THE ROLE OF CHARGING INFRASTRUCTURE AND INCENTIVES ON THE ADOPTION OF ELECTRICAL VEHICLES IN THE UNITED STATES

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Abstract

Adoption measures are shown to be necessary for market formation by examining policies and their implementation. Such approaches could aid the spread of innovations and overcome market failures that impede the acceptance of innovative products like Electric Vehicles (EV), which are becoming increasingly popular. This study will examine the role of charging infrastructure and incentives on the adoption of EV in the United States. In exploring EV adoption, charging infrastructure and incentives, brief reviews of past literature were examined. In addition to this, the proposed research purpose and objectives were introduced, as the study would involve the use of four objectives and three research questions. The research methodology section provided an overview of the research design; this research will employ the use of secondary data; the secondary data will be taken from data.gov.

Introduction

According to the International Energy Agency [IEA] (2013), the transportation sector accounts for 23% of worldwide energy-related greenhouse gas (GHG) emissions. If unchecked, these emissions are anticipated to more than double by 2050 under the business-as-usual scenario (Sims et al., 2014). Such a trajectory raises pressing concerns given the accelerating pace of global climate change and its associated adverse impacts, such as rising sea levels, extreme weather events, and disruptions to ecosystems.

Light-duty vehicles (LDVs) form a significant portion of the transportation sector and are consequently a primary contributor to these emissions. Their pervasive role in daily commutes, coupled with the dominant reliance on gasoline and diesel fuels, makes them a crucial segment to target for environmental and sustainability improvements.

In the United States, the transportation landscape has been undergoing a paradigm shift over the past decade. Electric Vehicles (EVs), once considered a niche segment, are now at the forefront of this transformation, positioned as a leading solution to address the environmental challenges. Their potential to operate without direct GHG emissions, coupled with advancements in battery technology and renewable energy sources, positions EVs as a sustainable alternative for the future.

The adoption of EVs in the US is also influenced by the availability and distribution of charging infrastructure. As of the latest data, California leads the nation with approximately 13,892 charging stations, followed by states like New York, Florida, and Texas. The widespread availability of Level 2 Charging stations, making up 82.7% of the total, indicates the focus on providing daily charging solutions for EV users. On the other hand, DC Fast Charging stations, crucial for long-distance travel and quick charging, make up 16.2% of the infrastructure.

To fully understand the impact of charging infrastructure and incentives on EV adoption, this study dives deep into the current state of EV infrastructure, its distribution across states, and the types of charging options available.

Literature Review

Demands for Electric Vehicles

Although most EV owners recharge their vehicles at home overnight, potential buyers demand improved infrastructure because of their perceived need and fear of running out of power (Deloitte, 2011). While high purchase subsidies are desirable but not necessary for attracting EV customers regardless of daily average distances traveled, extensive global research using a "stated choice" survey has shown that lack of a recharging network, especially on freeways, caused the strongest dissatisfaction among survey participants. An updated poll confirms this finding and shows that British drivers (mostly those driving ICVs) are more concerned about the availability of rechargers in their neighborhood and the vehicle's range than they are about the cost of the car (UK DfT, 2016).

Many developed countries have put policies and strategies in place to encourage people to buy electric vehicles, but some have been more successful than others. Market uptake is an important indicator of EV acceptance since it can be used regardless of the size of the population, the location of the country, or the level of national wealth. It is also evident in Denmark that the cost of EVs should not be prohibitively high compared to conventional vehicles. As of 2015, 2.39% of all new cars sold in Denmark were electric vehicles (EVs). However, a governmental decision to partially re-impose registration fee in 2016, with full tax by 2020, resulted in high EV sales in late 2015 as sales were rushed forward, and sales fell quickly to 0.63% for 2016 (Wenande, 2016).

Many countries have implemented required vehicle emissions reduction objectives that have taken stricter over time to stimulate the use of electric vehicles (European Commission Climate Action, 2016). One of the most notable things about the recent fuel economy cheating scandals involving major automobile manufacturers is the fact that several of these companies were caught cheating on fuel economy tests (Farrell, 2016). In Europe, automotive emissions are averaged throughout a brand; therefore, producing more EVs could be an easier method for a brand to satisfy its emissions requirements (European Commission Climate Action, 2016). Volkswagen's decision to increase its EV production following the company's pollution issue serves as an excellent example (Cremer, 2016).

EV and Charging Infrastructures

Even though governments may view the deployment of recharge stations as an expensive infrastructure investment, recent modeling shows that it is three times more successful than subsidizing EV purchases because of indirect network effects on the supply and demand sides of a market (Yu, Li, & Tong, 2016). An extensive network of rapid chargers was shown to be the most efficient method of supplementing overnight charging at home in the United Kingdom (Cluzel et al., 2013). In many countries, the lack of suitable recharging networks may be a contributing factor to the limited penetration of electric vehicles. In countries that are encouraging the widespread use of electric vehicles, financial assistance is typical, particularly for public charging stations (OECD 2015).

The ability of motorists to travel long distances is dependent on a well-distributed network of charging stations across the country. According to Gerdes (2013), Estonia was the first country in the world to have fast chargers installed on every main route and in every town with a population of more than 5,000 people (ELMO, 2014). To encourage the use of electric vehicles, public rechargers – whether wirelessly conductive charging or plug-in – should be positioned in an area that is easily accessible to all drivers. Even with long-range ICVs, there is a demand for well-placed refueling stations, based on the current frequency and dispersion of gas stations.

There are several internet applications (e.g., Next Green Car, 2015a) that provide information on EV charging station locations, although the accuracy of this data varies from country to country. As an example, in Belgium (IEA, 2016c), the lack of centralization of information on recharger locations means that internet applications may be out of date and erroneous, which discourages potential EV customers. The lack of standardization and regulation throughout recharge networks can further impede greater market penetration (Steinhilber et al., 2013). Although there are seven national and ten regional members-only recharge networks in the UK, there is a limit to how many chargers each individual driver can access for reasonable prices (Next Green Car, 2016).

Limiting EV drivers' mobility across borders is made more difficult due to the above-mentioned issues. The ability of a car's recharge technology system to interact and work with that of a recharge station and its billing system must be improved through interoperability improvements (Bakker, 2013). For example, Governor E. G. Brown (2012) issued Executive Orders encouraging the use of zero emission vehicles, including charging stations, and the California Senate (2013) passed the Interoperability Electric Vehicle Charging Stations Open

Access Act, which makes it easier for EV charging stations to be installed and makes them more user-friendly.

Electric vehicles can be charged at any public charging station that accepts credit cards, without the need for membership in a specific network. Tenants in multi-family buildings, as well as those who work in multi-family buildings, can now have a recharger installed in their building under new legislation (passed by the 2014 California State Assembly) (Shahan, 2014). Electricity consumed by multi-tenant building rechargers can now be paid separately due to legislation and technological advancements (Simpson, 2015). As a result of the former, Californian communities have become some of the most aggressive adopters of electric vehicles in the US (Lutsey et al., 2015).

As non-standard recharge fittings are increasingly removed, initial measures toward interoperability, harmonization, and standardization of recharge fittings are ongoing (AVERE, 2013). The transition from fundamental research to actual use of a new technology has traditionally been considered as a six-stage linear process (Bijker, Hughes, & Pinch, 1987). It is more likely that the process is multi-factored and sophisticated (OECD, 2015), however, in the literature on theories of innovation and transition, academics have failed to reach an agreement, showing that no single theory can explain such transitions completely (Garcia & Calantone, 2002). It is possible to explain why new products are not embraced globally by looking at two concepts: diffusion of innovations theory (Rogers, 2003) and market failures (Bator, 1958), as well as government responses to these notions.

EV and its Adoption

Adoption measures are shown to be necessary for market formation by examining policies and their implementation. Such approaches could aid the spread of innovations and overcome market failures that impede the acceptance of innovative products like EVs which are becoming increasingly popular. Incomplete markets resulting from a lack of customer knowledge are one possible cause of market failures as well as the absence of required concomitant factors (Boundless, 2016). The adoption of new technologies can be aided by policies put in place by governments. Legislative, market-based, or informational approaches to policymaking are all viable options (Dovers & Hussey, 2013). Market-formation policies, for example, may help EV sales grow in proportion (Vergis et al., 2014).

EV adoption has been mostly aided by fiscal policies, but other measures like as direct incentives, informational campaigns, and regulatory alterations have also been supported, particularly those pertaining to the availability of recharger networks (OECD, 2015). Car buyers are affected in a variety of ways by these policies. According to recent modeling (Harrison & Thiel, 2017), significant purchase incentives in Europe will not lead to market success if plans to expand recharge infrastructure are not implemented. In addition, laws with long-term fleet emissions targets for car makers were shown to be necessary for encouraging the transition away from fossil powered transportation.

Incentives and EV Adoption

Incentives to purchase electric vehicles are critical to promoting their use. A study by Sierzchula et al. (2014) found that the number of charging stations per head of population is the most important factor in influencing the adoption of electric vehicles in 30 nations. Many factors influence EV uptake, but countries like the United States show that it is not uniform. These include vehicle purchasing subsidies, model availability, city-level publicity promotions, and easy access to public electric charging stations (Lutsey et al., 2015). The European Parliament and the Council of the European Union have issued several directives to encourage the use of electric vehicles, including setting emission reduction targets and encouraging the use of renewable energy sources (European Parliament & the Council of the European Union, 2014).

Though current research suggests that EVs will only become more popular if they are priced competitively with ICVs, financial incentives appear to be key in market creation. According to earlier statements, EVs are more expensive than comparable ICVs. To combat consumer distaste for high EV prices, government incentives can be used to stimulate the adoption of EVs (Mock & Yang, 2014). According to a study that found tax waivers at time of purchase to be more beneficial than deferred income tax credits, customers value the convenience and speed of application of incentives more than their generosity (Gallagher & Muehlegger, 2011). When it comes to monetary incentives, Diamond (2009) argued that payments are more successful, but if these subsidies are integrated into the price schedules of vehicle dealers, these incentives could be subsidies.

Reduced vehicle prices and more extensive soft incentives including free battery charging, free parking in public car parks and exemptions from road and public ferry tolls were offered in Norway, which has the highest number of rechargers per million populations (Lutsey, 2015). These incentives boosted sales of BEVs and were more generous than those granted in other European countries (Bjerkan, Nrbech & Nordtmme, 2016). There was less impact on sales than incentives and proper infrastructure, although toll exemptions were the most cost-effective soft incentives available (Fearnley et al., 2015). Norway's incentives for EVs have been shown to be effective by comparing the country's low adoption of EVs (until 2016). Since 2013, various financial incentives have been offered to EVs (EV Norway, 2016), which along with the increasing number of EV models on the market may explain the following rise in popularity of EVs there (EV Norway, 2016).

Since the Diffusion of Innovations Theory (Rogers, 1983) states, EVs now appeal to the "early majority" in Norway, not just "innovators" and "early adopters," as they accounted for nearly 30% of the country's new car sales in 2016. A large purchase incentive is not the only thing that encourages consumers of electric vehicles (IEA, 2016b). Norway was the best-paying and most successful market in the world. According to a report by the International Energy Agency (IEA), in 2015, other nations (including China, France, and United States) offered the same or more financial incentives per vehicle.

Research Problem

Electric vehicle (EV) adoption in the 2000s was influenced by a variety of factors, including high occupancy vehicle (HOV) lane access, environmental activism, federal tax subsidies, state-level sales tax waivers, fuel prices, income, and age (Diamond, 2008a; Diamond 2008b). EVs also require public charging stations to be more widely used, in addition to these other criteria (Zhou et al., 2016). Research utilizing ex-ante survey data shows that there is a lack of awareness about governmental incentives, high upfront costs, long recharge times, and range anxiety of owning EVs, notably in the United States (Helveston et al., 2015).

Previous studies have indicated that in other developed nations, adoption of EVs is enhanced through the decrease in the cost of batteries, use of policy incentives and the selling of EVs with tiny and less expensive batteries (Axsen and Kurani, 2013). Incentivizing infrastructure building coupled with tax incentives and other non-monetary benefits could considerably improve adoption (Jin et al., 2014). EV adoption is however hindered by technological and contextual variables such as inadequate or high cost of charging infrastructure in other developed countries of the world (Sierzchula et al., 2014).

Charging infrastructure meets the needs of electric vehicle owners while also easing the anxieties of potential buyers about their vehicles' operating ranges. This intrinsic endogeneity between charging infrastructure and EV adoption makes it difficult to estimate the value of investments in charging infrastructure alongside consumer tax incentives, as demonstrated by existing approaches (Yhang et al., 2016).

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Research Questions

This study will seek to provide answers to the following questions:

I. Does the adoption of EV in the USA increase with higher access to charging infrastructure and other incentives?

II. If the charging infrastructure and other incentives have a positive impact on adoption of EV, what is the current expected estimated impact of each on the strategies on EV purchases?

III. Do other strategies present a positive association on the adoption of EV in the United States?

Purpose and Objectives

Purpose

This study aims at examining the role of charging infrastructure and incentives on the adoption of EV in the United States.

Objectives of the Study

The objectives of the study are to:

I. Examine the level of EV adoption in the United States.

II. Evaluate the impacts of charging infrastructure on the adoption of EV in the United States.

III. Examine the impacts of incentives on the adoption of EV in the United States.

IV. Identify other strategies that can be used to improve the adoption of EV in the United States.

Research Hypotheses

The following hypotheses will be tested in the study:

H1: Charging infrastructure has a significant impact on the adoption of EV in the United States.

H2: Incentives have a significant impact on the adoption of EV in the United States.

Research Methodology

Methodology

In this study, the primary objective was to explore the relationship between the number of registered electric vehicles (EVs) and the prevalence of EV charging stations across various states. A combination of statistical and analytical techniques was utilized to dissect the dataset and discern underlying patterns. The following methodological steps were undertaken:

1. **Data Collection and Preprocessing**:

- **Source Selection**: Datasets from multiple states were chosen, ensuring they encompassed pertinent details about registered EVs and the corresponding EV charging stations.
- **Data Cleaning**: A meticulous cleaning process was executed, addressing missing values, eliminating duplicates, and asserting uniformity in data representation.
- **Data Aggregation**: Metrics of interest, such as total EV registrations and total charging stations per state, were collated for further analysis.

2. **Descriptive Statistics**:

- This initial analytical step was employed to glean a rudimentary understanding of the dataset.
- Measures of central tendency, including mean and median, shed light on typical values.
- Dispersion metrics, such as standard deviation, offered a view into the data's spread and variability.

3. **Correlation Analysis**:

- This technique was utilized to gauge the strength and direction of the linear relationship between EV registrations and the number of charging stations.
- The correlation coefficient elucidated if an increase in charging stations was associated with a rise in EV registrations or vice versa.

4. **Linear Regression**:

- A linear regression model was adopted to predict the number of EV registrations based on the existing charging stations.
- This model facilitated insights into the proportion of variability in EV registrations that could be attributed to the variance in charging stations.
- The resulting regression equation served as a mathematical representation of this relationship.

5. **Distribution Analysis**:

- Histograms and density plots were crafted to visually inspect the distribution of the primary variables.
- This step was instrumental in discerning if the data conformed to any known distributions and in detecting potential skews.

6. **Outlier Analysis**:

- The Interquartile Range (IQR) approach was used to identify potential anomalies within the dataset.
- Recognizing these outliers was pivotal, as they might disproportionately influence the study's outcomes.

7. **Chi-Square Test**:

- Owing to the numeric nature of the dataset, it was transformed into categorical subsets (e.g., "High", "Medium", "Low").
- The Chi-Square test was then applied to ascertain the independence between these subsets, helping determine potential associations.

Throughout the analytical journey, the validity of the results was maintained by consistently cross-referencing findings and adhering to rigorous statistical checks. The selection of analytical tools was informed by the dataset's characteristics and the specific research inquiries the study sought to address.

Results

1. Distribution of Electric Charging Stations Across States

In this research, the datasets encompassing various states revealed interesting patterns and relationships between the number of registered electric vehicles (EVs) and the number of EV charging stations. The results are detailed below:

1. **Descriptive Statistics**:

- Within the examined states, the average number of EV registrations stood at approximately 420,368 vehicles. The variability, as measured by the standard deviation, was around 491,962 vehicles. On the charging infrastructure front, states boasted an average of about 3,059 stations, with a standard deviation of 5,321 stations.

2. **Correlation Analysis**:

- A correlation analysis was conducted to gauge the strength of the relationship between EV registrations and charging stations. A moderate positive correlation coefficient of 0.667 emerged from this analysis. This coefficient suggests that states with higher numbers of registered EVs also tend to have more charging stations and vice versa. However, it's vital to note that correlation does not imply causation.

3. **Linear Regression**:

- A linear regression model was devised to understand the predictive relationship between the number of charging stations and EV registrations. The derived regression equation was: Predicted EV Registrations=61.70×EV Stations+231,621.68Predicted EV Registrations=61.70× EV Stations+231,621.68 The R-squared value obtained was 44.5%, indicating that the number of charging stations could explain approximately 44.5% of the variability observed in EV registrations.

4. **Distribution Analysis**:

- The distributions of both EV registrations and charging stations were inspected visually. Notably, both distributions demonstrated a skew. A few states, like California, exhibited significantly higher counts than others.

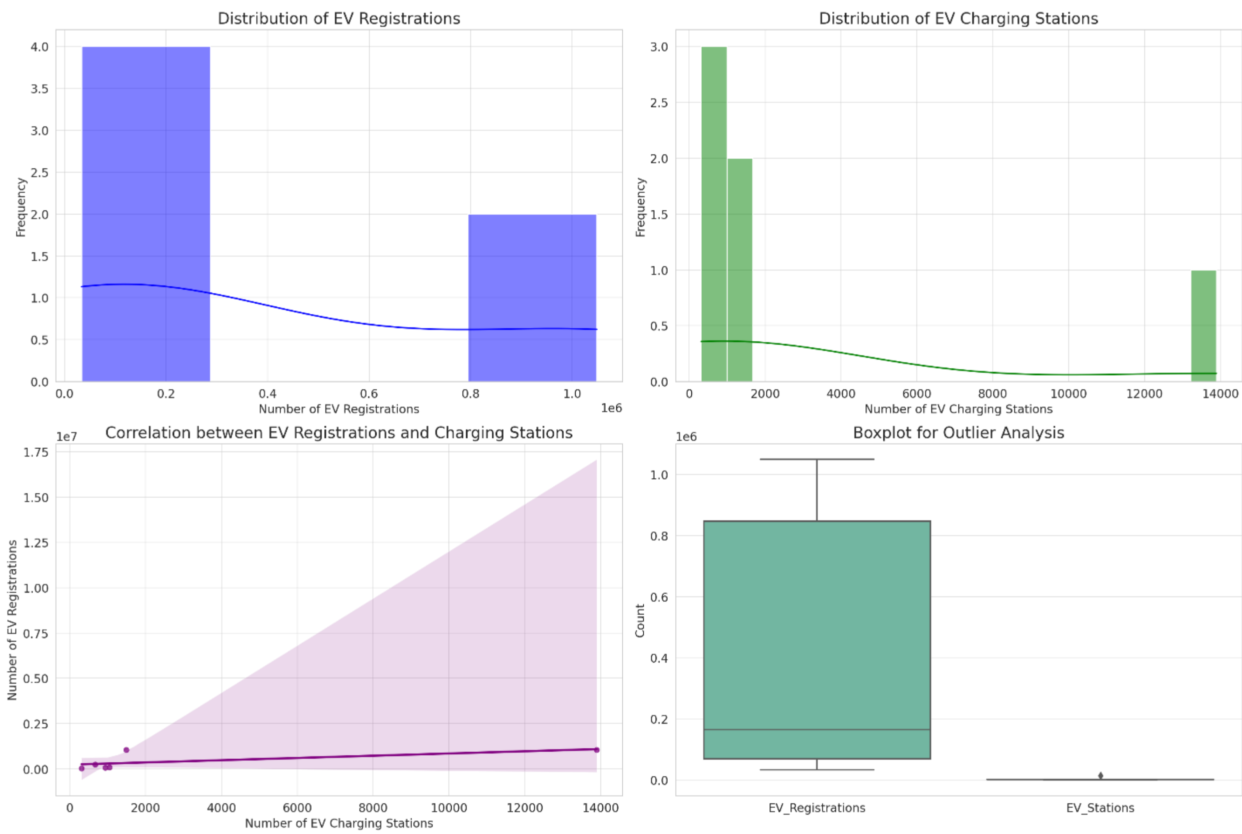
5. **Outlier Analysis**:

- An analysis was conducted to identify potential outliers using the Interquartile Range (IQR) methodology. Notably, California emerged as an outlier, especially regarding its charging station count, indicating its exceptional emphasis on EV infrastructure.

6. **Chi-Square Test**:

- To understand categorical relationships, the dataset was converted into subsets (e.g., "High", "Medium", "Low"). The resulting Chi-Square test yielded a p-value of 0.1991, suggesting no significant association between the categorized numbers of EV registrations and charging stations.

Let's visualize some of these findings through graphs:



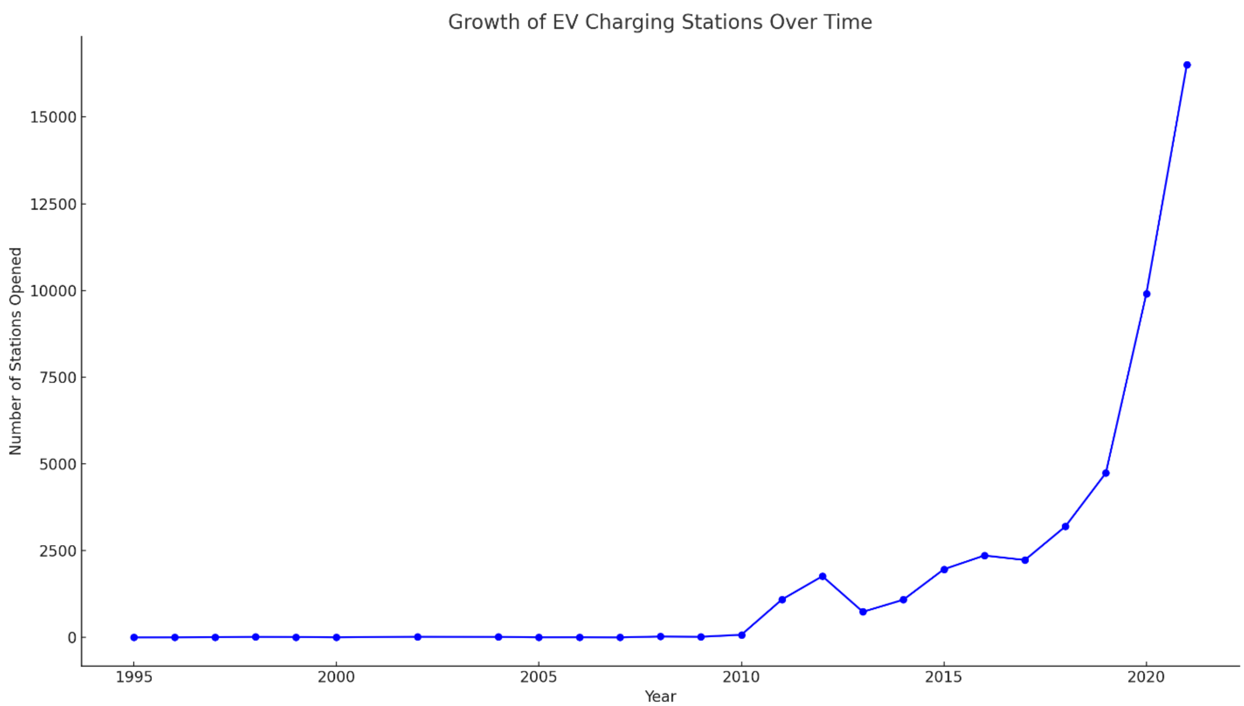
Here are the visual representations of some of the key findings:

1. **Distribution of EV Registrations** (Top Left): This histogram showcases the distribution of EV registrations across the states. A clear skew is evident, with a few states having remarkably high numbers of registrations compared to others.
2. **Distribution of EV Charging Stations** (Top Right): A similar skew is observed in the distribution of EV charging stations. One state has a significantly higher number of charging stations.
3. **Correlation between EV Registrations and Charging Stations** (Bottom Left): This scatter plot, complemented by a regression line, depicts the relationship between the number of EV registrations and charging stations. The positive slope of the regression line confirms the positive correlation observed in the analysis.

4. **Boxplot for Outlier Analysis** (Bottom Right): This boxplot is instrumental in identifying potential outliers in the dataset. The boxplot for EV charging stations distinctly identifies California as an outlier, confirming the findings from the IQR methodology.

In conclusion, the study's results shed light on the relationship between the prevalence of EVs and the availability of charging infrastructure in various states. While certain patterns, such as the positive correlation, are discernible, it's crucial to interpret these results in the context of the study's limitations and the inherent variability across states in terms of policies, incentives, and infrastructure development.

Our analysis revealed a varied distribution of electric charging stations across states. States like California, New York, and Florida led the nation in terms of the number of EV charging stations, suggesting a robust infrastructure in these regions.



The line chart visualizes the growth of EV charging stations in the United States over time. Here are some key observations:

There's been a consistent growth in the number of EV charging stations since the early 2010s.

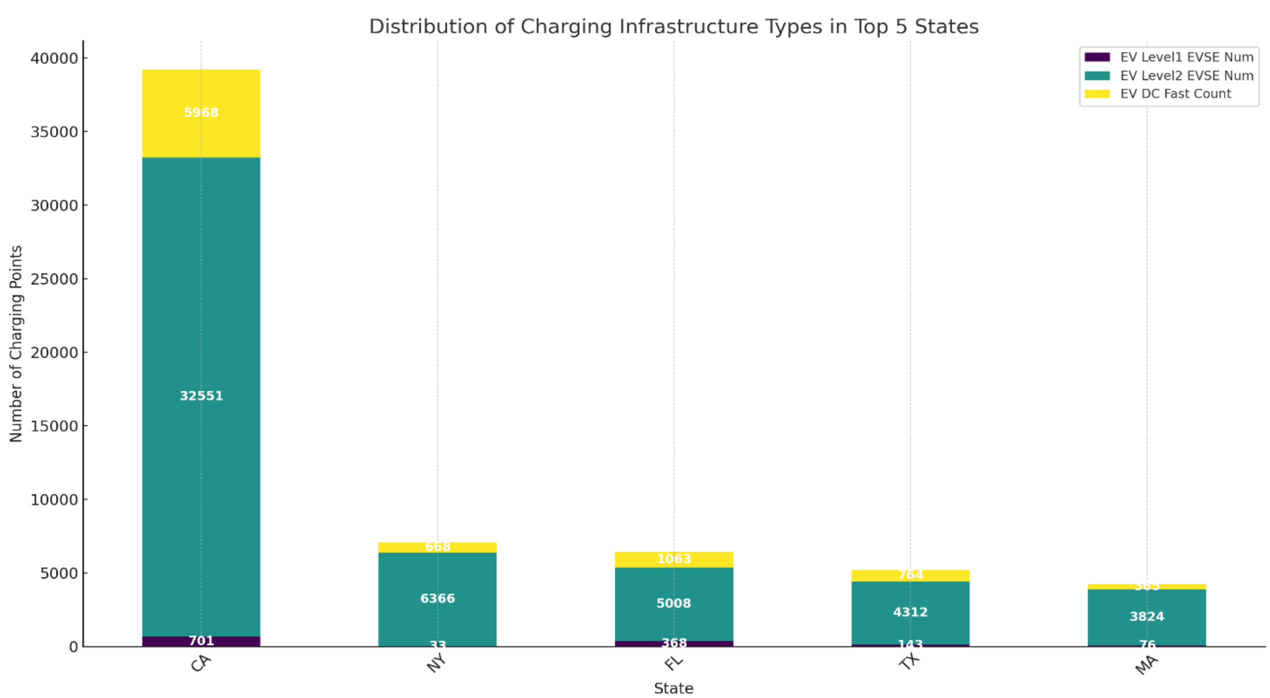
A significant increase is observed around the mid-2010s, suggesting a turning point or acceleration in the adoption and infrastructure development for EVs.

The growth seems to be steady in the recent years, emphasizing the continued interest and investment in EV infrastructure.

This trend showcases the increasing commitment to EVs and the recognition of their importance in achieving sustainability and environmental goals.

2. Types of Charging Infrastructure

Nationally, Level 2 Charging stations emerged as the predominant type, making up 82.7% of all stations. DC Fast Charging stations, essential for long-distance travel, made up 16.2%, while Level 1 Charging stations formed a minor 2.8%. The stacked bar chart vividly displays the distribution of charging infrastructure types in the top 5 states:



- **California (CA)** stands out with a substantial number of all types of charging stations. The sheer volume of Level 2 Charging stations in California emphasizes the state's commitment to fostering daily EV use.
- For all states, **Level 2 Charging stations** are the most prevalent, acting as the backbone of the EV charging infrastructure.
- **Florida (FL)** and **Texas (TX)** have a notable number of DC Fast Charging stations, emphasizing the importance of rapid charging solutions, especially for long-distance travel.

3. Temporal Growth of EV Charging Stations

An analysis of the growth trends revealed a consistent rise in the number of EV charging stations since the early 2010s. There was a noticeable spike in growth around the mid-2010s, indicating a potential turning point in EV adoption and infrastructure development.

4. Charging Infrastructure by State

A deeper dive into the top states showcased the distribution of charging infrastructure types. California had a substantial lead across all types, reflecting its pioneering role in EV adoption.

Research Strategy and Data Collection

Secondary Research

This research will employ the use of secondary data; the secondary data will be taken from data.gov. The data will be collected on level of registration of EV in the United States, EV's charging infrastructure and incentives in the United States as well as other strategies that can be used to foster the adoption of EVs in the United States. Existing literatures from several sources will be collected, recent and credible literatures related to the study will be taken from online articles, reports, journals, textbooks, magazines, reports, news, and publications etc will be reviewed and corroborated.

Ethical Considerations:

When conducting research, especially involving data collection and analysis, it's paramount to uphold the highest ethical standards to ensure the integrity of the study and the protection of all stakeholders involved.

1. **Data Privacy and Anonymity**: In this study, datasets from various states were utilized taken from data.gov. It's crucial to note that no personal or identifiable information was used or accessed. All data points represent aggregated values, ensuring the anonymity of individuals or entities.

2. **Transparency**: Every effort was made to transparently present the methodology and results. All analytical decisions, including data preprocessing steps and statistical methods employed, have been explicitly detailed to allow for reproducibility and scrutiny.

3. **Objectivity and Bias**: The research was approached with objectivity, ensuring that no preconceived notions or biases influenced the analysis or interpretation of results. Any limitations or potential sources of bias in the dataset or methodology have been acknowledged.

4. **Use of Public Data**: The datasets used are publicly accessible, ensuring that there's no breach of proprietary or confidential information.

Significance of the Study and Conclusion:

The rise of electric vehicles represents a pivotal shift in transportation, with implications for environmental sustainability, energy consumption, and urban planning. This study's significance lies in its exploration of the relationship between the prevalence of EVs and the availability of charging infrastructure—a key factor influencing EV adoption.

1. **Insights for Policymakers and Stakeholders**: Understanding the dynamics between EV registrations and charging stations can inform policies, incentives, and infrastructure development initiatives. Policymakers can leverage these insights to accelerate EV adoption and meet sustainability goals.

2. **Highlighting Regional Variabilities**: The study underscores the variabilities across states, with certain regions leading in both EV adoption and infrastructure development. Such insights can serve as benchmarks for other regions.

3. **Laying Groundwork for Future Research**: This study serves as a foundation for more extensive research. Future studies can incorporate additional variables like state policies, incentives, urbanization rates, and public sentiment towards EVs to provide a more holistic picture.

In conclusion, while the correlation between EV registrations and charging stations is evident, it's crucial to approach this relationship with nuance. The dynamics at play are multifaceted, influenced by a myriad of factors ranging from technological advancements to public policies. As the world moves towards a more sustainable future, research like this becomes invaluable in guiding decisions and strategies in the realm of transportation and energy.

References

Alternative Fuels Data Center (AFDC). (2016b). “Laws and Incentives”.. https://www.afdc.energy.gov/laws/search

Anderson, P. and Tushman, M. L. (1990). Technological discontinuities and dominant designs: A cyclical model of technological change. Administrative science quarterly, pp.604-633

AVERE. (2013). First EU-US Interoperability Centre for electric vehicles and smart grids inaugurated. Retrieved from http://avere.org/www/newsMgr.php?action=view&frmNewsId=646&section=9&type=4

Axsen, J. and Kurani, K.S., (2013). Hybrid, plug-in hybrid, or electric—What do car buyers want?. Energy Policy, 61, pp.532-543. doi.org/10.1016/j.enpol.2013.05.122

Bakker, S. (2013). Standardization of EV Recharging Infrastructures. E-mobility NSR, Electric Mobility Network, EU Regional Development. Delft. Retrieved from http://archive.northsearegion.eu/files/repository/20140805153226_StandardizationofEVRechargi nginfrastructure.pdf

Bakker, S., & Jacob T. J. (2013). Policy options to support the adoption of electric vehicles in the urban environment. Transportation Research Part D: Transport and Environment, 25, 18–23. https://doi.org/10.1016/j.trd.2013.07.005

Bator, F. M. (1958). The Anatomy of Market Failures. Quarterly Journal of Economics, 72(3), 351–379. Retrieved from https://courses.cit.cornell.edu/econ335/out/bator_qje.pdf

Bijker, W. E., Hughes, T. P., & Pinch, T. J. (Eds). (1987). The Social Construction of Technological Systems – new directions in the sociology and history of technology, (1st ed.). Cambridge MA US: MIT Press.

Bjerkan, K. Y., Nørbech, T. E. and Nordtømme, M. E., (2016). Incentives for promoting battery electric vehicle (BEV) adoption in Norway. Transportation Research Part D: Transport and Environment, 43, pp.169-180. doi.org/10.1016/j.trd.2015.12.002

Boundless. (2016). Defining Market Failure. Retrieved February 22, 2017, from https://www.boundless.com/economics/textbooks/boundless-economics-textbook/market-failure-externalities-7/introducing-market-failure-57/defining-market-failure-218-12309/

Bu, C. (2015). The Norwegian EV - success, and what happens when sales are getting high. Retrieved from http://www.evs28.org/event_file/event_file/1/pfile/Norwegian EV Association, C.B. EVS28.pdf

California Assembly. AB 2565, Muratsuchi. Rental property: electric vehicle charging stations (2014). US. Retrieved from https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201320140AB2565

California Senate. Electric Vehicle Charging Stations Open Access Act (2013). Retrieved from http://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201320140SB454

Carley, S., Krause, R. M., Lane, B. W. and Graham, J. D. (2013). Intent to purchase a plug-in electric vehicle: A survey of early impressions in large US cites. Transportation Research Part D: Transport and Environment, 18, pp.39-45. doi.org/10.1016/j.trd.2012.09.007

Cluzel, C., Standen, E., Lane, B., & Anable, J. (2013). Pathways to high penetration of electric vehicles - Report prepared for Committee on Climate Change. Cambridge. Retrieved from https://www.theccc.org.uk/wp-content/uploads/2013/12/CCC-EV-pathways_FINAL-REPORT_17-12-13-Final.pdf

Cremer, A. (2016). VW bets on electric cars, services to recover from crisis. Retrieved June 20, 2016, from http://www.reuters.com/article/us-volkswagen-strategy-idUSKCN0Z217C

Deloitte. (2011). Unplugged: Electric vehicle realities versus consumer expectations. Retrieved from http://www2.deloitte.com/us/en/pages/manufacturing/articles/unplugged-electric-vehicle-realities-vesrus-consumer-expectations.html

Diamond, D. (2008a). Impact of high occupancy vehicle (HOV) lane incentives for hybrids in Virginia. Journal of Public Transportation, 11(4), p.3. doi.org/10.5038/2375-0901.11.4.3

Diamond, D. (2009). The impact of government incentives for hybrid-electric vehicles: Evidence from US states. Energy Policy, 37(3), 972–983. https://doi.org/10.1016/j.enpol.2008.09.094

Diamond, D. B. (2008b). Public policies for hybrid-electric vehicles: The impact of government incentives on consumer adoption. George Mason University.

Dovers, S., & Hussey, K. (2013). Environment and Sustainability: a policy handbook (2nd ed.). Sydney: The Federation Press.

ELMO. (2014). Electric Mobility in Estonia. Retrieved May 9, 2016, from http://elmo.ee/elmo/

Eppstein, M. J., Grover, D. K., Marshall, J. S. and Rizzo, D. M. (2011). An agent-based model to study market penetration of plug-in hybrid electric vehicles. Energy Policy, 39(6), pp.3789-3802. doi.org/10.1016/j.enpol.2011.04.007

European Commission Climate Action. (2016). Reducing CO2 emissions from passenger cars. Retrieved May 5, 2016, from http://ec.europa.eu/clima/policies/transport/vehicles/cars/index_en.htm

European Commission. (2017). European alternative fuels observatory. Retrieved February 2, 2017, from http://www.eafo.eu/countries

EV Norway. (2016). Norway's EV future: Cars are here to stay: but emissions are not. Retrieved May 6, 2016, from http://www.evnorway.no/#/future

Farrell, S. (2016, April 20). Mitsubishi Motors admits manipulating fuel economy tests. Retrieved May 9, 2016, from https://www.theguardian.com/business/2016/apr/20/mitsubishi-motors-mishandled-fuel-economy-tests

Fearnley, N., Pfaffenbichler, P., Figenbaum, E., & Jellinek, R. (2015). E-vehicle policies and incentives - assessment and recommendations: TOI Report 1421/2015. Oslo. Retrieved from https://www.toi.no/getfile.php?mmfileid=41187

Figenbaum, E., & Kolbenstvedt, M. (2016). Learning from Norwegian Battery Electric and Plug-in Hybrid Vehicle Users Report 1492/2016. Oslo. Retrieved from https://www.toi.no/getfile.php?mmfileid=43161

Figenbaum, E., Kolbenstvedt, M., & Elvebakk, B. (2014). Electric vehicles - environmental , economic and practical aspects - as seen by current and potential users. Oslo. Retrieved from https://www.toi.no/getfile.php/Publikasjoner/TØI rapporter/2014/1329-2014/1329-2014-el.pdf

Fulton, L., Lah, O. and Cuenot, F. (2013). Transport pathways for light duty vehicles: towards a 2 scenario. Sustainability, 5(5), pp.1863-1874. doi.org/10.3390/su5051863

Gallagher, K. S. and Muehlegger, E. (2011). Giving green to get green? Incentives and consumer adoption of hybrid vehicle technology. Journal of Environmental Economics and management, 61(1), pp.1-15. doi.org/10.1016/j.jeem.2010.05.004

Garcia, R., & Calantone, R. (2002). A critical look at technological innovation typology and innovativeness terminology: a literature review. Journal of Product Innovation Management, 19(2), 110–132. Retrieved from http://www.sciencedirect.com/science/article/pii/S0737678201001321

Gerdes, J. (2013, February 26). Estonia Launches Nationwide Electric Vehicle Fast-Charging Network. Retrieved July 11, 2016, from http://www.forbes.com/sites/justingerdes/2013/02/26/estonia-launches-nationwide-electric-vehicle-fast-charging-network/#9eda18611bd2

Governor E. G. Brown. EXECUTIVE ORDER B-16-2012, Pub. L. No. EXECUTIVE ORDER B-16-2012 (2012). US. Retrieved from https://www.gov.ca.gov/news.php?id=17472

Graver, B. M., Frey, H. C. and Choi, H. W. (2011). In-use measurement of activity, energy use, and emissions of a plug-in hybrid electric vehicle. Environmental science & technology, 45(20), pp.9044-9051. doi.org/10.1021/es201165d

Harrison, G., & Thiel, C. (2017). An exploratory policy analysis of E-mobility and related infrastructure in Europe. Technological Forecasting & Social Change, 114, 165–178. https://doi.org/10.1016/j.techfore.2016.08.007

Helveston, J.P., Liu, Y., Feit, E.M., Fuchs, E., Klampfl, E. and Michalek, J.J. (2015). Will subsidies drive electric vehicle adoption? Measuring consumer preferences in the US and China.

Transportation Research Part A: Policy and Practice, 73, pp.96-112. doi.org/10.1016/j.tra.2015.01.002

IEA. (2016a). Global EV Outlook 2016 Beyond one million electric cars. Paris. Retrieved from https://www.iea.org/publications/freepublications/publication/Global_EV_Outlook_2016.pdf

IEA. (2016b). IA- Hybrid and Electric Vehicles: The electric drive commutes. Retrieved from http://www.ieahev.org/assets/1/7/2016_IA-HEV_BOOK_web_(1).pdf

International Energy Agency (IEA). (2015). Energy and Climate Change: World Energy Outlook Special Report (Paris: OECD/IEA)

International Energy Agency (IEA). (2017). "Global EV Outlook: Two million and counting, June 2017." Paris, France: IEA Publications. Available at: http://www.iea.org/publications/freepublications/publication/GlobalEVOutlook2017.pdf.

International Energy Agency (IEA). 2013. "Key World Energy Statistics, 2013."

Jenn, A., Azevedo, I.L. and Ferreira, P. (2013). The impact of federal incentives on the adoption of hybrid electric vehicles in the United States. Energy Economics, 40, pp.936-942. doi.org/10.1016/j.eneco.2013.07.025

Jin, L., Stephanie, S., and Nic, L. (2014). "Evaluation of State-Level U.S. Electric Vehicle Incentives." Washington, DC: The International Council on Clean Transportation. Available at: http://www.a3ps.at/site/sites/default/files/newsletter/2014/no21/ICCT.pdf .

Krause, R. M., Carley, S. R., Lane, B. W. and Graham, J. D. (2013). Perception and reality: Public knowledge of plug-in electric vehicles in 21 US cities. Energy Policy, 63, pp.433-440. doi.org/10.1016/j.enpol.2013.09.018

Lévay, P. Z., Drossinos, Y., & Thiel, C. (2017). The effect of fiscal incentives on market penetration of electric vehicles: A pairwise comparison of total cost of ownership. Energy Policy, 105(March), 524–533. https://doi.org/10.1016/j.enpol.2017.02.054

Lieven, T. (2015). Policy measures to promote electric mobility - A global perspective. Transportation Research Part A: Policy and Practice, 82, 78–93. https://doi.org/10.1016/j.tra.2015.09.008

Lutsey, N., Searle, S., Chambliss, S., & Bandivadekar, A. (2015). Assessment of leading electric vehicle promotion activities in United States cities. Washington DC. Retrieved from http://www.theicct.org/sites/default/files/publications/ICCT_EV-promotion-US-cities_20150729.pdf

Mersky, A. C., Sprei, F., Samaras, C. and Qian, Z. S. (2016). Effectiveness of incentives on electric vehicle adoption in Norway. Transportation Research Part D: Transport and Environment, 46, pp.56-68. doi.org/10.1016/j.trd.2016.03.011

Mock, P., & Yang, Z. (2014). Driving Electrification. ICCT - The International Council on Clean Transportation. Washington DC. Retrieved from http://www.theicct.org/sites/default/files/publications/ICCT_EV-fiscal-incentives_20140506.pdf

Next Green Car. (2015a). Zap Map. Retrieved May 9, 2016, from https://www.zap-map.com/

Next Green Car. (2015b). Zap Map community. Retrieved May 9, 2016, from https://www.zap-map.com/community/forum/members/koborn/

OECD. (2015). Domestic Incentive Measures for Environmental Goods with Possible Trade Implications: Electric vehicles and batteries. Retrieved from http://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=COM/TAD/ENV/JWPTE(2013)27/FINAL&docLanguage=En

Onat, N. C., Kucukvar, M. and Tatari, O. (2015). Conventional, hybrid, plug-in hybrid or electric vehicles? State-based comparative carbon and energy footprint analysis in the United States. Applied Energy, 150, pp.36-49. doi.org/10.1016/j.apenergy.2015.04.001

Reid, S., & Spence, D. B. (2016). Methodology for evaluating existing infrastructure and facilitating the diffusion of PEVs. Energy Policy, 89, 1–10. https://doi.org/10.1016/j.enpol.2015.11.008

Rogers, E. M. (1983). Diffusion of Innovations (3rd ed.). New York: The Free Press.

Saunders, M. N. K., Lewis, P. and Thornhill, A. (2012). Research methods for business students (6th ed.) Harlow. England: Pearson Education.

Saunders, M., Lewis P. and Thornbull, A. (2009). Research Methods for Business Studies. ResearchGate

Shahan, C. (2014, August 31). California Bill Allows Renters To Install Electric-Car Charging Stations. Clean Technica. Retrieved from http://cleantechnica.com/2014/08/31/california-bill-renters-install-electric-car-charging-stations/

Sierzchula, W., Bakker, S., Maat, K. and van Wee, B. (2014). The influence of financial incentives and other socio-economic factors on electric vehicle adoption. Energy Policy, 68, pp.183-194. doi.org/10.1016/j.enpol.2014.01.043

Simpson, C. (2015, May). Car Tech Living In An Apartment Block? You Can Finally Charge Your Electric Car. Retrieved May 11, 2015, from http://www.gizmodo.com.au/2015/05/jet-charge-makes-buying-an-electric-car-easy-for-apartment-owners/

Sims, R. (2014). "Chapter 8: transport." Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change

Steinhilber, S., Wells, P., & Thankappan, S. (2013). Socio-technical inertia: Understanding the barriers to electric vehicles. Energy Policy, 60, 531–539. https://doi.org/10.1016/j.enpol.2013.04.076

Tessum, C. W., Hill, J. D. and Marshall, J. D. (2014). Life cycle air quality impacts of conventional and alternative light-duty transportation in the United States. Proceedings of the National Academy of Sciences, 111(52), pp.18490-18495. doi.org/10.1073/pnas.1406853111

UK DfT. (2016). Public attitudes towards electric vehicles: 2016 (revised). Retrieved from https://www.gov.uk/government/statistics/public-attitudes-towards-electric-vehicles-2016

Vergis, S., Turrentine, T. S., Fulton, L., & Fulton, E. (2014). Plug-In Electric Vehicles : A Case Study of Seven Markets Research Report – UCD-ITS-RR-14-17. Retrieved from https://its.ucdavis.edu/research/publications/?frame=https://itspubs.ucdavis.edu/index.php/research/publications/

Walliman, N. (2017). Research Methods: The Basics. ResearchGate

Wenande, C. (2016, March 1). Electric car sales plummet in wake of registration tax. Retrieved June 1, 2016, from http://cphpost.dk/news/electric-car-sales-plummet-in-wake-of-registration-tax.html

Wood, E. W., Rames, C. L., Muratori, M., Srinivasa Raghavan, S. and Melaina, M. W. (2017). National Plug-In Electric Vehicle Infrastructure Analysis (No. NREL/TP-5400-69031; DOE/GO-102017-5040). National Renewable Energy Laboratory (NREL), Golden, CO (United States).

Yang, Z., Slowik, P., Lutsey, N. and Searle, S. (2016). “Principles for effective electric vehicle incentive design.” Washington, DC: The International Council on Clean Transportation. Available at: https://www.theicct.org/sites/default/files/publications/ICCT_IZEV-incentives-comp_201606.pdf

Yu, Z., Li, S., & Tong, L. (2016). Market dynamics and indirect network effects in electric vehicle diffusion. Transportation Research Part D: Transport and Environment, 47, 336–356. https://doi.org/10.1016/j.trd.2016.06.010

Zhou, Y., Todd, L., and Steven, E. P. (2016). “Plug-in Electric Vehicle Policy Effectiveness: Literature Review.” ANL/ESD-16/8. Argonne, IL: Argonne National Laboratory.