Final Project Guideline

BSAN 6030- Programming for Data Analytics

Topic: Electric Vehicle (EV) Technology Adoption Dynamics

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Electric Vehicle (EV) Technology Adoption and Market Dynamics

Executive Summary

This section should be written last, but included here in the template. It must be a maximum of one page and summarize the entire report. Do not use headings within this section.

[Insert Executive Summary here, covering the four key points below:]

- Purpose: Briefly state the problem (understanding the factors driving EV success) and the core questions addressed (analyzing the interplay of technology, policy, and regional factors on EV adoption in the US).
- Methodology: Briefly mention the use of Python (Pandas, Matplotlib, Plotly, NumPy, SciPy) to analyze the **Kaggle EV Registrations Dataset**, focusing on time-series analysis, interactive visualization, and hypothesis testing against policy variables (CAFV eligibility, Legislative Districts).
- Key Findings: Summarize the main results (e.g., strong technological trend in range, impact of CAFV incentives, identification of top-performing manufacturers, and fastest-growing regions/counties).
- Practical Recommendations: State the key actionable advice for managers (e.g., policy adjustments for CAFV, strategic investment in charging infrastructure aligned with high-growth regions, or competitive strategy advice for manufacturers).

(After pasting this into your document, use your word processor's feature to generate a dynamic Table of Contents based on the headings below.)

Introduction

1.1 Purpose and Questions

This report analyzes the complex factors driving the success and market dynamics of Electric Vehicle (EV) technology and adoption in the United States. The core purpose is to provide a comprehensive, data-driven understanding of how technology evolution, policy

environment, and local market characteristics influence the consumer's decision to adopt EVs.

The study aims to answer the following detailed questions:

Overview

Electric vehicle technology was first introduced in the 1830s, became practical in the 1880s, popular in the 1900s, disappeared for decades, and re-emerged in the 1990s with modern lithium-ion EVs beginning around 2008.

Technology Trends

1. How has the average electric range of EVs evolved over time (2015–2025)?
2. Which manufacturers (Tesla, Nissan, Chevrolet, etc.) dominate registrations, and how do their models compare in range and affordability (Base MSRP)?

Policy and Sustainability Impact

3. Do vehicles eligible for Clean Alternative Fuel Vehicle (CAFV) incentives show higher registration counts compared to non-eligible vehicles? 4. How do legislative districts and utility providers influence EV adoption rates?

Regional Adoption

5. How do EV registration counts vary across states and counties, and what regions show the fastest adoption growth? 6. Are areas with higher EV adoption aligned with stronger utility support or legislative district policies?

1.2 Why the Topic Matters (Context and Importance)

The transition to electric mobility is a critical component of national decarbonization goals and represents a massive shift in the automotive and energy sectors. Understanding the drivers of adoption is crucial for policymakers to design effective incentives (CAFV), for utility providers to plan necessary grid infrastructure, and for manufacturers to optimize product offerings (range, MSRP) for market dominance. This analysis provides the necessary data-driven insights to accelerate sustainable growth.

(Required Citation: Use external resources (e.g., government policy reports, industry news) to provide evidence and support for the importance of EV *adoption and policy impact, citing sources in* APA *format.)*

1.3 Approach and Methods

This report employs a quantitative, data-driven approach based on the Kaggle EV Registrations Dataset.

The methodology involves cleaning and transforming the raw data using Python's **Pandas** and **NumPy** libraries, followed by:

- **Exploratory Data Analysis (**EDA**):** Time-series trend analysis (Matplotlib) and interactive visualization (Plotly).
- **Statistical Analysis:** Ratio calculations and hypothesis testing to assess policy effectiveness.
- **Geospatial Analysis:** Grouping by State and County to analyze regional variations and growth rates.

1.3 Data Preparation for Cleaning

Main Content And Analysis

2.1 Methodology: Data Collection and Processing

2.1.1 Data Acquisition and Cleaning

- DataFrames Loaded:
    - df_ev (Kaggle CSV: EV Registrations Data)
- Filtering: The dataset was filtered to exclude records outside the 2015–2025 Model Year range and ensure data consistency across key fields.
- Data Cleaning and Standardization:
    - Missing values (NaN) in key columns like Electric Range and Base MSRP were handled using [State your chosen method: e.g., removal of rows or median imputation].

- The VIN (1-10) column was used as the unique identifier for counting registrations, yet are not real VIN with should have more digits
- Removed
- Electric Range 27
- Base MSRP 27
- Legislative District 481
- Dropped NA values with

```
ev.dropna(subset=["County"], inplace=True)
```

-
- A new column, Adoption Growth Rate (Feature Engineering), was calculated at the county level to address Q5.

2.1.2 Exploratory Data Analysis (EDA)

- **Technological Trend Analysis (Q1):** We analyzed the evolution of EV technology by plotting the average Electric Range over Model Year using a line chart (Matplotlib).
- **Market Dynamics (Q2):** We analyzed market competition by aggregating total registrations by Make and generated an **interactive scatter plot (**Plotly**)** comparing the tradeoff between Base MSRP (affordability) and Electric Range for the dominant models.
- **Adoption Distribution (Q5):** We calculated and printed the top 10 counties by total registration count and plotted multi-series line charts of adoption growth by State over Model Year.

2.2 Cross-Factor Analysis and Findings

2.2.1 Policy Impact (CAFV)

- **CAFV Analysis (Q3):** We grouped registrations by Clean Alternative Fuel Vehicle (CAFV) Eligibility and used bar charts to visually compare the counts.
- **Ratio Quantification (Q3):** The **NumPy** library was used to calculate the proportion of CAFV-eligible vehicles among total registrations: **Proportion** CAFV**-eligible:** [Insert Ratio Value].

2.2.2 Regional and Policy Alignment (Q4 & Q6)

- **Policy Segmentation (Q4):** We analyzed EV concentration by **Legislative District** and **Electric Utility** using aggregated bar charts to understand the role of local policy and infrastructure support in driving adoption.
- **Regional Alignment (Q6):** We created a merged dataset containing registration counts, Legislative District, and Electric Utility information.
- **Critical Finding (Q6):** The inspection of the top 10 high-adoption regions indicated that [State/County/Utility] showed a strong alignment with [Specific Policy/Utility Support Characteristic]. This suggests [Present the Python analysis result here].

2.2.3 Interpretation of the findings

*(This section must clearly explain what the numbers and graphs mean in the context of the business problem. Discuss the implications of technological advancement (range parity) versus policy support (*CAFV *eligibility) in accelerating mass market penetration.)*

Practical Recommendations

(Provide 3-5 clear, actionable recommendations derived directly from the findings.)

1. **Incentive Optimization:** Based on the CAFV eligibility ratio (Q3), recommend policy adjustments (e.g., extending the incentive to [Specific Vehicle Type] or adjusting income caps) to maximize incentive efficiency.
2. **Targeted Infrastructure Investment:** Recommend that utility providers prioritize charging station installation in the **top-growth counties** (Q5) identified in the regional adoption analysis to eliminate charging deserts where demand is accelerating fastest.
3. **Manufacturer Strategy:** Advise manufacturers to focus R&D on achieving a minimum Electric Range of [Value] miles, as this represents the [Year] technological median required for competitive positioning (Q1, Q2).
4. **Legislative Focus:** Recommend that EV advocacy groups target Legislative Districts with below-median adoption rates, leveraging insights from high-performing districts (Q4) as models for new policy implementation.

Summary And Conclusions

4.1 Summary of Work

This report provided a detailed analysis of EV adoption dynamics, confirming the rapid growth in technological capability (range) and quantifying the measurable impact of policy factors (CAFV) and local regional alignment (Utility, District).

4.2 Shortcomings and Future Work

- Shortcoming 1 (Data Scope): The dataset is limited to registrations and lacks consumer demographic or income data.
- Data Collections, preparation and cleaning
-
    - Future Work: Future analysis should incorporate Census income data merged by County to assess the price elasticity of EV demand.
- Shortcoming 2 (Causal Inference): Correlation between high registrations and Legislative District does not prove causality (e.g., wealthy districts may simply buy more EVs).
    - Future Work: Further research should apply regression analysis controlling for median County income to isolate the true policy effect.

Bibliography

(Required: Use a standard citation format, such as APA. *All sources mentioned in the report, including the* Kaggle *dataset, must be listed here.)*

References

- [Kaggle Dataset Name] ([Year Published/Accessed]). EV Registrations Dataset. Retrieved from [Full Kaggle URL]
- [External Citation 1]
- [External Citation 2]
- CHATGPT, GEMINI, COPILOTE

APPENDICES (Optional)

(Include any supplementary material or visualizations that support your main analysis.)

6.1 Appendix A:

Detailed Data Cleaning and Transformation Steps 6.2 Appendix B: Supplementary Visualizations (e.g., Scatter plot of all MSRP vs Range) 6.3 Appendix C: Raw Aggregation Tables (e.g., Full list of Registration Counts by Utility)

6.2 Appendix B:

LINK TO SCRIPT

LINK TO DATASET

Kaggle; Electric Vehicles