To: Lex Luther, Managing Partner, Janzen Consulting Group
From: Data Analysis Team
Date: October 14, 2024
Re: Analysis of Electric Vehicle Population Data in Washington State

Mr. Luther, I have conducted an analysis of electric vehicle (EV) population data currently registered through the Washington State Department of Licensing (DOL), as electric vehicles (EVs) become increasingly prevalent, understanding the factors influencing their range is crucial for policymakers, manufacturers, and consumers. This analysis aims to inform our consulting strategy for clients in the automotive and energy sectors, with implications for urban planning, energy infrastructure, and environmental policies in Washington State.
I hypothesize that newer model year electric vehicles, those eligible for Clean Alternative Fuel Vehicle (CAFV) status, and Battery Electric Vehicles (BEVs) will have a greater electric range compared to older models, non-CAFV eligible vehicles, and Plug-in Hybrid Electric Vehicles (PHEVs), respectively. H0: There is no significant relationship between electric range and model year, CAFV eligibility, EV type, or county.
H1: There is a significant positive relationship between electric range and newer model years, CAFV eligibility, BEV type, and certain counties.

I used the Electric Vehicle Population Data from the Washington State Department of Licensing (2024), focusing on **five** key variables:

1. **Electric Range (Dependent Variable)**: The distance an EV can travel on a single charge, measured in miles. It ranges from **6 to 337 miles (M = 127.6, SD = 99.7)**. The distribution is slightly right-skewed (skewness = 0.34), indicating a concentration of vehicles with lower ranges and fewer high-range vehicles.

Summary Statistics for Electric Range in Miles								
N	Minimum	1st Quartile	Median	Mean	3rd Quartile	Maximum	SD	Skewness
60344	6	32	84	127.6	215	337	99.7	0.34

2. **Model Year (Independent Variable)**: The year the electric vehicle was manufactured. It spans from **1997 to 2024 (M = 2018.35, SD = 2.94).** The slight left skew (**skewness = -0.25**) suggests a higher concentration of **newer models** in the dataset. The concentration of newer models indicates rapid recent adoption of EVs.

Summary Statistics for Model Year								
N	Minimum	1st Quartile	Median	Mean	3rd Quartile	Maximum	SD	Skewness
60344	1997	2017	2018	2018	2020	2024	2.9	-0.25

3. **CAFV Eligibility (Independent Variable)**: Indicates whether a vehicle qualifies as a Clean Alternative Fuel Vehicle. It's a binary variable with **78.1%** of vehicles being eligible, suggesting most EVs in these counties meet **clean fuel standards**.

Clean Alternative Fuel Vehicle (CAFV) Eligibility	N	PCT
Clean Alternative Fuel Vehicle Eligible	47156	78.10%
Not eligible due to low battery range	13188	21.90%
Total	60344	100.00%

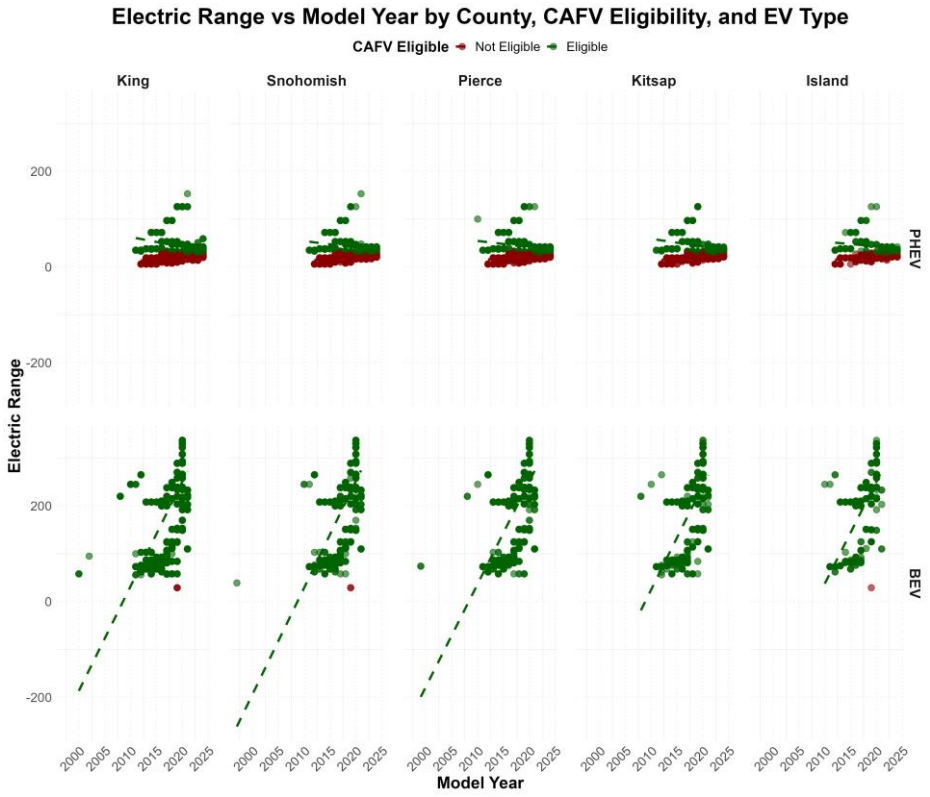
Electric Vehicle Type	N	PCT
Battery Electric Vehicle (BEV)	35166	58.30%
Plug-in Hybrid Electric Vehicle (PHEV)	25178	41.70%
Total	60344	100.00%

4. **Electric Vehicle Type (Independent Variable)**: Categorizes vehicles as either Battery Electric Vehicles (BEVs) or Plug-in Hybrid Electric Vehicles (PHEVs). BEVs comprise **58.3%** of the sample, indicating a slight preference for fully electric vehicles.
5. **County (Independent Variable)**: The Washington State County where the vehicle is registered. The distribution shows a significant concentration in King County (68%), suggesting urban areas are favorable for EV adoption.

County	N	PCT
King	41027	68%
Snohomish	8632	14.3%
Pierce	6555	10.9%
Kitsap	3103	5.14%
Island	1027	1.70%
Total	60344	100%

The analysis confirms that newer models, CAFV-eligible vehicles, and BEVs are indeed associated with increased electric range. Interestingly, there are significant differences in range across counties, which may reflect varying infrastructure or consumer preferences. Some variation in range across counties is also expected.

No missing values or significant outliers were identified in these variables. I recoded the CAFV Eligibility and Electric Vehicle Type variables into binary format for the regression analysis.
I performed a multiple OLS regression to examine the relationship between Electric Range and the independent variables. **The alpha level for this analysis was set at 0.05. (Ref. Table 1)**



The regression model can be specified as: Electric Range = -17,124 + 8.49(Model Year) + 17.3(CAFV Eligible) + 173.85(EV Type BEV) + 0.75(CountySnohomish) + 2.94(CountyPierce) - 4.22(CountyKitsap) + 4.94(CountyIsland) + ε

Where King County serves as the reference category for the County variable. The findings are **statistically significant** at the 0.05 alpha level. The overall model is significant ($F(7, 60336) = 24590$, $p < 0.05$), and all individual predictors are significant ($p < 0.05$). The model explains a substantial portion of the variance in Electric Range **(Adjusted R^2 = .74)**, indicating that chosen variables are strong predictors of electric vehicle range.
Interpreting each IV regression coefficient:

1. Model Year: For every additional year increase in the vehicle's model year, the electric range of the vehicle increases by **8.49 miles**, holding other variables constant. ($p < 0.001$)
2. CAFV Eligible: Vehicles eligible for CAFV have, on average, **17.3 miles** more range than non-eligible vehicles, holding other variables constant. ($p < .001$)
3. EV Type BEV (Battery Electric Vehicles compared to Plug-in Hybrid Electric Vehicles, PHEV): Battery Electric Vehicles (BEV) have an electric range that is, on average, **173.85 miles** longer than Plug-in Hybrid Electric Vehicles (PHEV), holding other variables constant. ($p < .001$)
4. County: Compared to King County:

- Pierce County: Vehicles registered in Pierce County have, on average, **2.94** more miles of electric range compared to those in King County, holding other variables constant. ($p < 0.001$)
- Kitsap County: Vehicles in Kitsap County have, on average, **4.22** miles **less** range than those in King County, holding other factors constant. ($p < 0.001$)
- Island County: Vehicles in Island County have, on average, **4.94** more miles of electric range compared to those in King County, holding other factors constant. ($p < 0.01$)
- Vehicles registered in Snohomish County have, on average, **0.75** miles more electric range than those in King County (the reference category), holding other variables constant.

Regression Assumptions:

Looking at the regression assumptions, I checked for linearity, homoscedasticity, normality of residuals, and multicollinearity, there was no multicollinearity. While most assumptions were met, I observed slight heteroscedasticity, **(Ref. Table 3)** which might affect the precision of the estimates. Given the statistical significance and large sample size (N = 60,344), I can generalize these findings to the target population of electric vehicles in the top five counties of Washington State.

These findings are both statistically and substantively significant. The large coefficient for BEVs is particularly notable, reflecting the substantial difference in range between fully electric and hybrid vehicles. The year-over-year improvement in range and the impact of CAFV eligibility are also meaningful for policy and consumer decisions.

Potential Weaknesses and Gaps:

1. Slight heteroscedasticity is observed, which is potentially affecting estimate precision.
2. Possible self-selection bias in EV ownership is not addressed.

Major Takeaways:

The Adjusted R-squared value of 0.74 indicates that this model explains 74.1% of the variance in Electric Range, which is a strong fit for social science research. The f^2 value is 2.87, and the power of the regression analysis is 1, indicating that the sample size is more than adequate to detect the observed effects.

My analysis further reveals several key insights:

1. Newer models consistently offer longer ranges, with each year adding about 8.5 miles of range.
2. Battery Electric Vehicles significantly outperform Plug-in Hybrids in range, with an average difference of 174 miles.
3. CAFV eligibility is associated with increased range, suggesting that environmental standards align with performance improvements.
4. While there are statistically significant differences between counties, their practical impact on range is minimal compared to other factors.

This analysis highlighted the importance of considering both statistical and practical significance, especially with large datasets where even small effects can be statistically significant.

Conclusion:

Based on these takeaways, I recommend that our clients focus on:

1. Incentivizing the adoption of Battery Electric Vehicles over Plug-in Hybrids.
2. Promoting CAFV-eligible vehicles to align environmental goals with performance benefits.
3. Investigating and addressing the factors leading to range differences across counties.

These actions should help accelerate the transition to longer-range electric vehicles, supporting both environmental goals and consumer needs.

Table 1: Stargazer Output for Regression Results:

Regression Results

	Dependent variable:
	Electric Range
Model Year	8.490***
	(0.074)
CAFV Eligible	17.299***
	(0.641)
EV Type (BEV)	173.854***
	(0.562)
County (Snohomish)	0.746
	(0.601)
County (Pierce)	2.937***
	(0.676)
County (Kitsap)	-4.215***
	(0.945)
County (Island)	4.944**
	(1.602)
Constant	-17,124.320***
	(149.988)
County Reference	King
Observations	60,344
R2	0.741
Adjusted R2	0.741
Note:	*p<0.05; **p<0.01; ***p<0.001

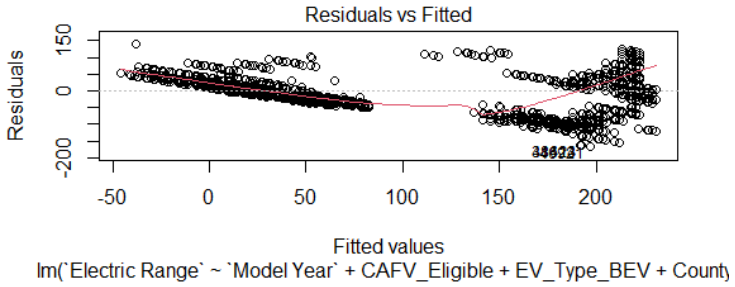


Table 3

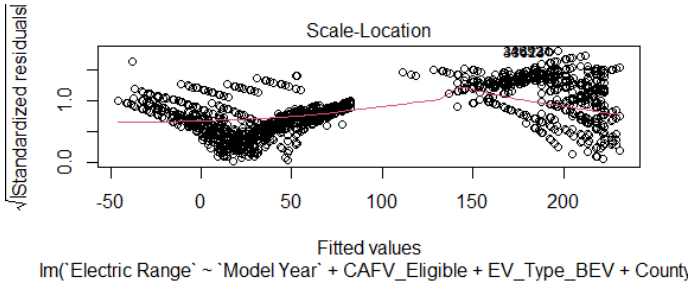


Table 4

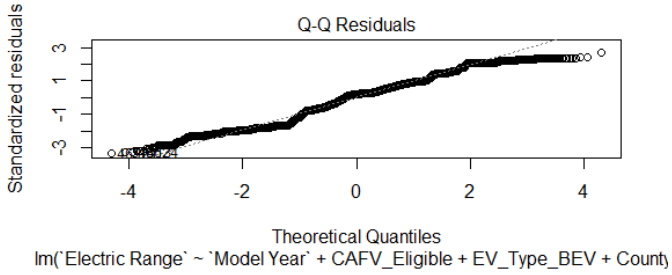
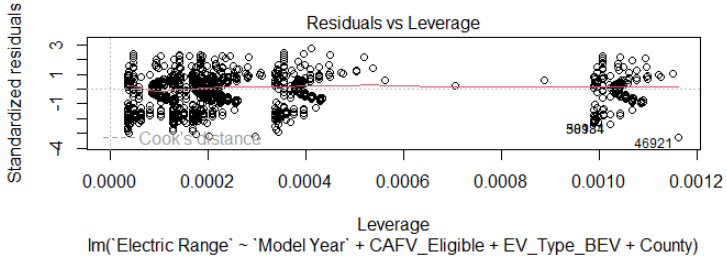


Table 5



Washington State Department of Licensing. (2024, September 20). *Electric vehicle population data* [Data set]. Data.gov. https://catalog.data.gov/dataset/electric-vehicle-population-data