akaike’s Information Criterion (AIC) | 1170.548             | 907.171                |
| Finite Sample Corrected AIC (AICC) | 1178.725             | 915.348                |
| Bayesian Information Criterion (BIC) | 1231.559             | 968.181                |
| Consistent AIC (CAIC)            | 1252.559               | 989.181                |

\(^{a}\) Information criteria are in smaller-is-better form. \(^{b}\) The full log-likelihood function used in computing information criteria. \(^{c}\) Model 1: Percent of BEV per AFV sales per year. \(^{d}\) Model 2: Percent of BEV per total passenger car sales per year.

The results of the analysis to study the effect of the number of fast chargers, adjusted for 100,000 urban population, the total number of chargers, vehicles per charging points, income, employment ratio, electricity prices, gas prices, urban density, purchase subsidy, registration tax benefit, ownership tax benefit, company tax benefit, value-added tax (VAT) benefit, presence of production facility, infrastructure incentives, local incentives and other incentives of the BEV market share across the selected countries between 2010 and 2018 are presented in Table 4.

The residual values which indicate how well the line has fitted the sample are presented in Table 5. The model’s adjusted R\(^2\) value being 0.768 indicates that more than three-quarters of the variation in the BEV market share were explained by the tested variables. The mean of residuals was zero, which implies that the residuals were normally distributed, and the model was reliable. The calculated value of skewness being close to zero also infers that the distribution of residuals was fairly symmetrical and normally distributed.
Table 4. Results of BEV market analysis from 2010–2018.

| Model 2 | Unstandardized Coefficients | Standardized Coefficients | Sig. |
|---------|-----------------------------|---------------------------|------|
| (Constant) | −284.0034 | 0.734 |
| Prod | 24.9076 | 0.880 | 0.000 * |
| Comp | −16.9491 | −0.561 | 0.000 * |
| GDP | 0.0005 | 0.538 | 0.000 * |
| FCUP | 1.7571 | 0.530 | 0.000 * |
| Emp | −0.8974 | −0.471 | 0.000 * |
| VAT | 9.9685 | 0.330 | 0.000 * |
| Reg | −9.4810 | −0.317 | 0.000 * |
| Purchase | −7.8017 | −0.292 | 0.001 * |
| V/C | 0.6767 | 0.276 | 0.001 * |
| Infra | −7.4017 | −0.255 | 0.000 * |
| Urban Density | −0.0028 | −0.217 | 0.001 * |
| Gas | −11.4346 | −0.174 | 0.008 * |
| Elec | −0.3407 | −0.108 | 0.131 |
| Own | 4.0963 | 0.099 | 0.218 |
| Other | 1.2978 | 0.041 | 0.701 |
| Local | 0.4558 | 0.014 | 0.845 |
| Year | 0.1761 | 0.034 | 0.672 |
| Fast&Norm | 0.0001 | 0.038 | 0.546 |

* *p* < 0.05.

Table 5. Residual statistics.

| Raw Residual | Statistic |
|--------------|-----------|
| Mean | 0.00000 |
| 95% Confidence Interval for Mean | Lower Bound | Upper Bound |
| 5% Trimmed Mean | −0.00829 | 0.00829 |
| Median | 0.59505 |
| Variance | 35.810 |
| Std. Deviation | 5.984149 |
| Minimum | −26.412 |
| Maximum | 31.532 |
| Range | 57.944 |
| Interquartile Range | 6.168 |
| Skewness | 0.327 |
| N | 135.000 |
| R² | 0.801 |
| Adjusted R² | 0.768 |

4. Discussion

From the results, the coefficient of Prod, GDP, FCUP, VAT, and V/C were positive and statistically significant to the adoption levels, with *p*-values less than 0.05 as shown in Table 4. The presence of a BEV production facility was the most effective factor in determining the BEV market share with the Beta value 0.88. Income was the second most effective factor in measuring the adoption level with the Beta value 0.538. The number of fast charging points per 100,000 of the urban population, value-added tax (VAT), and finally the vehicles per charging point (V/C) had Beta values of 0.530, 0.330, and 0.276, respectively.

In agreement with [14], the model results cannot be automatically adopted to any country without criticism. Although the model could show reasonable significance for selected factors, due to social, cultural, geographical, economical, and analyzed time period differences, the coherencies, significances and extent of desirable impact need specific investigations.
The presence of production facilities has proven to be an important factor in determining the adoption level; [14] concluded "local presence of production facilities to be significant and positively correlated to a country’s electric vehicle market share”. This is further confirmed by the findings of this study, as the model postulates that the presence of production facilities in a country such as Germany determined 90% of the BEV market share in 2010, with the effect growing yearly. Similarly, in the UK, 80% of the BEVs market share was explained by the presence of a production facility at different times within the study period. This extends to other countries where the market share is significantly influenced by the availability of production facilities in the country.

The GDP per capita was the second most significant factor (Beta = 0.538) in determining BEV adoption rates. This aligns with the findings of [31–33], who postulated that income and some other socio-demographic variables effectively measure the EVs adoption rates. The GDP per capita is one of the main reasons behind the strong BEV market share in some countries such as Norway. It also suggests the reason behind the weak BEV market in some others, and this relationship could be attributed to the high purchase cost of BEVs. For example, the market share in Spain and Portugal is very low compared to Norway. With Spain having a comparatively lower GDP per capita, using the model, Spain’s BEV market share could be increased by 12% with an increase in GDP of 5%. However, a similar increase in Portugal’s GDP per capita would boost the market share of BEVs by more than 20%.

The third most effective variable was the availability of fast charging points, with a Beta value of 0.530. While previous studies have affirmed the importance of the availability of charging points in general, this finding specifies that the provision of fast charging infrastructure is particularly more effective in the drive to spur the electric vehicle market. In one such study, [16] found that the provision of one charging station was twice as effective as expending USD 1000 on financial incentives directly to potential adopters. Based on the analysis of this study, we can conservatively postulate similarly that in a society such as Norway where the provision of fast chargers has reached saturation point, the provision of an additional fast-charging station per 100,000 urban population has the potential to increase the market share of BEVs by 0.25%.

Some of the research findings support the previous analysis reports, as reviewed by [13]; however, in some cases, such as electricity prices, annual circulation tax benefits, local incentives, and other benefits (as shown in Table 4), there are no significant relations to growing market penetration.

Furthermore, the model identified that some factors have negatively affected BEV market share, such as the company tax benefit, employment ratio, registration tax benefit and the purchase subsidies, urban density, infrastructure subsidies, and gasoline prices (all significantly affected, with a p-value less than 0.05), as shown in Table 4.

This study found negative relations to BEV adoption rates with, for example, purchase subsidies, registration tax benefits, gasoline prices, and others. However, this does not dispute or undermine the methodological approaches and findings of earlier studies, such as [14,30,34,35]. Apart from the differences in countries studied and datasets, there are other fundamental differences in those studies which further explain the differing outcomes. Firstly, EVs were generally examined in their studies, while BEVs were specifically targeted in this study, where many factors hinder their market share. Secondly, most of the previous studies focused on data from a single year as a study period, while this study used data spanning nine years. Finally, many countries—including those selected in this study—do not distinguish between different types of EVs while allocating market incentives. This has made PHEVs and HEVs more attractive to potential buyers, as they can benefit from these incentives while still enjoying lower purchase prices, longer driving range, and shorter fueling time. The majority of countries involved in this study made no differentiation between BEVs and the other types of EVs, for example, the purchase subsidies, registration tax benefits, company tax benefits, and other benefits are available to all types of EVs with no distinction between BEVs and other types of EVs, such as PHEVs, one of the main competitors of BEVs in the market. They are more attractive to potential buyers because
they have a lower purchase price, longer driving range, and shorter refueling time, and the owner can still obtain the advantage of all incentives offered to BEVs.

5. Conclusions

The goal of this research study was to investigate the relationship between the socio-economic and socio-demographic technological factors and incentives offered to improve the adoption of BEVs across 15 European countries between 2010 and 2018. The factors included in this research study were divided into three groups.

The first group described the variables with a positive and significant relation to the adoption rates, which included the number of fast chargers (adjusted for urban population), income, presence of local EV manufacturing facilities, value-added tax (VAT) benefits, and vehicles per charging point. Among these factors, the presence of a local EV production facility was found to be the most significant factor in estimating the adoption rates. However, descriptive analyses illustrated how countries’ specific factors could dramatically influence the nation’s adoption rates.

The second group covered all variables with a negative and significant relation to adoption levels. These variables were purchase subsidies, registration tax benefits, company tax benefits, employment ratio, infrastructure subsidies, gasoline price, and urban density. Conversely, the literature confirmed the positive effect of some of these factors on the EV market, such as purchase subsidies, registration tax benefits and company tax benefits; however, there are fundamental differences between the previous studies and the current research, which could elaborate these negative results. First, all EV types were investigated in earlier studies, while BEVs were targeted among all types of EVs in this study. Second, the majority of previous studies examined these factors in a single year, while this research focused on a nine-year period (2010–2018). Third, and the most influential point behind these negative results, was because of the covering range of the incentives. The incentives offered by the majority of countries involved in this study covered all types of EVs without any differentiation between BEVs and other types of EVs, namely PHEVs. As a result, the potential buyer would prefer an EV with a lower purchase price, longer range and shorter refueling time, such as a PHEV, rather than a BEV which has a high purchase price, shorter range and longer refueling time.

The third group contained the variables which were not effective in predicting the adoption rates, such as electricity price, ownership tax benefits, the total number of charging points, local incentives, and other benefits. The change in the electricity price was not an effective factor in estimating the BEV adoption level, as expected and proved by the previous studies; perhaps this is because EV charging is free in most of the countries involved in our study. Further studies are recommended to investigate the effect of ownership tax benefits, local incentives and other financial incentives on the BEV market share.

Overall, this analysis ensures a tentative endorsement of the provision of fast chargers, the presence of production facilities, and value-added tax exemptions as an approach to encourage the BEV market. The incentives, specifically those which were found to be negatively related to BEV adoption rates, especially the purchase subsidies and tax exemptions, should be more precisely directed only to BEVs if a country wants to encourage its BEV market share.

Drawing inference from the significant relationships found among the investigated factors and incentives, recommendations can be made for policymakers to boost the market share of BEVs and harness the environmental goals they offer in the coming years. Policymakers should:

- Enact policies that will drive economic development thereby improving the purchasing power of the citizenry;
- Attract the investment of EV original equipment manufacturers (OEMs) in production facilities, as this will boost the availability of EVs and components, with a further chance of reducing the technological uncertainty amidst potential adopters;
• Invest in and promote charging infrastructure provisions, particularly fast chargers, to lower range anxiety;
• Consider offering incentives based on the potential sustainability impact associated with the vehicle types.

Despite the significant positive results, this study has addressed some countries whose adoption rates were not particularly responsive to these factors, as explained in detail above. Moreover, the application of such approaches could mask other dynamics that effectively increase local BEV adoption rates. At the same time, it is concluded that while these factors are positively correlated to the national BEV adoption rates, they may not necessarily apply to every country. For example, the establishment of a local manufacturing facility may not give the same results in two countries where the GDP of one of them is half, or less than half of the other, or the number of fast charging points of one is much lower than the other, as this fact was proven in this study. Therefore, it should be treated with prudence. After identifying the policies that could spur BEV adoption rates, it is necessary to check the feasibility of these policies, and whether they are economically efficient or not; therefore, cost–benefit analysis (CBA) is essential, and it is worth knowing that impacts from radical innovations are usually significant on a long-term basis. Hence, policymaking and investments to decarbonize the transport sector should be built around a long-term strategic vision.

The temporal limitations of this study predict the need for future investigation of the pandemic’s impact on BEV markets. According to [36], there has been no break in tendencies of BEV market penetration in Europe, with global electric car sales defying the shock of the pandemic. This could be attributed to existing policy support and additional stimulus efforts through COVID-19 recovery packages by authorities, e.g., in France, Germany, Italy, and the United Kingdom. In addition, recent EU directives and regulations (e.g., alternative fueling infrastructure, batteries, emission standards, recovery and resilience facilities) may have strengthened political will and economic interest in maintaining the growth of the EV sector. Consequently, further study considering these developments and regional variation will be required to ascertain the responsible factors for BEV growth beyond the period covered in this study.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/su14074234/s1, Table S1: Empirical values used for the statistical analysis; Table S2: Person’s correlation coefficient (r) and statistical significance between the variables.

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