Market Segmentation Analysis of Electric Vehicle(EV) Market in India

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GitHub Link: https://github.com/Decode369/Feyn-Labs/blob/main/Project-2%20EV%20Market%20Segmentation/EV.ipynb

EV Market Overview in India

India's electric vehicle (EV) market is undergoing a significant transformation, driven by a confluence of factors. Environmental concerns, government initiatives, and technological advancements are propelling the adoption of EVs, making them a prominent feature of the country's transportation landscape.

The EV market in India is primarily dominated by electric two-wheelers, which have gained popularity due to their affordability, practicality, and suitability for urban commuting. While electric four-wheelers are experiencing steady growth, challenges such as higher costs and limited charging infrastructure hinder their widespread adoption.

A range of domestic and international manufacturers, including Tata Motors, Ola Electric, Ather Energy, and Hero Electric, are actively participating in the Indian EV market. Government schemes like FAME II and state-level policies provide incentives for EV purchase and infrastructure development, further accelerating the market's growth.

Despite the positive strides made, the Indian EV market faces certain hurdles. High upfront costs, range anxiety, and inadequate charging infrastructure, particularly in rural areas, are key challenges that need to be addressed. Nevertheless, the EV sector is poised for continued expansion as consumers and businesses increasingly embrace electric vehicles for their environmental and economic benefits.

To effectively enter the Indian EV market, understanding the diverse consumer segments, their motivations, and the factors influencing their EV adoption is crucial. By tailoring market strategies to address these aspects, companies can capitalize on the burgeoning EV market and contribute to India's sustainable transportation future.

Problem Statement

Identify the most viable customer and vehicle segments in India for the Start-up to develop its Electric Vehicles, and create a data-backed market entry strategy that aligns with these segments.

Problem Statement Breakdown Using Fermi Estimation

To use Fermi estimation for this problem, we'll break down the questions into smaller, manageable parts and estimate values based on assumptions and logical reasoning. The goal is to arrive at rough, yet insightful, conclusions about what type of EV the start-up should produce and the potential target market.

Question 1: What type of Electric Vehicle will the company produce?

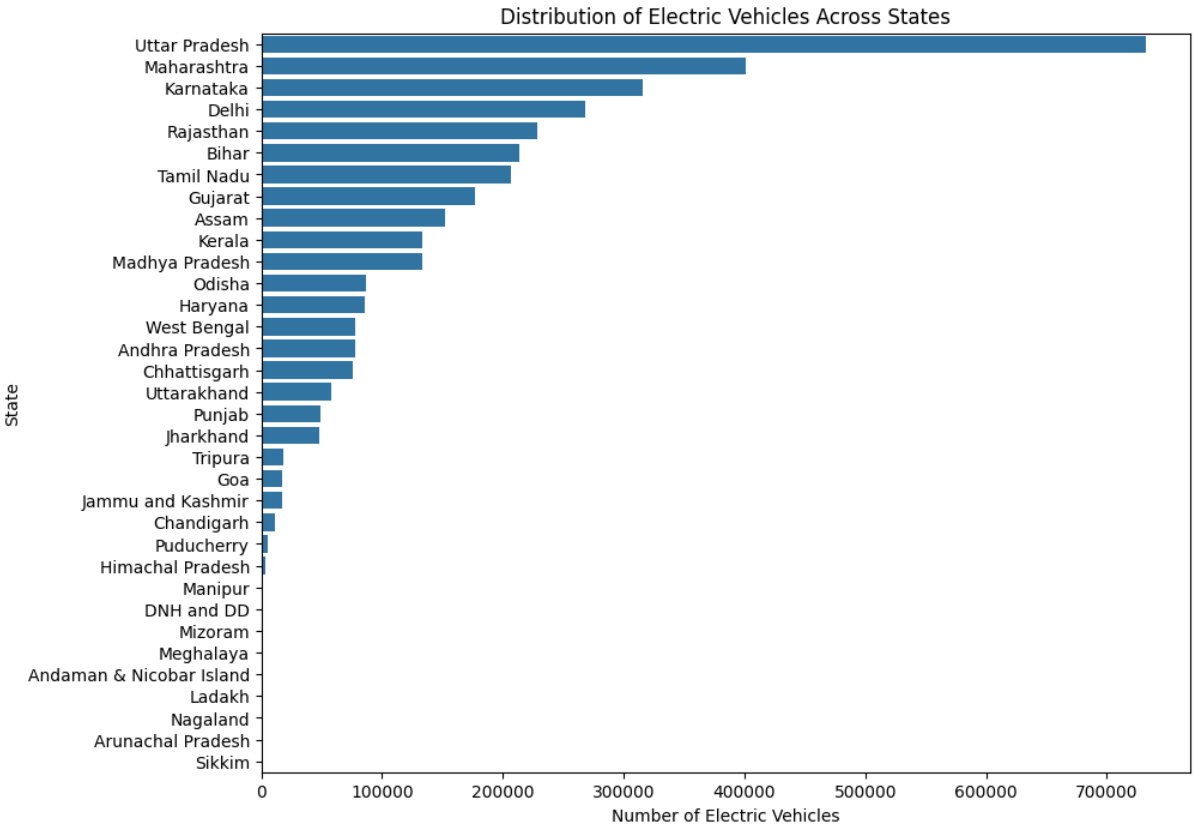
- Considering data for a 10- year period (2014-2024)
- Based on the available data in the market, the chief categories of vehicles include:
  - 2-Wheelers
  - 3-Wheelers
  - 4-Wheelers (Cars)
  - Bus
  - Others (Commercial Vehicles)
- Main fuel types category used are:
  - Petrol
  - Diesel
  - Electric (BOV-Battery Operated Vehicle)
  - Petrol/CNG
- Dataset collected from:
  Dataset 1: https://cleanmobilityshift.com/ev-dashboard/

Question 2: What target market should start-up company focus on?

- Geographic Segmentation would be ideal by looking into factors like vehicle usage in cities, available charging station infrastructure locally, EV incentives in each state, environmental awareness etc.
- Dataset collected from:
  Dataset 2: Combining the below two datasets on key-column State/UT.
  https://www.data.gov.in/resource/stateut-wise-details-electric-and-non-electric-vehicles-country-03-08-2023
  https://www.data.gov.in/resource/stateut-wise-number-operational-public-electric-vehicles-ev-public-charging-station-pcs

Dataset-1

EDA

- 

  The above graph describes about the frequency distribution of electric vehicles across different states in India. The top 5 states using EV's include Uttar Pradesh, Maharashtra, Karnataka, Delhi and Rajasthan.

- When discussing market penetration in the context of electric vehicles (EVs), the concept involves understanding how widely EVs have been adopted within the broader automotive market. This helps assess the success of EVs compared to traditional internal combustion engine (ICE) vehicles and identifies opportunities for further growth.

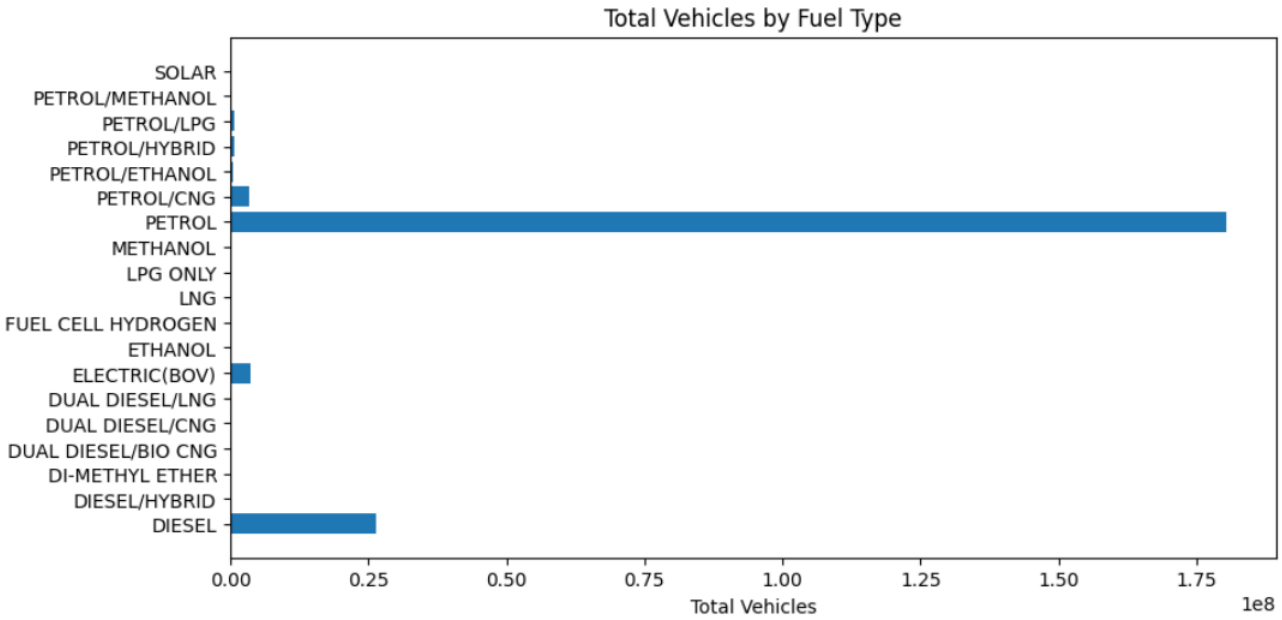
$$Market\ Penetration\ of\ EV = \frac{EV\ Sales}{Overall\ Sales}$$

  By using the above formula, we can compute State wise EV sales penetration.

State	ELECTRIC(BOV)	Total	EV Penetration
Uttar Pradesh	732074	29383067	0.335644
Maharashtra	401535	23419395	0.184097
Karnataka	315498	15487780	0.144651
Delhi	268538	6180530	0.123120
Rajasthan	228573	13342013	0.104797
Bihar	213465	10292645	0.097870
Tamil Nadu	206902	17950858	0.094861
Gujarat	176713	15676576	0.081020
Assam	151917	4445923	0.069651
Kerala	133246	8713655	0.061091
Madhya Pradesh	133182	12772083	0.061062
Odisha	86823	6805282	0.039807
Haryana	85250	7467928	0.039086
West Bengal	78112	9943549	0.035813
Andhra Pradesh	77356	9822283	0.035466
Chhattisgarh	75275	5275169	0.034512
Uttarakhand	57606	2322300	0.026411
Punjab	49285	7096446	0.022596
Jharkhand	47871	5006236	0.021948
Tripura	18346	479777	0.008411
Goa	17382	723889	0.007969
Jammu and Kashmir	16840	1517822	0.007721
Chandigarh	11453	459496	0.005251
Puducherry	5139	565221	0.002356
Himachal Pradesh	2886	1266700	0.001323
Manipur	1284	318422	0.000589
DNH and DD	431	180947	0.000198
Mizoram	235	225539	0.000108
Meghalaya	208	289562	0.000095
Andaman & Nicobar Island	202	83648	0.000093

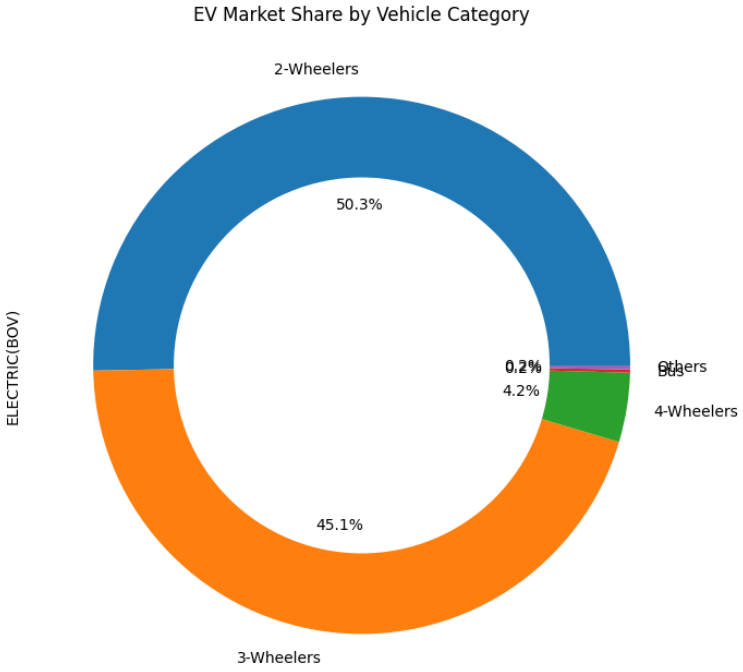
A higher market penetration indicates that EVs are becoming more mainstream, potentially due to factors like increasing consumer demand, supportive policies, or advancements in technology.

The following states have the most market penetration - Uttar Pradesh, Maharashtra, Karnataka, Delhi and Rajasthan.

- 

The above graph shows the number of vehicles in each fuel type category in India. We can observe that the majority share of vehicles is from petrol, diesel, Electric(BOV) and Petrol/CNG fuel type. These 4 types will be used in segmentation process.

- The below donut chart shows frequency distribution of EV by vehicle category in India. It is observed most of the EV's in either are 2-wheelers or 3-wheelers.



Segmentation using K-Means to identify Vehicle type in dataset.

K-means is a widely used clustering algorithm in machine learning that partitions a dataset into ‘K’ distinct clusters. The process begins by randomly selecting ‘K’ initial centroids from the data. Each data point is then assigned to the nearest centroid, forming clusters based on proximity. After this assignment, the centroids are recalculated as the mean of all data points within each cluster. These steps of assigning data points and updating centroids are repeated until the centroids stabilize, meaning they no longer change significantly. The primary objective of K-means is to minimize the within-cluster variance, ensuring that the data points in each cluster are as similar as possible. However, the algorithm can be sensitive to the initial choice of centroids, potentially leading to different results with different initializations, so it is often run multiple times to find the best clustering solution.

Dataset is filtered and only relevant variables are considered for segmentation process.

```
seg_features = ["Vehicle Category","PETROL","DIESEL","ELECTRIC(BOV)","PETROL/CNG","Total","Vehicle Type"]
```

Ordinal variables are converted to numeric type using get_dummies function from pandas.

```
df_relevant = pd.get_dummies(data[seg_features], columns=["Vehicle Type"])
```

Dataset is then grouped with respect to vehicle type i.e. 2-wheelers,3-wheelers,4-wheelers, buses and others.

```
df_grouped = df_relevant.groupby("Vehicle Category").sum().reset_index()
```

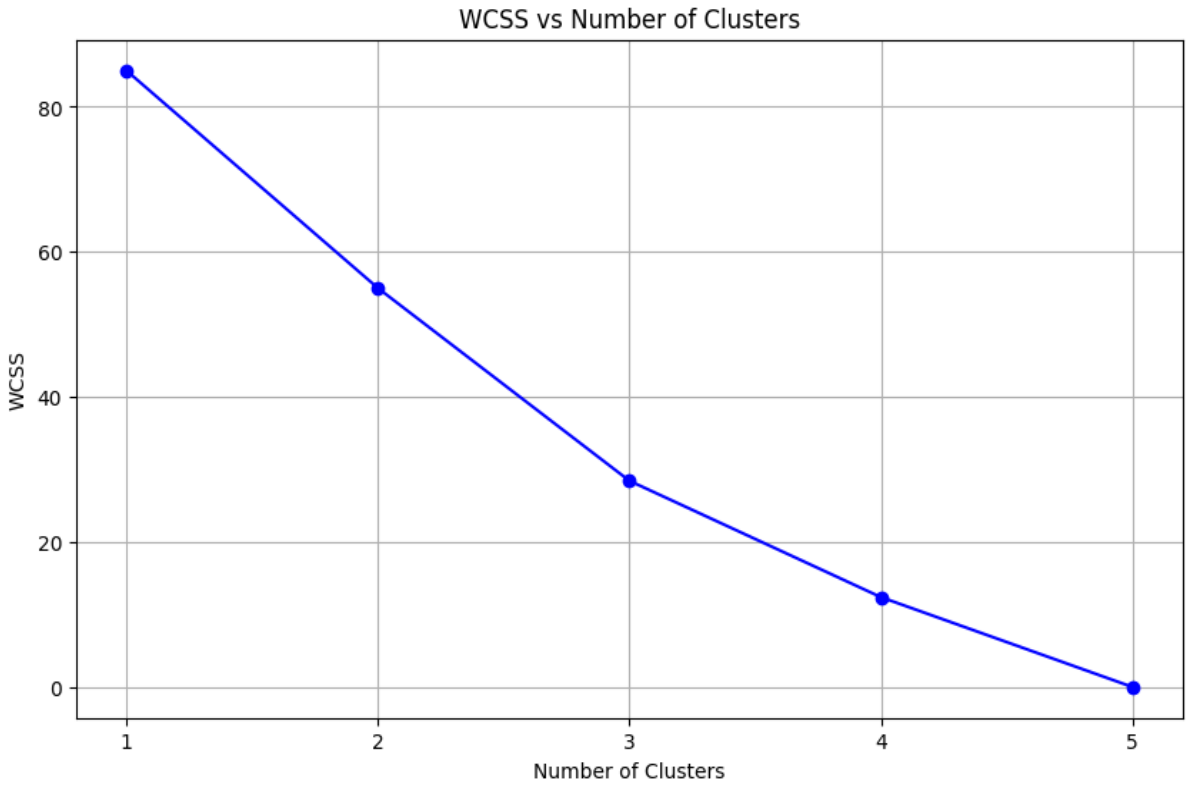
Since we are using a distance based algorithm for segmentation, it is essential to scale the data before applying the model. For this we normalize the dataset.

```
scaler = StandardScaler()
scaled_data = scaler.fit_transform(df_grouped.drop("Vehicle Category",axis=1))
```

To find the optimal number of clusters for the model, Elbow-Curve method is used as a guideline. Elbow-Curve graph is a plot between WCSS (Within Clusters Sum of Squares) vs Number of clusters. This plot helps determine the optimal number of clusters by looking for the "elbow point," where the rate of

decrease in WCSS slows down significantly, indicating a suitable number of clusters for your dataset.

```
wcss = []
for i in range(1, 6):
    kmeans = KMeans(n_clusters=i, random_state=42)
    kmeans.fit(scaled_data)
    wcss.append(kmeans.inertia_)

# Plot WCSS vs number of clusters
plt.figure(figsize=(10, 6))
plt.plot(range(1, 6), wcss, marker='o', linestyle='-', color='b')
plt.title('WCSS vs Number of Clusters')
plt.xlabel('Number of Clusters')
plt.ylabel('WCSS')
plt.xticks(range(1, 6))
plt.grid(True)
plt.show()
```



By using the above plot, the optimal number of clusters is assumed as 3.

Building the optimal K-Means segmentation model using number of clusters as 3.

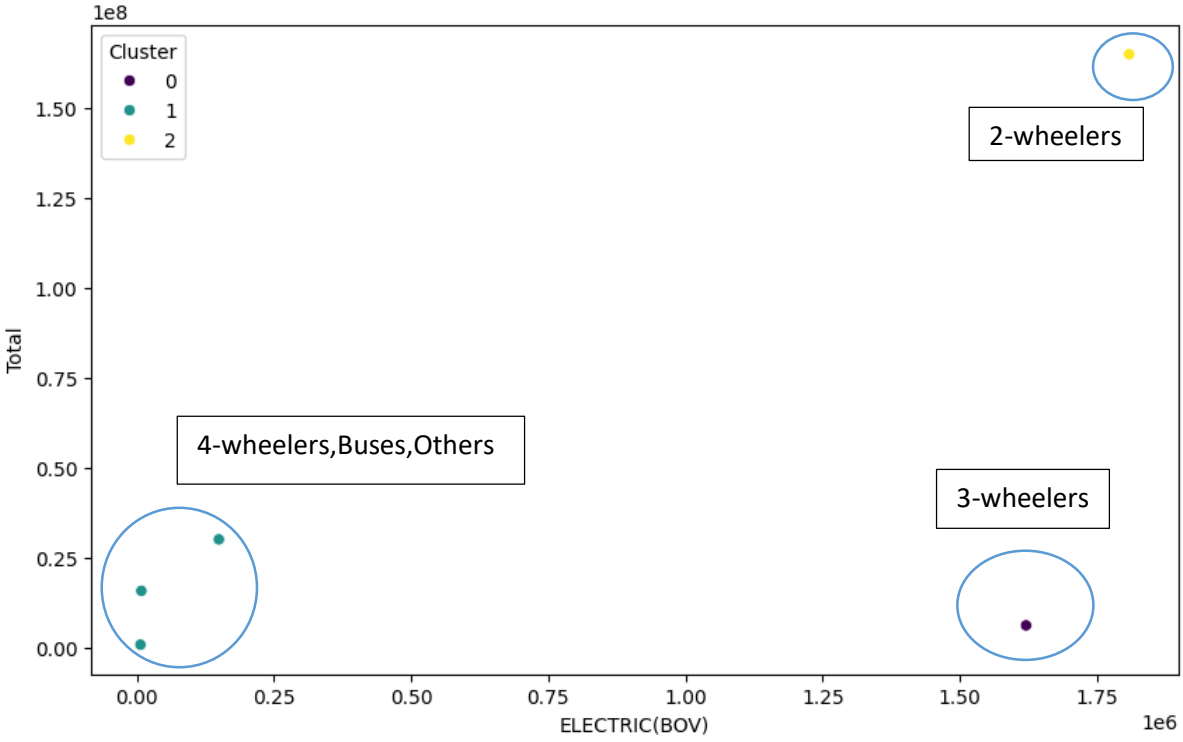
```
#Optimal clusters = 3

kmeans = KMeans(n_clusters=3, random_state=42)
df_grouped['Cluster'] = kmeans.fit_predict(scaled_data)

#Viewing Clusters graphically in scatterplot

plt.figure(figsize=(10, 6))
sns.scatterplot(x='ELECTRIC(BOV)', y='Total', hue='Cluster', data=df_grouped, palette='viridis')
```

Cluster Summary

- **Cluster 0 (3-wheelers)**: Moderate electric vehicle presence and overall count make this segment potentially promising but not as strong as 2-wheelers.
- **Cluster 1 (4-wheelers, buses, others)**: These categories show lower electric adoption, suggesting they may be less favourable for an EV-focused start-up.
- **Cluster 2 (2-wheelers)**: Given the high number of electric vehicles and overall vehicles, focusing on producing electric 2-wheelers could be a viable strategy.

Cluster Scatterplot

The scatter plot shows how the clusters are differentiated based on the total number of vehicles and the number of electric vehicles (BOV). This visualization helps identify which vehicle categories are more inclined towards electric vehicle production.



Dataset-2

The following dataset will be used to identify the areas with the highest potential for electric vehicle (EV) adoption.

State/UT	Electric	Non-electric	No. of Operational PCS
andaman and nicobar	190	161258	3
andhra pradesh	67905	16553509	222
arunachal pradesh	28	303673	9
assam	120423	5312457	48
bihar	161060	11631081	83

The data is checked for missing values and feature engineering is done to add key metrics such as:

- **Total vehicles(Total):** Electric vehicle + Non- Electric Vehicle
- **Electric vehicle percentage(Electric_Percentage):** This gives the percentage of electric vehicles in each State/UT, helping identify areas with higher EV adoption.
- **Public Charging stations per 1000 electric vehicles (PCS_per_1000_vehicles)**: This metric normalizes the number of charging stations by the total number of electric vehicles, providing insight into infrastructure adequacy.

```
ev_df['Total'] = ev_df['Electric'] + ev_df['Non-electric']
ev_df['Electric_Percentage'] = (ev_df['Electric'] / ev_df['Total']) * 100
ev_df['PCS_per_1000_vehicles'] = (ev_df['No. of Operational PCS'] / ev_df['Electric']) * 1000
```

State/UT	Electric	Non-electric	No. of Operational PCS	Total	Electric_Percentage	PCS_per_1000_vehicles
andaman and nicobar	190	161258	3	161448	0.117685	15.789474
andhra pradesh	67905	16553509	222	16621414	0.408539	3.269273
arunachal pradesh	28	303673	9	303701	0.009220	321.428571
assam	120423	5312457	48	5432880	2.216559	0.398595
bihar	161060	11631081	83	11792141	1.365825	0.515336

The features required for clustering are then selected and normalized using Standard Scaler.

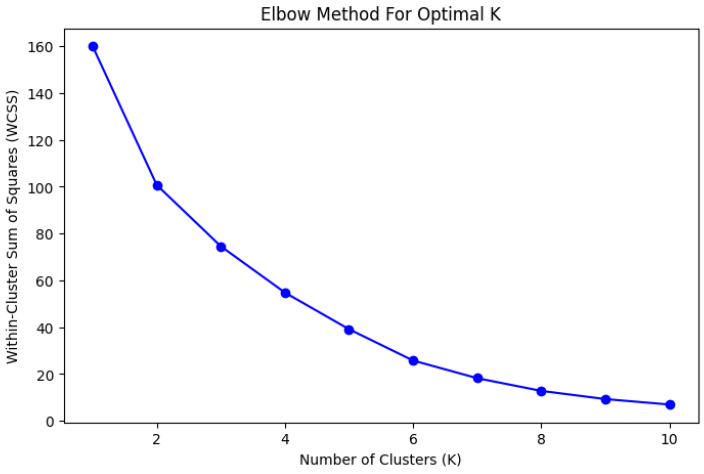
```
#Feature Scaling

features = ["Electric","Non-electric","No. of Operational PCS","Electric_Percentage","PCS_per_1000_vehicles"]
scaler = StandardScaler()
scaled_features = scaler.fit_transform(ev_df[features])
scaled_df = pd.DataFrame(scaled_features, columns=features)
scaled_df.head()
```

The optimal number of clusters is calculated by using elbow-curve and silhouette method.

Elbow-Curve plot:

The Elbow Method involves plotting the Within-Cluster Sum of Squares (WCSS) against the number of clusters and looking for an "elbow" point where the rate of decrease sharply changes.

```
wcss = []
K_range = range(1, 11)
for k in K_range:
    kmeans = KMeans(n_clusters=k, random_state=42)
    kmeans.fit(scaled_df)
    wcss.append(kmeans.inertia_)

plt.figure(figsize=(8, 5))
plt.plot(K_range, wcss, 'bo-')
plt.xlabel('Number of Clusters (K)')
plt.ylabel('Within-Cluster Sum of Squares (WCSS)')
plt.title('Elbow Method For Optimal K')
plt.show()
```

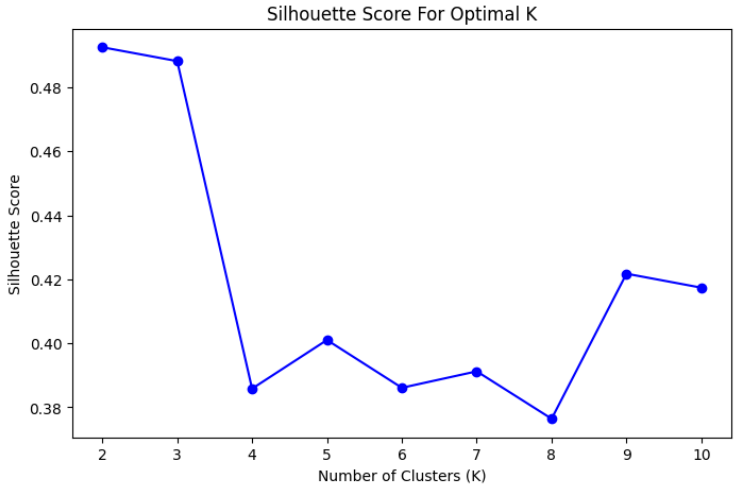


We can infer from the graph that the elbow point is observed at 2-3 range. Assuming optimal number of clusters as 2.

Silhouette method:

The Silhouette Score measures how similar an object is to its own cluster compared to other clusters. Scores range from -1 to 1, with higher values indicating better clustering.

```
silhouette_scores = []
for k in range(2, 11):
    kmeans = KMeans(n_clusters=k, random_state=42)
    cluster_labels = kmeans.fit_predict(scaled_df)
    score = silhouette_score(scaled_df, cluster_labels)
    silhouette_scores.append(score)

plt.figure(figsize=(8, 5))
plt.plot(range(2, 11), silhouette_scores, 'bo-')
plt.xlabel('Number of Clusters (K)')
plt.ylabel('Silhouette Score')
plt.title('Silhouette Score For Optimal K')
plt.show()
```



Since Cluster 2 has highest silhouette score, we will use optimal number of clusters as 2 and build the K-means model.

```
# Define the number of clusters
optimal_k = 2

# Initialize KMeans
kmeans = KMeans(n_clusters=optimal_k, random_state=42)

# Fit the model and predict clusters
ev_df['Cluster'] = kmeans.fit_predict(scaled_df)

# Display cluster centers
print("Cluster Centers (Scaled):")
print(pd.DataFrame(kmeans.cluster_centers_, columns=features))
```

Cluster Summary:

```
cluster_summary = ev_df.groupby('Cluster')[features].mean().reset_index()
print(cluster_summary)
```

```
   Cluster  Electric  Non-electric  No. of Operational PCS  \
0        0   47974.0  7.094908e+06               80.148148
1        1  307016.8  3.071490e+07              811.200000

   Electric_Percentage  PCS_per_1000_vehicles
0             0.614189              25.268554
1             1.037383               3.231671
```

Cluster 0: States/UTs with low electric vehicle numbers and low PCS.

These States/UT represent emerging markets.

- Advantages:

  ❖ First-mover advantage in untapped markets.
  ❖ Long-term growth prospects as infrastructure develops.

- Strategies:

  ❖ Collaborate with government bodies to support EV infrastructure development.
  ❖ Offer incentives or financing options to encourage EV adoption.

Cluster 1: States/UTs with high EV adoption and strong infrastructure

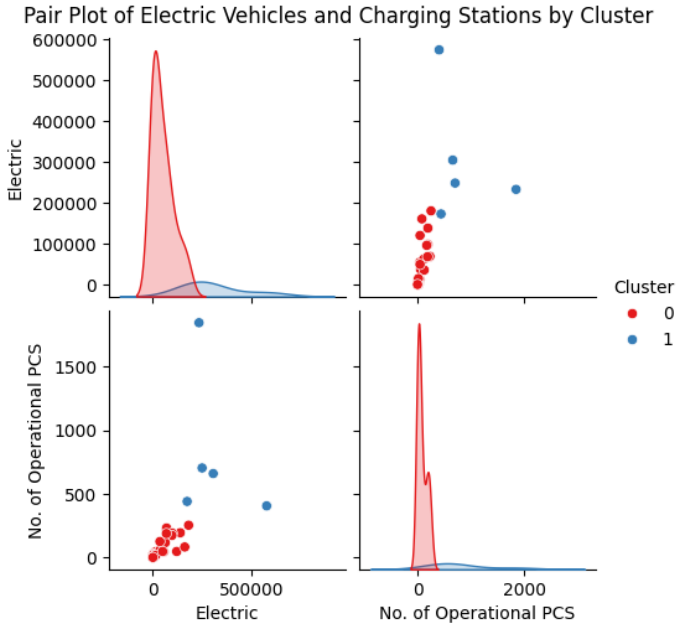
These States/UT represent high growth potential markets.

- Advantages:

  ❖ Immediate market demand.
  ❖ Existing infrastructure supports quick deployment and user convenience.

- Strategies:

  ❖ Launch premium or high-performance EV models.
  ❖ Partner with local PCS providers for enhanced service offerings.



The pair plot suggests that entering into a market with established public charging stations is easier for the EV-start up.

There are 5 States which fall under Cluster 1.

```
ev_df.groupby('Cluster').size()
```

Cluster	0
0	27
1	5

State/UT	Electric	Non-electric	No. of Operational PCS	Total	Electric_Percentage	PCS_per_1000_vehicles	Cluster
delhi	233212	13994966	1845	14228178	1.639085	7.911257	1
karnataka	248747	29785247	704	30033994	0.828218	2.830185	1
maharashtra	305006	34323748	660	34628754	0.880788	2.163892	1
tamil nadu	173152	31618002	441	31791154	0.544655	2.546895	1
uttar pradesh	574967	43852548	406	44427515	1.294169	0.706127	1

Geographic Segmentation

With the results of the above segmentation, the EV- startup can focus on the following segments:

- **Emerging Markets**

- **Regions Included**: States/UTs like Bihar, Gujarat, Madhya Pradesh, Kerala, and Rajasthan.
- **Key Features**:

  - **Low EV Penetration**: These regions have a lower number of electric vehicles compared to others, indicating untapped potential.
  - **Developing Infrastructure**: Public charging stations are limited, but there is an opportunity to influence infrastructure growth through partnerships with local authorities.

- **Recommendations**:

  - **Distribution Strategy**: Establish a strong network of dealerships in key cities and towns. Utilize mobile service centers to reach remote areas.
  - **Incentive Programs**: Introduce financing schemes and government-supported incentives to make EVs more accessible.

- **High-Growth Markets**

  - **Regions Included**: States/UTs like Maharashtra, Karnataka, Tamil Nadu, Delhi, and Uttar Pradesh.

  - **Key Features**:

    - **High EV Penetration**: These states have high adoption rates of EVs, supported by strong government initiatives and awareness.
    - **Robust Infrastructure**: A well-established network of public charging stations and service centres makes these regions ideal for launching premium models.

- **Recommendations**:

    - **Premium Positioning**: Focus on launching high-end models with advanced features to cater to the sophisticated consumer base in these regions.
    - **Enhanced Customer Experience**: Partner with local PCS providers to offer exclusive benefits such as faster charging or loyalty programs for customers.

Marketing Mix

1. Product

- **Core Offering**: Electric 2-wheelers designed for urban and semi-urban areas.
- **Variants**:
    - **For High Growth Markets:**
        - **Premium Models**: High-performance, feature-rich models with advanced technology (e.g., longer battery life, faster charging, smart connectivity).
        - **Urban Mobility Focus**: Sleek design, lightweight, suitable for city commuting.
    - **For Emerging Markets:**
        - **Affordable Models**: Cost-effective 2-wheelers with basic features for first-time EV buyers.
        - **Rugged Design**: Durable models to handle less developed infrastructure.
- **Customization**: Options for customization based on user preferences (e.g., colours, accessories).

2. Price

- **High Growth Markets**:

    - **Premium Pricing**: Position the EVs as a premium product, justifying with advanced features, performance, and brand positioning.

    - **Flexible Payment Plans**: Offer financing options like EMI, trade-ins, and leasing to attract a broader customer base.

- **Emerging Markets**:

    - **Competitive Pricing**: Set a competitive price to attract price-sensitive customers.
    - **Subsidies/Incentives**: Collaborate with local governments to offer incentives or subsidies to reduce the effective cost.

3. Place

- **High Growth Markets**:

    - **Widespread Availability**: Focus on urban centres with strong EV infrastructure, ensuring the product is available in high-demand areas.
    - **Online and Offline Sales Channels**: Use a combination of online platforms and physical stores to reach tech-savvy customers and those preferring traditional buying methods.

- **Emerging Markets**:

    - **Strategic Distribution**: Establish dealerships in key towns and cities with emerging demand.
    - **Partnership with Local Dealers**: Collaborate with existing auto dealers to leverage their distribution networks.
    - **Mobile Service Centres**: Deploy mobile service units to provide after-sales support in areas with less developed infrastructure.

4. Promotion

- **High Growth Markets**:

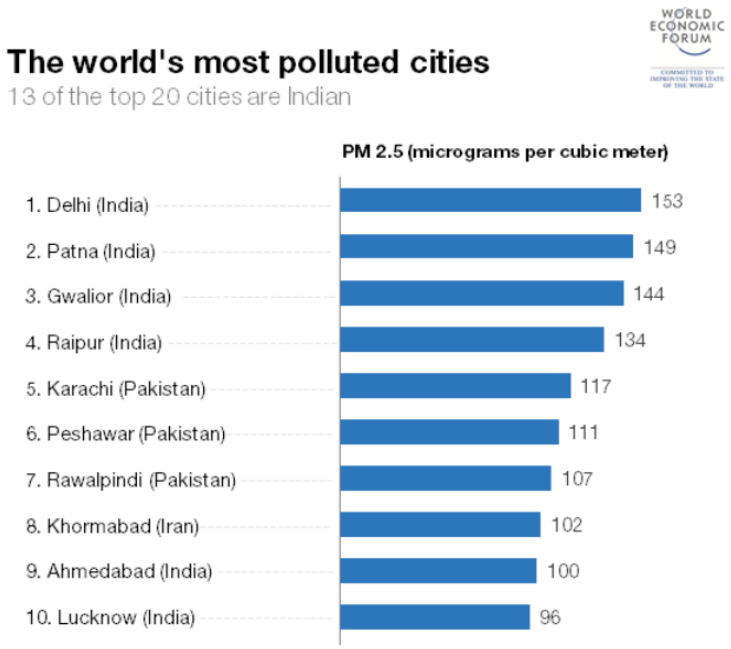
    - **Brand Positioning**: Position the product as a premium, eco-friendly alternative to traditional 2-wheelers.
    - **Digital Marketing**: Use social media, influencer marketing, and targeted online ads to reach urban customers.
    - **Collaborations**: Partner with lifestyle brands and eco-conscious organizations to enhance brand image.

- **Emerging Markets**:

- **Awareness Campaigns**: Educate the market about the benefits of EVs through local events, roadshows, and community engagement.
- **Government Partnerships**: Work with local governments to promote EV adoption through subsidies and public endorsements.
- **Referral Programs**: Encourage existing customers to refer new buyers through incentives and rewards

Optimal Market Segments as per Market Research

- The EV- startup should initially focus on producing only 2-Wheelers as it is the most widely used EV transport in India.
- The EV- startup should initially open up one manufacturing branch in the north and south India.
- In the north, the company can open its branch in Delhi.
  - Delhi has a high number of operational public charging stations.
  - According to World Economic Forum, Delhi is one of the most polluted cities in India. There is currently high environmental consciousness among people and a demand for a lesser carbon footprint. The EV startup can take advantage of this and use it in its marketing campaign.



  - Stores can be set up in nearby states like Uttar Pradesh, Rajasthan and Madhya Pradesh which has high growth market potential.
- In the south the EV startup can set up its manufacturing plant in Karnataka.
  - The state has a high number of operation charging stations.

- Since Karnataka is geographically in central location in south India, stores can be easily set up in Maharashtra and Tamil Nadu which are other high growth markets in the South.
- The Karnataka state government does not offer any direct incentive to electric vehicle buyers, but it does offer concessions and subsidies to EV makers, such as charging enterprises, battery makers and components.

❖ The EV start-up should make use State-level EV incentives set up by the government. These subsidies can be used in marketing campaigns to further attract more customers.

Government Subsidy on Electric Vehicles (Scooters and Bikes)

Like subsidies on EV cars and SUVs, electric scooters and bikes are eligible for state government subsidies. Below are the government subsidies on electric two-wheelers.

State	Subsidy (Per kWh)	Maximum Subsidy	Discount on road tax
Maharashtra	₹5,000	₹25,000	1
Assam	₹10,000	₹20,000	1
Gujarat	₹10,000	₹20,000	0.5
West Bengal	₹10,000	₹20,000	1
Meghalaya	₹10,000	₹20,000	1
Bihar	₹10,000	₹20,000	1
Rajasthan	₹2,500	₹10,000	NA
Odisha	NA	₹5,000	1
Madhya Pradesh	Nil	Nil	0.99
Punjab	Nil	Nil	1
Telangana	Nil	Nil	1
Kerala	Nil	Nil	0.5
Uttar Pradesh	Nil	Nil	1
Karnataka	Nil	Nil	1
Andhra Pradesh	Nil	Nil	1
Tamil Nadu	Nil	Nil	1

❖ Once the company performs well on 2-wheeler product, the startup can then venture into 3- wheeler and 4-wheeler products and slowly expand its business into emerging market sectors.

References

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❖ https://www.weforum.org/agenda/2015/06/which-is-the-worlds-most-polluted-city/
❖ https://www.data.gov.in/
❖ https://cleanmobilityshift.com/ev-dashboard/