

Market Segmentation Analysis Of Electric Vehicles In India

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Problem Statement

The task at hand involves conducting a segmentation analysis to assess the Electric Vehicles Market in India. The objective is to formulate a viable market entry strategy by focusing on specific customer segments that are most likely to adopt their product. These segments are defined based on geographical, demographic, psychographic, and behavioral factors.

This report delves into a comprehensive analysis of the Indian Electric Vehicles Market, employing segmentation criteria such as:

- Geographical location
- Pricing tiers
- Charging infrastructure availability
- Vehicle types (e.g., 2-wheelers, 3-wheelers, 4-wheelers, etc.)
- Manufacturers
- Body types (e.g., Hatchback, Sedan, SUV, etc.)
- Plug types, and more.

The aim is to provide a thorough understanding of the market landscape, enabling the development of a tailored strategy for entering into the Indian market that effectively targets the most promising customer segments.

Market Size for EV in India in the Coming Years

The estimated market size for the electric vehicles (EV) market in India by 2029 is USD 113.99 billion. This is according to a report by Mordor Intelligence. The market is expected to grow at a CAGR of 66.52% during the forecast period.

The growth of the EV market in India is being driven by a number of factors, including:

- Increasing government support: The Indian government is offering a number of incentives to promote the adoption of electric vehicles, such as tax breaks, subsidies, and access to restricted lanes.
- Rising fuel prices: The rising cost of petrol and diesel is making electric vehicles a more attractive option for consumers.
- Increasing environmental awareness: There is a growing awareness among consumers about the environmental benefits of electric vehicles.

- Growing demand for two-wheelers: The two-wheeler segment is the largest segment of the EV market in India, and is expected to continue to grow in the coming years.
- Growing demand for commercial vehicles: The commercial vehicle segment is expected to grow significantly in the coming years, driven by the need to reduce emissions and improve fuel efficiency.
- Increasing investment by OEMs: Original equipment manufacturers (OEMs) are investing heavily in the development of electric vehicles, which is expected to boost the market.
- Growing demand for two-wheelers: The two-wheeler segment is the largest segment of the EV market in India, and is expected to continue to grow in the coming years.

Data Collection

The data was collected from the following websites:

<https://evreporter.com/q1-fy-2022-23-region-wise-ev-sale-trends-in-india/>

<https://pib.gov.in/PressReleasePage.aspx?PRID=1942055>

<https://www.kaggle.com/datasets/geoffnel/evs-one-electric-vehicle-dataset>

You can find the data in .csv format in the GitHub link as well:

https://github.com/kesavakrishna/feynn-labs/tree/main/EV_MSA_Proj%202/datasets

Data Preprocessing

I have encoded 'PowerTrain', 'RapidCharge', 'BodyStyle', and 'PlugType' features in a numerical format.

GitHub Link for Code and Datasets

The code and datasets can be found in the GitHub link below

https://github.com/kesavakrishna/feynn-labs/tree/main/EV_MSA_Proj%202

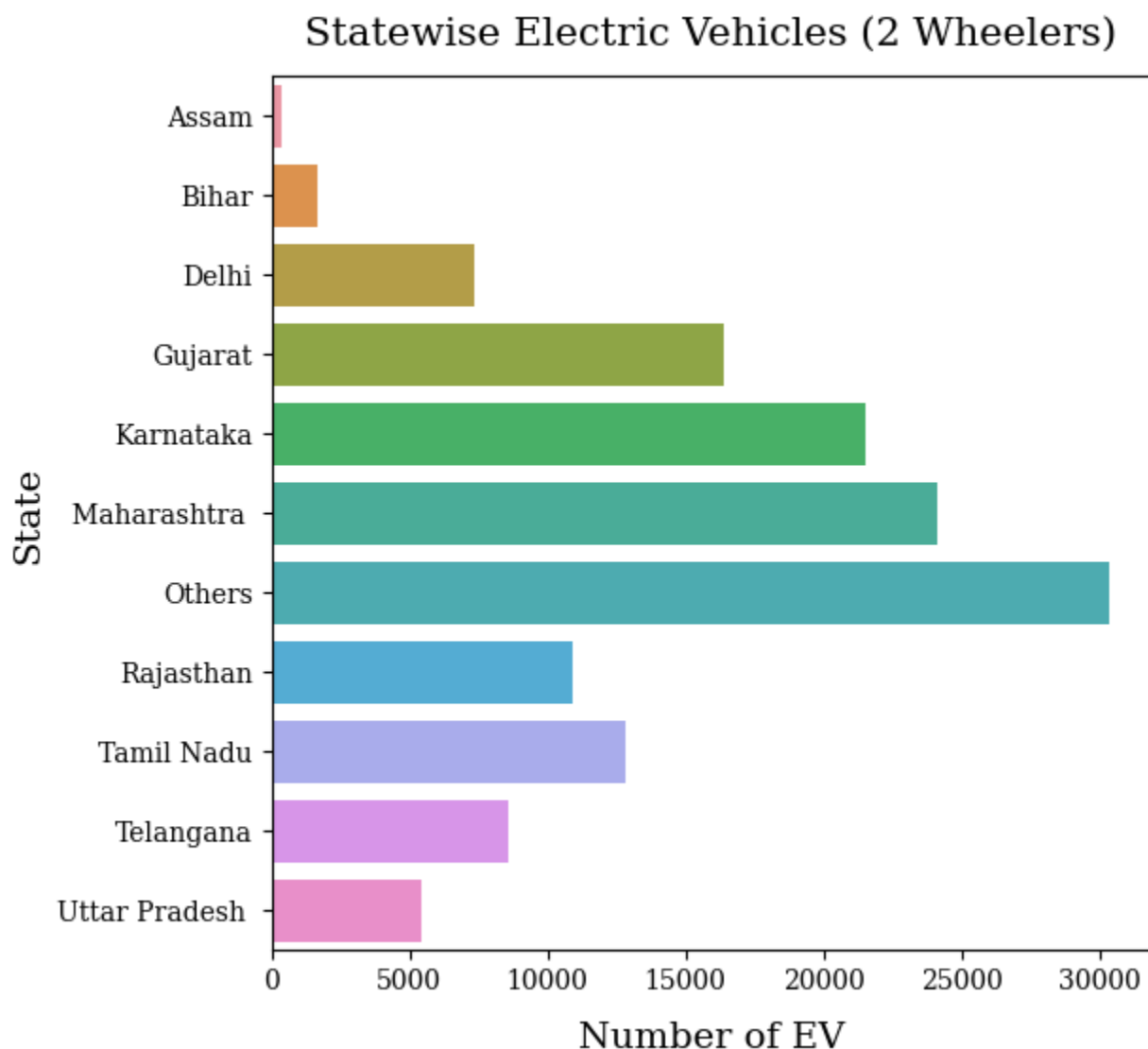
Exploratory Data Analysis(EDA)

EDA is a comprehensive investigation aimed at unveiling the inherent structure within a dataset. It holds significance for businesses as it reveals hidden trends, patterns, and correlations that may not be immediately evident. In our analysis, we thoroughly examined our dataset through three distinct approaches:

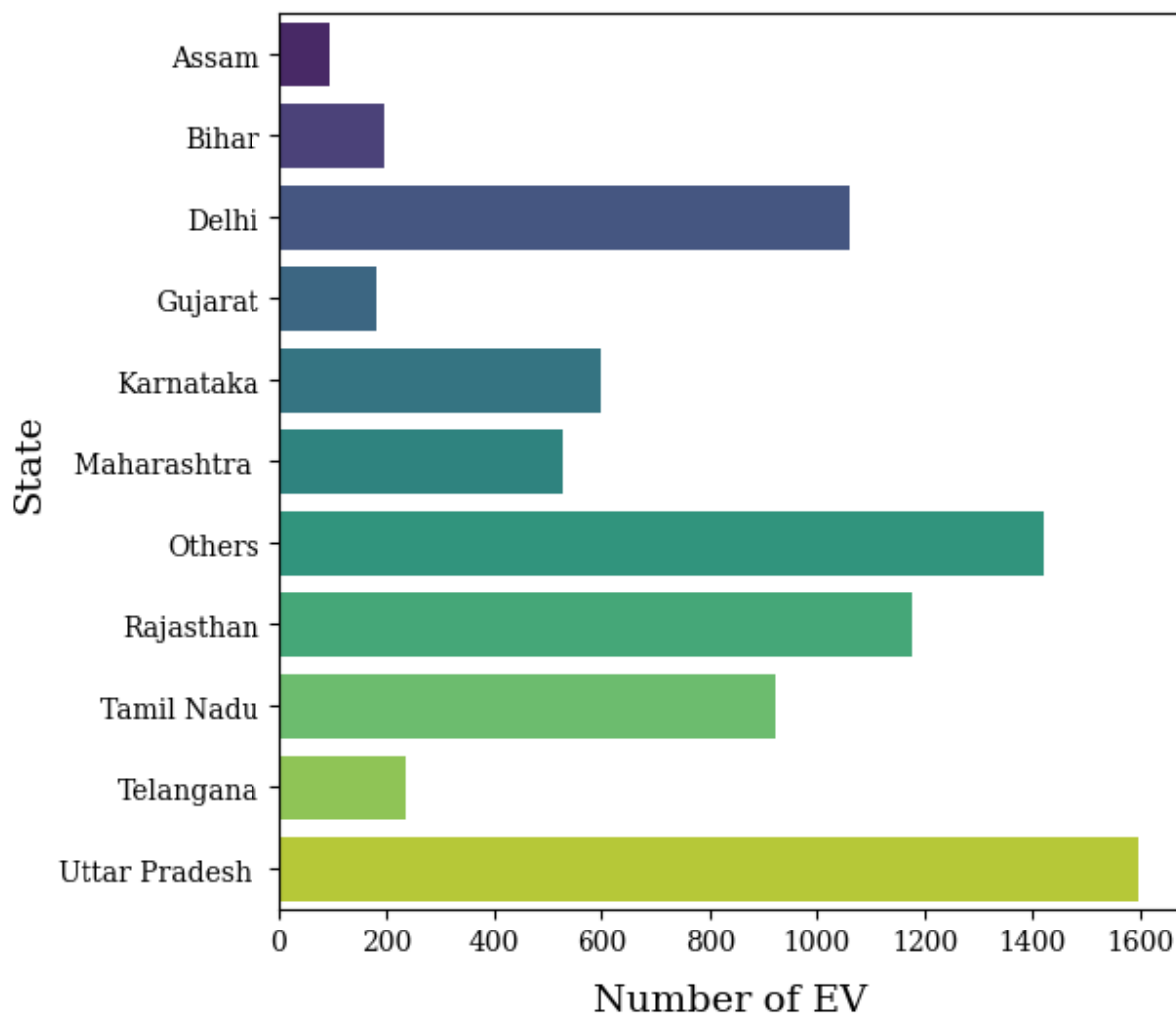
- Univariate analysis, which involves scrutinizing data pertaining to a single variable or column within the dataset.
- Bivariate analysis, where we delved into the data by considering the interplay between two variables or columns from the dataset.
- Multivariate analysis, a more complex examination that incorporates the interactions between more than two variables or columns within the dataset.

By employing these analytical methods, we gained a deeper understanding of our data, allowing us to uncover valuable insights and make informed decisions.

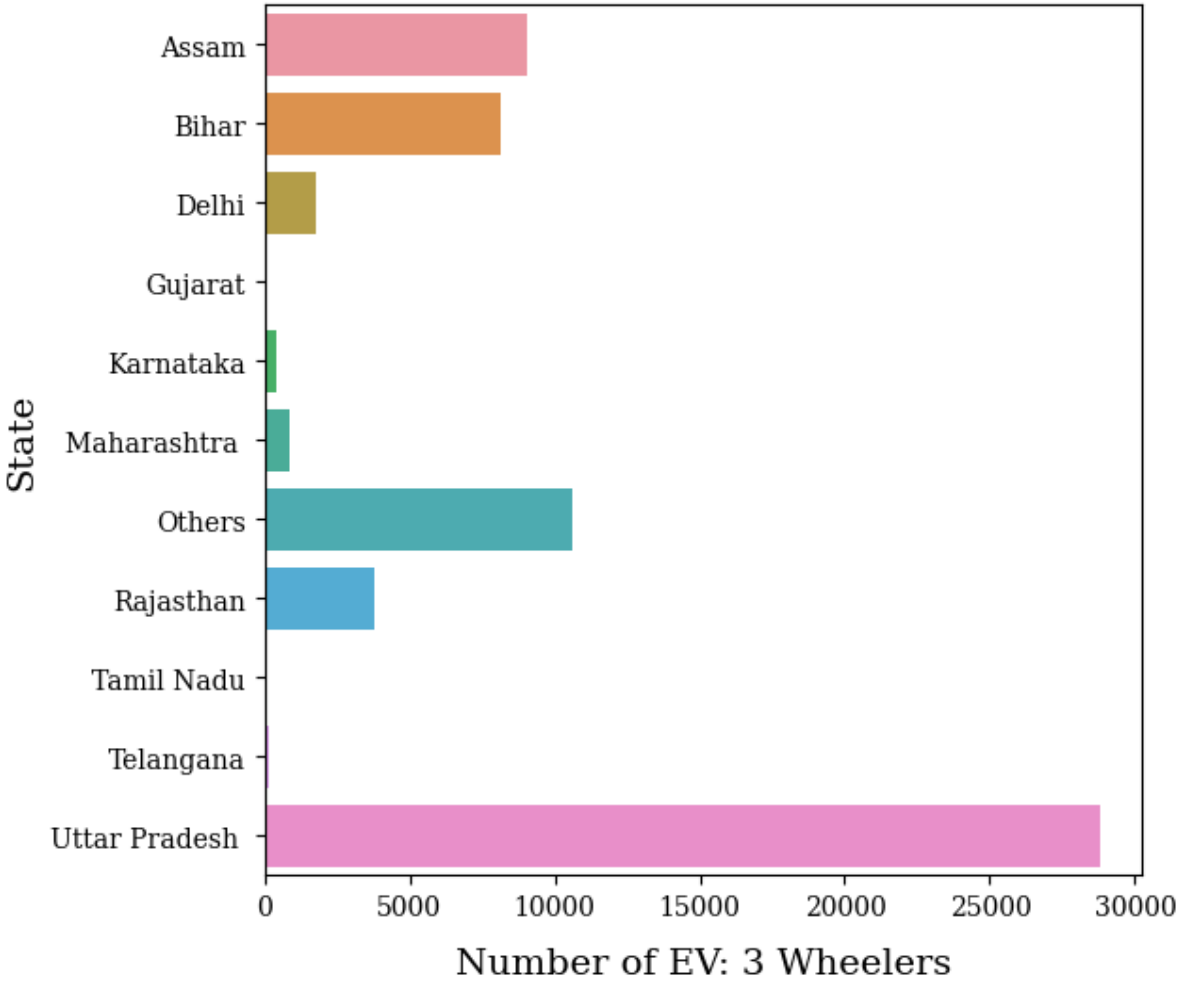
The following bargraphs show the top 10 states for EV sales in India in Q1 of FY 22-23. We will be looking at 5 different types of EV: 2 wheeler, 3 wheeler cargo, 3 wheeler passenger, 4 wheeler, other types of EV.



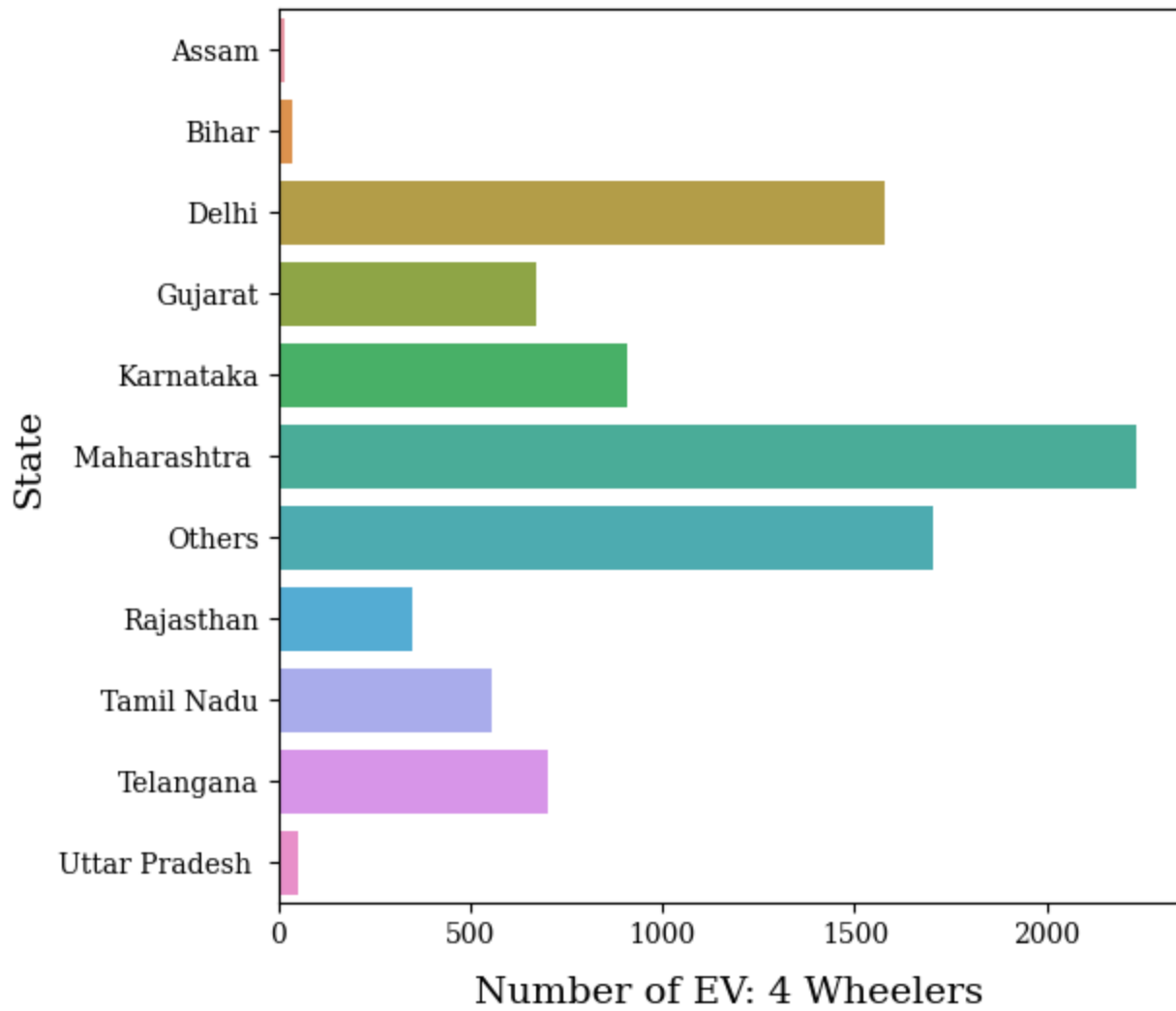
Statewise Electric Vehicles (3 Wheelers Cargo)

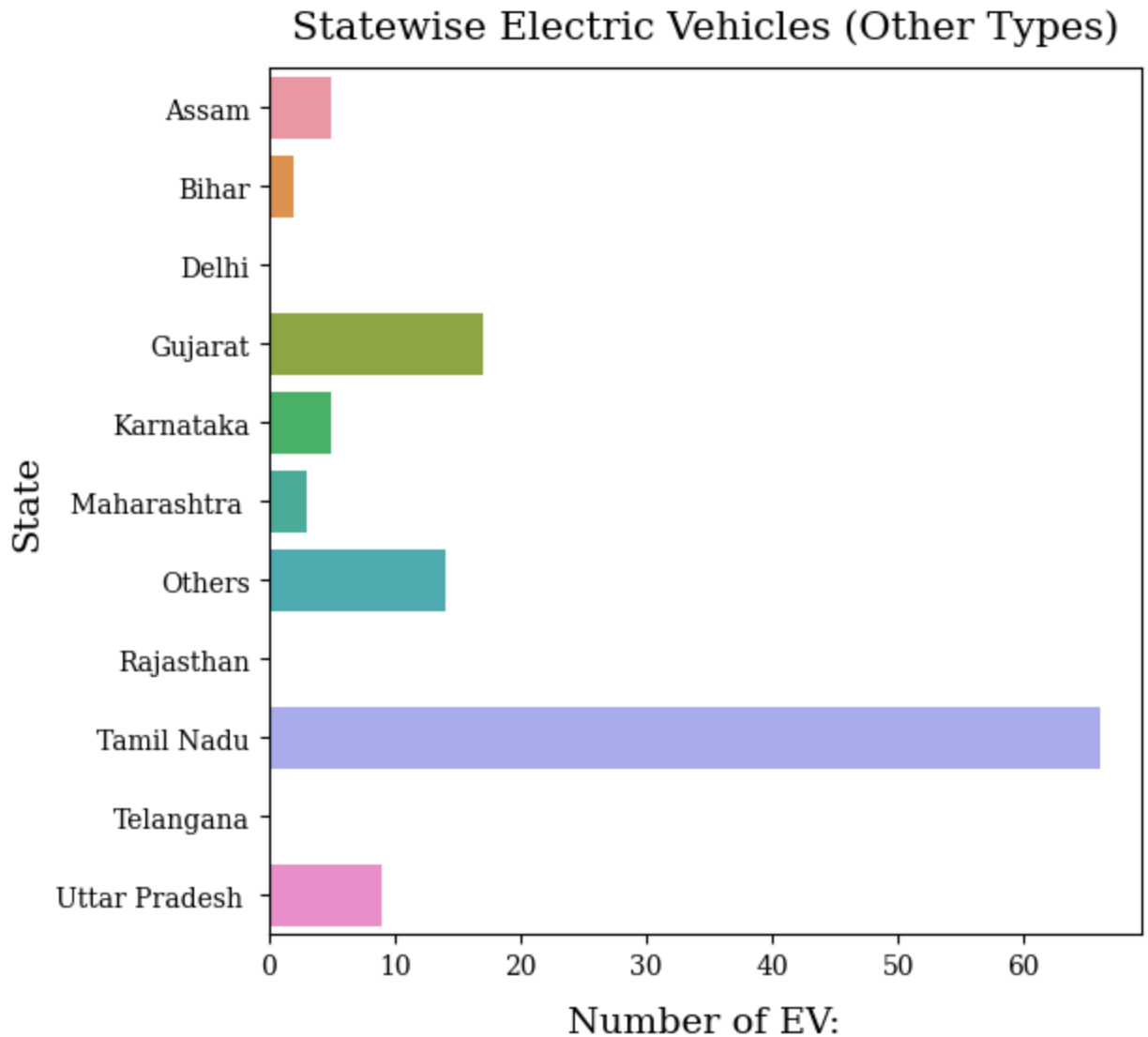


Statewise Electric Vehicles (3 Wheelers Passenger)



Statewise Electric Vehicles (4 Wheelers)



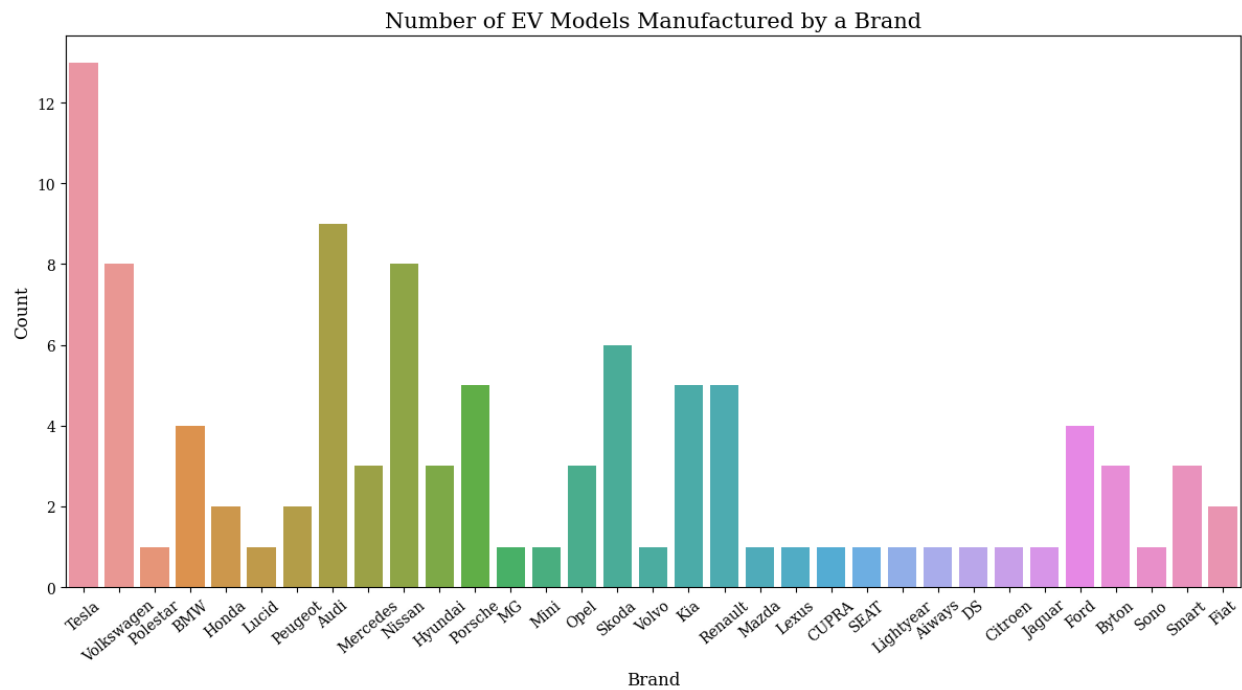


From the bargraphs, we can observe that when it comes to 2 wheeler vehicles, Maharashtra, Karnataka and Gujarat take the top spots followed by other states. For 3 wheeler cargo vehicles, Uttar Pradesh, Delhi and Rajasthan take the top spots followed by other states. For 3 wheeler passenger vehicles, Uttar Pradesh takes the top spot by a large margin. For 4 wheeler vehicles, Maharashtra and Delhi take the top spots followed by other states. For other EV types, Tamil Nadu takes the top spot but in general, there are very little vehicles that fall under this category.

Some of the factors which led to high sales in these states include

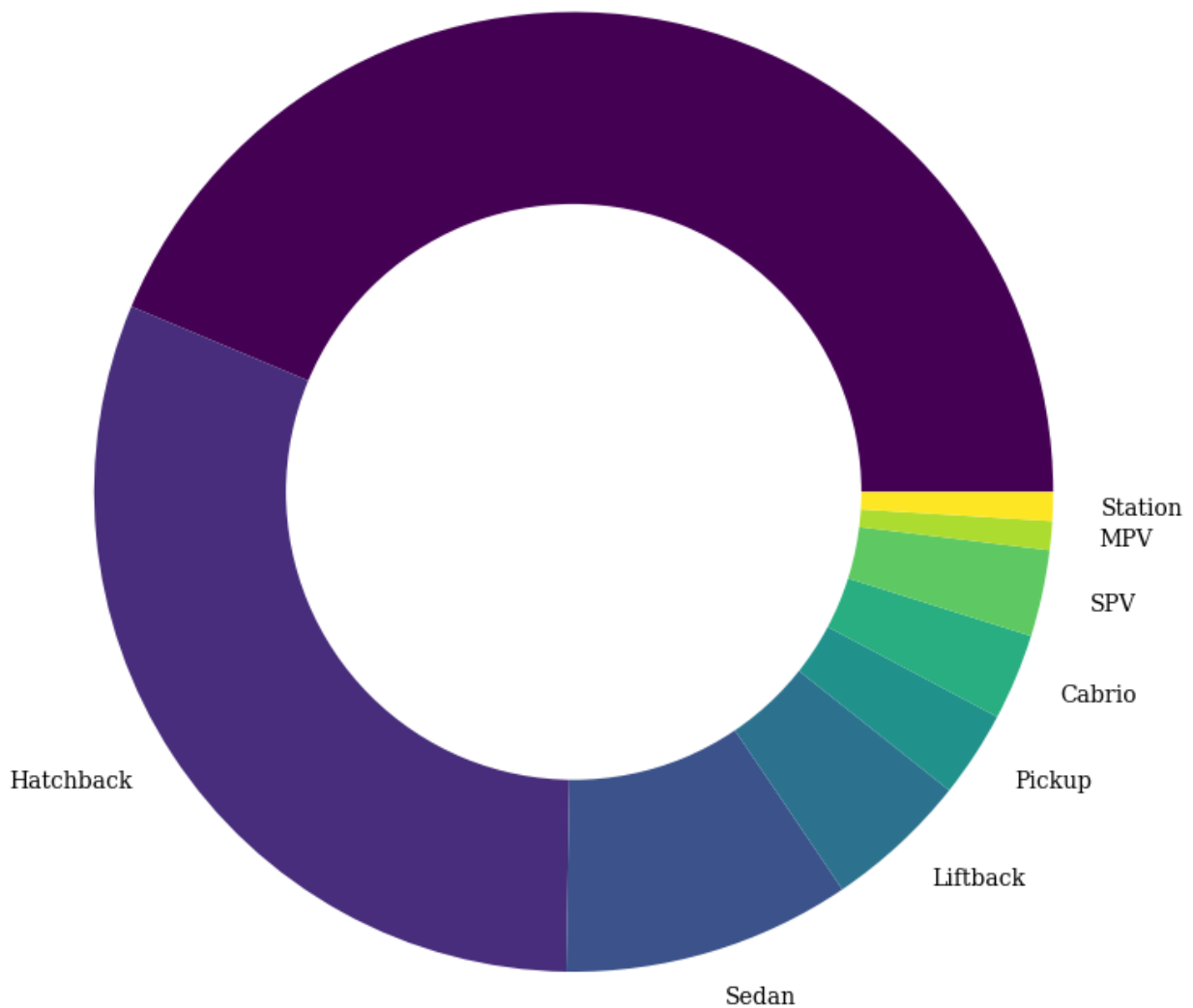
- High population
- Government incentives for the purchase of an EV
- Good disposable income
- Promotion by OEM's

- Availability of charging infrastructure



This bargraph shows us the different EV brands and the number of models they have manufactured.

Electric Vehicles of Different Body Types in India

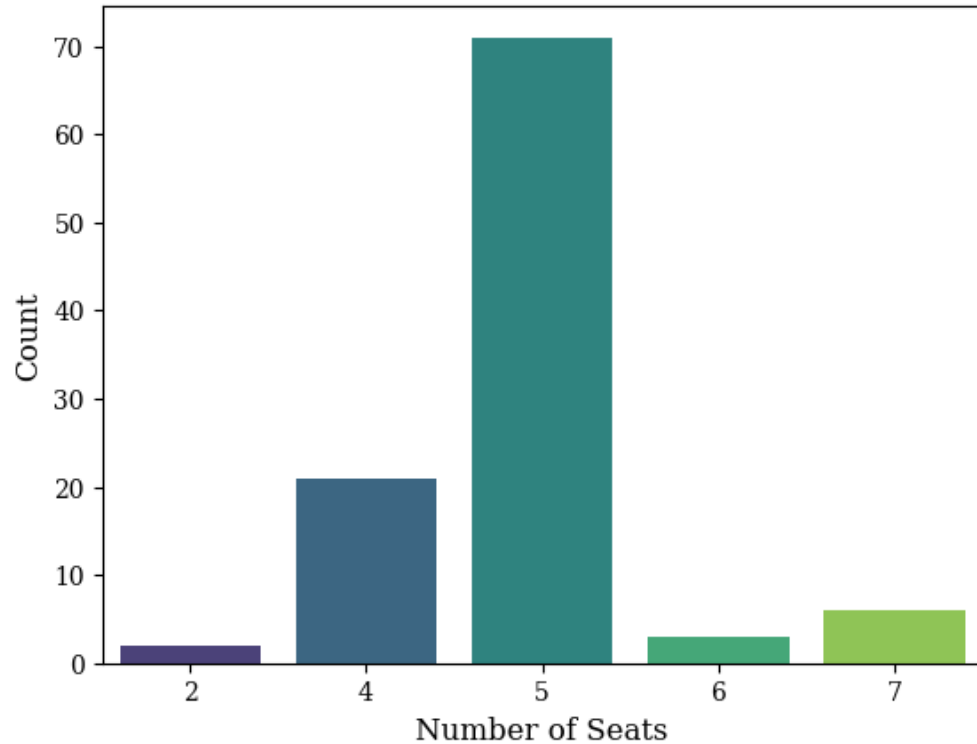


This piechart shows us the different body types of EV's. We can observe that companies prefer manufacturing SUV's and Hatchback's compared to other types of EV's.

Some of the factors which led to high production of these body types include

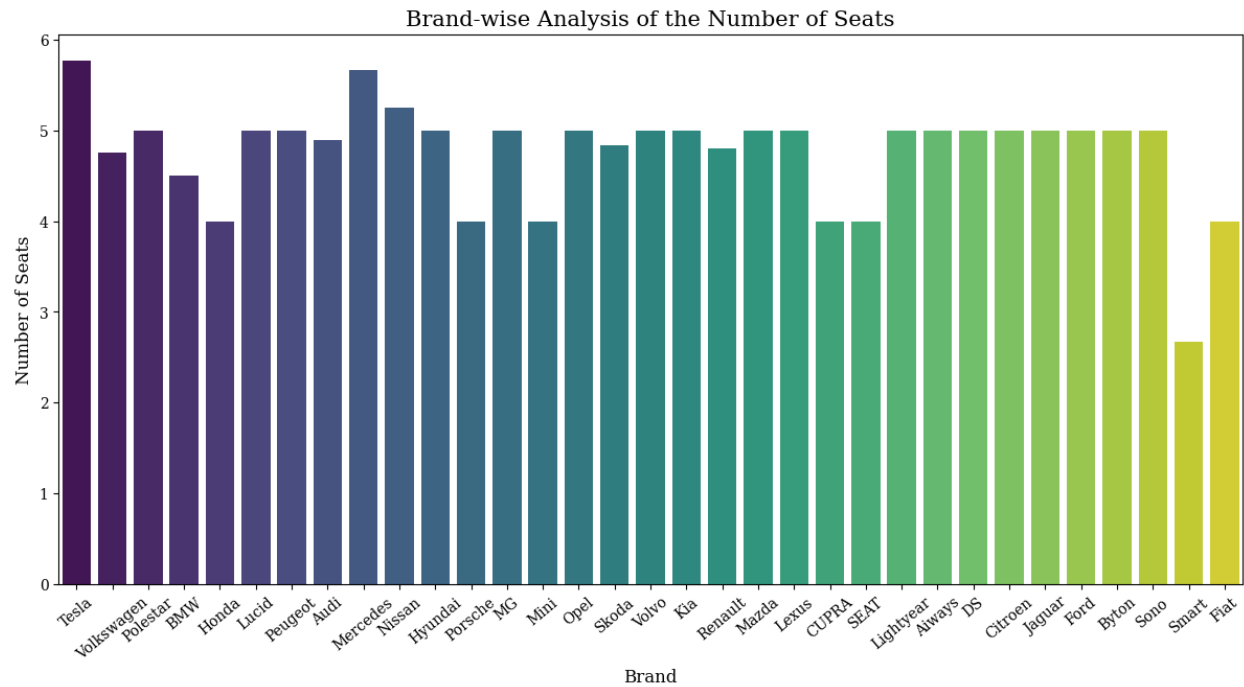
- High demand for SUV's and Hatchback's in India.
- Profitable for automakers to manufacture.

Available Electric Vehicles of Different Number of Seats in India

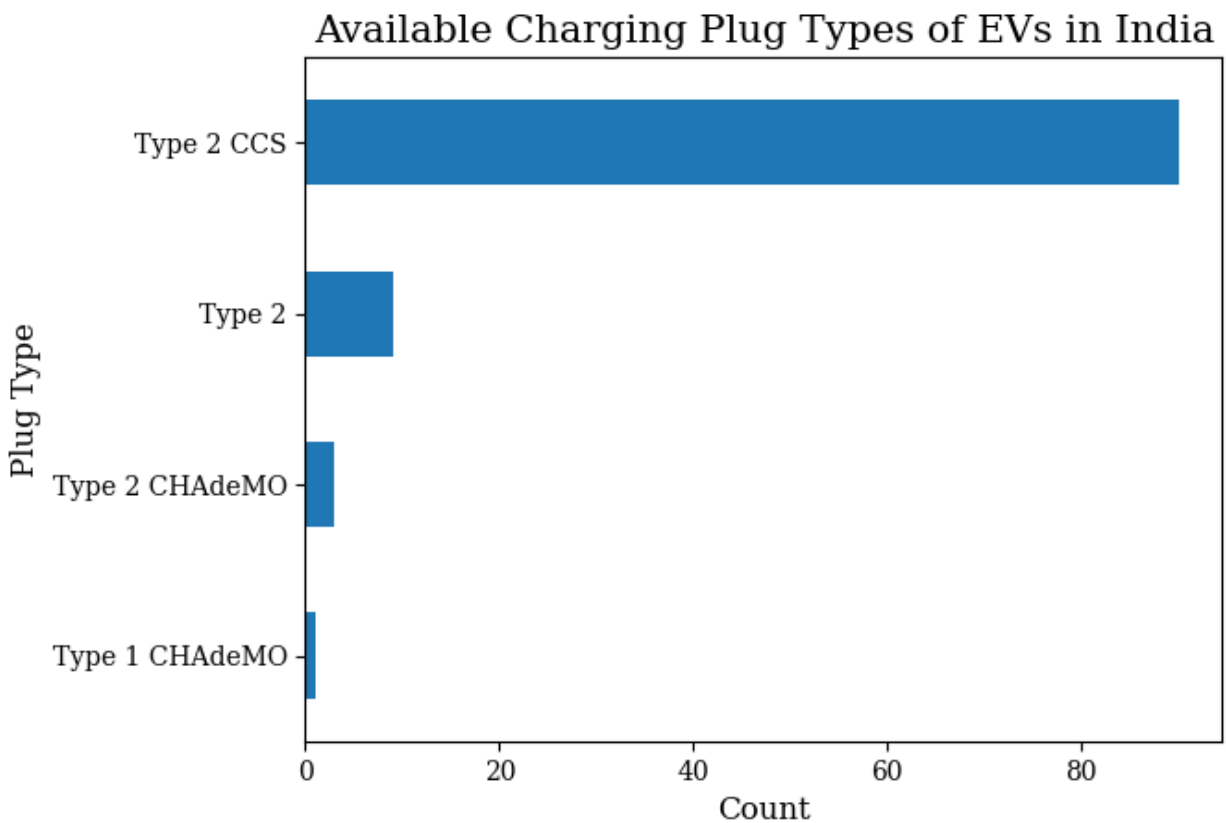


This bargraph shows us the number of seats EV's usually have. We can observe that a large number of EV's are 5 seaters. Some of the factors why EV's are usually 5 seaters are

- Demand for 5 seater cars in India.
- 5 seaters being cheaper to manufacture than larger SUV's
- 5-seater EVs can typically offer a good range on a single charge.
- 5-seater EVs typically have a good safety rating.

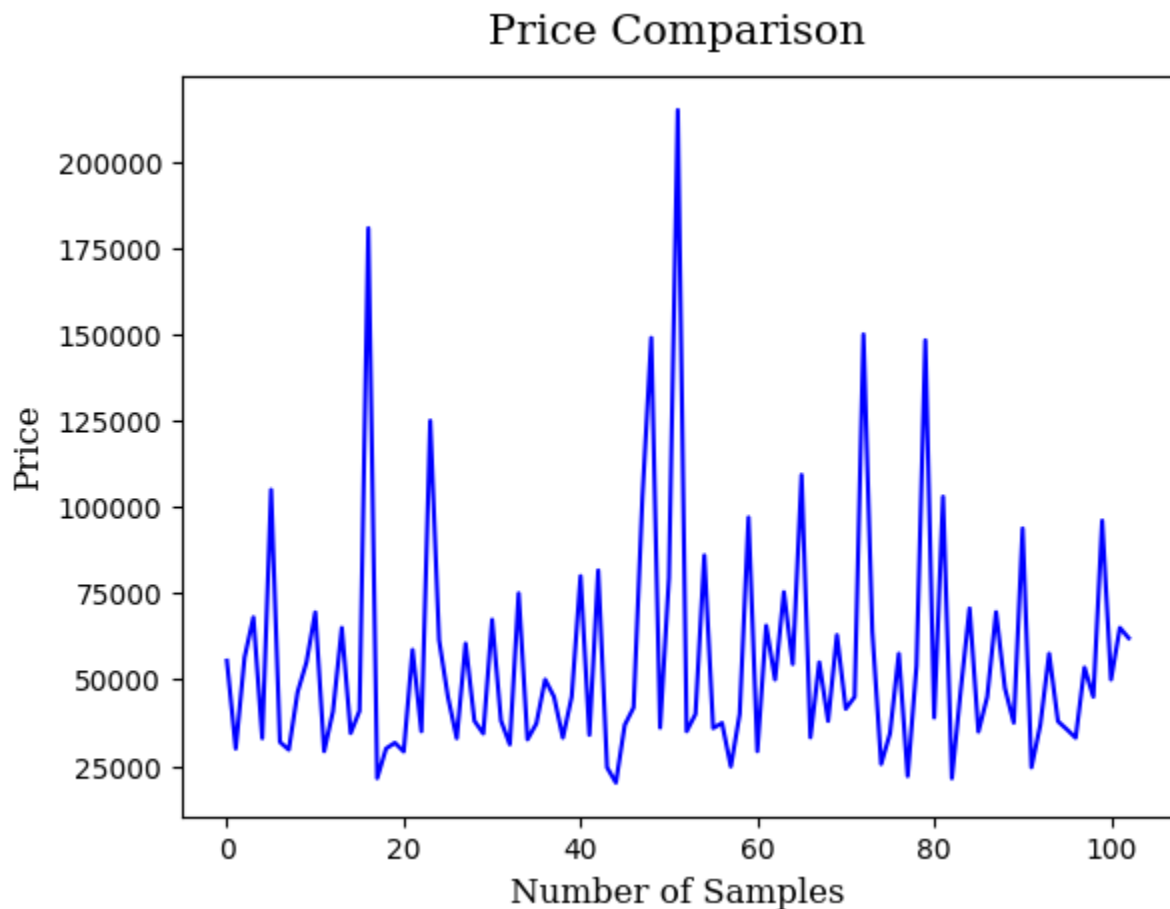


This bargraph shows us the number of seats each brand usually has. We can see that most brands generally prefer to manufacture 5 seater EV's

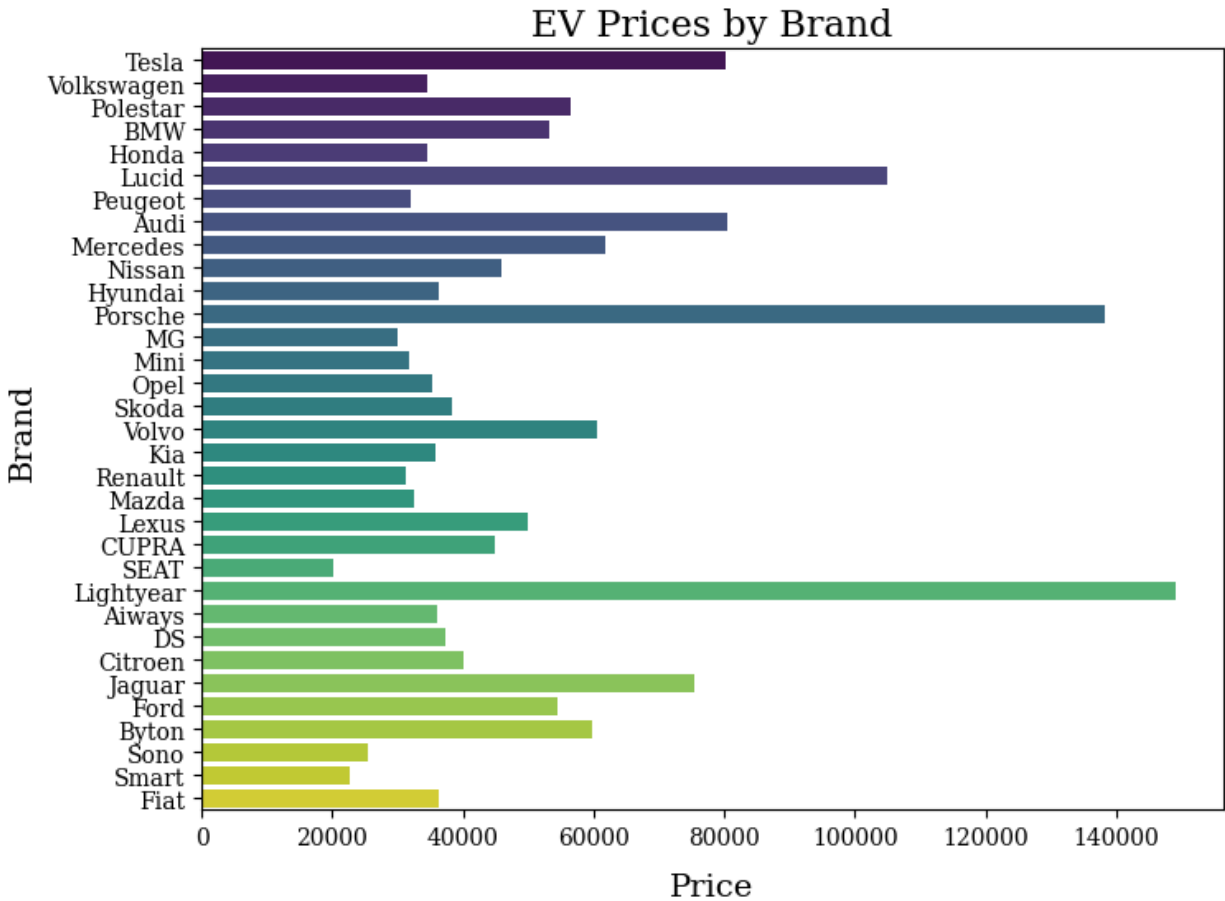


This bargraph shows us the available charging plug types in India. We can observe that Type 2 CCS chargers dominate the market. Some of the reasons why this charger is mostly used are:

- They are the most widely used charging standard in the world. This means that they are compatible with a wide range of EVs, both domestic and imported.
- They are capable of delivering high power, which can quickly charge EVs.
- They are relatively affordable. This makes them a good option for both private and public charging stations.
- They are supported by the government. The Indian government is promoting the adoption of Type 2 CCS chargers as part of its efforts to boost the EV market.

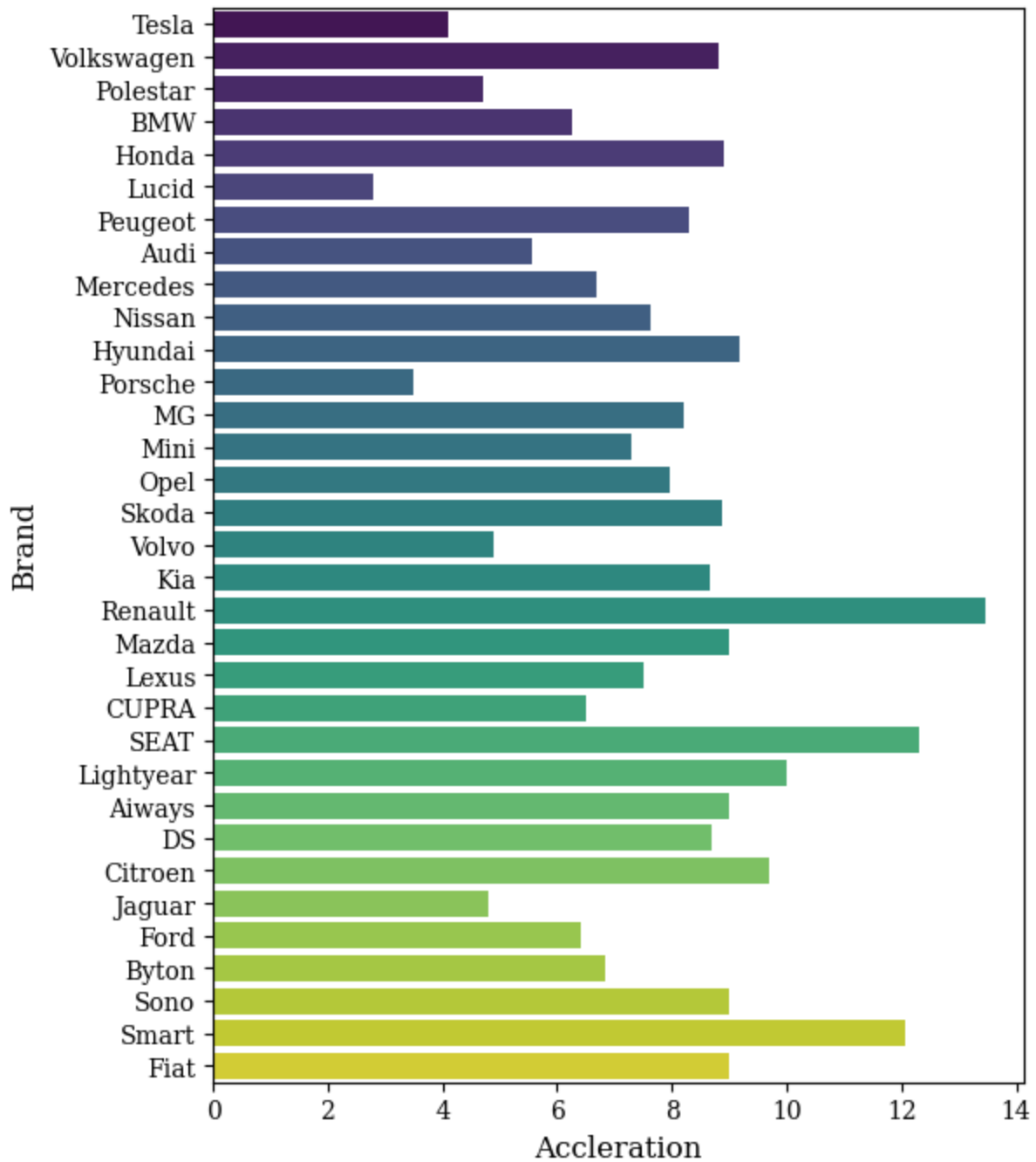


This is the price comparison of all the EV's produced.



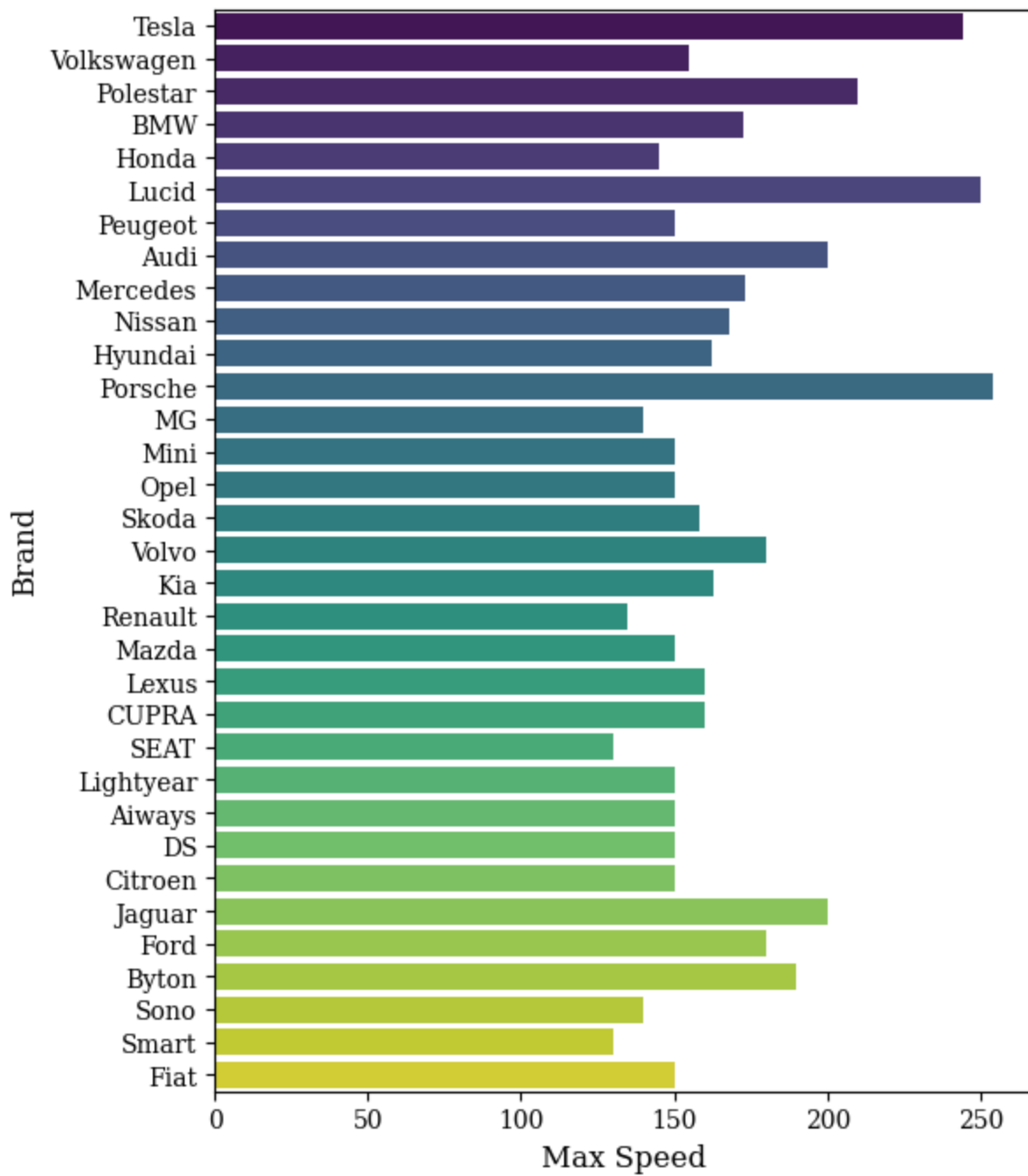
This is the price comparison of all the EV's produced by the brands. We can see that most brands sell their EV's at around the 40000 - 60000 Euros range which is really expensive for the average Indian person to buy.

Accleration of EVs in India



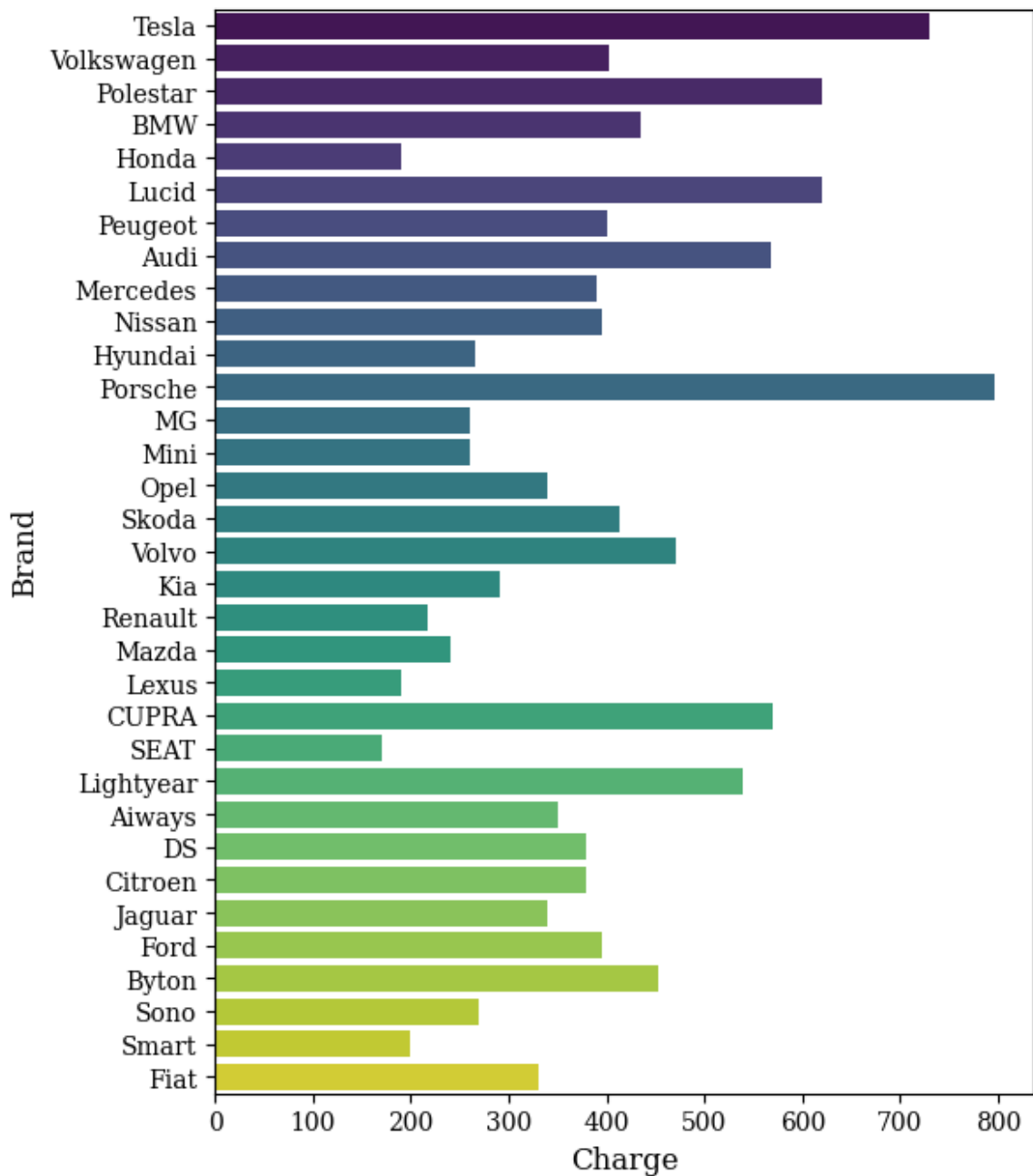
This graph shows us the acceleration of EV's.

Brand-wise Speed Comparison of EVs in India



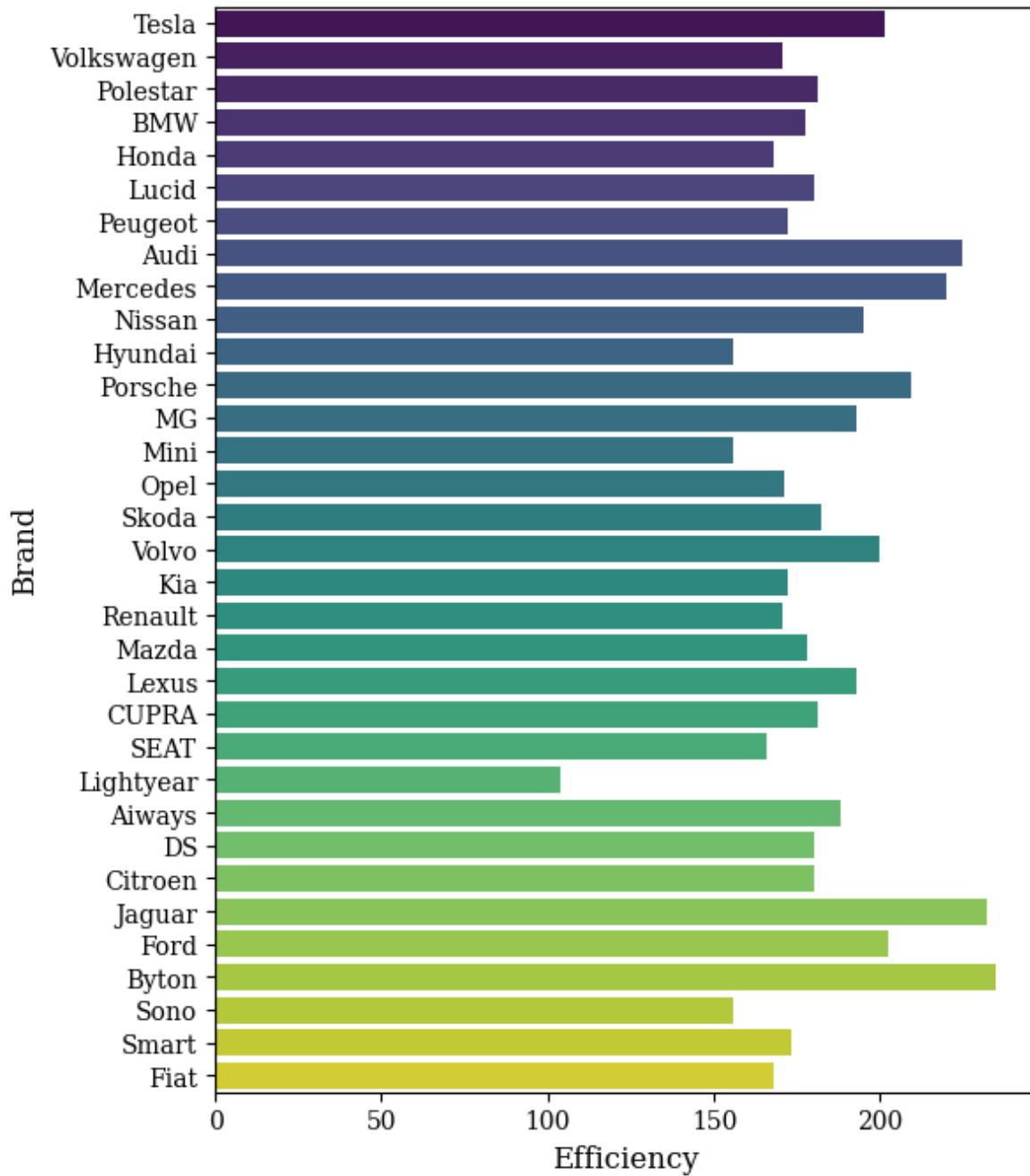
This graph shows us the max speed of the brands.

Brand-wise Fast Charge Comparison of EVs in India

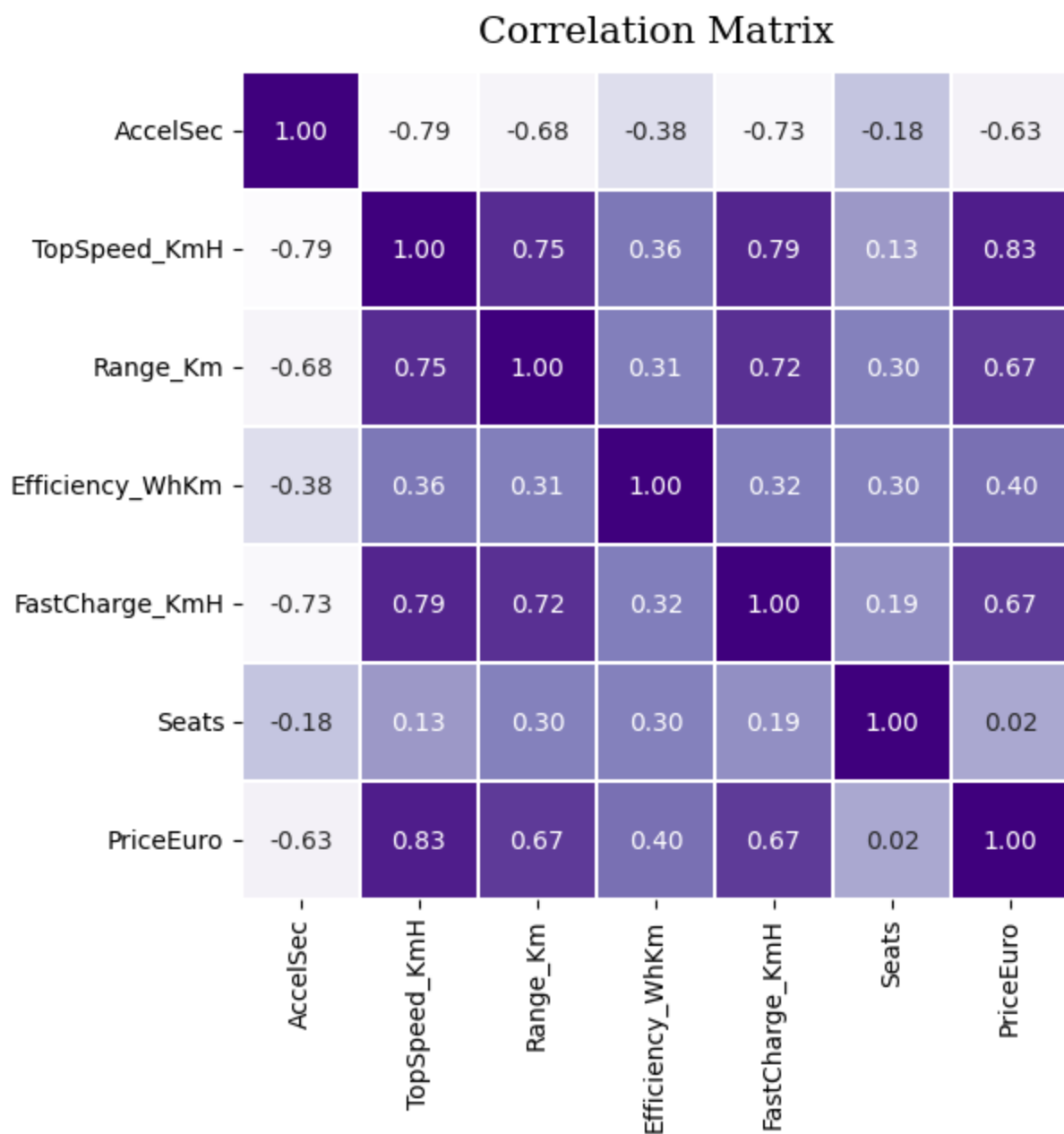


This is the Brand wise charge comparison of EV's.

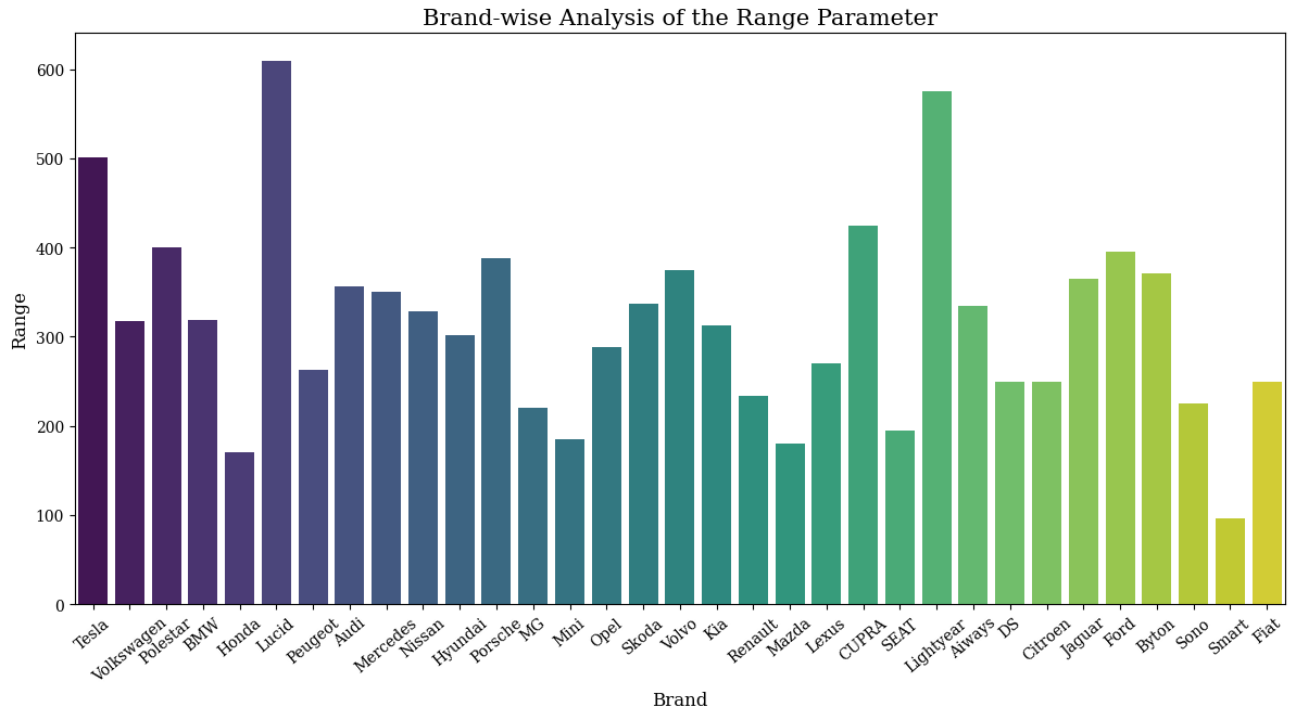
Brand-wise Efficiency Comparison of EVs in India



This is the Brand wise Efficiency comparison of EV's.



This is the correlation matrix that we got where we took some of the features from the dataset.



This is the range that each brand gets on a full charge. In general, most of the models of a single brand have around the same range for a full charge.

From the Exploratory Data Analysis, we can understand that some of the most important features required to create the to create most optimal Market Segments are

- **Range:** The range an electric vehicle can travel on a single charge is a fundamental factor for EV buyers. It's a critical consideration because it directly impacts the convenience and usability of the vehicle. Segments based on range can include short-range urban commuters, mid-range users, and long-range travelers.
- **Price:** Price is a significant determinant for consumers when choosing an EV. Segmenting by price can help target different customer segments based on their budget and willingness to invest in an electric vehicle. This can include budget-friendly EVs, mid-priced options, and premium, high-end models.
- **Charging Infrastructure:** The availability and speed of charging infrastructure are vital for EV owners. Segmentation based on charging infrastructure can distinguish between customers who have access to fast-charging networks, those who primarily rely on standard charging, and regions with limited charging infrastructure.
- **Body Style:** The type and style of electric vehicles, such as compact cars, SUVs, crossovers, or electric sports cars, can significantly impact buyer preferences. Segmenting by body style allows you to target consumers with specific lifestyle and usage needs.

Model Building Using K-Means Clustering

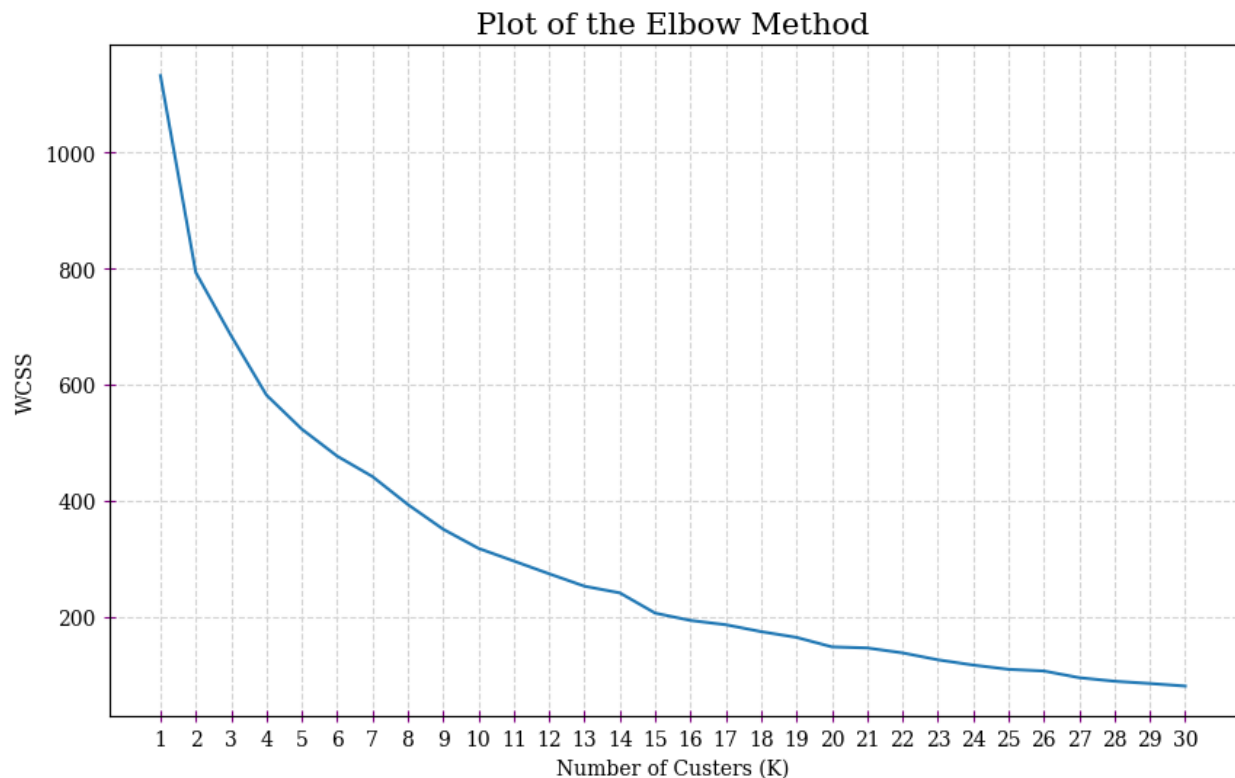
K-Means clustering is a popular and versatile clustering algorithm that can be a good choice for market segmentation analysis projects for several reasons:

- **Simplicity and Ease of Implementation:** K-Means is relatively simple to understand and implement. It's a centroid-based algorithm that assigns data points to clusters based on their proximity to cluster centroids. This simplicity makes it accessible and a good starting point for clustering analysis.
- **Scalability:** K-Means can handle large datasets efficiently. It scales well with the number of data points, making it suitable for analyzing large market datasets with potentially thousands of customers or observations.
- **Interpretability:** The results of K-Means are relatively easy to interpret. Each cluster is represented by its centroid, which can be seen as a prototype of the cluster. This makes it straightforward to describe and understand the characteristics of each segment, which is valuable in market segmentation.
- **Speed:** K-Means is a fast algorithm, and it typically converges quickly. This speed is advantageous when you need to perform multiple runs or iterations of clustering to explore different solutions or sensitivity analyses.
- **Quantitative Segmentation:** K-Means provides a quantitative segmentation, meaning that it assigns each data point to one specific cluster. This can be beneficial when you want discrete, non-overlapping segments for marketing strategies or targeted campaigns.
- **Cluster Centers as Market Profiles:** The cluster centroids can serve as representative market profiles. These profiles can be used to understand the characteristics of each segment, such as average spending behavior, preferences, or demographics.
- **Initialization Control:** K-Means allows you to control the initialization of cluster centroids. You can either start with random initializations or use more strategic methods to improve clustering results.
- **Elbow Method for Determining K:** The Elbow Method is a common technique for selecting the optimal number of clusters (K) in K-Means. It helps you find a suitable balance between granularity and interpretability in your market segments.
- **Flexibility:** While K-Means assumes clusters with similar sizes and spherical shapes, it can still produce meaningful results in many real-world scenarios. If you have prior knowledge about your data and clusters, you can consider using variations of K-Means, such as K-Means with constraints or hierarchical K-Means.
- **Versatility for Preprocessing:** K-Means can be used as a preprocessing step to create cluster labels that you can later incorporate into other machine learning or data analysis tasks, such as predictive modeling or customer profiling.

In K means clustering, we first select the important features for model building. In our case, we take the following features: 'AccelSec', 'TopSpeed_KmH', 'Efficiency_WhKm',

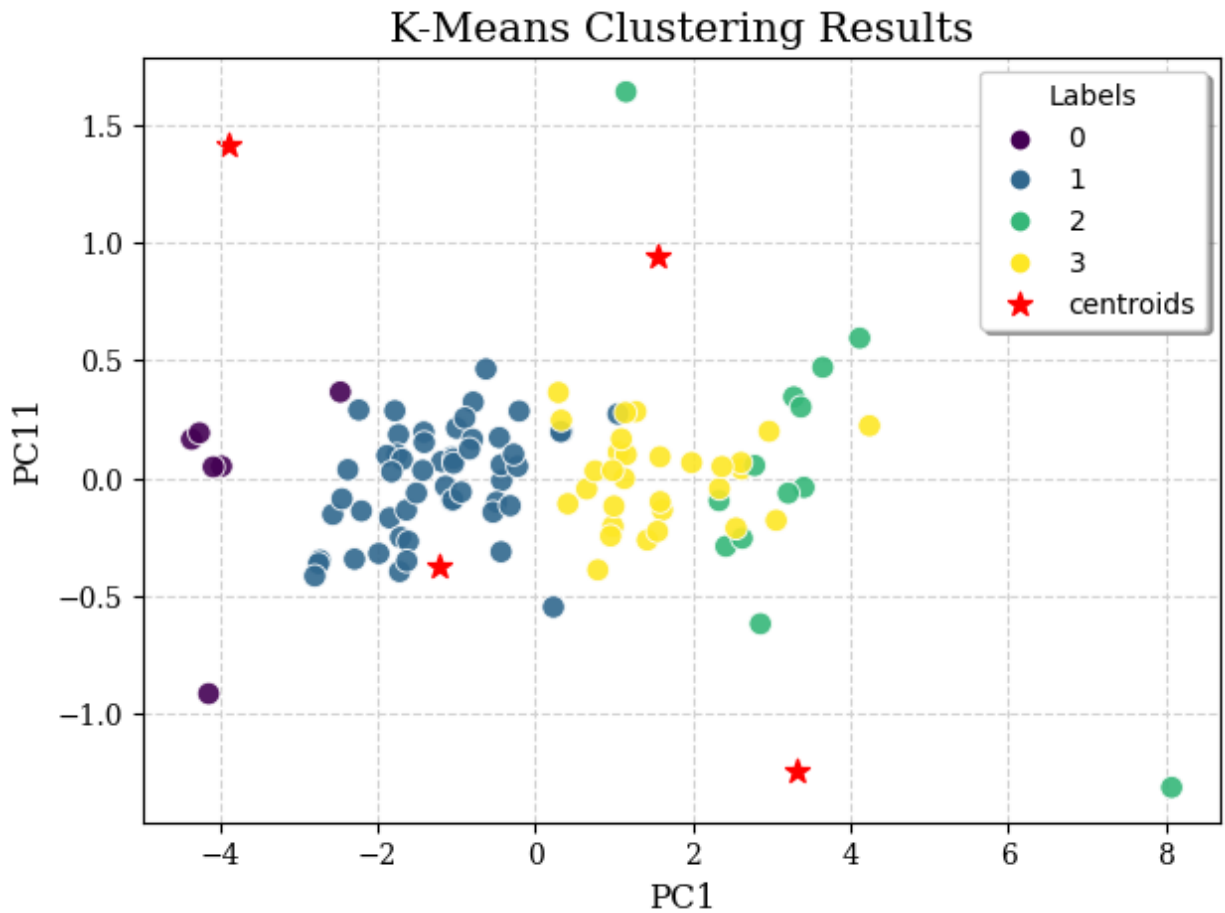
'FastCharge_KmH', 'Range_Km', 'RapidCharge', 'PlugType', 'BodyStyle', 'Seats',
'PriceEuro','PowerTrain'

After taking the features, we start our feature scaling. After it is done, we then apply Principle Component Analysis(PCA). We take 11 components for PCA from PC1 to PC11 since we have also taken 11 features. With this we get the PCA values. After we get the values, we start potting the Elbow graph



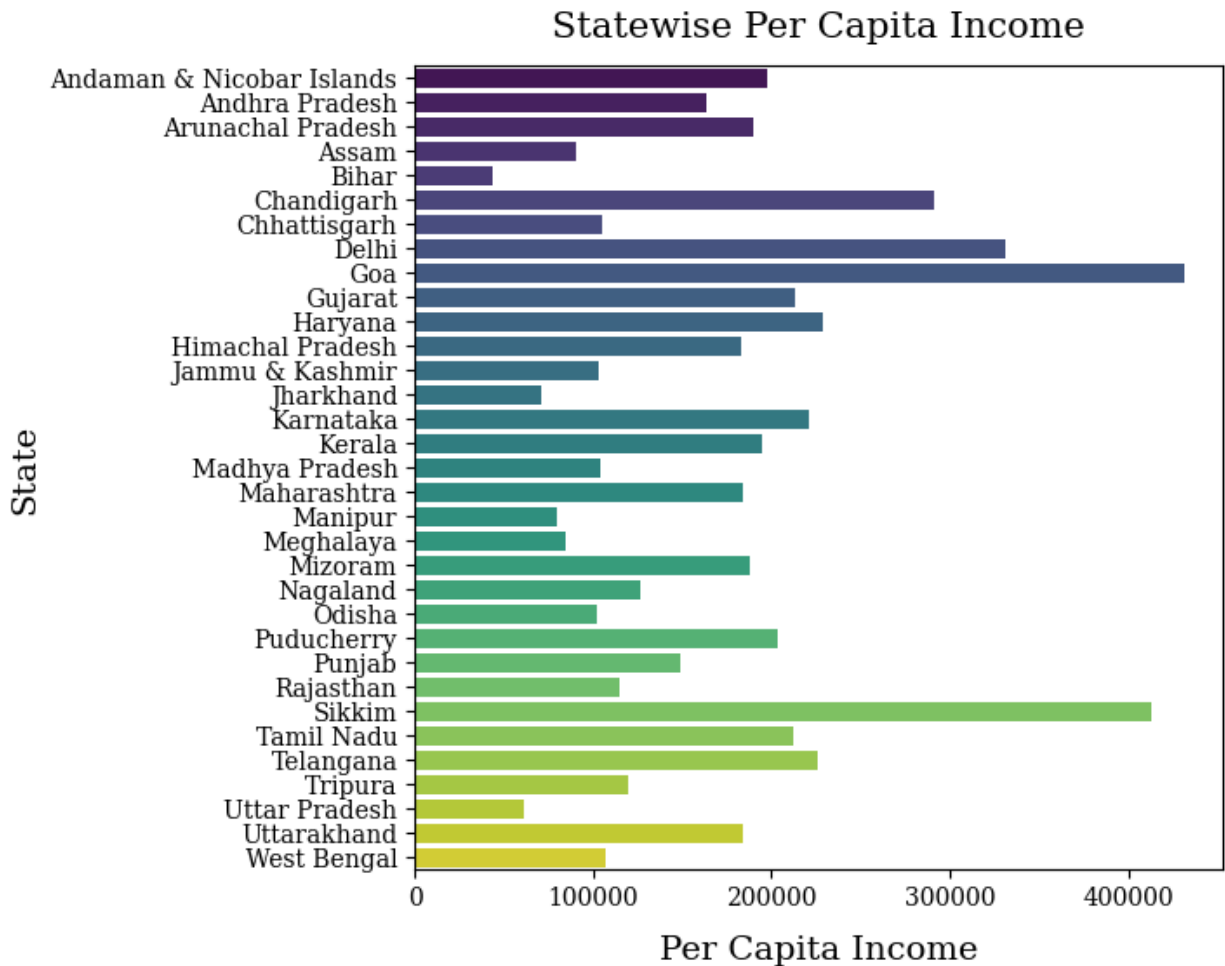
We can observe the elbow point in the graph. The WCSS decreases significantly from $k=3$ to $k=4$, and then the rate of decrease slows down. This suggests that the data points are best clustered into 4 groups.

Then we start training the model using $k=4$ as rendered by the above plot. Followed by checking the labels assigned to each data point, checking the size of clusters and more. Finally, we move to visualising the cluster.



Per Capita Income Analysis

We will also have a look at the per capita income data. In general, people with higher per capita income are more likely to buy EVs. This is because EVs are typically more expensive than petrol or diesel-powered vehicles.



So we can see that states with higher per capita income generally earn more and have higher disposable income. So this means we have to target states with high per capita income since people who have higher disposable income can generally afford an EV. This is where Geographic segmentation comes into play.

Similar to geographic segmentation, we can do Behavioral and Psychographic segmentation by using the information from the datasets and graphs

Geographic, Behavioral and Psychographic segmentation

Following the analysis, we can refine the target segment to encompass Electric Vehicles (EVs) that possess the following characteristics:

- Geographic factors: States with higher per capita income, better EV incentives, more EV friendly cities, high EV sales, etc.
- Psychographic factors: Comfort, Environmentally Conscious People, Visual Appeal, etc.

- Behavioral factors: Good Efficiency, Decent Price Range, High Charge and High Range, etc.

So, with these details and information, we can assume that the target segment should comprise of EVs having good charge and high range, high in Comfort and 5 seater SUV and Hatchback, has good visual appeal and more appealing to environmentally conscious people, have a Price range of 15-30 Lakhs, and be focused mainly on States having good EV sales and high per capita income such as Delhi, Maharashtra, Karnataka and Tamil Nadu.

Keep in mind this is for 4 wheeler vehicles. If it was 2 wheeler and 3 wheeler vehicles, the demographic might change.

For example, 3 wheeler vehicles are generally used as cargo and passenger vehicles. So, brands will focus on high range and good charge instead of factors such as visual appeal and they will reduce the price of the vehicles. And, as seen by the graphs, instead of states like Delhi, Maharashtra, Karnataka and Tamil Nadu, states like Uttar Pradesh will have higher demand for 3 wheelers. The same analysis can also be applied for 2 wheeler EV's as well.

Future Work

- Expanded Data Collection: Collecting a more extensive dataset with a broader range of features. Including additional attributes related to customer behavior, demographics, brand loyalty, purchase history, or interactions with the product or service.
- Feature Engineering: Creating new features from the existing data that could provide valuable insights for segmentation. These features might capture customer engagement, lifetime value, or sentiment analysis based on text data.
- Ensemble Algorithms: Combining multiple clustering algorithms or using ensemble algorithms to improve the robustness and stability of segmentation results. Ensemble clustering methods can be particularly useful when dealing with diverse datasets.
- Deep Learning: If we have a large and multi dimensional dataset using deep learning-based clustering methods like autoencoders for feature extraction and clustering can provide better results.