Business Analytics Case Study

- Analyzing Electric Vehicle Market Dynamics in Washington -

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About me

Data-driven problem solver with experience in business analytics, turning data into actionable insights to support strategic decisions. Skilled in applying R, SQL, Power BI and data visualization tools

Industry Experience

F&B, Sustainability & Energy e-Commerce, Consumer Product, Mobility & Aviation

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Data Analysis Case Study

Analyzing Electric Vehicle Market Dynamics in Washington

Purpose of the Project

Exploring the dynamics of the electric vehicle market in Washington State, focusing on data-driven insights to understand adoption patterns and influencing factors

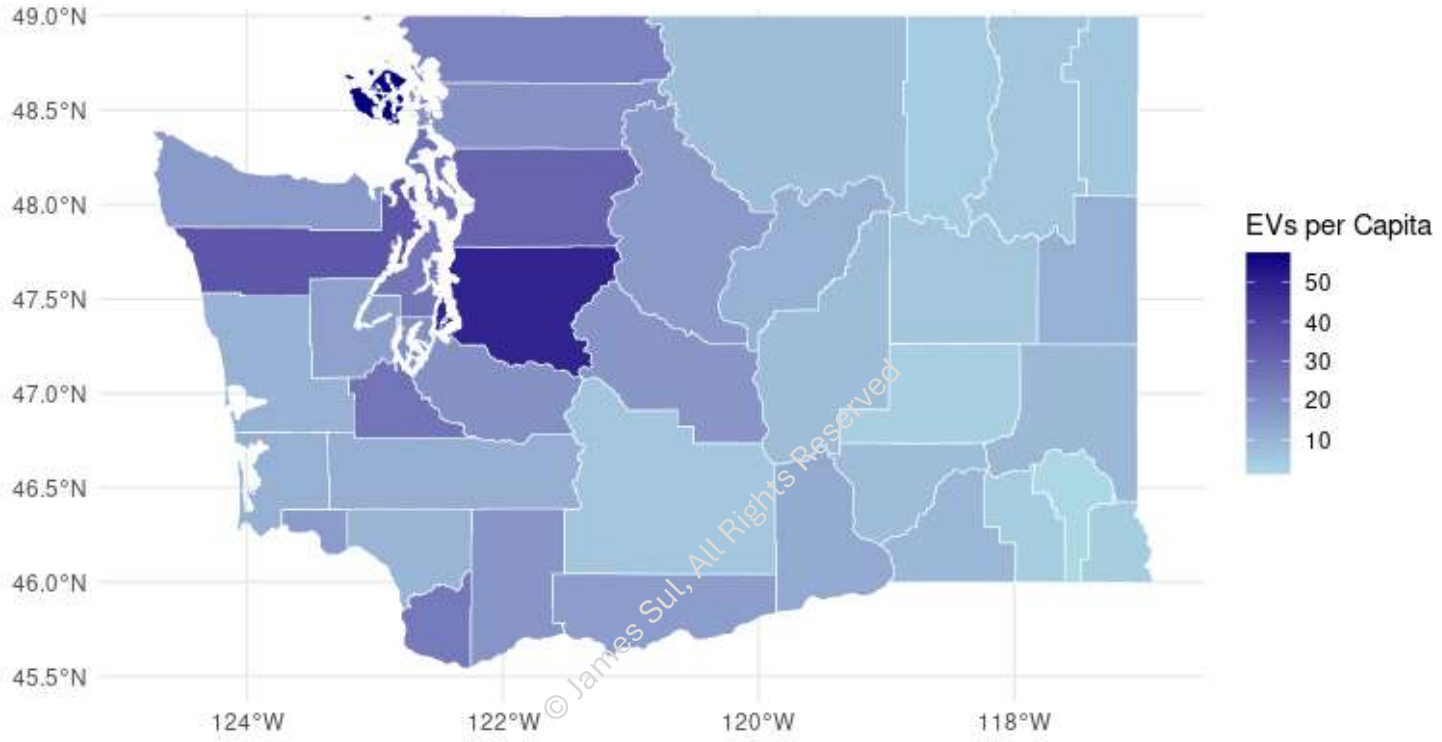
Data Analysis Process

- *Data Collection* *(Electric Vehicle Population and Demographic Data in WA)*
- *Data Cleaning & Preparation* *(Cleaning, Formatting, and Feature Engineering)*
- *Exploratory Data Analysis* *(Detection and Correction of Outliers)*
- *Modeling and Analysis* *(Regression Analysis and Time Series Visualization)*
- *Insights and Interpretation*
- *Summary and Visualization*

Data Analysis Tool Used : R, Excel, and ChatGPT

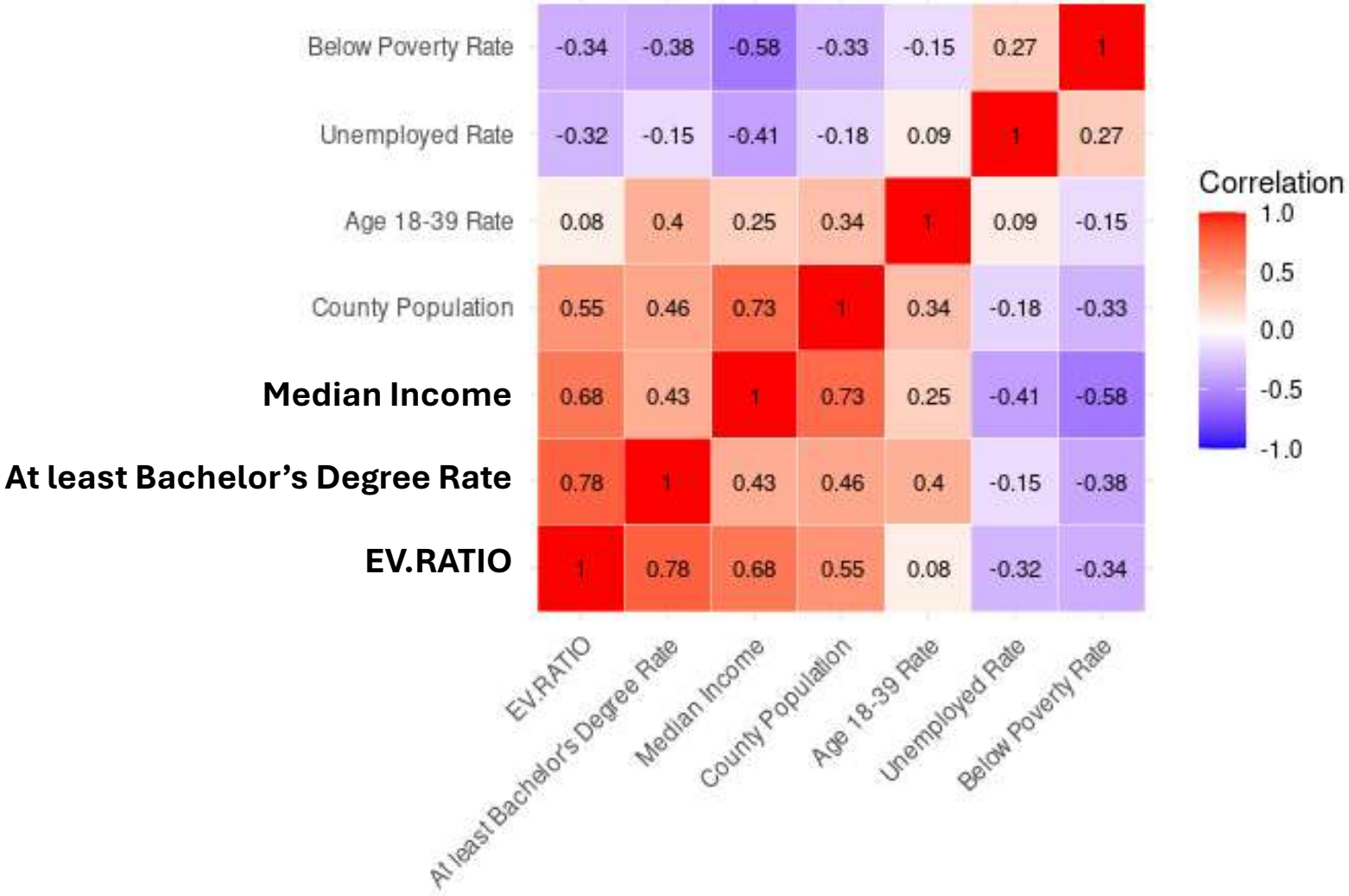
Electric Vehicles per Capita in WA

Ratio of EV Count to Population by County



- ☑ Electric Vehicles per Capita (EV.RATIO) represents the ratio of electric vehicles to the population for each county
- ☑ King County, home to major tech companies like Microsoft and Amazon, demonstrates the highest EV adoption rate in Washington State
- ☑ *What factors contribute to this high adoption rate?*

Correlation Heat Map by EV.RATIO



- ☑ To identify correlated factors, demographic data was merged, and a heatmap was created for visual analysis

- ☑ The heatmap indicates that the '**At least Bachelor's Degree Rate**' has the highest correlation with '**EV.RATIO'**, followed by '**Median Income**'

Regression Model

```
Call:
lm(formula = EV.RATIO ~ `Median Income` + `County Population` +
    `Age 18-39 Rate` + `At least Bachelor's Degree Rate` + `Unemployed Rate` +
    `Below Poverty Rate`, data = regression_data)

Residuals:
       Min         1Q     Median         3Q        Max
-0.0091471 -0.0016700  0.0000589  0.0022811  0.0078930

Coefficients:
                                    Estimate Std. Error t value Pr(>|t|)
(Intercept)                       -3.700e-02  9.498e-03  -3.896 0.000508 ***
`Median Income`                    4.240e-07  8.193e-08   5.175 1.42e-05 ***
`County Population`               -1.838e-09  2.462e-09  -0.747 0.461094
`Age 18-39 Rate`                  -4.442e-04  1.037e-04  -4.283 0.000175 ***
`At least Bachelor's Degree Rate`  7.519e-04  7.929e-05   9.483 1.55e-10 ***
`Unemployed Rate`                  4.871e-05  6.197e-04   0.079 0.937873
`Below Poverty Rate`               1.093e-03  3.877e-04   2.818 0.008476 **
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.003808 on 30 degrees of freedom
Multiple R-squared:  0.871,     Adjusted R-squared:  0.8452
F-statistic: 33.75 on 6 and 30 DF,  p-value: 4.81e-12
```

- ☑ When running the regression with variables from the heatmap, the two most significant predictors, ‘**At least Bachelor’s Degree Rate**' and ‘**Median Income**', show strong statistical significance with p-values below 0.05.

- ☑ On the other hands ‘**County Population**’ and ‘**Unemployed Rate**’ shows no statistically significant impact on EV adoption, with p-values above 0.05 suggesting they are less relevant predictors in this model

Regression Model

```
Call:
lm(formula = EV.RATIO ~ `Median Income` + `Age 18-39 Rate` + 
    `At least Bachelor's Degree Rate` + `Below Poverty Rate`, 
    data = regression_data)

Residuals:
       Min         1Q     Median         3Q        Max 
-0.0086540 -0.0016954 -0.0001837  0.0023606  0.0085729 

Coefficients:
                                  Estimate Std. Error t value Pr(>|t|)    
(Intercept)                     -3.300e-02  6.247e-03  -5.282 8.75e-06 ***
`Median Income`                  3.833e-07  5.514e-08   6.952 7.11e-08 ***
`Age 18-39 Rate`                -4.553e-04  9.815e-05  -4.639 5.65e-05 ***
`At least Bachelor's Degree Rate`  7.393e-04  7.561e-05   9.778 3.92e-11 ***
`Below Poverty Rate`             1.028e-03  3.692e-04   2.783  0.00895 ** 
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.003721 on 32 degrees of freedom
Multiple R-squared:  0.8686,    Adjusted R-squared:  0.8521 
F-statistic: 52.86 on 4 and 32 DF,  p-value: 1.182e-13
```

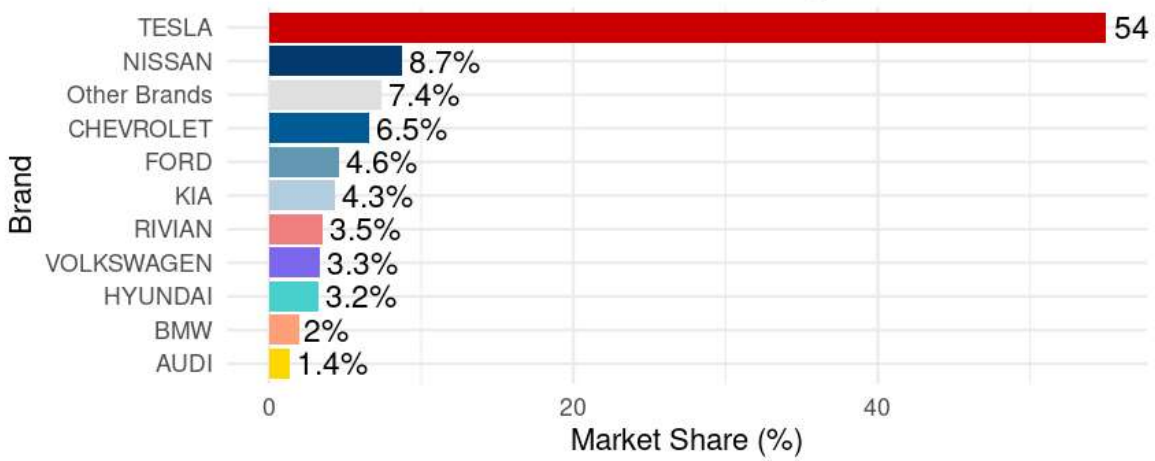
- ☑ After removing two irrelevant variables, the regression model achieved an **R-squared of 0.8686**
- ☑ To address potential overfitting, I checked for multicollinearity using the Variance Inflation Factor (VIF). All variables showed acceptable VIF values ranging between 1.2 and 1.65, indicating no significant multicollinearity issues

Key Insights on Market Analysis

The analysis reveals that demographic factors such as income, education, and age play a significant role in influencing EV adoption. With an R-squared value of 0.8686 and no multicollinearity issues, the model offers a reliable foundation for developing data-driven EV policies and targeted marketing strategies.

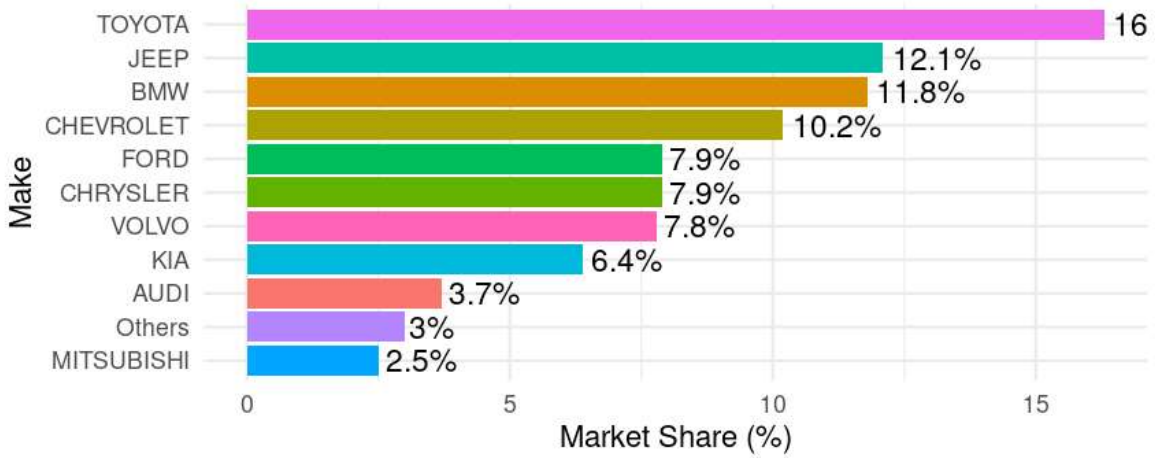
The next step was to dive into the data to uncover key market trends and drivers, starting with brand performance across BEV and PHEV categories

BEV Market Share by Brand



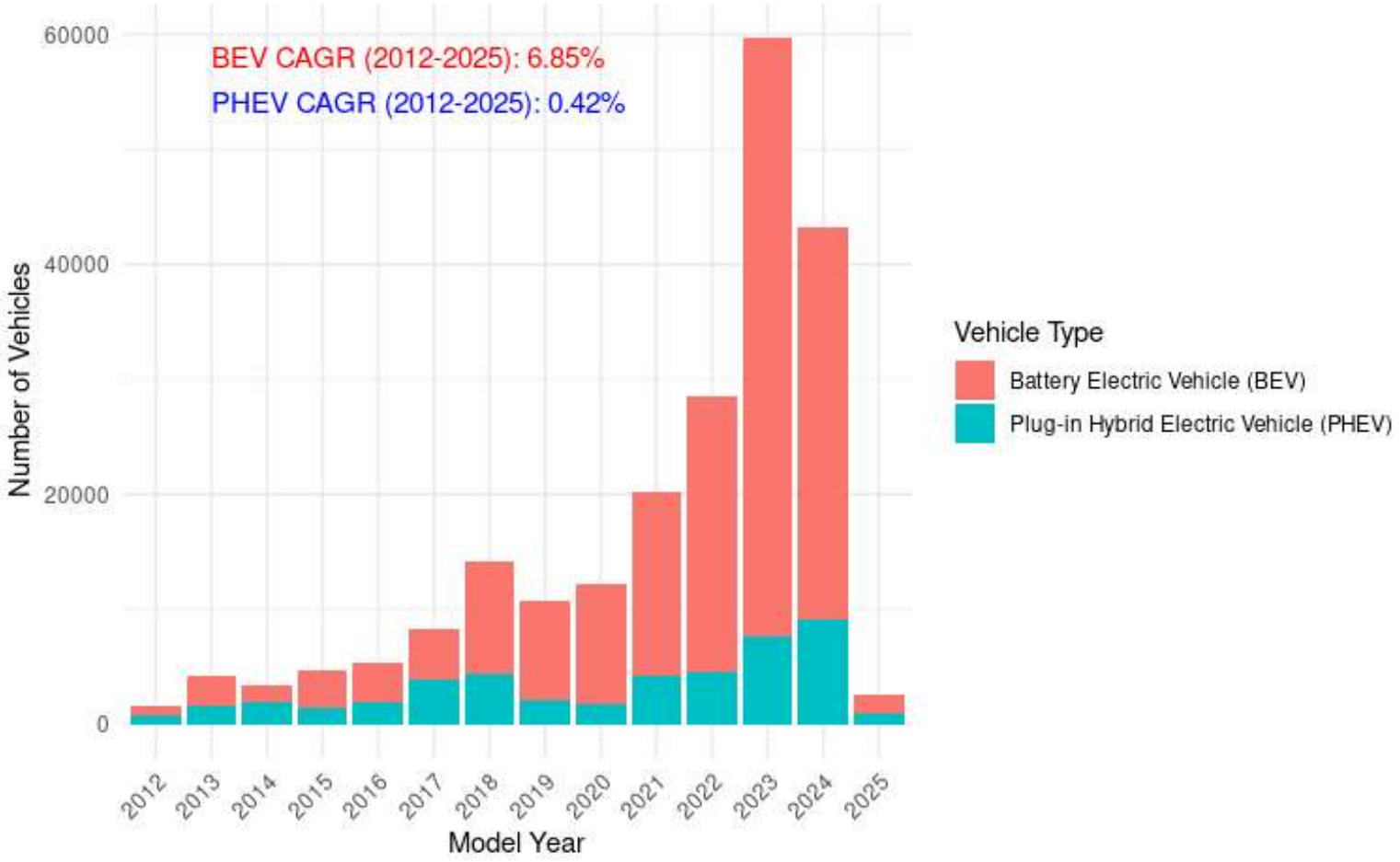
- [x] For the BEV market in WA, Tesla dominates with 54% of the total market share, highlighting a significant lead over its competitors

PHEV Market Share by Brand



- [x] For the PHEV market, Toyota leads; however, the gap between competitors is much smaller compared to the BEV market, indicating a more evenly distributed market share.

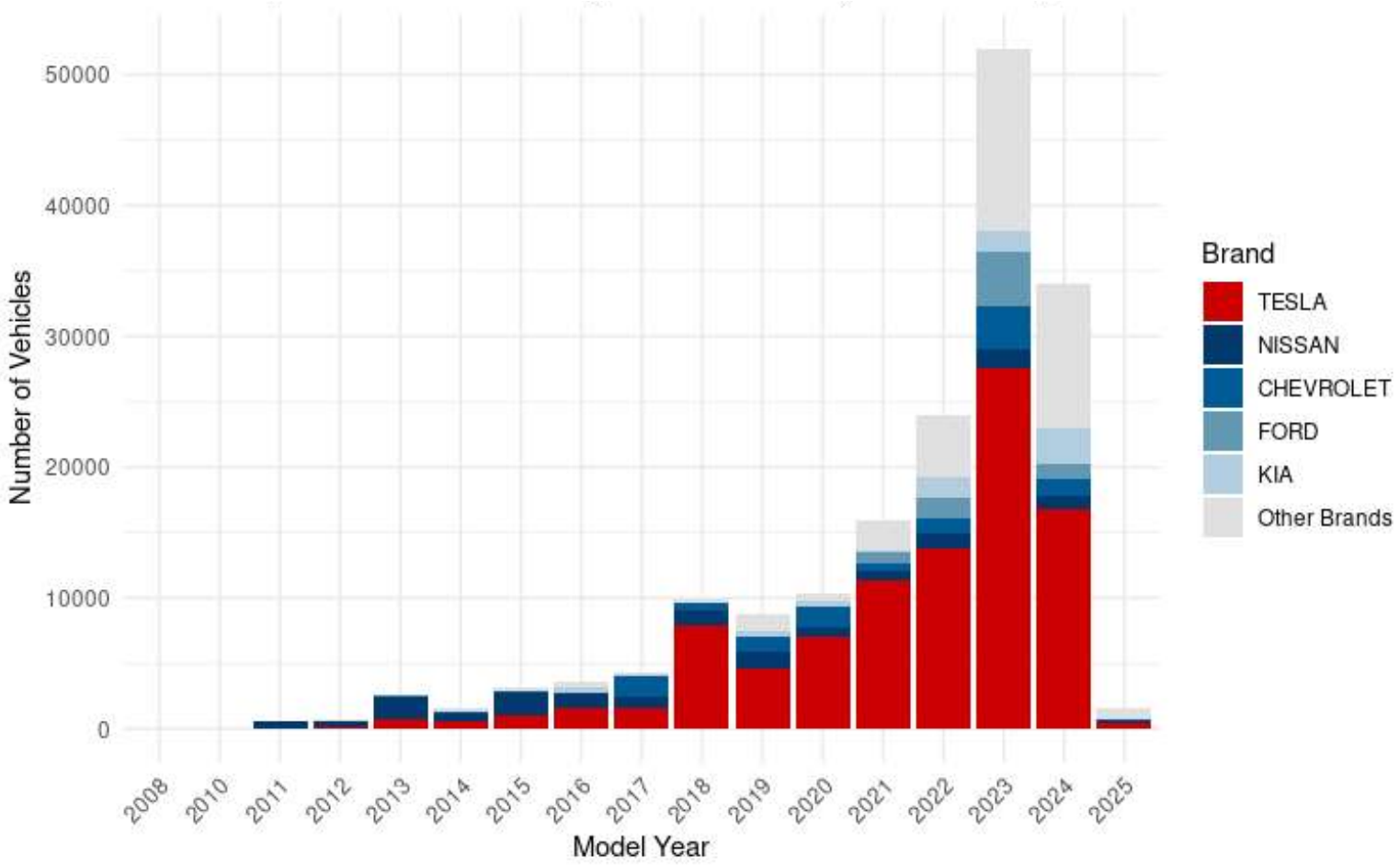
BEV vs PHEV Market Share (2012-2025)



☑ When incorporating a time series by model year, Battery Electric Vehicles (BEVs) have driven EV growth in Washington with a CAGR of 6.58%, while Plug-in Hybrid Electric Vehicles (PHEVs) show a modest CAGR of 0.42%

☑ *What factors have driven this increase in BEV?*

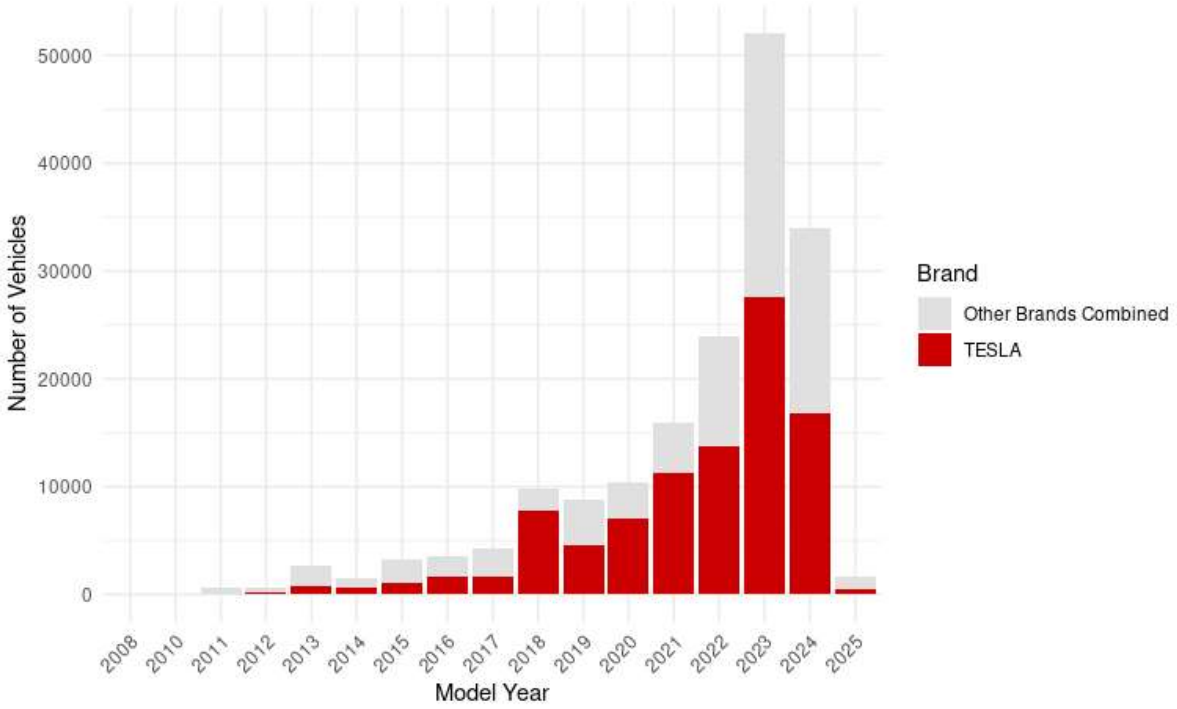
Top 5 BEV Brands by Model Year (2012-2025)



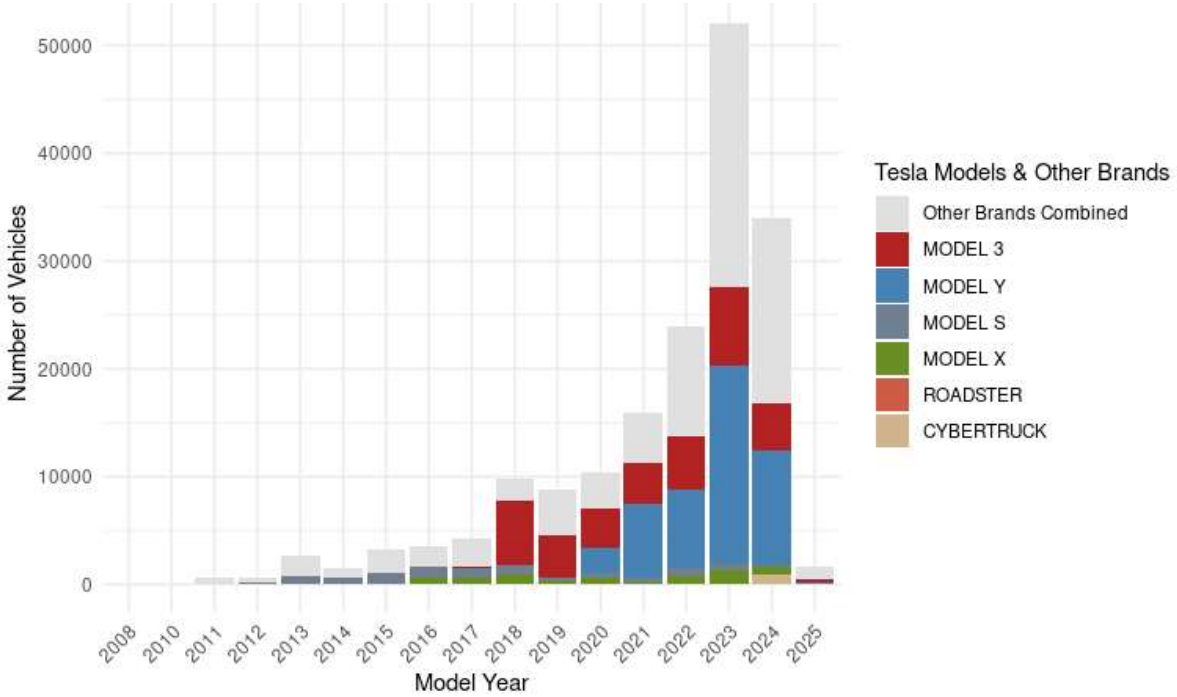
- ☑ To identify key drivers, I divided the bar graph by brand to highlight the contribution of each BEV brand among the 37 brands in total

- ☑ The graph highlights that Tesla has contributed the most significantly to the upward trend, clearly dominating the BEV market share

BEV Brand Comparison by Model Year



BEV Comparison by Model and Year



- ☑ *What factors influenced this explosive growth for the model years 2022 and 2023?*

- ☑ Focusing on Tesla, the breakdown by model shows that the Model Y significantly contributed to the sharp increase in 2023, playing a pivotal role in the explosive growth observed

- ☑ I hypothesize that the growth may have been driven by:

  1) Product Upgrades: Introduction of a refreshed version or new features for the Model Y, enhancing its value proposition

  2) Price Incentives: Strategic pricing adjustments and policy-driven subsidies, such as tax credits and rebates, likely reduced the effective purchase price and boosted demand

Hypothesis1: Product Upgrades

Mar 2023 ——— ***Mar 2025*** →

Model Y

Starting Price After Est. Savings:
$31,490[1]
Available Now

New Model Y

Starting Price After Est. Savings:
$46,490[1]
Available Starting March

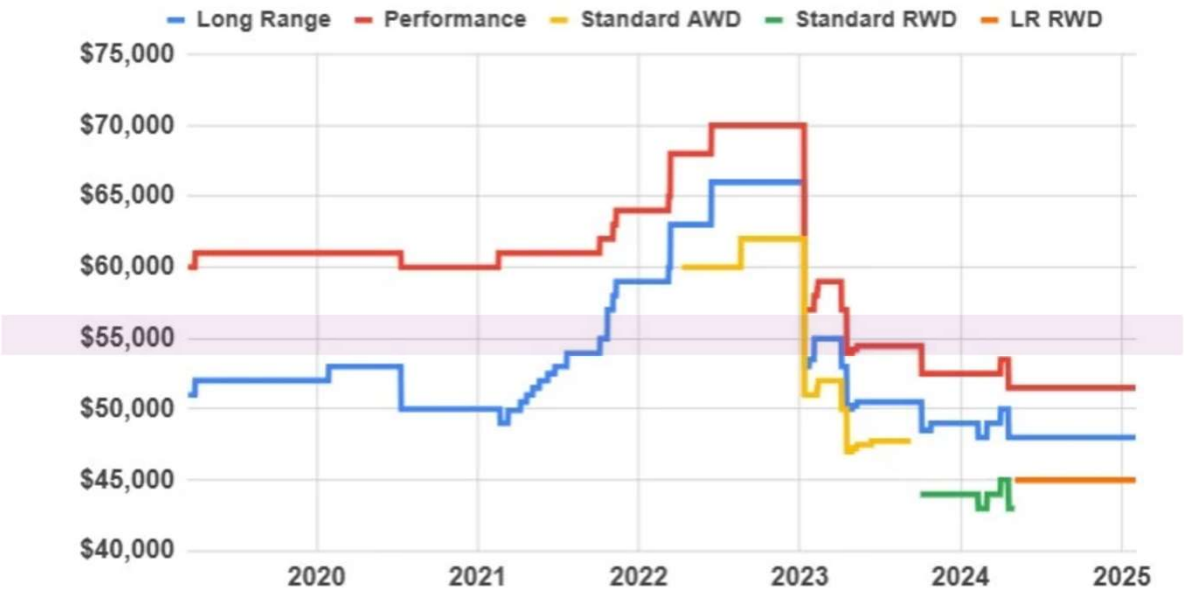
** Image Source: Tesla. (2025). Model Y Overview. Retrieved from https://www.tesla.com/modely*

- ☑ Research indicates that while Tesla Model Y underwent interior refreshes and Vision & Safety upgrades, these changes were incremental rather than groundbreaking. Therefore, they are unlikely to account for the explosive growth observed during the analyzed period

- ☑ Furthermore, the significantly upgraded new Model Y only began deliveries in March this year, outside the scope of this analysis. Thus, **Hypothesis 1 is rejected** as the primary explanation for the sharp increase in sales

Hypothesis2: Price Incentives

Tesla Model Y Price History



EV Tax Incentives Overview in WA

Row	2012_2018	2019	2020	2021	2022	2023	2024
Up to Sales Tax Exemption	$32,000	$25,000	$20,000	$15,000	$15,000	$20,000	$20,000
Up to Eligible Vehicle Price	$42,500	$45,000	$45,000	$45,000	$45,000	$55,000	$55,000
Tax Savings (6.5%)	$ 2,080	$ 1,625	$ 1,300	$ 975	$ 975	$ 1,300	$ 1,300
Tax Savings (9.5%)	$ 3,040	$ 2,375	$ 1,900	$ 1,425	$ 1,425	$ 1,900	$ 1,900

- ☑ In 2023, Tesla's pricing strategy aligned with Washington State's expanded sales tax exemption policies
- ☑ The price of the Model Y Performance dropped below the newly raised eligibility limit of $55,000, while the sales tax exemption increased from $15,000 to $20,000, providing buyers with significant additional savings
- ☑ These factors likely contributed to the observed surge in Model Y sales, **supporting Hypothesis 2**

Key Insights on Policy and Pricing Impact

The Tesla Model Y price reduction combined with Washington's expanded EV incentives substantially lowered the effective purchase price, significantly improving affordability and likely driving higher demand for the Model Y

Overall Conclusion

1. The EV market in Washington is primarily driven by King County, which includes Seattle, home to major tech companies
2. Tech industry professionals in this region, with over 60% holding a bachelor's degree or higher and a median income exceeding $90K, exhibit a strong correlation with higher EV adoption
3. Yearly EV adoption trends are led by Tesla, which holds over 54% of the BEV market share in Washington, playing a dominant role in shaping the market
4. Tesla's pricing strategy aligned with WA's flexible EV tax incentives. The 2023 sales tax exemption raised to $55,000 influenced adoption dynamics and boosted demand

*** Data Sources**

- Data.gov – Electric Vehicle Population Data
- National Institute on Minority Health and Health Disparities Data Portal – Link
- Tesla (2025). *Model Y Overview*. Retrieved from https://www.tesla.com/modely
- Kehm, B. (2025). *Tesla Model Y Price History*. Retrieved from https://briankehm.com/tesla-model-y-price-history/