ELECTRIC VEHICLE MARKET SEGMENTATION ANALYSIS

Soha Raqshi

https://github.com/SooRaq/EV-Market-Segmentation-Analysis/blob/main/EV%20Market%20Segmentation%20Analysis.ipynb

12th September, 2024

Abstract

The rapid expansion of the Electric Vehicle (EV) market is driven by environmental concerns, government incentives, and technological advancements, which have intensified competition among startups. Traditional demographic-based segmentation methods are no longer adequate for the diverse EV market. Instead, machine learning provides a more advanced approach by analyzing large datasets to reveal complex patterns in consumer demographics, psychographics, and behaviors. The report includes visualizations of the segmentation analysis, offering deeper insights into market dynamics and helping to understand key customer segments. By utilizing machine learning, EV startups can develop tailored strategies that enhance market positioning, customer engagement, and long-term growth.

1.0 Introduction

The electric vehicle (EV) market is experiencing rapid growth, driven by increasing environmental awareness, government incentives, and continuous advancements in technology. As more players enter the field, the competition intensifies, making it crucial for EV startups to carve out a unique position. Traditional demographic-based segmentation strategies, while still valuable, are no longer sufficient to address the complexity and diversity of the modern EV market. Startups now need to embrace more advanced, data-driven approaches to market segmentation. Machine learning has emerged as a powerful tool in this context, as it can process large and complex datasets, uncovering subtle patterns and correlations that traditional methods often overlook. By leveraging machine learning, startups can gain a deeper understanding of their target audience, segmenting them not only based on demographics but also by psychographic and behavioral characteristics.

This nuanced segmentation allows companies to develop more targeted and effective marketing strategies, offering products and services that resonate deeply with each specific group. The interpretability of machine learning models further enhances this process by providing clear, actionable insights that guide strategic decision-making. These insights enable EV startups to engage more effectively with customers, optimizing their messaging, branding, and overall market positioning. Ultimately, applying machine learning for market segmentation gives startups a distinct competitive advantage in an increasingly saturated market, fostering sustainable growth and better equipping them to navigate the challenges of evolving consumer preferences and industry trends.

2.0 Problem Statement and Fermi Estimation

2.1 Problem Statement

As the electric vehicle (EV) market becomes increasingly competitive, startups face challenges in identifying and targeting the right customer segments. Traditional demographic-based market segmentation approaches are insufficient to capture the complex and diverse consumer base. To

effectively differentiate themselves and drive growth, EV startups need to adopt more advanced segmentation techniques, such as machine learning, to analyze consumer behavior and preferences. This report aims to explore how machine learning can be applied to segment the EV market and provide visual insights into customer demographics, psychographics, and behaviors, aiding in strategic decision-making.

2.2   Fermi Estimation

Let's estimate the potential market size and segmentation needs for an EV startup in India:

- **India's Population**: Approximately 1.4 billion people.
- **Percentage of Population in Urban Areas**: About 35% (490 million people).
- **Target Demographic (Middle Class and Above)**: Estimate around 30% of the urban population (~147 million people).
- **Potential EV Adopters (Environmentally Conscious + Early Adopters of Tech)**: Assume about 10% of this group could be early EV adopters (~14.7 million people).
- **Annual New Car Buyers**: Suppose 5% of the potential adopters buy new cars annually (~735,000 potential customers for EVs per year).

This Fermi estimate highlights a substantial market opportunity for EV startups, with segmentation analysis being crucial to effectively target these diverse potential customers. Machine learning could help identify specific subgroups (e.g., eco-conscious millennials or high-income tech enthusiasts), leading to more efficient marketing and product development strategies.

3.0   Data Collection

To kickstart the market segmentation analysis for our EV startup's upcoming launch in India, data acquisition by conducting thorough research across various sources is focused upon. The data collected from Kaggle includes key information such as top EV makers, operational electric vehicles (EVs), registration numbers, and sales trends. These insights are crucial for analyzing market dynamics and shaping our segmentation strategy for the upcoming EV startup launch in India.

This dataset offers a comprehensive view of the electric vehicle (EV) market in India from 2001 to 2024, detailing monthly sales figures, manufacturer-specific sales data, and sales data segmented by vehicle class. It is an invaluable resource for conducting market analysis, forecasting trends, and studying the adoption and growth of EVs in India.

- **EV Maker by Place**: A list of popular EV manufacturers along with the locations of their production plants.
- **Operational PC**: The number of operational public charging stations available in each state.
- **Vehicle Class**: A record of vehicles (both electric and other fuel types) registered across different categories from 2001 to August 2024.
- **ev_cat_01-24**: Data on the total number of electric vehicles manufactured from 2001 to August 2024, organized by vehicle category.
- **ev_sales_by_makers_and_cat_15-24:** Information on the total electric vehicles produced by various manufacturers from 2015 to August 2024, categorized by vehicle class.
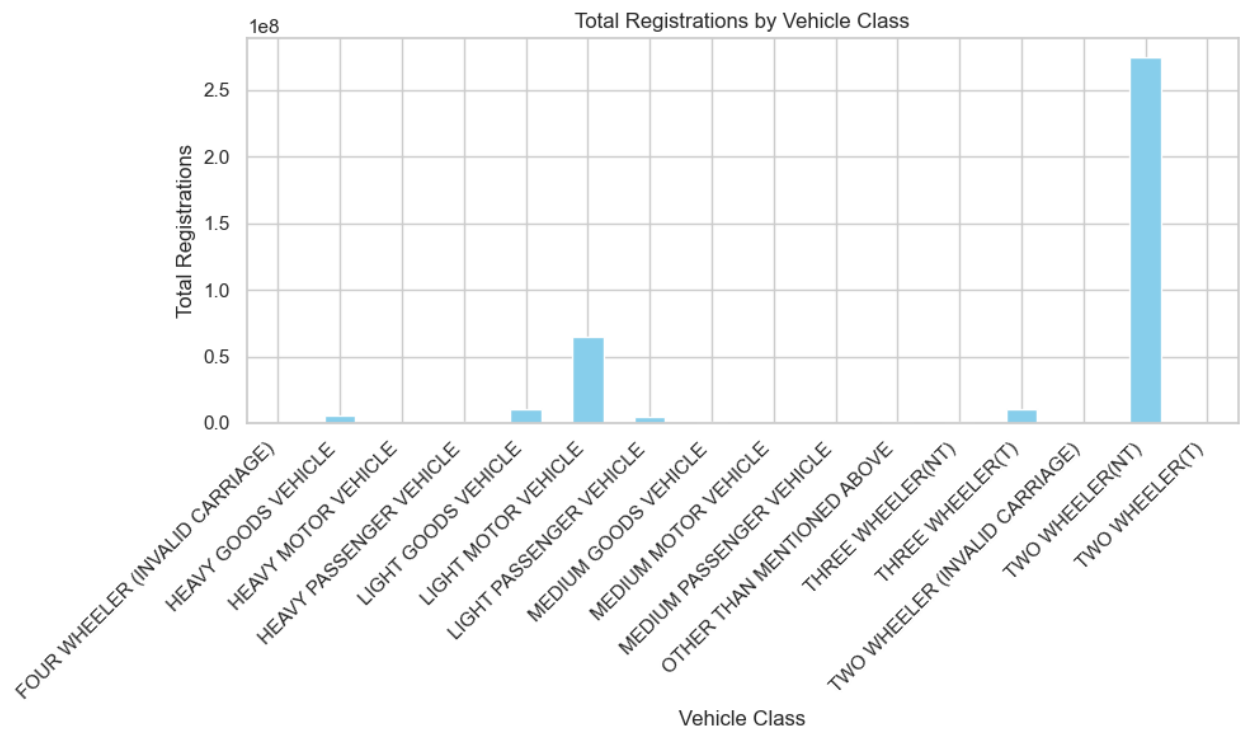
4.0   Exploratory Data Analysis and Visualizations

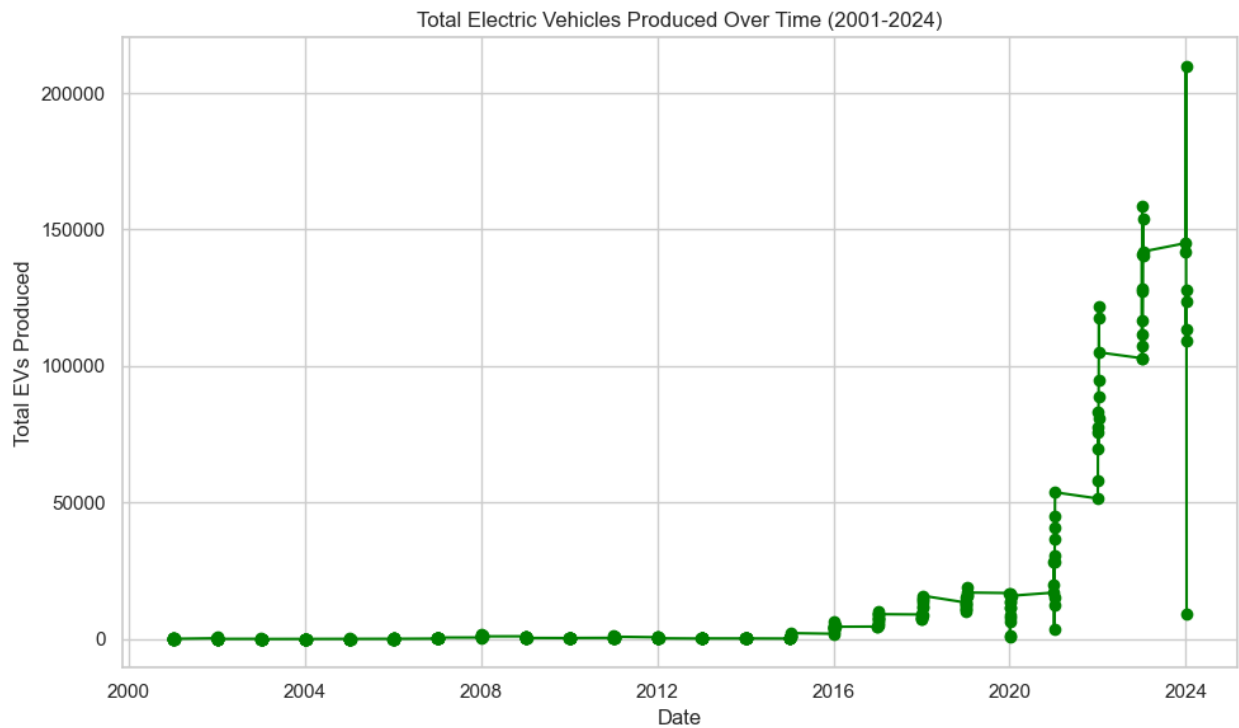**Number of Operational Public Charging Stations by State**

Number of Operational Public Charging Stations by State
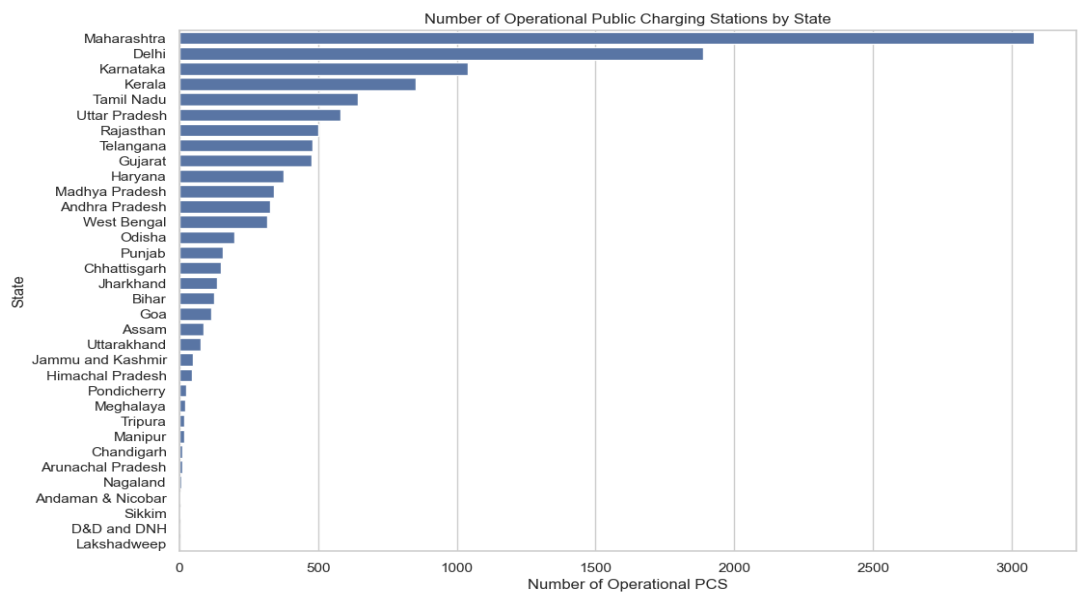
Number of EV Makers by State
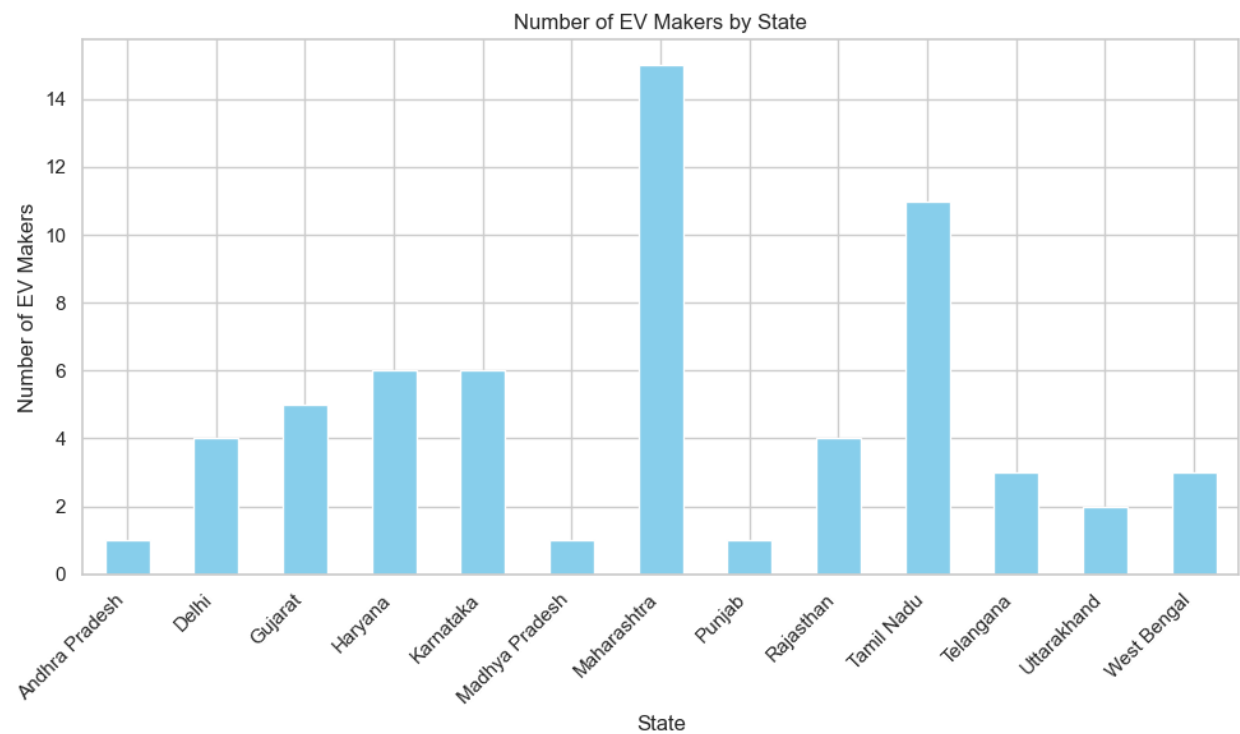
Total Registrations by Vehicle Class

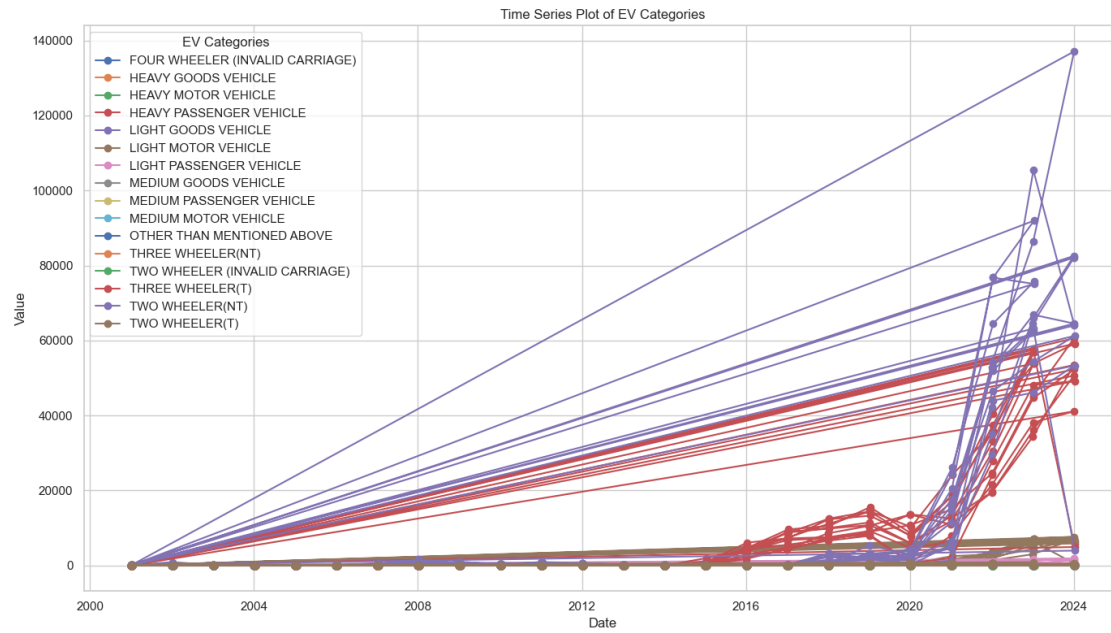## Total Electric Vehicles Produced Over Time (2021-2024)

Total Electric Vehicles Produced Over Time (2001-2024)

Distribution of Total Registrations by Vehicle Class

Distribution of Total Registrations by Vehicle Class

Time Series Plot of EV Categories
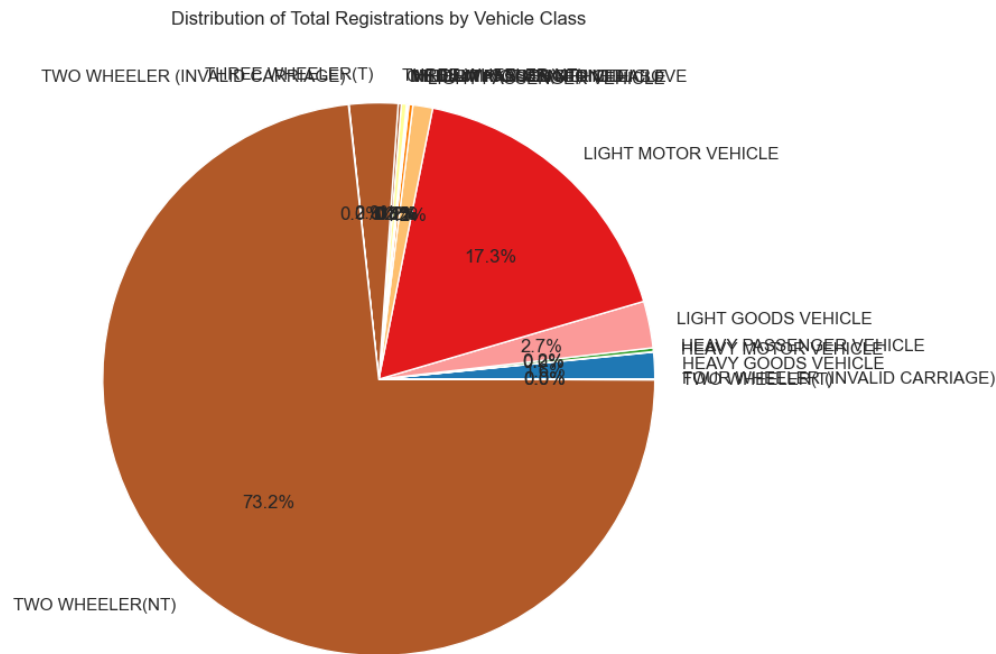
Time Series Plot of EV Categories

5.0   Segment Extraction

K-means clustering is an unsupervised machine learning algorithm used to group similar data points into clusters. The goal is to partition the data into 'k' distinct groups based on their feature similarity.

After clustering, PCA is applied to reduce the dataset to two dimensions. This makes it easier to visualize the clusters in a 2D space, allowing for intuitive interpretation of the results.

2D PCA of K-Means Clustering
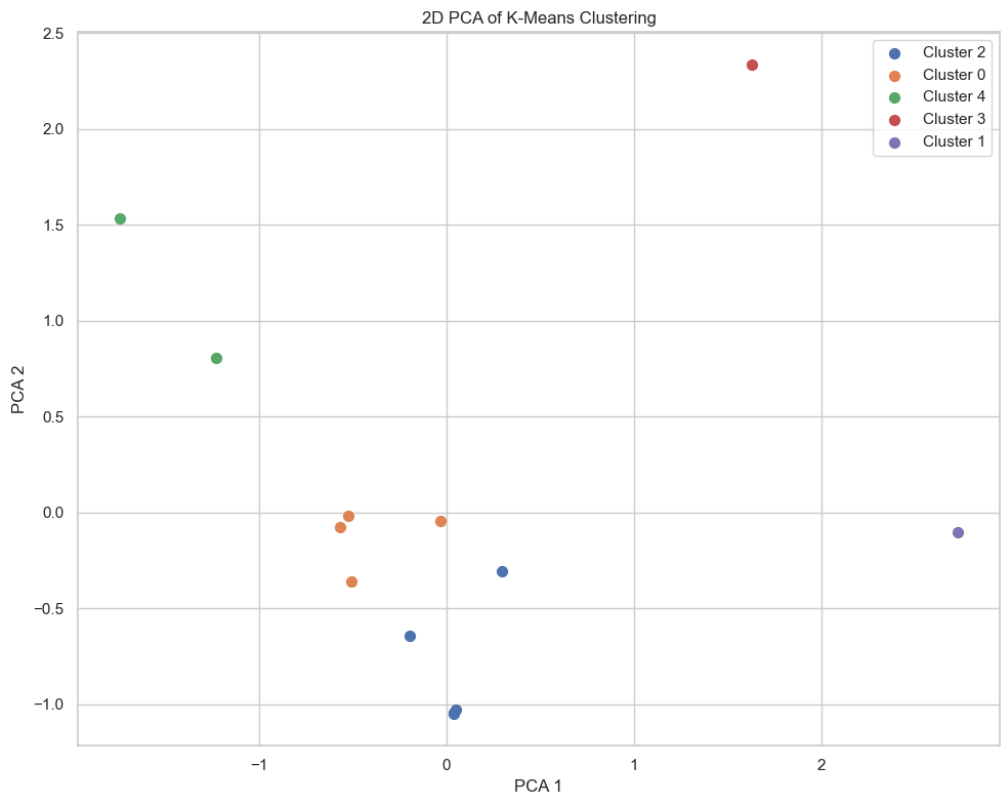
Number of Data Points in Each Cluster
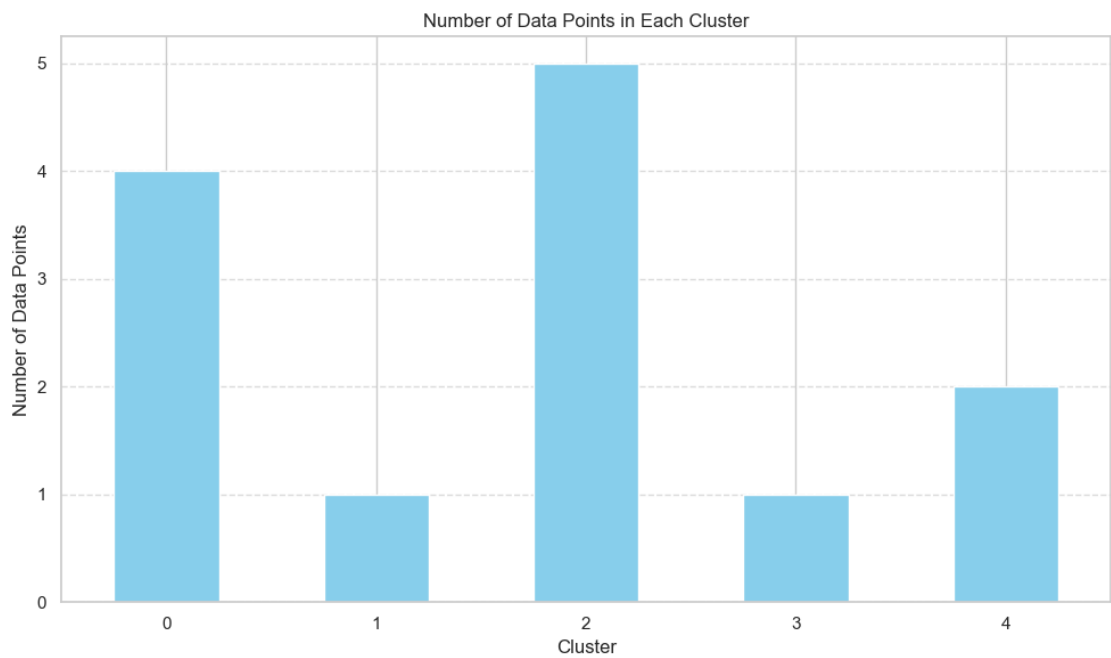
Average Number of Operational PCS by Cluster

Average No. of Operational PCS by Cluster

6.0   Profiling Segments

Here is an output of segment profiling

```
Cluster 2 Summary:
      No. of Operational PCS  Total Sales  Number of Makers  Cluster
count            5.000000          5.0          5.000000       5.0
mean            87.400000          0.0          1.600000       2.0
std            162.807555          0.0          0.894427       0.0
min              1.000000          0.0          1.000000       2.0
25%              3.000000          0.0          1.000000       2.0
50%             12.000000          0.0          1.000000       2.0
75%             44.000000          0.0          2.000000       2.0
max            377.000000          0.0          3.000000       2.0
Cluster 0 Summary:
      No. of Operational PCS  Total Sales  Number of Makers  Cluster
count            4.000000          4.0          4.000000       4.0
mean           136.500000          0.0          5.250000       0.0
std            135.711704          0.0          0.957427       0.0
min              9.000000          0.0          4.000000       0.0
25%             66.750000          0.0          4.750000       0.0
50%            105.000000          0.0          5.500000       0.0
75%            174.750000          0.0          6.000000       0.0
max            327.000000          0.0          6.000000       0.0
Cluster 4 Summary:
      No. of Operational PCS  Total Sales  Number of Makers  Cluster
count            2.000000          2.0          2.000000       2.0
mean           131.000000          0.0         13.000000       4.0
std             25.455844          0.0          2.828427       0.0
...
25%            476.0             31.0              3.0           1.0
50%            476.0             31.0              3.0           1.0
75%            476.0             31.0              3.0           1.0
max            476.0             31.0              3.0           1.0
```

6.1   Cluster 2 Summary

➢ **Number of Operational PCS**:

- **Count**: 5 (indicating there are 5 data points in this cluster).
- **Mean**: 87.4 operational PCS (indicating an average).
- **Standard Deviation (std)**: 162.8 (indicating variability in the number of operational PCS).

- **Min/Max**: The range of operational PCS goes from 1 to 377.

> **Number of Makers**:

- **Mean**: 1.6 makers (suggesting that most observations have either one or two makers).
- **Range**: Minimum of 1 maker to a maximum of 3 makers.

6.2   Cluster 0 Summary

> **Number of Operational PCS**:

- **Count**: 4 (indicating there are 4 data points in this cluster).
- **Mean**: 136.5 operational PCS.
- **Standard Deviation**: 135.7 (indicating variability).
- **Min/Max**: Ranges from 9 to 327 operational PCS.

> **Number of Makers**:

- **Mean**: 5.25 makers, which indicates a higher average number of makers compared to Cluster 2.
- **Range**: Minimum of 4 to a maximum of 6 makers.

6.3   Cluster 4 Summary

> **Number of Operational PCS**:

- **Count**: 2 (indicating only 2 data points in this cluster).
- **Mean**: 131 operational PCS.
- **Standard Deviation**: 25.5 (indicating less variability compared to the other clusters).
- **Min/Max**: Both data points have the same values (476 operational PCS).

➢ **Number of Makers**:

- **Mean**: 13 makers, which is significantly higher than in the other clusters.
- Both observations have the same values for this feature.

7.0 Selection of Target Segment

From the analysis, **Cluster 4** appears to be the most promising target segment. It has:

- A substantial number of operational charging stations.
- A high number of vehicle makers, indicating a competitive market with options for consumers.
- Recorded sales, suggesting existing demand and market viability.
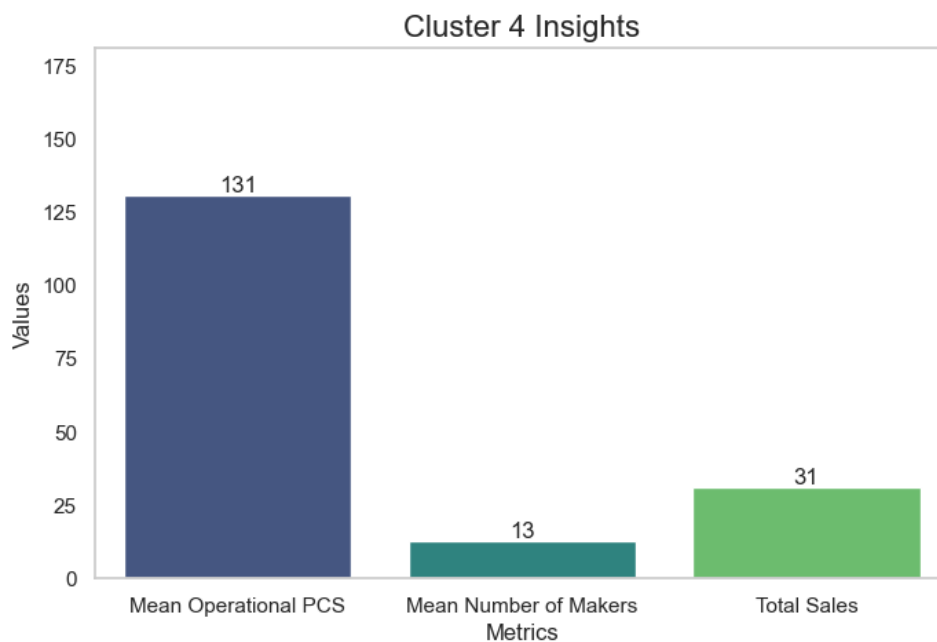
7.1 Leveraging Strategies

- **Marketing Campaigns**: Focus on increasing awareness and highlighting the advantages of EVs.

- **Partnerships**: Collaborate with vehicle makers in this cluster to enhance product availability and consumer choice.
- **Consumer Incentives**: Introduce incentives to encourage EV adoption in areas with operational charging stations.

8.0   Customizing the Market Mix

8.1   Product

- **Variety of Offerings**: Introduce a range of electric vehicles (EVs) that cater to different consumer preferences (e.g., sedans, SUVs, commercial vehicles).
- **Technology Features**: Highlight advanced features like fast charging, smart connectivity, and enhanced safety features, as consumers in this segment may value innovation.
- **Sustainability**: Emphasize the environmental benefits of EVs, including lower emissions and sustainability initiatives related to the production and lifecycle of the vehicles.

8.2   Price

- **Competitive Pricing**: Analyze competitors' pricing in Cluster 4 and set prices that offer good value while remaining competitive.
- **Financing Options**: Provide flexible financing plans, such as low-interest loans or lease options, to make EVs more accessible to consumers.
- **Incentives and Rebates**: Offer promotional discounts or government-backed incentives for EV purchases to encourage adoption.

8.3   Place

- **Distribution Channels**: Partner with local dealerships in the region that cater to this cluster. Ensure they have adequate training to sell and support EVs.

- **Charging Infrastructure**: Work with local governments or private entities to expand charging stations, ensuring they are conveniently located in areas with high EV ownership.
- **Online Sales**: Develop an online platform for easy purchasing and information access, including virtual tours of vehicles and home delivery options.

8.4   Promotion

- **Targeted Advertising**: Use data analytics to target potential customers in Cluster 4 with tailored digital marketing campaigns through social media and online platforms.
- **Community Engagement**: Organize local events or workshops to educate consumers about EVs and their benefits, allowing potential buyers to test-drive vehicles.
- **Partnerships**: Collaborate with environmental organizations to promote sustainability initiatives and align your brand with eco-friendly values.

9.0   Potential Profit

$$\boxed{\textbf{Potential Profit = Potential Customer Base} \times \textbf{Target Price Range}}$$

- **Potential Customer Base**: Assume you estimate that there are 1,000 potential customers in Cluster 4.
- **Target Price Range**: Let's say the average price of your electric vehicles is ₹22,00,000.

Calculation:

$$\text{Potential Profit} = 1,000 \text{customers} \times ₹22,00,000 = ₹2,20,00,00,000$$

10.0 Most Optimal Market Segments to open in the market

➢ **Urban Professionals (Cluster 4)**

- **Characteristics**: High disposable income, eco-conscious, and looking for sustainable commuting options.
- **Potential**: This segment is expected to yield significant profits due to their willingness to invest in premium electric vehicles.
- **Target Price Range**: ₹20,00,000 - ₹30,00,000.
- **Estimated Customer Base**: 1,000 potential customers.

➢ **Fleet Operators**

- **Characteristics**: Businesses looking to convert their fleets to electric to reduce operational costs.
- **Potential**: High volume sales with a focus on lower-cost models that promise savings on fuel and maintenance.
- **Target Price Range**: ₹15,00,000 - ₹20,00,000.
- **Estimated Customer Base**: 500 potential fleet customers.

➢ **First-Time EV Buyers (Mid-Range)**

- **Characteristics**: Customers transitioning from traditional vehicles, seeking affordable and efficient alternatives.
- **Potential**: Moderate profit margins with a larger customer base, making it a crucial segment for growth.
- **Target Price Range**: ₹10,00,000 - ₹15,00,000.
- **Estimated Customer Base**: 2,000 potential customers.

➢ **Environmentally Conscious Families**

- **Characteristics**: Families looking for eco-friendly options for their daily commuting.
- **Potential**: Steady demand for family-oriented electric vehicles with spacious interiors.
- **Target Price Range**: ₹12,00,000 - ₹18,00,000.
- **Estimated Customer Base**: 1,500 potential customers.