Electric Vehicle Population Analysis

Wangcong Xuan
Sultan Alfoory
Dennis Pozhidaev
RJ Wiebe
waxu7633@colorado.edu
sultan.alfoory@colorado.edu
depo5023@colorado.edu
rowi2520@colorado.edu

ACM Reference Format:
Wangcong Xuan, Sultan Alfoory, Dennis Pozhidaev, and RJ Wiebe. 2018. Electric Vehicle Population Analysis. In *Proceedings of Make sure to enter the correct conference title from your rights confirmation emai (Conference acronym 'XX)*. ACM, New York, NY, USA, 4 pages. https://doi.org/XXXXXXX.XXXXXXX

1 PROBLEM STATEMENT/MOTIVATION

The automotive industry is undergoing a significant transformation towards sustainable and environmentally friendly transportation solutions. Electric vehicles (EVs) have emerged as a key component in this transition, offering a promising alternative to traditional internal combustion engine (ICE) vehicles. This shift is driven by technological advancements, regulatory policies, economic incentives, and changing consumer preferences. Understanding these factors and their interplay is crucial for policymakers, manufacturers, and consumers alike.

A primary motivation for this study is the urgent need to reduce greenhouse gas emissions and combat climate change. The transportation sector is a major contributor to global emissions, and the adoption of EVs is a viable solution to mitigate this impact. Governments worldwide have introduced various regulations and incentives to promote EV use, aiming to reduce dependency on fossil fuels and decrease carbon footprints. This study aims to analyze the effectiveness of these policies and understand their role in driving EV adoption.

The economic dimension of EV adoption is another significant aspect of this study. While EVs typically have higher upfront costs compared to traditional vehicles, they offer lower operating and maintenance costs over their lifetime. Financial incentives such as subsidies, tax rebates, and lower operational costs play a crucial role in influencing consumer decisions. This study seeks to explore how these economic factors impact the adoption rates of EVs and whether they are sufficient to overcome the initial cost barrier.

Consumer preferences and motivations also form a critical part of this investigation. Growing awareness about environmental issues motivates many consumers to adopt EVs to reduce their carbon footprint and contribute to a cleaner environment. However, factors such as vehicle performance, range anxiety, and the availability of charging infrastructure also influence consumer choices. By examining these aspects, the study aims to provide a comprehensive understanding of the drivers behind consumer adoption of EVs.

The study will also delve into the demographic trends associated with EV adoption. Factors such as age, income, education level, and geographic location play a significant role in determining who is more likely to adopt EVs. Younger consumers and higher-income households are often early adopters of new technologies, including EVs. Urban areas with better access to charging infrastructure also show higher adoption rates compared to rural areas. This study will analyze these demographic patterns to identify key segments of the population driving the growth of the EV market.

Furthermore, the manufacturing and supply side of the EV market is a crucial area of investigation. The increasing production of EVs is influenced by both regulatory mandates and market demand. Understanding the relationship between regulations, such as emissions standards and zero-emission vehicle mandates, and the supply of EVs is essential to comprehend market dynamics. This study will explore whether the increase in EV manufacturing is primarily driven by regulatory requirements or by consumer demand and market forces.

In summary, the motivation for this study is multifaceted, encompassing environmental, economic, consumer, and regulatory dimensions. By addressing these aspects, the study aims to provide a comprehensive analysis of the growth and demographic trends of electric car adoption. The findings will offer valuable insights for policymakers to design effective regulations, for manufacturers to strategize production and marketing efforts, and for consumers to make informed decisions about adopting EVs. This study will contribute to promoting sustainable transportation solutions and advancing the transition towards a cleaner and greener automotive industry.

2 LITERATURE SURVEY

The adoption of electric vehicles (EVs) has been a focal point of research due to its implications for environmental sustainability, energy consumption, and economic development. As governments worldwide introduce stringent regulations to curb carbon emissions and as consumers become increasingly eco-conscious, understanding the dynamics of EV adoption becomes imperative. This literature survey aims to synthesize existing research on the factors

Permission to make digital or hard copies of all or part of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage and that copies bear this notice and the full citation on the first page. Copyrights for components of this work owned by others than the author(s) must be honored. Abstracting with credit is permitted. To copy otherwise, or republish, to post on servers or to redistribute to lists, requires prior specific permission and/or a fee. Request permissions from permissions@acm.org.
Conference acronym 'XX, June 03–05, 2018, Woodstock, NY
© 2018 Copyright held by the owner/author(s). Publication rights licensed to ACM.
ACM ISBN 978-1-4503-XXXX-X/18/06
https://doi.org/XXXXXXX.XXXXXXX

influencing EV adoption, providing a foundation for the proposed study on growth and demographic trends in the electric car market.

2.1 Factors Influencing EV Adoption

2.1.1 Technological Advancements and Systemic Factors. Peters and Dutschke [1] provide a comprehensive analysis of the systemic factors influencing EV adoption. Their study highlights the importance of technological advancements in battery efficiency, charging infrastructure, and vehicle performance. The authors argue that the integration of these technologies within a supportive policy framework is crucial for widespread adoption. They emphasize the need for a holistic approach, considering not only the technological innovations but also the social, economic, and political systems that influence EV adoption.

2.1.2 Economic and Policy Incentives. Li et al. [2] explore the economic and policy factors that affect EV adoption rates. Their comparative analysis across different regions underscores the varying impact of financial incentives such as subsidies, tax rebates, and lower operational costs. The study reveals that while financial incentives play a significant role, their effectiveness varies by region due to differences in economic conditions and policy environments.

2.1.3 Financial Incentives and Consumer Decision-Making. Mersky et al. [3] delve into the role of financial incentives in the consumer decision-making process. Their analysis shows that financial incentives, particularly upfront cost reductions through subsidies and tax rebates, are pivotal in making EVs more attractive to consumers. However, the study also highlights the diminishing returns of such incentives over time as the market matures and consumer awareness increases.

2.1.4 Consumer Preferences and Environmental Impact. Krupa et al. [4] investigate consumer motivations and preferences related to EV adoption, focusing on environmental consciousness and the desire to reduce greenhouse gas emissions. The study finds that consumers who prioritize environmental sustainability are more likely to adopt EVs. Additionally, the perceived environmental benefits of EVs, such as lower emissions and reduced reliance on fossil fuels, are significant factors in the decision-making process.

2.2 Demographic Trends in EV Adoption

Several studies have explored the demographic trends associated with EV adoption. For instance, Carley et al. [5] identify demographic factors such as age, income, education level, and urbanization as influential in EV adoption rates. Younger consumers, higher-income households, and individuals with higher education levels are more likely to adopt EVs. Additionally, urban areas with better access to charging infrastructure show higher adoption rates.

2.3 Policy and Regulatory Impact

The impact of policy and regulation on EV adoption has been a critical area of research. Sierzchula et al. [6] examine the role of government policies in promoting EV adoption, including direct incentives, infrastructure investments, and regulatory measures. Their study concludes that strong policy support is essential for overcoming market barriers and accelerating EV adoption.

3 PROPOSED WORK

To address the research questions, the proposed work involves several key steps that diverge from previous studies in the literature. This study will leverage a new and up-to-date dataset to perform comprehensive analyses, with a particular focus on demographic factors influencing EV adoption, in addition to traditional regression analysis.

3.1 Data Collection

Data collection will be a critical initial step, involving the gathering of relevant datasets from reliable sources. We have chosen the "Electric Vehicle" dataset from the Kaggle website as our primary data source. This dataset is recent and provides comprehensive information necessary for our analysis.

3.2 Data Preprocessing

Data preprocessing will involve several steps to ensure the accuracy and consistency of the data:

Cleaning: Remove duplicates, handle missing values, and ensure consistency in data formats. This step will involve thorough data validation and correction processes to prepare the data for accurate analysis.

Transformation: Normalize and scale data for analysis. This step will include data transformation techniques such as standardization and normalization to prepare the data for statistical analysis.

3.3 Data Analysis

The data analysis phase will involve various statistical and analytical techniques to uncover insights and answer the research questions:

Descriptive Statistics: Summarize the data to understand basic trends and patterns. This will include calculating measures such as mean, median, and standard deviation to provide an overview of the data.

Regression Analysis: Identify relationships between variables such as price, consumer motivation, and EV adoption rates. Regression analysis will help in understanding the factors that significantly influence EV adoption.

Demographic Analysis: Explore demographic factors influencing EV adoption using specific techniques:

Cluster Analysis: Identify distinct demographic groups based on variables such as age, income, education level, and geographic location. This technique will help in segmenting the population and understanding the characteristics of each group.

Heatmaps and Geographic Information System (GIS) Mapping: Visualize the geographic distribution of EV adoption rates. This will highlight areas with higher adoption and correlate these with demographic variables.

Logistic Regression: Model the probability of EV adoption based on demographic factors. This will provide insights into which demographic characteristics are most predictive of EV adoption.

Cohort Analysis: Examine the adoption patterns of different cohorts over time. This technique will allow us to track changes in adoption rates among different demographic groups and identify long-term trends.

By following these steps, the proposed work aims to provide a comprehensive and up-to-date analysis of the factors driving electric vehicle adoption. This study will build on existing literature by integrating recent data and focusing on demographic influences, offering valuable insights for policymakers, manufacturers, and consumers in the transition towards sustainable transportation solutions.

4 DATASET

We chose the "Electric Vehicle" dataset from Kaggle website Electric Vehicle as our raw dataset because it provides comprehensive aspects of the EV data we need for analysis. The Electric Vehicle Population dataset has 181458 data points and comprises 13 attributes with a mix of categorical and numerical data types. The Vehicle Identification Number (VIN), Make, Model, Electric Vehicle Type, Legislative District, City, State, Postal Code, County, and Electric Utility are categorical attributes, typically represented as strings. The Model Year is a numerical attribute, specifically an integer, while the Electric Range and Base MSRP are also numerical, represented as integers and floats, respectively. This combination of categorical and numerical data allows for a diverse range of analyses, including understanding demographic patterns, vehicle popularity, and the impact of economic factors on electric vehicle adoption.

5 EVALUATION METHODS

To ensure the robustness and validity of our analysis, we will employ several evaluation methods. These methods will help us clean, visualize, and interpret the data effectively to answer our research questions.

1. Root Mean Square Error (RMSE)

By utilizing the Root Mean Square Error (RMSE), we will evaluate the accuracy of our predictive models. RMSE is a standard metric for measuring the differences between values predicted by a model and the values observed. It provides a clear indication of how well our model fits the data, with lower RMSE values indicating better model performance. This metric will be particularly useful in assessing the effectiveness of regression models used to predict variables such as EV adoption rates and price differences.

2. Data Cleaning and Visualization

Visualization techniques will be employed to clean and preprocess the data. By visualizing the data, we can identify and address inconsistencies, outliers, and missing values. Techniques such as histograms, box plots, and scatter plots will allow us to detect anomalies and ensure the integrity of our dataset. This step is crucial for preparing the data for further analysis and ensuring the accuracy of our results.

3. Answering Research Questions Through Visualizations

Finally, we will use the data to create visualizations that address our research questions. Various types of visualizations, such as line charts, bar graphs, heat maps, and geographical maps, will be utilized to illustrate trends and patterns in EV adoption. These visualizations will help us explore demographic trends, analyze the popularity of different EV models, and understand the impact of economic factors and policies on EV adoption. By presenting the data visually, we can communicate our findings effectively and provide actionable insights for stakeholders.

6 TOOLS

We will be using python mainly for the analysis.

7 MILESTONES

7.1 Milestones Completed

We have finished the data preprocessing by examining the duplicates and the missing values. There are no replicates but some missing values in Legislative district attribute. We also do the basic analysis by looking at the distribution of the EV cars, the distribution of the electric ranges, the count of EV cars by model year and the top 10 counties by number of EV cars.

7.1.1 Data Acquisition and Validation:

- Acquired the “Electric Vehicle” dataset from Kaggle.
- Performed initial data validation checks to ensure integrity and reliability.
- Confirmed completeness of essential data fields for analysis.

7.1.2 Data Preprocessing and Standardization:

- Executed cleaning processes to remove duplicates and handle missing values.
- Standardized data formats across attributes to facilitate analysis.
- Employed outlier detection using Z-scores and IQR methods to refine the dataset.

7.1.3 Preliminary Descriptive Analysis:

- Conducted analysis to outline statistics like mean, median, mode, and range.
- Identified trends in EV adoption, categorizing data by make and model.

7.1.4 Infrastructure and Tool Setup:

- Established an analytical environment using Python and relevant libraries.
- Configured a Git repository for version-controlled codebase management.

7.2 Milestones to do

Next week, we will look at the relationships between EV usage and demographic factors. We will be using cohort analysis to examine the adoption patterns of different counties over time and identify distinct demographic groups based on variables such as Model, Electric Range, and geographic location. We will also be using visualizations to present the relationships we might find by using heat maps and geographic information systems. Along with this, we will be studying correlations between this rise in number of sales of both BEV and PHEV and how it relates to the effectiveness and price of modern day electric vehicles.

7.2.1 Advanced Data Modeling:

- Implement multivariate and logistic regression models to explore predictors of EV adoption.

7.2.2 *Geospatial Analysis:*

- Integrate GIS mapping to visualize EV adoption distribution.
- Use cluster analysis to profile demographic groups based on geographic and economic variables.

7.2.3 *Consumer Behavior Study:*

- Launch a survey targeting EV owners to gather data on consumer behavior and satisfaction.
- Analyze survey data to provide a holistic view of factors driving EV adoption.

7.2.4 *Longitudinal Study Setup:*

- Plan a longitudinal study to track EV adoption patterns post-policy changes.
- Design update mechanisms for the dataset to ensure ongoing relevance.

7.2.5 *Collaboration and Peer Review:*

- Establish collaborations with academic institutions and industry experts.
- Submit findings for peer review in scientific journals.

7.2.6 *Policy Impact Assessment:*

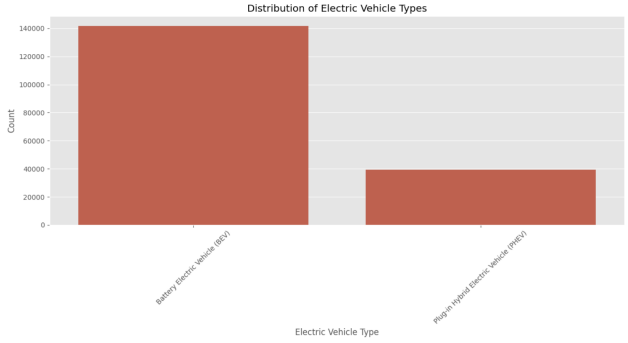
- Develop models to simulate the impact of EV policies on adoption rates.
- Organize workshops with policymakers to translate findings into actions.

7.2.7 *Final Deliverables.*

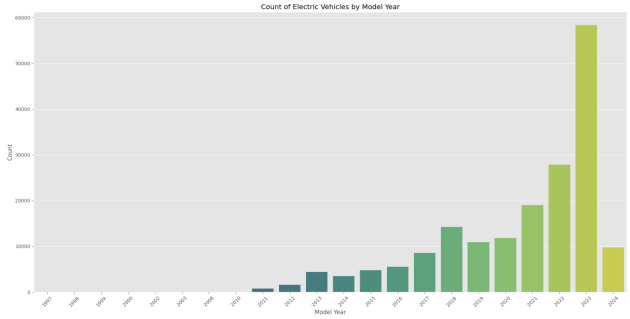
- Compile a comprehensive report and target high-impact journals for publication.
- Develop an interactive dashboard to visualize and disseminate findings.
- Design an educational campaign to promote sustainable transportation.

8 RESULTS SO FAR

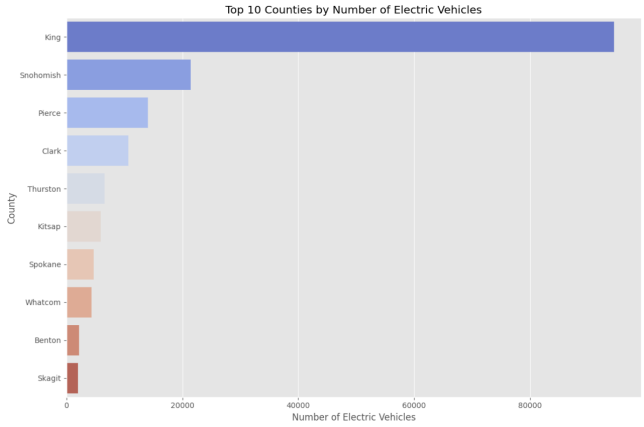
We compared the type of EV cars and found that Battery Electric Vehicle (BEV) is much more popular than Plug-in Hybrid Electric Vehicle (PHEV).



Also, we found that 2023 may be the top year that EV cars are made and sold out.



We selected the top 10 Counties by the Number of Electric Vehicles and found that King remains the first, Snohomish second, and Pierce afterward.



REFERENCES

[1] Anja Peters and Elisabeth Dütschke. How do consumers perceive electric vehicles? a comparison of german consumer groups. *Journal of Environmental Policy & Planning*, 16(3):359–377, 2014.

[2] Wenbo Li, Ruyin Long, Hong Chen, and Jichao Geng. A review of factors influencing consumer intentions to adopt battery electric vehicles. *Renewable and Sustainable Energy Reviews*, 78:318–328, 2017.

[3] Avi Chaim Mersky, Frances Sprei, Constantine Samaras, and Zhen (Sean) Qian. Effectiveness of incentives on electric vehicle adoption in norway. *Transportation Research Part D: Transport and Environment*, 46:56–68, 2016.

[4] Joseph S. Krupa, Donna M. Rizzo, Margaret J. Eppstein, D. Brad Lanute, Diann E. Gaalema, Kiran Lakkaraju, and Christina E. Warrender. Analysis of a consumer survey on plug-in hybrid electric vehicles. *Transportation Research Part A: Policy and Practice*, 64:14–31, 2014.

[5] Sanya Carley, Rachel M. Krause, Bradley W. Lane, and John D. Graham. Intent to purchase a plug-in electric vehicle: A survey of early impressions in large us cites. *Transportation Research Part D: Transport and Environment*, 18:39–45, 2013.

[6] William Sierzchula, Sjoerd Bakker, Kees Maat, and Bert van Wee. The influence of financial incentives and other socio-economic factors on electric vehicle adoption. *Energy Policy*, 68:183–194, 2014.