Electrifying the Road to Net Zero: Developing a Strategic Entry Plan in a Competitive Electric Vehicle Market.

Raymond David, Angel Hsu, Hyoju Kang

Nov 20, 2023

Abstract

This report presents a comprehensive analysis of the current Battery electric vehicle (BEV) landscape through the utilization of the Alternative Fuel Vehicle Dataset and Washington Electric Population Dataset. Supplementing this analysis with external datasets, including Vehicle Features and EV Public Charging Population, facilitated a holistic understanding of the factors influencing consumer purchasing behaviors. Notably, this study examines the influence of product diversity and brand image variations among key industry players, serving as a robust benchmark for potential market entry strategies. Furthermore, correlations established between vehicle ownership and charging station availability, using the EV Charging Population Dataset, offer valuable insights for developing sustainable infrastructure, particularly in light of initial capacity constraints faced by our client, Electrify. Aligned with Electrify's vision of fostering a sustainable and dynamic society by 2050, this report offers strategic market insights essential for the company's growth trajectory. The analysis equips Electrify with a focused strategy for launching new product lines, refining brand positioning, and establishing crucial infrastructure, such as Charging Stations, in targeted markets.

DATA NERDS

Electrify

Table of Contents

I. Executive Summary

In tandem with the inception of the Paris Agreement on December 12, 2015, and the global movement toward achieving a net-zero target by 2050, the electric vehicle market stands on the brink of remarkable expansion (Federal EV policy). As a newcomer in this industry, **Electrify** ("Client") needs to establish a forward-thinking framework that tackles both present and future challenges within the EV market. Employing statistical tools and refined data, **Data Nerds** ("We") aim to devise a competitive entry strategy. This strategy relies on industry benchmarks as an entry indicator, aligns our client's features with those of key market players, targets well-suited markets, and explores potential strategic alliances.

II. Market Landscape (Visualization, Regulations, Market Attractiveness)

Ratified by 196 nations, the Paris Agreement embodies an ambitious objective to limit the global temperature rise to 1.5 degrees Celsius above pre-industrial levels (UNFCCC) . This far-reaching goal serves as the cornerstone for a more sustainable future, pivotal not only for environmental sustainability but also for enhancing overall quality of life. Carbon Dioxide, primarily emitted by conventional Internal Combustion Engine (ICE) Vehicles, is a significant contributor to escalating temperatures, prompting a pressing need to explore alternative fuel vehicle options.

In line with this collective commitment, the US Environmental Protection Agency has set an ambitious target, mandating that two-thirds of all new vehicles sold in the United States must be electrically powered (Nilsen). Projections indicate that this mandate could result in electric vehicle (EV) adoption rates reaching approximately 64-69% by 2032, with EVs constituting up to 50% of new medium-duty vehicles during the same period (Nilsen). In a bid to reinforce the commitment to achieving net-zero emissions, the Biden Administration enacted two significant legislations, namely the *Infrastructure Investment and Jobs Act* in 2021 and the *Inflation Reduction Act* in 2022 (Federal EV policy). These legislations are strategically designed to prioritize and expedite the development of electric vehicles, shaping the market through various avenues: incentivizing purchases, funding charging infrastructure, electrifying federal fleets, and investing in EV manufacturing and production (Federal EV policy).

Presently, leveraging the *Historic Electric Vehicle Sales Dataset*, we've observed a dramatic surge in electric vehicle sales since 2020 (refer to Appendix 1). This substantiates the earlier identified arguments and suggests a sustained growth trajectory in the future.

The appeal of EVs comes in two different forms. Firstly, EVs contribute significantly to environmental preservation. According to the nationwide average provided by the U.S. Department of Energy, EVs produce a minimal 3,932 lbs. of CO_2 equivalent per year, in contrast to hybrids and gasoline vehicles (see Appendix 2). Secondly, EVs offer substantial cost savings. To delve into this, we examine the cost disparity between EVs and traditional gasoline cars. The eGallon (see Appendix 3) represents the cost of driving an EV the same distance that a gasoline-powered vehicle could cover on one gallon of gasoline. On average, EV drivers benefit from a remarkable 60% reduction in fuel costs (see Appendix 4).

The appeal of the electric vehicle (EV) industry is more comprehensively detailed through the PESTEL analysis in *Appendix 19* and Porter's five forces in *Appendix 20*.

III. Research & Methodologies (Regression & Clustering)

Our investigation began by analyzing the *Alternative Fuel Vehicle Dataset* and *Washington Electric Population Dataset* to identify key EV manufacturers in the U.S. and evaluate market leaders in Washington. We pinpointed the industry's top 20 giants, including

Ford, Tesla, and BYD. This initial analysis underscores the competitiveness within the EV marketplace, indicating a robust global race for innovation and market share (see Appendix 5).

We then honed in on the *Washington Electric Population Dataset* to decipher the competitive landscape among top sellers in Washington. Our findings indicated that the top 10 sellers include major brands like Tesla, Nissan, and Chevrolet (see Appendix 5).

Our analysis shows Tesla's consistent prominence both as a leading manufacturer and in sales within Washington. While this outcome doesn't immediately suggest a strong link between product variety and sales, it highlights the exceptional market reception of Tesla's products. Tesla's successful market strategy sets important benchmarks for our strategic planning purposes.

Enhancing our EV market analysis, we integrated our Vehicle Features Dataset with sales data for the top 10 EV models that achieved over 500 units in sales. (refer to Appendix 6). We aimed to identify shared features among these models. We then categorized the data by body style—SUV, Sedan, and Hatchback—and calculated the average numerical values (see Appendix 7). This approach is crucial for gaining a thorough understanding of average EV specifications and laying the groundwork for our strategic market entry.

Following the initial market analysis, we shifted to a more nuanced statistical approach to discern the correlation between car ownership and charging station availability through regression analysis. This enables us to strategically target areas with a high density of charging infrastructure, anticipating greater consumer interest in our products. Additionally, it allows us to identify regions with underdeveloped infrastructure, presenting opportunities to establish our charging stations or have third-party partnerships under government incentive programs.

We initiated the analysis by importing the *EV Public Charging Population dataset* sourced from the U.S. Department of Energy. Subsequently, we filtered only the pertinent columns required for our analysis and merged it with the *Washington Electric Population Dataset* using zip codes as the basis, facilitating the extraction of valuable information such as County names. Our following action involved conducting a regression analysis, juxtaposing the count of vehicle ownerships against the count of charging stations across each County within the dataset. The results of the initial regression can be found in *Appendix 8*.

Continuing our analysis, we conducted an additional regression analysis. This time, we focused on scrutinizing the total count of vehicle ownership against the aggregated count of charging stations categorized by three distinct charger types (Level I, Level II, and DC Fast Chargers). The rationale behind this approach was to ascertain the degree of variation explained by the predictors (R^2) in both regression models (see Appendix 9). Essentially, this second regression provided deeper insights into which charger types wielded greater significance in augmenting vehicle ownership. We replicated these two sets of regressions for the *EV Private Charging Population* to explore analogous patterns within the context of private charging locations (see Appendix 10 and Appendix 11).

In line with our core goal of making data-driven decisions—while avoiding reliance solely on qualitative research and governmental regulations to shape our recommendations—we engaged in cluster analysis to uncover inherent patterns within the datasets.

Initially, our focus was on a curated edition of the *Vehicle Features Dataset*, where we selectively honed in on particular columns—Acceleration, Top Speed, Range, Efficiency, Fast Charging Speed, and Drive Type. By employing K-means clustering with One Hot Encoding (k = 3) the resultant output unveiled natural groupings of car features prevailing in the market, offering a clearer path to discerning the optimal feature combinations to target.

Subsequently, we extended this analytical approach by applying the same K-means clustering methodology with One Hot Encoding (k = 3) to a subset of the *Washington Electric Population Dataset*. This subset specifically considered variables such as Sales Count, Acceleration, Top Speed, Body Style, and Range. These two comprehensive cluster analyses serve as critical guides, furnishing us with imperative insights and actionable information to navigate our strategies effectively.

IV. Alternative Approaches Considered

Throughout our analysis, our primary focus remained on Battery Electric Vehicles (BEVs). While exploring Plug-in Hybrid Electric Vehicles (PHEVs) and Hybrid Electric Vehicles (HEVs) could potentially offer additional options for product positioning, since both PHEVs and HEVs are not emission-free, we opted to exclude them from our considerations.

Before formulating the county-level regression analysis for both the private and public charging datasets, our initial approach involved conducting a zip-level regression analysis. However, we observed that almost all variables were statistically insignificant at the 5% significance level, indicating weak or non-existent relationships between vehicle ownership and charging stations at the zip code level. Furthermore, the R^2 values were notably minimal, suggesting that the variables inadequately explained the variability in vehicle ownership.

Upon deeper investigation, we identified that the granularity of the data played a crucial role in these findings. The transition from zip-level to county-level analysis underscored the significance of aggregation in statistical analysis. Aggregating data at the county level mitigated the noise or variability present at the zip code level, providing a more comprehensive perspective on the relationship between vehicle ownership and charging stations. Additionally, this shift accounted for the spatial dependence and spatial autocorrelation within the data. Spatial dependencies between nearby locations (zip codes) and the potential spatial autocorrelation of variables across these spaces might have influenced the regression outcomes. Notably, the increased granularity of zip codes, where individuals traverse multiple zip codes when seeking charging stations, emphasized the need for a broader scope of analysis at the county level, which more accurately reflects the spatial behaviors of individuals in search of charging stations. When individuals spend 5-10 minutes searching for a charging station, they are likely to cross several zip code boundaries. Thus, the county-level aggregation emerged as a more appropriate approach to capture the spatial nuances and derive meaningful insights.

V. Results

The prevailing body of research identifies the insufficiency of charging infrastructure as a primary impediment to the widespread adoption of EVs (G. Krishna, 2021). As part of our initial analysis, we opted to visually represent the aggregate number of charging stations and the overall vehicle population in the state of Washington through two distinct filled maps (see Appendix 13 and 14). A comparative examination of these maps allows for a visual assessment of the degree of correlation between the two datasets, underscoring the accuracy of our research.

Initiating with our base regression model presented in Appendix 8, it is evident that the total number of charging stations within a county can account for approximately 95.4% of the total variance in vehicle ownership, with a p-value of 0. Our adapted regression analysis (refer to Appendix 9) reveals a conspicuous positive correlation: areas equipped with Level 2 and DC Fast chargers demonstrate a positive association with increased EV ownership, denoted by p-values approaching zero. Conversely, Level 1 chargers exhibit no significant relationship, with p-values surpassing 0.05. This emphasizes the pivotal role of sophisticated charging infrastructure, such as Level 2 and DC Fast chargers, in fostering the proliferation of EVs.

Notably, the slightly lower p-value for DC Fast Chargers indicates consumer expectations and preferences for the fastest charging types at public stations. Furthermore, the coefficient of DC Fast Chargers suggests a stronger influence on augmenting vehicle ownership compared to Level 2 chargers. These predictive factors collectively elucidate 98% of the variance in vehicle ownership (refer to Appendix 9).

Expanding our scrutiny to encompass private charging stations, as delineated in Appendix 10, a similar trend emerges. Private charging stations emerge as profoundly influential, evidenced by a coefficient of 2.2167. This implies that for each additional unit of private charging station, an estimated increase of approximately 2 cars in vehicle ownership is anticipated. Upon conducting a similar regression analysis based on charger levels, it is apparent that only Level 1 and Level 2 chargers exhibit significance, as indicated by the p-values. However, the negative coefficient attributed to Level 1 charging stations is not an anomaly but aligns with our initial discovery that EV owners tend to prefer at least Level 2 chargers in their residential premises due to the protracted duration required for full charging by standard Level 1 chargers. Given that most Level 1 chargers are provided as a complimentary addition during an EV purchase, this trend does not come as a surprise.

Our analysis of the Vehicle Features Dataset reveals distinct clusters, each portraying unique characteristics within the automotive landscape. In the initial group, vehicles exhibit well-balanced performance attributes, slightly leaning towards enhanced efficiency and fast charging capabilities. Although All-Wheel Drive stands prevalent, it does not assert exclusive dominance within this cluster. In contrast, the second cluster encompasses vehicles with diverse performance traits, markedly emphasizing speed and range. The presence of various drive types underscores a broad spectrum of vehicles, each possessing distinct performance features. Lastly, the third cluster suggests vehicles with more modest performance attributes, demonstrating a slight inclination towards acceleration while exhibiting lower efficiency, moderately reduced top speed, and range. The cluster portrays a mixed representation of vehicles, with a notable focus on front and rear-wheel drives (refer to Appendix 15 & 16).

These insights provide a comprehensive understanding of performance characteristics, drive types, and specific attributes prevalent within each distinct cluster. Such delineation aids in segmenting vehicles based on their shared traits, facilitating targeted marketing, informed product development, and strategic decision-making within the automotive industry. Moreover, these clusters illuminate the inherent groupings observed within the US automotive market.

During the clustering process using a segment of the *Washington Electric Population Dataset*, distinct groups emerged, each displaying specific automotive characteristics. The initial group predominantly comprises hatchback cars with sales figures that align with the average. These vehicles notably exhibit higher acceleration but relatively lower top speeds, highlighting a trade-off between these performance metrics. Contrastingly, the second cluster presents a blend of SUVs, fewer hatchbacks, and sedans. Vehicles in this cluster generally showcase higher acceleration but demonstrate lower top speeds, indicating a distinctive category of cars encompassing diverse body styles yet sharing analogous performance attributes. Furthermore, the third cluster primarily consists of sedans boasting sales counts higher than the average. These vehicles display lower acceleration but boast higher top speeds, possibly targeting a market segment prioritizing velocity over rapid acceleration (refer to Appendix 17 & 18).

These analyses of the clusters succinctly summarize the predominant vehicle body styles and their associated features within each cluster. A comprehensive understanding of these cluster profiles offers valuable insights into discrete market segments defined by preferences in body style, sales figures, and variations in performance attributes like acceleration and top speed. This delineation elucidates the inherent clusters existing within the Washington automotive market.

VI. Solutions & Recommendations

Utilizing Benchmarks as a Proxy for Entry

We advise closely observing Tesla's successful strategies. Tesla, a relatively recent but dominant player in EV manufacturing and sales, emphasizes a comprehensive charging infrastructure, evidenced by its expansive Supercharger network ("Morgan Stanley: Tesla charging station network 'competitive moat'"). This approach not only facilitates convenience but also directly correlates with increased vehicle sales. Additionally, Tesla's commitment to enhancing customer experience through features like online customization and continuous software updates sets a high standard in market innovation and customer satisfaction ("How Tesla Drives Top Customer Experiences"). These elements should be central to our client's strategy for a competitive edge in the EV market.

Strategies based on different vehicle body types and their features

Based on Appendix 7's analysis, we recommend a tailored approach for different vehicle body types to our client, a new EV market entrant. SUVs, leading with 41,000 units sold, attract customers who prefer efficient, spacious, and family-friendly vehicles, typically with higher incomes, as reflected in their average price of $63,027. Sedans, appealing to a performance-focused segment, show distinct advantages with high top speeds and efficiency, indicated by their higher average price of $76,230. Meanwhile, Hatchbacks offer growth potential in the budget-conscious market, prioritizing practicality and affordability. This comprehensive understanding of customer preferences across different body types and price points should guide our client's product development and market strategy.

Strategic Targets for Vehicle Sales and Charging Infrastructure Investment

Our findings confirm a direct correlation between the prevalence of charging stations and the number of EV owners: more stations lead to greater consumer interest and sales. The data visualization in Appendix 12 indicates that states with robust charging infrastructure are prime markets for EV sales. Accordingly, we recommend that our clients focus on regions such as California, Texas, Florida, and New York, which are well-equipped to support and attract prospective BEV customers. For our long-term goal, we suggest being the first mover to establish the necessary infrastructure and initiate the development of our BEV network in regions with less infrastructure but high growth potential, reaping benefits from tax credits in rural areas.

Strategic Alliances and Industry-Specific Conventions

Considering our client's early-stage status, we advise pursuing strategic alliance initiatives. These alliances would facilitate the acquisition of crucial industry knowledge and enhance product visibility. The company must prioritize partnerships with well-established firms. Such collaborations would aid in entering challenging markets, acquiring new skills, and establishing access to valuable resources. Engaging with technology companies or even battery manufacturers would offer long-term benefits, paving the way for vertical integration. Equity alliances or joint ventures are the recommended solutions for our client.

To further enhance visibility, the company needs to introduce itself effectively into the market while aligning with its overall positioning. Participating in prominent automotive and clean energy conventions like the North American International Auto Show, SEMA show, and the CES would greatly benefit the company.

VII. References

"Federal EV Policy." Electrification Coalition, 3 July 2023, electrificationcoalition.org/work/federal-ev-policy/.

"How Tesla Drives Top Customer Experiences." *Qualtrics*, 28 August 2018, https://www.qualtrics.com/blog/tesla-customer-experience/. Accessed 17 November 2023.

Krishna, G. "Understanding and identifying barriers to electric vehicle adoption through thematic analysis." *Transportation Research Interdisciplinary Perspectives*, vol. 10, no. 100364, 2021, p. 9. *ScienceDirect*, https://www.sciencedirect.com/science/article/pii/S2590198221000713#s0145. Accessed 17 November 2023.

MARIN, EDSON. "Historic sales of electric vehicles." *Kaggle*, May 2023, https://www.kaggle.com/datasets/edsonmarin/historic-sales-of-electric-vehicles. Accessed 17 November 2023.

"Morgan Stanley: Tesla charging station network 'competitive moat.'" *CNBC*, 12 February 2019, https://www.cnbc.com/2019/02/12/morgan-stanley-tesla-charging-station-network-competitive-moat.html. Accessed 17 November 2023.

Nilsen, Ella. "EPA Proposes New Tailpipe Rules That Could Push Evs to Make up Two-Thirds of New Car Sales in US by 2032 ." CNN, Cable News Network, 12 Apr. 2023, www.cnn.com/2023/04/12/politics/car-pollution-standards-electric-vehicles-biden-climate/index.html.

UNFCCC.
unfccc.int/process-and-meetings/the-paris-agreement#:~:text=The%20Paris%20Agreement%20is%20a,force%20on%204%20November%202016. Accessed 19 Nov. 2023.

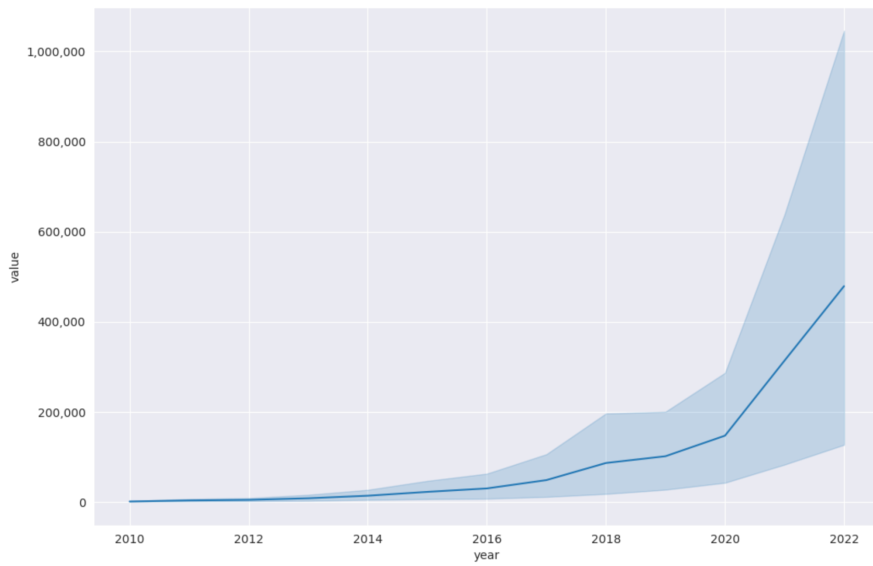
U.S. Department of Energy. "Emissions from Electric Vehicles." *Alternative Fuels Data Center*, https://afdc.energy.gov/vehicles/electric_emissions.html. Accessed 17 November 2023.

U.S. Department of Energy. "The National Average Cost of Fuel for an Electric Vehicle is about 60% Less than for a Gasoline Vehicle." *Office of Energy Efficiency & Renewable Energy*, 16 June 2023, https://www.energy.gov/maps/egallon. Accessed 17 November 2023.

VIII. Appendix

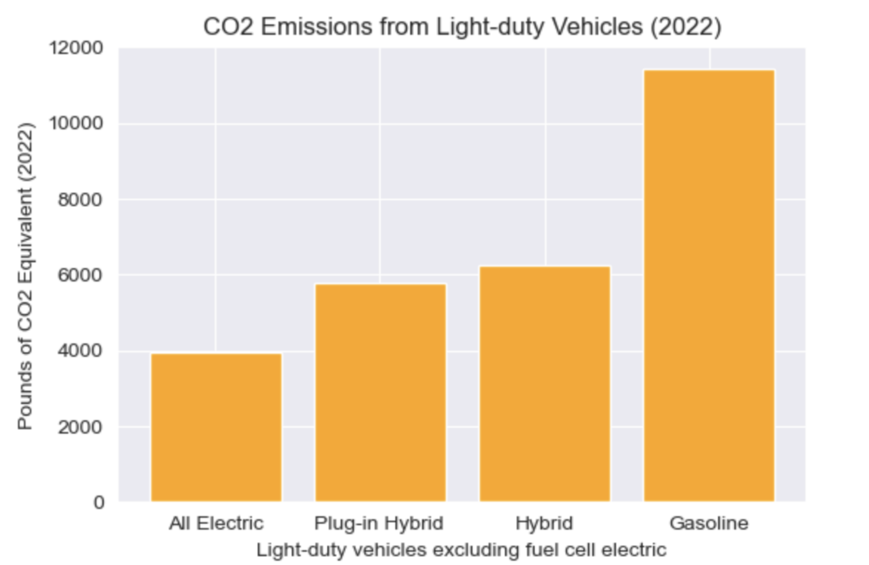
Appendix 1

<EV market sales since 2020>



Appendix 2

<CO2 Emissions from different types of vehicles>



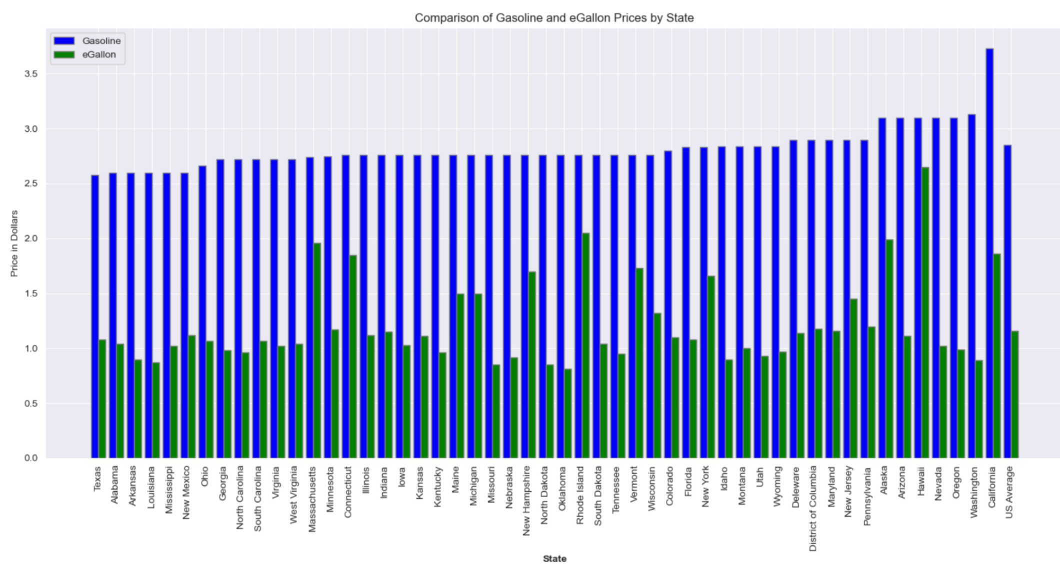
Appendix 3

*eGallon ($/gal) = FE * EC * EP*

Where (EP) is the average U.S. residential electricity price, (FE) is the average comparable passenger car adjusted combined fuel economy, and (EC) is the average fuel consumption of popular electric vehicles.

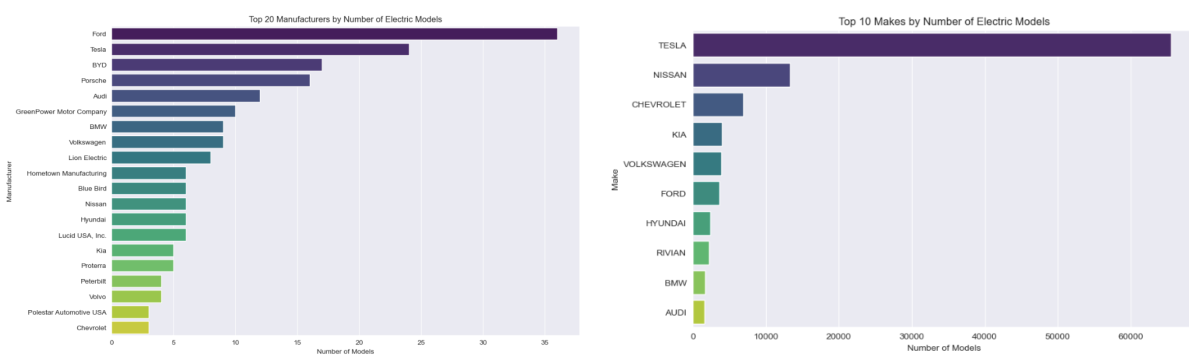
Appendix 4

<Cost comparison between EVs and Gasoline>



Appendix 5

<Top 20 EV manufacturers in the US and Top 10 EV Sellers in the Washington Market>



Appendix 6

<Features of EV Models by Top 10 Market Leaders>

	Make	Model	Body Style	Sales Count	Acceleration (sec)	TopSpeed (km/h)	Range (km)	Efficiency (Wh/km)	FastChargeSpeed (km/h)	Drive	NumberofSeats	PriceinGermany	PriceinUK	PriceUS ($)
0	VOLKSWAGEN	ID.4	SUV	2839	8.5	160	410	188	500	Rear Wheel Drive	5	0	40800.0	49,776.00
1	TESLA	MODEL Y	SUV	26194	5.1	217	450	169	750	All Wheel Drive	7	€59,965	54000.0	65,880.00
2	TESLA	MODEL X	SUV	5002	3.9	250	475	189	710	All Wheel Drive	7	€95,990	90980.0	110,995.60
3	TESLA	MODEL S	Sedan	7542	3.2	250	555	162	830	All Wheel Drive	5	€86,990	83980.0	102,455.60
4	TESLA	MODEL 3	Sedan	26766	5.6	225	340	150	570	Rear Wheel Drive	5	€43,560	40990.0	50,007.80
5	NISSAN	LEAF	Hatchbag	13093	7.9	144	220	164	230	Front Wheel Drive	5	€29,990	25995.0	31,713.90
6	KIA	NIRO	Hatchbag	1775	7.8	167	370	173	350	Front Wheel Drive	5	€39,090	32445.0	39,582.90
7	KIA	EV6	SUV	1561	8.5	185	320	181	740	Rear Wheel Drive	5	€44,990	40985.0	50,001.70
8	HYUNDAI	KONA ELECTRIC	SUV	557	7.9	167	395	162	370	Front Wheel Drive	5	41,850	0.0	44,779.50
9	HYUNDAI	IONIQ 5	SUV	1464	8.5	185	310	187	720	Rear Wheel Drive	5	€41,900	36995.0	45,133.90
10	FORD	MUSTANG MACH-E	SUV	2431	6.9	180	345	197	380	Rear Wheel Drive	5	€46,900	41330.0	50,422.60
11	AUDI	E-TRON	SUV	952	5.7	200	365	237	590	All Wheel Drive	5	0	71500.0	87,230.00

Appendix 7

<Models manufactured by top10 EV market sellers and features of each model>

	Body Style	Total_Sales_Count	Average_Acceleration	Average_Top_Speed	Average_Electric_Range	Average_Efficiency	Average_Charging_Speed	Average_Number_of_Seats	Average_Price_USD
0	SUV	41000	6.88	193.0	383.75	188.75	595.0	5.5	63027.41
1	Sedan	34308	4.40	237.5	447.50	156.00	700.0	5.0	76231.70
2	Hatchbag	14868	7.85	155.5	295.00	168.50	290.0	5.0	35648.40

Appendix 8

<Regression on Public Charging Station Number and Vehicle Ownership>

Dep. Variable:	VehicleCounts	**R-squared:**	0.954
Model:	OLS	**Adj. R-squared:**	0.954
Method:	Least Squares	**F-statistic:**	2917.
Date:	Fri, 17 Nov 2023	**Prob (F-statistic):**	1.25e-95
Time:	13:22:21	**Log-Likelihood:**	-1230.3
No. Observations:	142	**AIC:**	2465.
Df Residuals:	140	**BIC:**	2471.
Df Model:	1		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
const	329.1395	119.096	2.764	0.006	93.680	564.599
ChargingCounts	0.0562	0.001	54.009	0.000	0.054	0.058

Omnibus:	212.332	**Durbin-Watson:**	2.061
Prob(Omnibus):	0.000	**Jarque-Bera (JB):**	12011.595
Skew:	6.303	**Prob(JB):**	0.00
Kurtosis:	46.258	**Cond. No.**	1.15e+05

Appendix 9

<Regression on Public Charging Station Number categorized by different charging port types and Vehicle Ownership>

Dep. Variable:	count	**R-squared:**	0.980
Model:	OLS	**Adj. R-squared:**	0.980
Method:	Least Squares	**F-statistic:**	2275.
Date:	Fri, 17 Nov 2023	**Prob (F-statistic):**	2.92e-117
Time:	13:22:23	**Log-Likelihood:**	-1170.8
No. Observations:	142	**AIC:**	2350.
Df Residuals:	138	**BIC:**	2361.
Df Model:	3		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
const	123.0333	80.902	1.521	0.131	-36.935	283.002
Level1_Count	-3.8623	1.967	-1.963	0.052	-7.752	0.027
Level2_Count	0.0272	0.009	3.166	0.002	0.010	0.044
DC_Fast_Count	0.6807	0.061	11.130	0.000	0.560	0.802

Appendix 10

<Regression on Private Charging Station Number and Vehicle Ownership>

Dep. Variable:	VehicleCounts	**R-squared:**	0.807
Model:	OLS	**Adj. R-squared:**	0.804
Method:	Least Squares	**F-statistic:**	283.5
Date:	Fri, 17 Nov 2023	**Prob (F-statistic):**	5.95e-26
Time:	13:22:23	**Log-Likelihood:**	-680.91
No. Observations:	70	**AIC:**	1366.
Df Residuals:	68	**BIC:**	1370.
Df Model:	1		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
const	158.7803	503.685	0.315	0.754	-846.307	1163.868
ChargingCounts	2.2167	0.132	16.837	0.000	1.954	2.479

Omnibus:	87.016	**Durbin-Watson:**	1.968
Prob(Omnibus):	0.000	**Jarque-Bera (JB):**	2389.489
Skew:	-3.247	**Prob(JB):**	0.00
Kurtosis:	30.876	**Cond. No.**	3.92e+03

Appendix 11

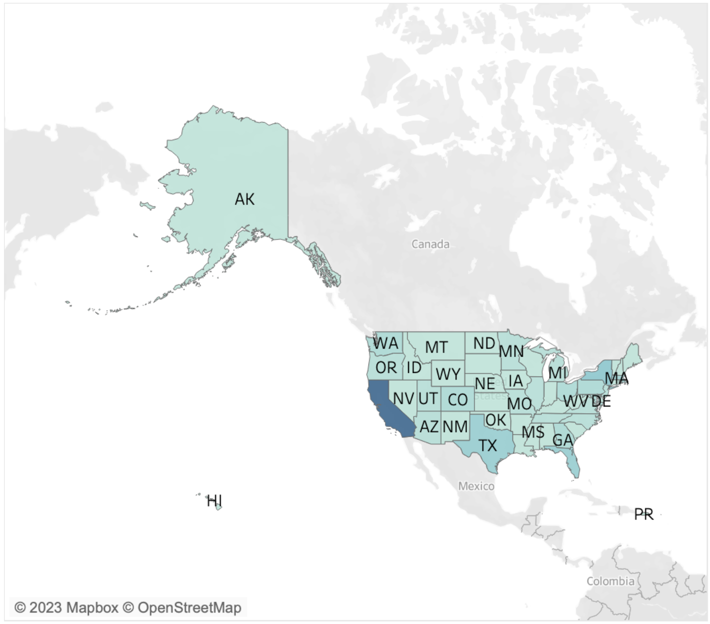
<Regression on Private Charging Station Number categorized by different charging port types and Vehicle Ownership>

Dep. Variable:	count	**R-squared:**	0.946
Model:	OLS	**Adj. R-squared:**	0.944
Method:	Least Squares	**F-statistic:**	386.5
Date:	Fri, 17 Nov 2023	**Prob (F-statistic):**	8.60e-42
Time:	13:22:23	**Log-Likelihood:**	-636.14
No. Observations:	70	**AIC:**	1280.
Df Residuals:	66	**BIC:**	1289.
Df Model:	3		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
const	642.8712	275.464	2.334	0.023	92.890	1192.853
Level1_Count	-4.0312	0.398	-10.120	0.000	-4.826	-3.236
Level2_Count	2.7412	0.083	32.924	0.000	2.575	2.907
DC_Fast_Count	-1.0238	1.359	-0.753	0.454	-3.737	1.689

Appendix 12

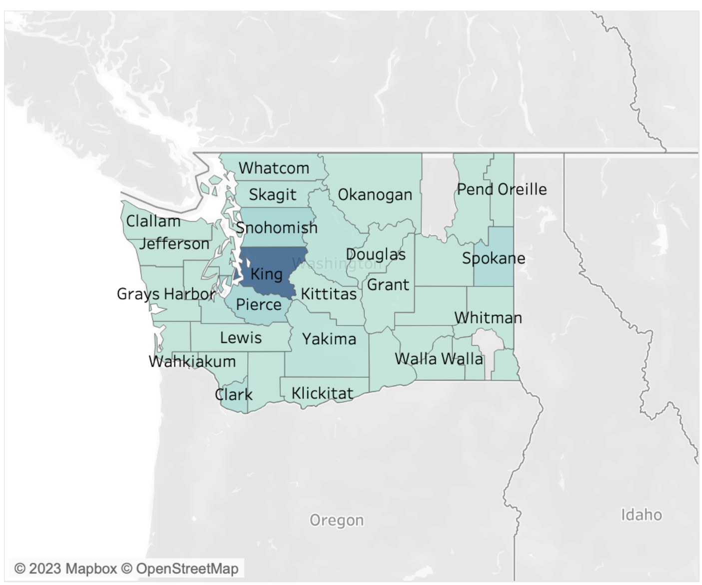
Population of Public Charging Stations Per US State



Map based on Longitude (generated) and Latitude (generated). Color shows distinct count of ID. The marks are labeled by State. Details are shown for State. The view is filtered on State, which excludes Null.

Appendix 13

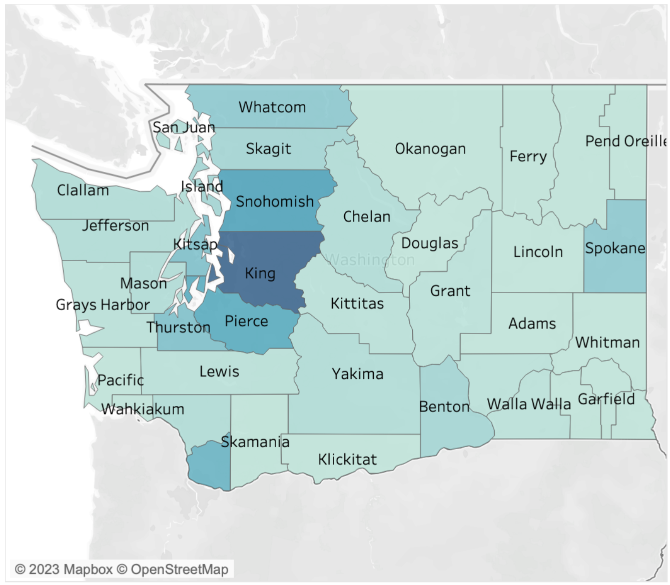
Population of EV Public Charging Stations in Washington



Map based on Longitude (generated) and Latitude (generated). Color shows distinct count of ID. The marks are labeled by County. Details are shown for State and County. The view is filtered on State, which keeps WA.

Appendix 14

Population of EVs per County in Washington



Map based on Longitude (generated) and Latitude (generated). Color shows distinct count of Vin (1-10). The marks are labeled by County. Details are shown for State (Electric Vehicle Population Data.csv). The view is filtered on State (Electric Vehicle Population Data.csv), which keeps WA.

Appendix 15

Clustering Output Based On US Vehicle Features Dataset

	Acceleration	TopSpeed	Range	Efficiency	FastChargeSpeed
1	-0.3954477	-0.01470931	-0.08249112	0.9241744	0.1401197
2	-1.3643853	1.56728242	1.23831303	-0.1610230	1.1170278
3	0.7942261	-0.59969251	-0.42657210	-0.5534962	-0.5278128

	DriveAll Wheel Drive	DriveFront Wheel Drive	DriveRear Wheel Drive
1	0.9104519	-0.5216648	-0.5334027
2	0.9932203	-0.5216648	-0.6251976
3	-0.9932203	0.5506462	0.5987342

Appendix 16

Clustering Output Based On US Vehicle Features Dataset			
Characteristics	**Cluster 1**	**Cluster 2**	**Cluster 3**
Characteristics #1	Moderate acceleration, possibly slightly lower than average.	Significantly lower acceleration but notably higher top speed and range.	Moderate acceleration, possibly slightly higher than average.
Characteristics #2	Average top speed and range.	Lower efficiency but significantly higher fast charge speed.	Moderately lower top speed and range compared to the dataset's average.
Characteristics #3	Slightly higher efficiency and fast charge speed compared to the dataset's average.	Dominated by vehicles across all drive types (All-Wheel Drive, Front-Wheel Drive, and Rear-Wheel Drive).	Lower efficiency and moderately lower fast charge speed.
Characteristics #4	Predominantly consists of vehicles with All-Wheel Drive, though Front-Wheel Drive and Rear-Wheel Drive are also present, but less prominently.		Relatively reduced representation of all drive types compared to the dataset's average.

Appendix 17

<Clustering Output Based On Washington EV Population Dataset>

```
  `Body Style`Hatchbag `Body Style`Sedan `Body Style`SUV   SalesCount Acceleration   TopSpeed
1            2.1408721        -0.4281744      -1.3540064 -0.008455543    0.6535816 -1.1132766
2           -0.4281744        -0.4281744       0.6770032 -0.616416078    0.5557667 -0.4222773
3           -0.4281744         0.8563488      -0.3385016  0.928851888   -1.1604408  1.1900543
```

Appendix 18

Clustering Output Based On Washington EV Population Dataset			
Characteristics	**Cluster 1**	**Cluster 2**	**Cluster 3**
Characteristics #1	Predominantly consists of hatchback vehicles.	Fewer occurrences of hatchback and sedan vehicles.	Fewer occurrences of hatchback and SUV vehicles.
Characteristics #2	Fewer occurrences of sedan and SUV vehicles.	Stronger representation of SUV vehicles.	Stronger representation of sedan vehicles.
Characteristics #3	Average sales count.	Average sales count.	Higher than average sales count.
Characteristics #4	Higher than average acceleration but lower than average top speed.	Higher than average acceleration but lower than average top speed.	Lower acceleration but higher than average top speed.

Appendix 19
PESTEL Analysis

Political	Economic	Sociocultural	Technological	Ecological	Legal
Global Tax Credits and Subsidies for Consumers and Manufacturers	Rebound in post-pandemic economic growth	Increased emphasis on sustainability and environmental protection	Expands the accessibility of the electric vehicle (EV) sector to technology enthusiasts.	Growing concern regarding the impact of emissions from transportation	Tightening emission regulations
Mandates for electrification of fleet	Strong economy signals a potential increase in consumer spending	More environment-conscious consumers (Younger generation)	High emphasis on technological integration and innovation; Potentially needing high upfront costs	Recent discussions about climate change and the Paris Agreement initiatives.	Bans on the sale of new petrol and diesel cars
Investments in Charging Infrastructure	EVs will become a huge part of the global economy	As a result of governmental backing/suppo rt, electric vehicles will maintain their significance and relevance as societal trends in the future.	Progress in battery capacity and energy efficiency conservation efforts	Increased focus in renewable energy	Complicated permit requirements for public charging stations
Bans for the sale of ICE in the near future	Fluctuations in the price of oil	Increased demand in ‘luxury’ goods	Slowed developments in improving EV range for longer travels	Evidence of climate change and frequency of natural disasters	Complicated requirements for residential charging ports

Appendix 20
Porter's Five Forces Model

Threat of New Entrants	Bargaining Power of Suppliers	Bargaining Power of Buyers	Threat of Substitutes	Rivalry Among Existing Competitors
Low	**High**	**Low**	**High**	**High**
High Capital Requirements	Small Number of Suppliers	A lot of buyers	Strong substitutes exist (ICE, PHEV, HEV)	Oligopoly Market
High economies of scale	Demand higher prices for inputs	Products are fairly differentiated	Price-performance has an attractive trade-off	Competitors have pricing power and differentiated products
Credible Threat of Retaliation	Supplier industry is concentrated	Moderate level of switching costs exist	Buyer switching costs are relatively low	High strategic commitments
High Network Effects	High supplier switching costs	Minimal backward integration threat	Strong, proven, track record of conventional vehicles	Firms make costly, long term, and difficult-to-reverse actions

Appendix 21
Data Source

Dataset Used	Source
Alternative Fuel Vehicles US	Provided by Competition
Elecric_Vehivle_Population_Data	Provided by Competition
Alt_fuel_stations (Nov 10 2023) Private	https://afdc.energy.gov/stations/#/find/nearest
Alt_fuel_stations (Nov 10 2023) Public	https://afdc.energy.gov/stations/#/find/nearest

Cheapestelectriccars-EVDatabase	https://www.kaggle.com/code/stpeteishii/cheapest-electric-cars-features-prediction/input
EV contribution	https://afdc.energy.gov/vehicles/electric_emissions.html
Price_Gas and eGallon	https://www.energy.gov/eere/vehicles/articles/fotw-1186-may-17-2021-national-average-cost-fuel-electric-vehicle-about-60
IEA-EV-dataEV salesCarsHistorical	https://www.kaggle.com/datasets/edsonmarin/historic-sales-of-electric-vehicles