

Electric Vehicle Competitive Landscape Analysis

A night-time photograph of a Tesla Supercharger station. Several electric vehicles are parked at charging stations under a large canopy with solar panels. The vehicles include a white pickup truck, a dark sedan, a silver sedan, a dark sedan, and a dark SUV. The background shows a modern building with large glass windows and a street with traffic lights.

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Problem Statement

- Electric vehicle adoption has been growing rapidly and will continue to do so in the future. Several different car companies are also in competition with one another.
- Outside of considerations such as brand loyalty and personal preferences, the most important factor for neutral consumers deciding which electric vehicle to purchase is how much value they can get in return for their money.
- This project will seek to uncover insights into which car brands and models provide the best value for potential consumers.

Goal

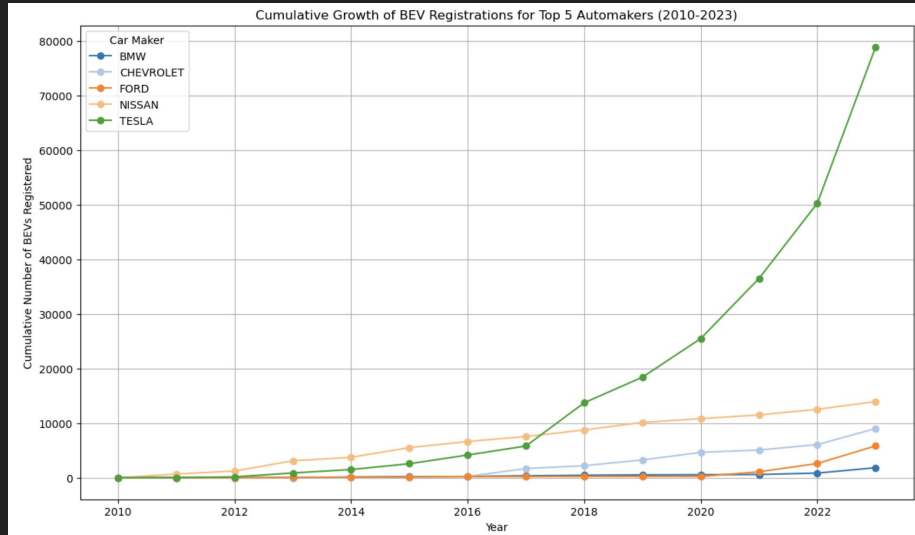
- Create a novel ranking system for EV models based on the purchase price in relation to key metrics such as range and performance, and then assign a score to each model.
- Segment consumers into different groups based on sensitivity to price and preferences towards range or performance, then provide recommendations for which EV model to purchase within each segment.
- Build a linear regression model to predict what the MSRP values for each EV should be and then compare to actual MSRP values to determine which models are overpriced versus underpriced.
- Answer the Question: Who is best positioned and who is worst positioned to continue growing their sales over the coming decade?

Data

- [Electric Vehicle Population Data](#) - This dataset shows the Battery Electric Vehicles (BEVs) and Plug-in Hybrid Electric Vehicles (PHEVs) that are currently registered through the Washington State Department of Licensing (DOL).
- [EV Ranking Data](#) - This dataset contains the price, range, and acceleration for 36 BEV models from the top 5 best-selling brands in Washington State. It also includes a ranking system which assigns points to each model based on how much bang for the buck they provide. This data was collected on May 4th, 2024.

Data Wrangling

- We wanted to use our [Electric Vehicle Population Data](#) to find the top 5 best-selling brands in Washington State.
 - We found they were: Tesla, Nissan, Chevrolet, Ford, and BMW.
- We then introduced our [EV Ranking Data](#) and trimmed it to include only the target variable and features to use for the modeling section (along with make and model).
 - Target: MSRP Price.
 - Features: Vehicle Type (SUV, Sedan, Etc.), Range, and Acceleration.



EV Ranking Dataset

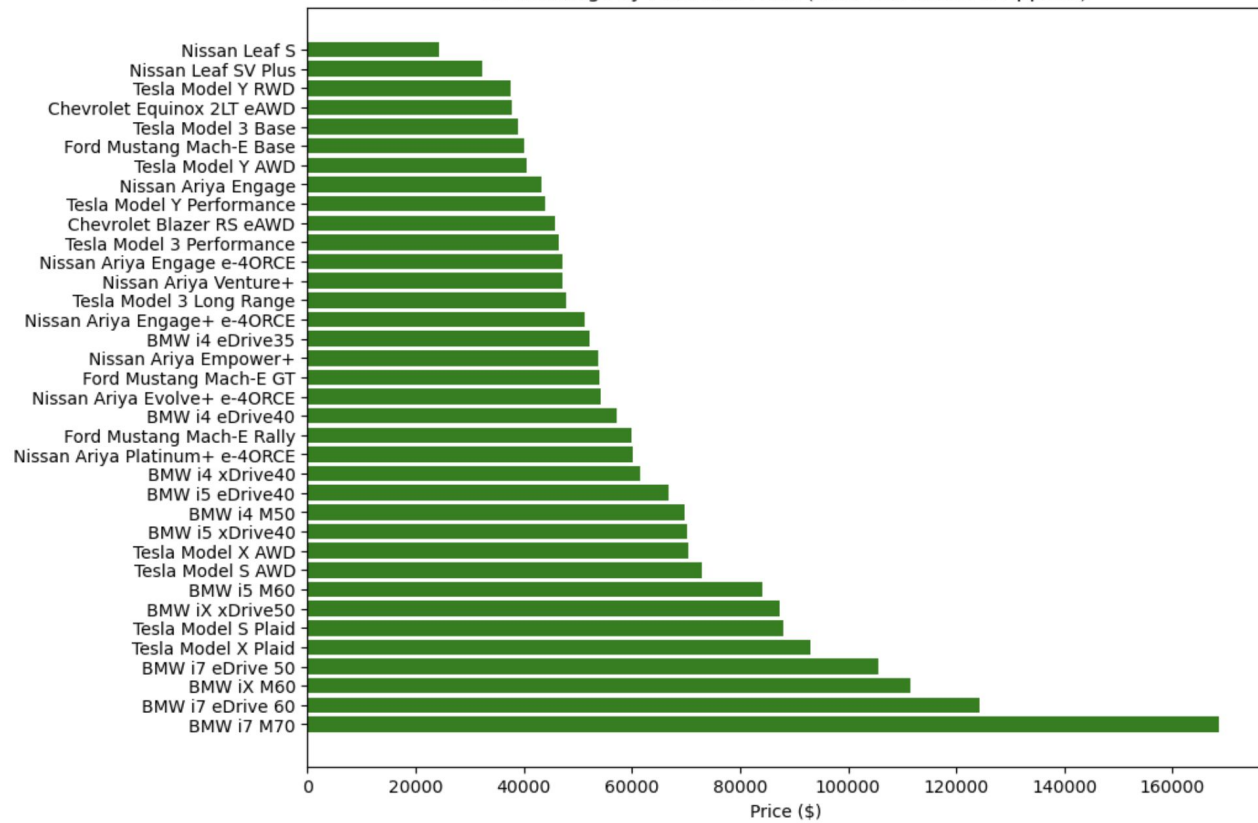
Make	Model	Type	MSRP	EV_Tax_Credit	Purchase_Price	Range_(mi)	0-60mph	Range/Price	0-60mph*Price	Bang/Buck_Score
Tesla	Model 3 Base	Sedan	\$38,990	\$0	\$38,990	272	5.8	6.98	2.26	4.71
Tesla	Model 3 Long Range	Sedan	\$47,740	\$0	\$47,740	341	4.2	7.14	2.01	5.14
Tesla	Model 3 Performance	Sedan	\$53,990	\$7,500	\$46,490	296	2.9	6.37	1.35	5.02
Tesla	Model Y RWD	Crossover SUV	\$44,990	\$7,500	\$37,490	320	6.5	8.54	2.44	6.10
Tesla	Model Y AWD	Crossover SUV	\$47,990	\$7,500	\$40,490	310	4.8	7.66	1.94	5.71
Tesla	Model Y Performance	Crossover SUV	\$51,490	\$7,500	\$43,990	279	3.5	6.34	1.54	4.80
Tesla	Model S AWD	Luxury Sedan	\$72,990	\$0	\$72,990	402	3.1	5.51	2.26	3.24
Tesla	Model S Plaid	Luxury Sedan	\$87,990	\$0	\$87,990	359	2.0	4.08	1.75	2.33
Tesla	Model X AWD	Luxury SUV	\$77,990	\$7,500	\$70,490	335	3.8	4.75	2.68	2.07
Tesla	Model X Plaid	Luxury SUV	\$92,990	\$0	\$92,990	326	2.5	3.51	2.32	1.18
Nissan	Ariya Engage	Crossover SUV	\$43,190	\$0	\$43,190	216	7.1	5.00	3.07	1.93
Nissan	Ariya Engage e-4ORCE	Crossover SUV	\$47,190	\$0	\$47,190	205	5.1	4.34	2.41	1.94
Nissan	Ariya Venture+	Crossover SUV	\$47,190	\$0	\$47,190	304	7.2	6.44	3.40	3.04
Nissan	Ariya Engage+ e-4ORCE	Crossover SUV	\$51,190	\$0	\$51,190	272	4.8	5.31	2.46	2.86
Nissan	Ariya Empower+	Crossover SUV	\$53,690	\$0	\$53,690	289	7.2	5.38	3.87	1.52
Nissan	Ariya Evolve+ e-4ORCE	Crossover SUV	\$54,190	\$0	\$54,190	272	4.8	5.02	2.60	2.42
Nissan	Ariya Platinum+ e-4ORCE	Crossover SUV	\$60,190	\$0	\$60,190	267	4.8	4.44	2.89	1.55
Nissan	Leaf S	Hatchback	\$28,140	\$3,750	\$24,390	149	7.5	6.11	1.83	4.28
Nissan	Leaf SV Plus	Hatchback	\$36,040	\$3,750	\$32,290	212	6.7	6.57	2.16	4.40
Chevrolet	Equinox 2LT eAWD	Crossover SUV	\$45,200	\$7,500	\$37,700	285	5.9	7.56	2.22	5.34
Chevrolet	Blazer RS eAWD	Crossover SUV	\$53,200	\$7,500	\$45,700	279	6.0	6.11	2.74	3.36
Ford	Mustang Mach-E Base	Crossover SUV	\$39,995	\$0	\$39,995	250	5.6	6.25	2.24	4.01
Ford	Mustang Mach-E GT	Crossover SUV	\$53,995	\$0	\$53,995	280	3.8	5.19	2.05	3.13
Ford	Mustang Mach-E Rally	Crossover SUV	\$59,995	\$0	\$59,995	265	3.4	4.42	2.04	2.38
BMW	i4 eDrive35	Sedan	\$52,200	\$0	\$52,200	276	5.8	5.29	3.03	2.26
BMW	i4 eDrive40	Sedan	\$57,300	\$0	\$57,300	301	5.4	5.25	3.09	2.16
BMW	i4 xDrive40	Sedan	\$61,600	\$0	\$61,600	307	4.9	4.98	3.02	1.97
BMW	i4 M50	Sedan	\$69,700	\$0	\$69,700	269	3.7	3.86	2.58	1.28
BMW	i5 eDrive40	Luxury Sedan	\$66,800	\$0	\$66,800	295	5.7	4.42	3.81	0.61
BMW	i5 xDrive40	Luxury Sedan	\$70,100	\$0	\$70,100	286	5.2	3.79	3.65	0.15
BMW	i5 M60	Luxury Sedan	\$84,100	\$0	\$84,100	256	3.7	3.04	3.11	-0.07
BMW	iX xDrive50	Luxury SUV	\$87,250	\$0	\$87,250	309	4.4	3.54	3.84	-0.30
BMW	iX M60	Luxury SUV	\$111,500	\$0	\$111,500	285	3.6	2.56	4.01	-1.46
BMW	i7 eDrive 50	Ultra-Luxury Sedan	\$105,700	\$0	\$105,700	321	5.3	3.04	5.60	-2.57
BMW	i7 eDrive 60	Ultra-Luxury Sedan	\$124,200	\$0	\$124,200	317	4.5	2.55	5.59	-3.04
BMW	i7 M70	Ultra-Luxury Sedan	\$168,500	\$0	\$168,500	291	3.5	1.73	5.90	-4.17

How the Ranking System Works:

- First, all the relevant data is collected and placed into the first 8 columns:
- Make:** The manufacturer or brand of the vehicle.
 - Model:** The specific model or name of the vehicle.
 - Type:** Indicates the vehicle type (Sedan, Crossover SUV, Hatchback, Luxury Sedan, Etc).
 - MSRP:** The Manufacturer's Suggested Retail Price.
 - EV_Tax_Credit:** Whether a vehicle is eligible for a tax credit – if it is, the amount is shown.
 - Purchase_Price:** MSRP minus the tax credit (if applicable).
 - Range_(mi):** The distance the vehicle can travel on electric power alone, measured in miles.
 - 0-60mph:** The time it takes to accelerate from 0-60mph, measured in seconds.
- Then, the data is used to calculate scores for the final 3 columns based on the following relationships:
- Range/Price:** The range in miles divided by the purchase price, multiplied by a scaling factor of 1,000.
(Higher values are better. Essentially, it measures how far you can travel per dollar spent).
 - 0-60mph*Price:** The acceleration multiplied by the purchase price, divided by a scaling factor of 100,000.
(Lower values are better. Essentially, it measures the quickness of the acceleration times dollar spent).
 - Bang/Buck_Score:** The difference between the Range/Price and 0-60mph*Price scores.
(Higher values are better. This is the overall score of how much "bang for your buck" a vehicle will provide).

Exploratory Data Analysis - Those Who are Most Sensitive to Price:

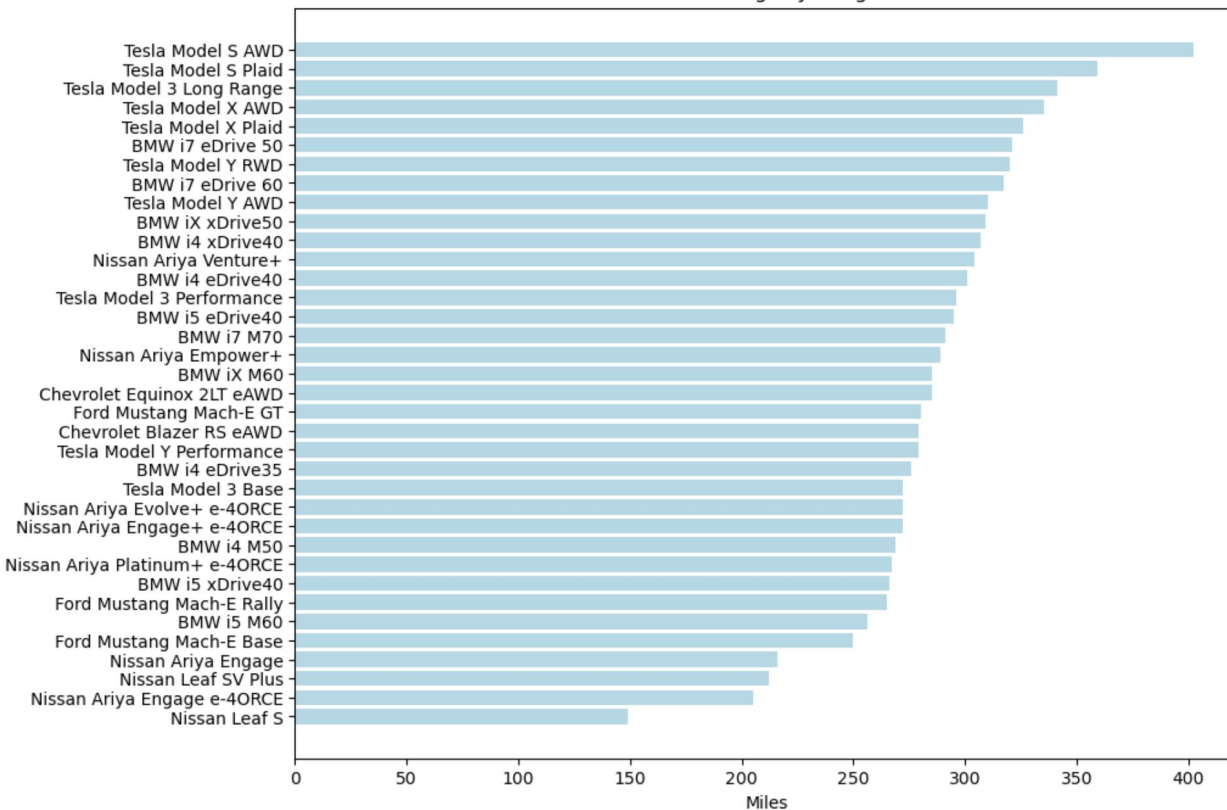
EV Rankings by Purchase Price (After Tax Credit is Applied)



- The Nissan Leaf S is the most affordable vehicle in our dataset.
- BMW models tend to be the most expensive.

Exploratory Data Analysis - Those Who Care Most About Range:

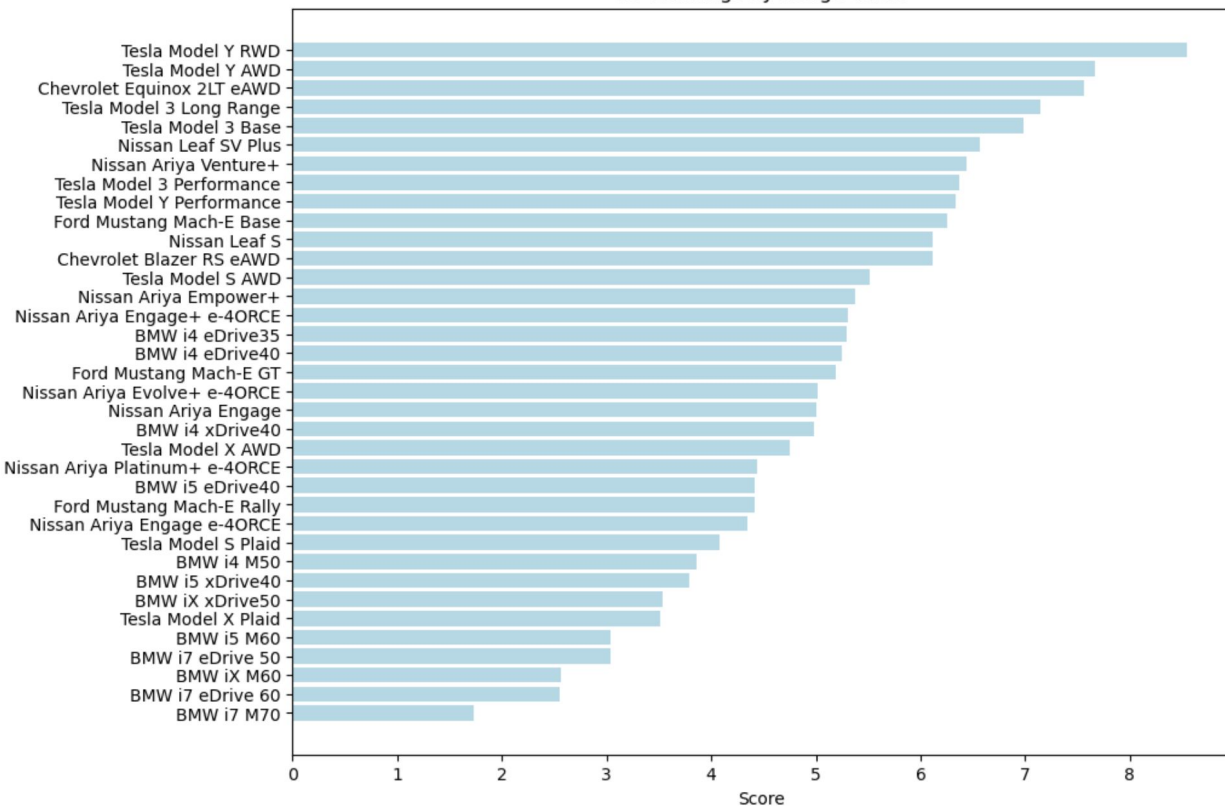
EV Rankings by Range



- The Tesla Model S AWD wins the prize for longest range with 402 miles.
- Nissan tends to offer models with the least amount of range.

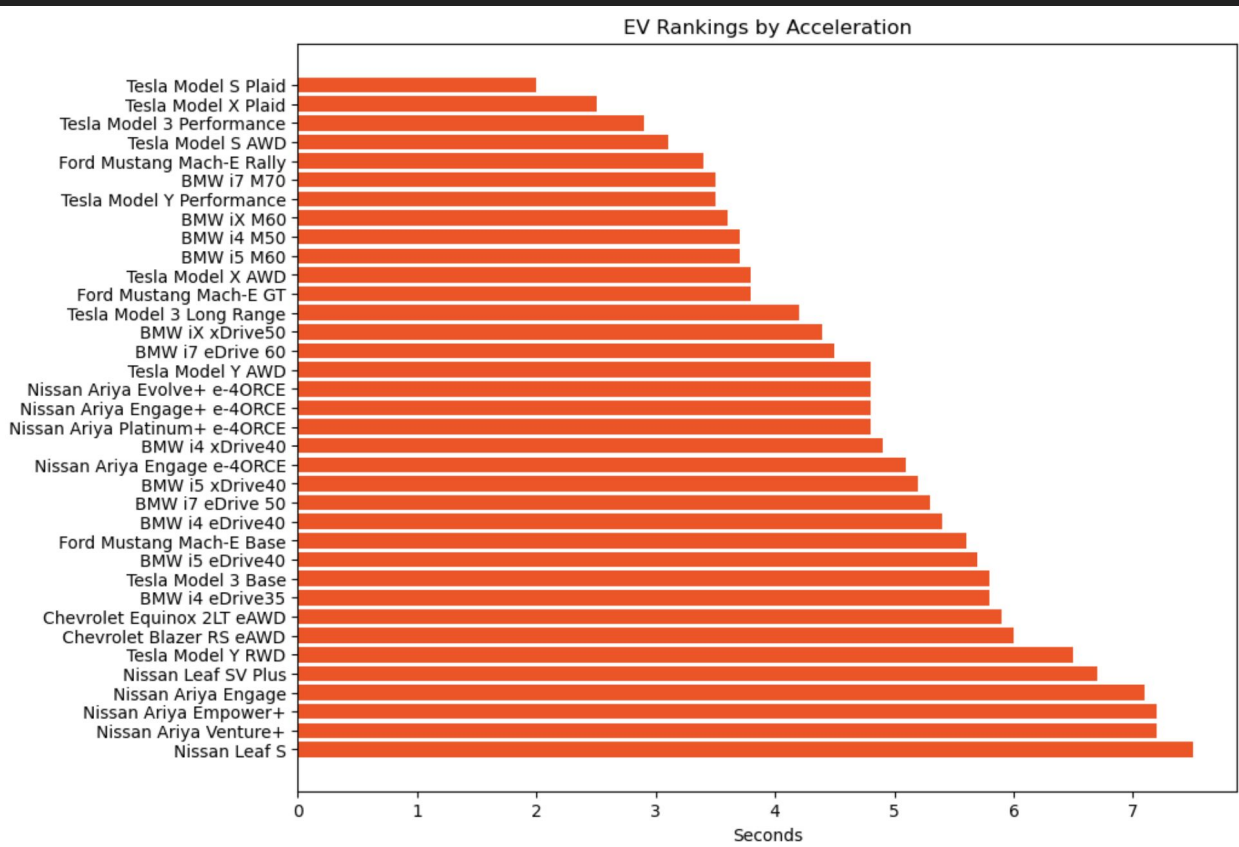
Exploratory Data Analysis - Those Who Want the Most Value for Range:

EV Rankings by Range Value



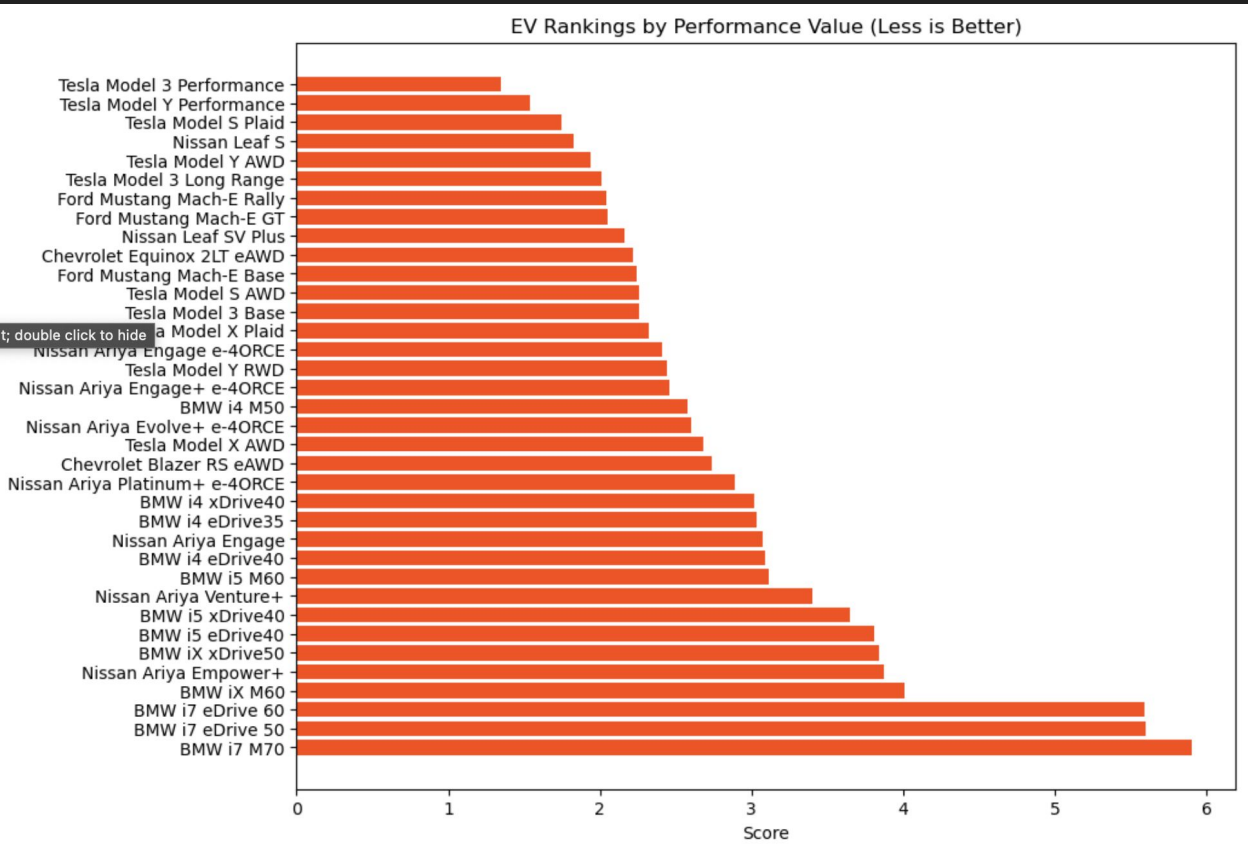
- The Tesla Model Y RWD wins this one, providing 320 miles of range for a \$37,490 purchase price.
- BMW tends to offer the worst value for range in the dataset.

Exploratory Data Analysis - Those Who Care Most About Performance:



- The Tesla Model S Plaid comes in 1st place with a 2s 0-60mph time!
- Nissan tends to offer the slowest EVs.

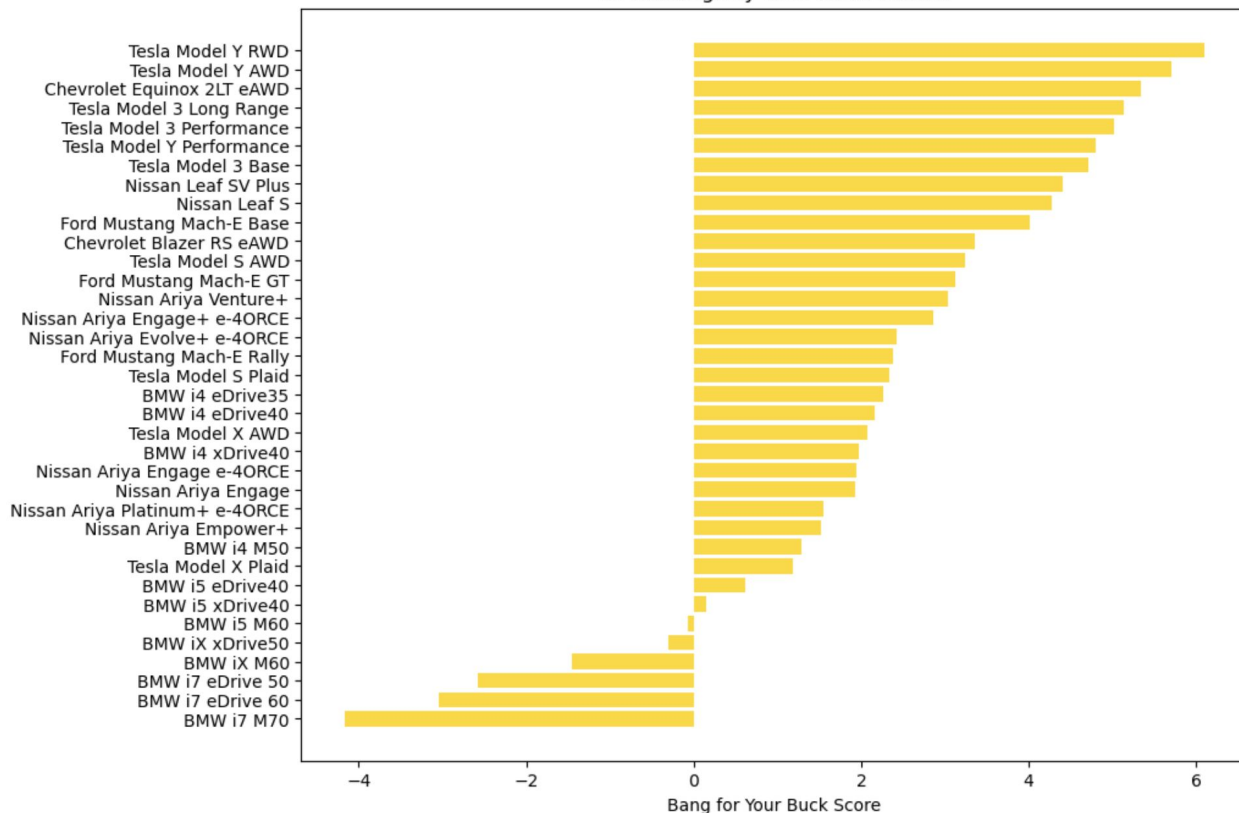
Exploratory Data Analysis - Those Who Want the Most Value for Performance:



- The Tesla Model 3 Performance wins this one, offering a 2.9s 0-60mph time for only \$46,490.
- BMW tends to offer the worst value for performance in the dataset.

Exploratory Data Analysis - Those Who Care Most About Overall Value:

EV Rankings by Best Value Overall



- Most of the top 7 best EVs for overall value are from Tesla, except for the Chevy Equinox 2LT eAWD which makes an impressive appearance at #3.
- Nissan and Ford also have models which make it into the top 10.
- BMW fares the worst, its best value model (i4 eDrive35) coming in at #19, while most of its remaining lineup can be found at the bottom of the list.

Modeling

- Linear regression model that predicts the MSRP price of each EV.
- Mean Absolute Error (MAE): \$11,223
 - This results indicate that, on average, the predicted MSRP values are about \$11,223 off from the actual MSRP values.
 - This is actually a reasonable amount to expect since some EV models were shown to offer good value for money while others offered bad value for money, so we expect the MAE to reflect the fact that some models are underpriced and others are overpriced compared to the market.
- R2 Score: 0.786
 - The R2 score suggests a relatively good fit of the model to the data, showing that it explains about 78.6% of the variance in MSRP.

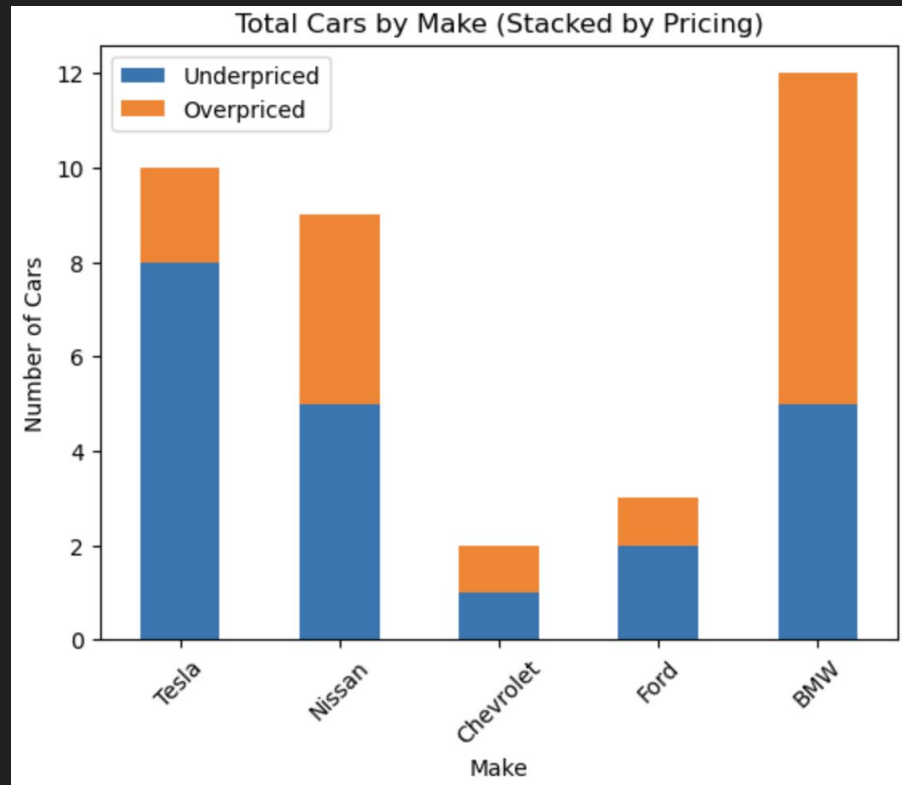
Modeling

- We ran cross-validation on our dataset to get MSRP comparisons for all EV models.
- We wanted to check how the predicted MSRP compares with the actual MSRP for the vehicles in our dataset.
- We added a new column to visualize which models were overpriced versus underpriced.

Make	Model	Actual MSRP	Predicted MSRP	Pricing
Tesla	Model 3 Base	\$38,990	\$52,883	Underpriced
Tesla	Model Y RWD	\$44,990	\$45,546	Underpriced
Tesla	Model 3 Long Range	\$47,740	\$57,164	Underpriced
Tesla	Model Y AWD	\$47,990	\$50,535	Underpriced
Tesla	Model Y Performance	\$51,490	\$63,327	Underpriced
Tesla	Model 3 Performance	\$53,990	\$69,034	Underpriced
Tesla	Model S AWD	\$72,990	\$69,801	Overpriced
Tesla	Model X AWD	\$77,990	\$97,786	Underpriced
Tesla	Model S Plaid	\$87,990	\$80,593	Overpriced
Tesla	Model X Plaid	\$92,990	\$104,232	Underpriced
Nissan	Leaf S	\$28,140	\$36,564	Underpriced
Nissan	Leaf SV Plus	\$36,040	\$25,994	Overpriced
Nissan	Ariya Engage	\$43,190	\$45,446	Underpriced
Nissan	Ariya Venture+	\$47,190	\$42,031	Overpriced
Nissan	Ariya Engage e-4ORCE	\$47,190	\$59,400	Underpriced
Nissan	Ariya Engage+ e-4ORCE	\$51,190	\$52,308	Underpriced
Nissan	Ariya Empower+	\$53,690	\$36,398	Overpriced
Nissan	Ariya Evolve+ e-4ORCE	\$54,190	\$55,751	Underpriced
Nissan	Ariya Platinum+ e-4ORCE	\$60,190	\$52,501	Overpriced
Chevrolet	Equinox 2LT eAWD	\$45,200	\$47,778	Underpriced
Chevrolet	Blazer RS eAWD	\$53,200	\$44,258	Overpriced
Ford	Mustang Mach-E Base	\$39,995	\$50,148	Underpriced
Ford	Mustang Mach-E GT	\$53,995	\$55,654	Underpriced
Ford	Mustang Mach-E Rally	\$59,995	\$57,324	Overpriced
BMW	i4 eDrive35	\$52,200	\$52,495	Underpriced
BMW	i4 eDrive40	\$57,300	\$48,425	Overpriced
BMW	i4 xDrive40	\$61,600	\$51,754	Overpriced
BMW	i5 eDrive40	\$66,800	\$66,412	Overpriced
BMW	i4 M50	\$69,700	\$56,461	Overpriced
BMW	i5 xDrive40	\$70,100	\$74,938	Underpriced
BMW	i5 M60	\$84,100	\$78,487	Overpriced
BMW	iX xDrive50	\$87,250	\$90,264	Underpriced
BMW	i7 eDrive 50	\$105,700	\$141,526	Underpriced
BMW	iX M60	\$111,500	\$86,690	Overpriced
BMW	i7 eDrive 60	\$124,200	\$135,929	Underpriced
BMW	i7 M70	\$168,500	\$121,306	Overpriced

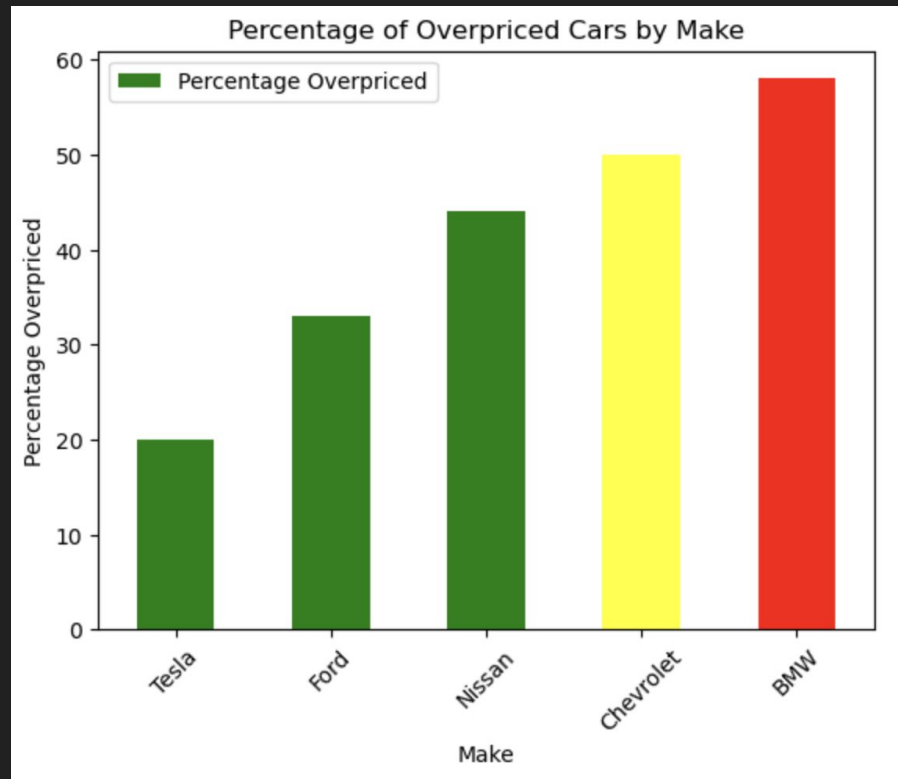
Modeling

- The amount of models for each brand that are either overpriced or underpriced:



Modeling

- The percentage of each EV brand's lineup that is overpriced:
- Tesla has the lowest percentage at 20%
- BMW has the highest percentage at 58%



Conclusion

- We were successful in creating a novel ranking system for EV models that was used to calculate scores for the best value for range, performance, and overall rating.
- We were able to provide the best recommendations for which EV models to purchase for potential consumers in each of the different segments.
- We successfully built a linear regression model that predicted what the MSRP values for each EV should be (to a reasonable accuracy) and then compared that to the actual MSRP values to determine which models were overpriced.
- After all of our analysis, it is clear that Tesla is best positioned to continue growing their sales over the coming decade while BMW is worst positioned.

Future Improvements

- Include more brands and EV models to compare across many more regional markets as well as globally.
 - The main difficulty includes creating the necessary datasets. New EV models are constantly introduced to the market and their prices and specs are also subject to change over time. As these factors change so will the ratings for each EV model.
- Include more factors such as battery charging speeds, safety ratings, cost of ownership, brand reputation, access to the Supercharger Network, Autonomous Driving capabilities, Etc.
 - Adding more dimensions could add more completeness to the overall final score, but may also add more complexities.
- Add missing vehicle categories (such as pickup trucks).
 - The reason why pickup trucks were left out in this iteration is because they come with their own set of ranking criteria, including torque, towing capacity, and payload capacity.