**University of Oklahoma**

**Data Science and Analytics Institute**

**DSA 5103- Intelligent Data Analytics**

(CHARLES NICHOLSON)

**EV Dynamics in Washington State: A Data-Driven Investigation of Electric Vehicle Adoption in Washington State**

**Ishaq Alalq**

**Binyam Ali**

**Jasmin Wilson**

**FALL 2023**

Table of Contents

1. [Introduction 2](#_Toc153226004)

[2. Problem overview 2](#_Toc153226005)

[3. Geographical Adoption Patterns 2](#_Toc153226006)

[4. Factors Influencing CAFV Eligibility 2](#_Toc153226007)

[5. Electric Range and Price Trend: 2](#_Toc153226008)

[6. Analysis of Electric Vehicle Trends and Predictions in Washington State 5](#_Toc153226009)

[7. APPENDICES 9](#_Toc153226010)

[8. REFERENCES 10](#_Toc153226011)

### 

### Introduction: Background on Electric Vehicles (EVs)

### Pinpointing the invention of the electric car to a single inventor or country proves challenging. Instead, a series of breakthroughs in the 1800s, spanning advancements from the battery to the electric motor, paved the way for the first electric vehicle. In the early part of the century, innovators in Hungary, the Netherlands, and the United States laid the groundwork [1]. Electric vehicles (EVs) now signify a transformative era in sustainable transportation, steering away from traditional combustion engines. Fueled by recent technological advancements, environmental awareness, and energy independence goals, EVs, primarily powered by lithium-ion batteries, promise zero emissions and a reduced carbon footprint [2]. Beyond their environmental benefits, EVs offer cost savings, reduced reliance on fossil fuels, and a platform for integrating renewable energy. The increasing prevalence of EVs propels innovations in batteries, charging infrastructure, and autonomous driving, fundamentally reshaping the automotive landscape [3]. Washington, with its diverse landscapes and commitment to sustainability, emerges as a hub for EVs, providing a rich context for analysis. This study delves into Washington's EV landscape, utilizing a comprehensive dataset to reveal trends and insights, enhancing our understanding of current dynamics and future trajectories in electric mobility.

### Problem overview

### Geographical Adoption Patterns:

### Factors Influencing CAFV Eligibility:

### Electric Range and Price Trend:

The analysis investigates the relationship between electric range and base Manufacturer's Suggested Retail Price (MSRP) in Electric Vehicles (EVs) registered in Washington. This exploration aims to illuminate consumer preferences and market dynamics within the state.

However, our findings in the Electric Vehicle Population Data Dataset reveal a limitation: the absence of Base MSRP values for all entries. This dataset encompasses Battery Electric Vehicles (BEVs) and Plug-in Hybrid Electric Vehicles (PHEVs) registered through the Washington State Department of Licensing (DOL). It seems that a significant portion of the dataset lacks disclosed pricing information. Out of 153,830 entries, only 3,431 have recorded Base MSRP values, while the remaining 150,399 entries have Base MSRP values set to zero.

Due to this limitation regarding Base MSRP availability, we conducted the analysis for Electric Range and Price Trends twice.

First, we analyzed the entire dataset, and then we focused on the subset where Base MSRP values are greater than zero.

The correlation coefficients differed between the two scenarios:

* For the entire dataset (Scenario 1), the correlation coefficient was 0.106.
* In the subset with Base MSRP greater than zero (Scenario 2), the correlation coefficient was 0.41.

These coefficients indicate the strength and direction of the relationship between electric range and Base MSRP:

* In Scenario 1 (entire dataset), the correlation was very weak, suggesting a negligible linear relationship between electric range and Base MSRP.
* In Scenario 2 (subset with non-zero MSRPs), the correlation was moderate, indicating a noticeable positive relationship between electric range and Base MSRP for entries where MSRPs are available and greater than zero.

The second scenario suggests a more tangible connection between electric range and Base MSRP, supporting the idea that as electric range increases, there's a tendency for higher Base MSRPs in entries where MSRPs are provided and not equal to zero.

We observe that the base MSRP vs Electric Range data points are clustered into three groups and hence a piecewise regression with two break points might capture the relationship better. We showed with one break point. (see Appendix A)

### Analysis of Electric Vehicle Trends and Predictions in Washington State

This analysis uncovers the trends shaping the adoption of electric vehicles (EVs) in Washington State. Furthermore, the study aimed to provide a foresight into the next decade, predicting adoption counts for both Battery Electric Vehicles (BEVs) and Plug-in Hybrid Electric Vehicles (PHEVs). The ensuing exploration delved into the potential benefits these projections might offer to key stakeholders, namely Washington State, car manufacturers, and consumers.

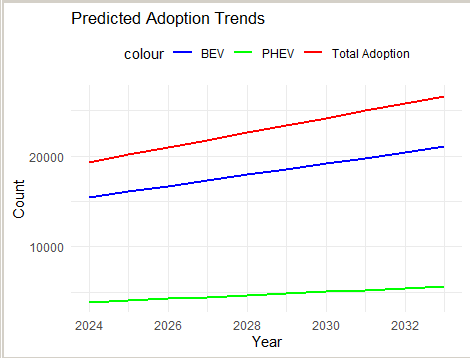
**Dataset Overview and Preparation:** The dataset at the core of this analysis encapsulates the registered counts of BEVs and PHEVs in Washington State, constituting a valuable resource for understanding the dynamics of electric vehicle adoption. The process commenced with the extraction of essential columns and the resolution of a missing year issue, crucial for subsequent predictive modeling. To address this gap, K-nearest neighbor (KNN) imputation was applied, ensuring a comprehensive and accurate dataset. The data was then strategically divided into training and testing sets, adopting a 70-30 ratio, with cross-validation serving as the chosen re-sampling technique.

**Models and Results:** Linear models were crafted to establish a relationship between the year and adoption counts for both BEVs and PHEVs. The results underscored a significant positive correlation, with the year acting as a strong predictor for adoption. The linear models, represented by the coefficients, indicated a noteworthy association between time and the increasing popularity of electric vehicles. The summary statistics provided insights into the goodness of fit for the models, affirming their efficacy in capturing the underlying trends.

*BEV Model:* The linear model for BEV adoption displayed a coefficient of 386 for the year, signifying a positive impact on adoption counts. The statistical significance of this relationship was affirmed by the low p-values, suggesting a robust model fit. (see Appendix B)

*PHEV Model:* Similarly, the linear model for PHEV adoption exhibited a positive correlation with the year, with a coefficient of 123.18. The statistical significance of this relationship was reinforced by low p-values, affirming the model's reliability in predicting PHEV adoption. (see Appendix C)

**Predictions for the Next Decade:** The culmination of the analysis involved forecasting the adoption counts for BEVs and PHEVs over the next 10 years. The predictions unveiled a promising trajectory, with BEV adoption showing a continuous positive growth trend. PHEV adoption predictions echoed this optimism, indicating a consistent positive growth pattern.



**Benefits for Stakeholders:**

**For Washington State:**

**Infrastructure Planning:** Policymakers in Washington State can leverage the forecasted positive growth in BEV and PHEV adoption to strategically plan and develop charging infrastructure. This anticipatory approach allows for the timely allocation of resources and the creation of a robust charging network to accommodate the increasing demand for electric vehicles. By staying ahead of the curve, the state can ensure that the infrastructure is not only sufficient but also strategically located to serve the evolving needs of electric vehicle owners.

**Environmental Impact:** The surge in electric vehicle adoption aligns seamlessly with the state's sustainability goals. As the number of BEVs and PHEVs on the roads increases, Washington State reinforces its commitment to green initiatives and reduced carbon emissions. The positive environmental impact goes beyond individual vehicle choices, contributing to a collective effort to combat climate change and promote a cleaner, healthier environment.

**For Car Manufacturers:**

**Production Planning:** Manufacturers gain invaluable insights into the expected demand for both BEVs and PHEVs through the predictive models. This information allows them to optimize production planning, ensuring that the supply aligns with the forecasted demand.

**Market Positioning:** Understanding the evolving dynamics of the electric vehicle market enables manufacturers to strategically position their offerings. By aligning product development and marketing strategies with the forecasted trends, manufacturers can capture a significant share of the market.

**For Consumers:**

**Expanded Choices:** As manufacturers respond to the increasing demand for electric vehicles, consumers stand to benefit from a richer and more diverse selection of options. The positive growth trajectory in BEV and PHEV adoption encourages manufacturers to innovate and introduce new models, catering to a broad spectrum of consumer preferences. This expanded choice empowers consumers to find electric vehicles that suit their specific needs, preferences, and lifestyles.

**Charging Infrastructure:** Anticipated growth in electric vehicle adoption acts as a catalyst for further investment in charging infrastructure. The increased focus on expanding charging networks enhances convenience and accessibility for consumers.

**Environmental Consciousness:** By adopting electric vehicles, consumers actively contribute to environmental sustainability. The positive environmental impact extends beyond the state's borders, aligning with Washington State's broader green initiatives.[4]

In conclusion, the forecasted growth in BEV and PHEV adoption sets the stage for a mutually beneficial scenario for all stakeholders involved. Policymakers can proactively plan for sustainable infrastructure, manufacturers can align their production with the expected demand, and consumers can enjoy an expanding market of environmentally friendly electric vehicles. This comprehensive analysis serves as a roadmap, guiding Washington State towards a future where electric vehicles play a pivotal role in shaping a sustainable and forward-thinking transportation landscape.

APPENDICES

**APPENDEX.A**

A graph with black dots and red line

Description automatically generated

**APPENDEX.B**

BEVfit <- glm(BEV ~ Year, data = FinaladoptionCountDF)

> summary(BEVfit )

Call:

glm(formula = BEV ~ Year, data = FinaladoptionCountDF)

Coefficients:

Estimate Std. Error t value Pr(>|t|)

(Intercept) -771127.6 264281.3 -2.918 0.00735 \*\*

Year 386.0 131.5 2.936 0.00704 \*\*

---

Signif. codes: 0 ‘\*\*\*’ 0.001 ‘\*\*’ 0.01 ‘\*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for gaussian family taken to be 28317061)

Null deviance: 951993548 on 26 degrees of freedom

Residual deviance: 707926520 on 25 degrees of freedom

AIC: 543.84

Number of Fisher Scoring iterations: 2

**APPENDEX.C**

# Fit a linear regression model predicting PHEV adoption based on Year

> PHEVfit <- glm(PHEV ~ Year, data = FinaladoptionCountDF)

> summary(PHEVfit)

Call:

glm(formula = PHEV ~ Year, data = FinaladoptionCountDF)

Coefficients:

Estimate Std. Error t value Pr(>|t|)

(Intercept) -246675.08 40707.54 -6.060 2.48e-06 \*\*\*

Year 123.18 20.25 6.082 2.35e-06 \*\*\*

---

Signif. codes: 0 ¡®\*\*\*¡¯ 0.001 ¡®\*\*¡¯ 0.01 ¡®\*¡¯ 0.05 ¡®.¡¯ 0.1 ¡® ¡¯ 1

(Dispersion parameter for gaussian family taken to be 671838.6)

Null deviance: 41650382 on 26 degrees of freedom

Residual deviance: 16795964 on 25 degrees of freedom

AIC: 442.82

Number of Fisher Scoring iterations: 2

### REFERENCES

### U.S. Department of Energy - The History of the Electric Car <https://www.energy.gov/articles/history-electric-car>

### Pesaran, Ahmad, Lauren Roman, and John Kincaide. 2023. "Electric Vehicle Lithium-Ion Battery Life Cycle Management." Golden, CO: National Renewable Energy Laboratory. NREL/TP-5700-84520. <https://www.nrel.gov/docs/fy23osti/84520.pdf>.

### U.S. Department of Energy - Electric Vehicle Benefits and Considerations <https://afdc.energy.gov/fuels/electricity_benefits.html>

### Washington state – Energy & Environment

### <https://governor.wa.gov/issues/energy-environment>