Electric Vehicle Market Segmentation Analysis

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Project Report Submission: EV Market Segmentation Analysis & Recommendations

This document presents a comprehensive analysis of the electric vehicle (EV) market segmentation and offers strategic recommendations tailored for startup companies. The report encapsulates the collaborative efforts of our entire team, whose individual contributions are detailed within. Additionally, our project and findings can be further explored through our GitHub repository.

GitHub Links:

https://github.com/Iswaryaparthi/EV_Market_Segmentation_Analysis

https://github.com/Nivetha-15/Electric-Vehicle-Market

https://github.com/clutch-god27/Market-Segmentation-Feynn-Labs

https://github.com/Samplergithub769/Indian-EV-Market-from-2001---2024

https://github.com/MohammedEhteshamAleem/EV_Market

https://github.com/uddhav724/Ev-market-analysis

Comprehensive Analysis of Electric Vehicle Market Segmentation in India

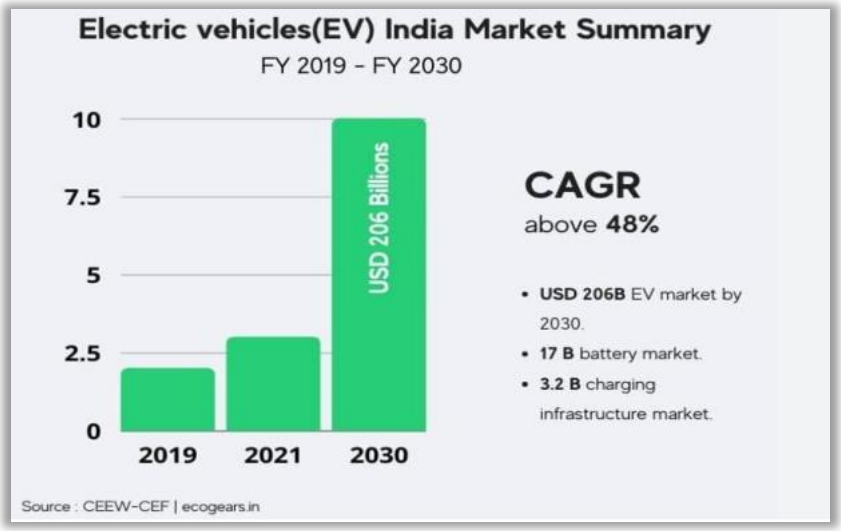
- Iswaryalakshmi

Introduction

India's Electric Vehicle (EV) sector is experiencing rapid growth, fuelled by government incentives, rising environmental concerns, and technological advancements. With initiatives like the Faster Adoption and Manufacturing of Hybrid and Electric Vehicles (FAME) scheme, India aims to significantly increase EV adoption, revolutionizing its transportation landscape towards sustainability and innovation.

India has established an objective to elevate the proportion of Electric Vehicle (EV) sales to 30% in private cars, 70% in commercial vehicles, 40% in buses, and 80% in two-wheelers and three-wheelers by the year 2030. This equates to an ambitious objective of 80 million EVs on Indian roads by 2030. Additionally, India strives for complete domestic EV production through the 'Make in India' initiative.

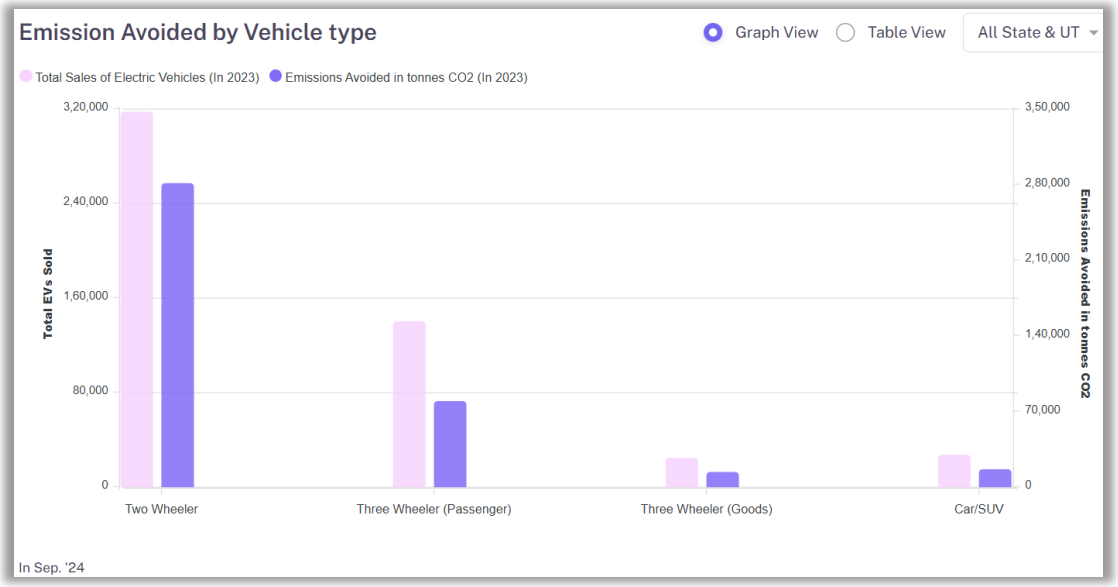
In 2023, the global electric vehicle market was valued at US$ 255.54 billion. It is forecasted to reach approximately US$ 2,108.80 billion by 2033, growing at a significant CAGR of 23.42% from 2024 to 2033.



India’s electric vehicle market is likely to reach Rs 20 trillion by 2030, and is expected to create around 50 million jobs in the EV ecosystem, said Road Transport and Highways Minister Nitin Gadkari in his message while addressing the ‘8th Catalyst Conference on Sustainability of E-Vehicle Industry-Evexpo 2024’. He said that by 2030, the finance market for electric vehicles is estimated to reach Rs 4 trillion.

Attributing 40 per cent of India’s air pollution to the transport sector, he appealed to the EV manufacturers to expand the production capacity while maintaining high-quality standards to meet the fast-growing domestic as well as export demand.

“The global focus on green energy presents enormous opportunities for India’s EV industry,” Gadkari said, adding the need for advanced technology and quality adherence in order to corner international markets.



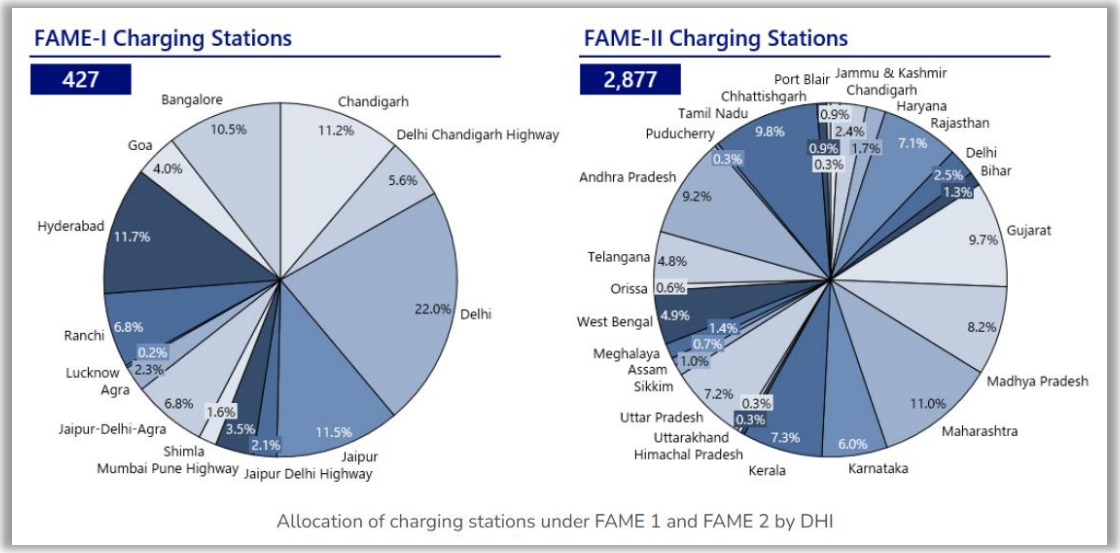
India’s current EV market

In May 2024, electric vehicle sales in India surged by 20.88% to 1.39 million units.

In 2023, electric vehicle sales in India saw a significant increase of 49.25%, reaching 1.52 million units. Although the sector is still in its early stages, it is steadily gaining traction. According to Fortune Business Insights, the Indian EV market is forecasted to expand from US$ 3.21 billion in 2022 to US$ 113.99 billion by 2029, with a 66.52% CAGR.

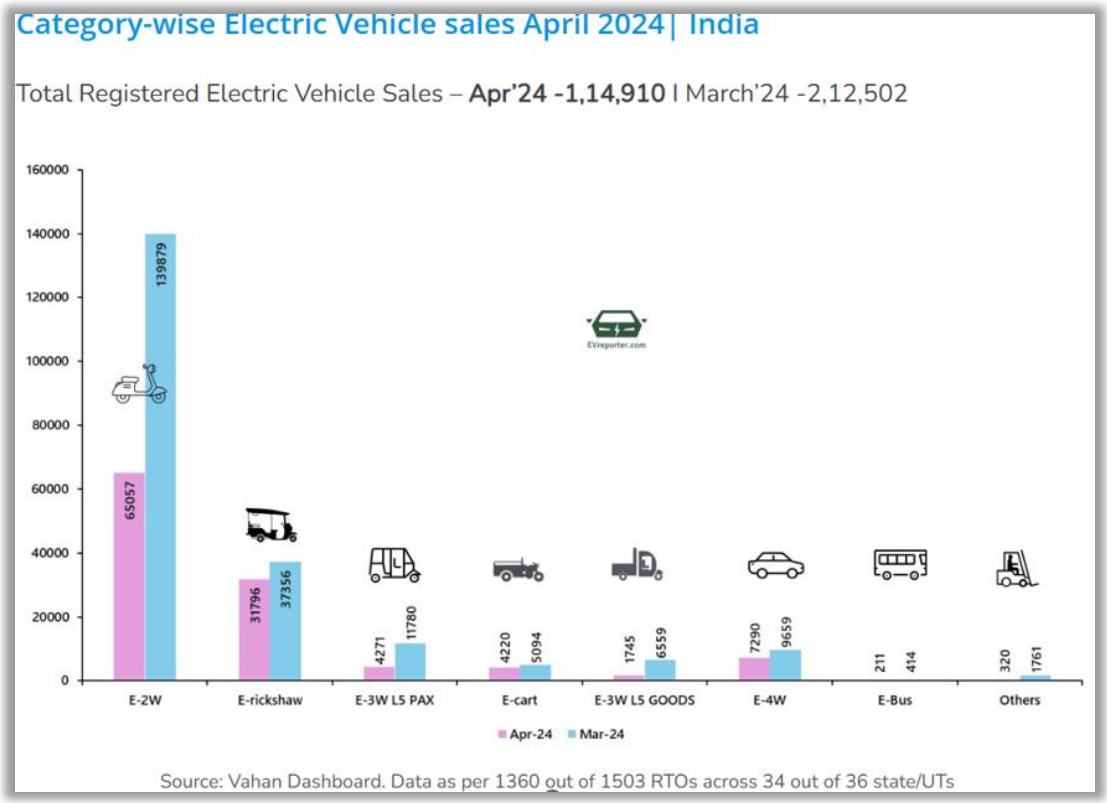
The shift towards electric vehicles on a global scale will create fresh opportunities for automotive suppliers. The Indian EV battery market is projected to surge from US$ 16.77 billion in 2023 to a remarkable US$ 27.70 billion by 2028.

On the infrastructure side, as of February 2024, there are 12,146 operational public EV charging stations nationwide, Maharashtra has the highest number of EV charging stations, followed by Delhi and other states. A recent Confederation of Indian Industry (CII) report emphasized the necessity of establishing at least 1.32 million charging stations in India by 2030 to facilitate the rapid growth of electric vehicles, requiring over 4,00,000 installations annually.



Major industry players are striving to improve electric vehicle charging infrastructure, Hyundai Motor India is enhancing accessibility to electric vehicles nationwide, expanding its ultra-fast EV charging network with 11 new stations strategically located in cities including Mumbai, Pune, Ahmedabad, Hyderabad, Gurugram, and Bangalore, as well as along major highways.

Maharashtra targets 10% share of EVs in all new vehicle registrations by Dec 2025. Karnataka has set a goal to electrify 100% of three and four-wheeler cargo vehicles by December 2030.



Project Objectives

1. Consumer Behaviour Analysis
    - Investigate factors influencing EV adoption, including demographics, environmental concerns, cost savings, and technological preferences.
    - Segment customers based on age, income, and other relevant factors to identify distinct market profiles.
2. Charging Infrastructure and Its Impact
    - Analyze the distribution and availability of public charging stations across different regions.
    - Study the impact of charging infrastructure on EV adoption rates and propose strategies to improve accessibility.
3. Economic and Environmental Impact
    - Compare the total cost of ownership of EVs versus traditional internal combustion engine vehicles.
    - Assess the environmental benefits of EV adoption, including reductions in greenhouse gas emissions and air pollutants.
4. Market Trends and Penetration
    - Examine the growth and penetration of EVs across various vehicle categories, such as two-wheelers, three-wheelers, four-wheelers, and public transport.
    - Identify high-growth segments and barriers to adoption in low-growth segments.
5. Manufacturer Strategies and Geographic Distribution
    - Evaluate the strategies of leading EV manufacturers and their competitive positioning.
    - Analyze the geographic distribution of EV manufacturers to identify regional hubs and opportunities for expansion.

Methodology

- Data Collection: Gathered data from various sources, including customer surveys, government reports, industry publications, and market research.
- Data Analysis: Use statistical and machine learning techniques to segment customers, analyze trends, and assess economic and environmental impacts.
- Visualization: Create visualizations to present key findings, such as consumer profiles, market trends, and charging station distribution.

- Recommendations: Develop strategic recommendations based on the analysis, tailored to different stakeholders such as manufacturers, policymakers, and consumers.

Key Deliverables

- Comprehensive Report: A detailed report covering all aspects of the analysis, including consumer behaviour, charging infrastructure, economic and environmental impacts, market trends, manufacturer strategies, and policy recommendations.
- Executive Summary: A concise summary of key findings and recommendations for quick reference by stakeholders.
- Visualizations: Infographics, charts, and maps to visually represent the data and insights.

Ideas and Recommendations on EV Market Segmentation for a Startup

Based on a comprehensive analysis of various datasets, I have identified key insights and trends in the electric vehicle (EV) market. My analysis covered customer segmentation, public charging station distribution, EV vehicle registration trends, and the geographic distribution of EV manufacturers. Leveraging these insights, I have formulated a set of strategic recommendations tailored to address the diverse needs and preferences of potential EV adopters.

The key datasets analysed include:

1. **Customer Data:** Segmentation of customers based on age, income, environmental friendliness, cost savings, and performance preferences.
2. **Public Charging Stations Data**: Distribution of charging stations across different states in India and **EV Vehicle Registration Trends**: Growth and penetration of EVs across various vehicle categories.
3. **EV Manufacturers by Place**: Geographic distribution of EV manufacturers across different states.

1. Customer Segmentation and Product Strategy

Cluster 0: Balanced Customers

- **Profile**: Middle-aged, financially stable, and value a mix of performance, environmental benefits, and cost-effectiveness.
- **Target Product**: Mid-range EV with moderate pricing, decent range, and good performance.
- **Marketing Approach**: Emphasize value-for-money, reliability, and a balanced approach to performance and eco-friendliness.

- **Distribution**: Expand into suburban or smaller cities where middle-aged, financially stable customers are located.

Cluster 1: Budget-Conscious, Low-Preference Customers

- **Profile**: Younger, limited financial means, lower interest in EV benefits.
- **Target Product**: Entry-level, low-cost EVs with basic features.
- **Marketing Approach**: Highlight affordability, cost savings, and basic functionalities. Focus on urban, budget-conscious youth.
- **Education Campaigns**: Promote cost savings, environmental benefits, and long-term value through marketing campaigns.

Cluster 2: Environmentally Conscious, High-Performance Seekers

- **Profile**: Relatively young to middle-aged, eco-conscious, and performance-oriented.
- **Target Product**: Premium EVs with advanced technology, high performance, and eco-friendly features.
- **Marketing Approach**: Promote premium features, cutting-edge technology, and environmental impact.
- **Distribution**: Focus on urban areas where eco-conscious customers are likely concentrated.

2. Public Charging Station Insights

- **Key States**: Karnataka, Maharashtra, Delhi, Gujarat, Haryana.
- **Strategy**: Collaborate with charging station providers to ensure adequate public charging infrastructure, particularly in key states with high EV adoption and for Clusters 0 and 2 who value performance and usability.

3. EV Vehicle Registration Trends

High-Growth Segments

- **Three-Wheeler**: Highest EV penetration, indicating strong adoption trends driven by affordability, government subsidies, and demand for cost-efficient transportation.
- **Two-Wheeler**: Rapid growth but still lagging compared to three-wheelers; consistent growth signals a shift in consumer preferences.

Low-Growth Segments

- **Goods Vehicles and Four-Wheeler**: Slower adoption rates due to barriers such as high costs and lack of suitable infrastructure.

Recommendations

- **Market Dynamics**: Focus on high-growth segments for faster adoption and penetration.
- **Address Barriers**: Invest in infrastructure and incentives to overcome barriers in low-growth segments.

4. Manufacturer Insights

- **Leading States**: Maharashtra, Tamil Nadu, Haryana, Karnataka, Gujarat.
- **Regional Hubs**: Leverage the dominance of top states for manufacturing and explore opportunities for growth and expansion in other regions.

General Recommendations

- Develop three distinct product lines catering to different clusters.
- Tailor marketing approaches to target specific segments effectively.
- Focus on urban areas for high-growth clusters and expand into suburban regions for balanced clusters.
- Invest in education campaigns and infrastructure support to enhance EV adoption.

Reference Articles & Websites:

https://parivahan.gov.in/

https://www.data.gov.in/

https://e-amrit.niti.gov.in/home

https://evreadyindia.org/

https://www.business-standard.com/industry/auto/india-electric-vehicle-market-growth-jobs-manufacturing-2030-124122000400_1.html

https://data.mendeley.com/

https://www.sciencedirect.com/

https://www.kaggle.com/

https://evreporter.com/ev-charging-infrastructure-india-status-challenges/

MARKET SEGMENT ANALYSIS
ELECTRIC VEHICLE MARKET

-Nivetha

Introduction:

The electric vehicle (EV) market has experienced rapid growth in recent years, driven by advancements in technology, increasing environmental concerns, and supportive government policies. EVs, which include both battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs), are reshaping the global automotive industry and paving the way for a sustainable future.

Global Market Size and Growth:

The global EV market was valued at over $200 billion in 2023 and is projected to grow at a compound annual growth rate (CAGR) of more than 20% through 2030.Key growth regions include North America, Europe, and Asia-Pacific, with China leading in EV production and sales. Increasing consumer awareness of environmental issues and lower operating costs of EVs are driving adoption. Government incentives, including tax credits, subsidies, and exemptions from tolls, have played a critical role in accelerating EV purchases.

Improvements in battery technology, such as higher energy densities and reduced costs, are making EVs more affordable and practical. The development of faster charging infrastructure is addressing consumer concerns about range anxiety. Many countries have announced plans to phase out internal combustion engine (ICE) vehicles, with ambitious targets for 100% EV adoption by 2035 or earlier. Emission regulations and carbon-neutrality goals are pushing automakers to invest heavily in EV production.

Segment Analysis

The EV market can be segmented based on vehicle type, powertrain, and end-user. Here is an overview of each segment:

Passenger Vehicles Comprise the largest segment of the EV market, driven by high consumer demand and government incentives. Examples include Tesla Model 3, Nissan Leaf, and BYD Tang.

Commercial Vehicles Adoption of electric buses and delivery vans is increasing, particularly in urban areas to meet emission reduction targets. Companies like Rivian and Arrival are investing heavily in this segment.

Two- and Three-Wheelers Popular in Asia-Pacific, these vehicles offer an affordable and efficient solution for short-distance travel.

Battery Electric Vehicles (BEVs) Fully electric vehicles powered by rechargeable batteries, accounting for the majority of EV sales. Plug-in Hybrid Electric Vehicles (PHEVs) Combine internal combustion engines with batteries, offering extended range and flexibility. Fuel Cell Electric Vehicles (FCEVs) Use hydrogen fuel cells for energy, a growing segment but currently limited by infrastructure.

Individual Consumers Dominate the passenger vehicle market, driven by environmental awareness and lower total cost of ownership. Fleet Operators Ride-hailing companies and logistics firms are increasingly transitioning to EV fleets to reduce operational costs and comply with regulations.

Public Sector Governments are adopting electric buses and municipal vehicles to lead by example and achieve sustainability goals. Challenges in the EV Market Infrastructure Gaps Despite advancements, the lack of widespread charging infrastructure remains a significant barrier in many regions.

Battery Supply Chain Dependence on raw materials like lithium, cobalt, and nickel has created supply chain vulnerabilities and raised ethical concerns about mining practices. High Initial Costs Although EV prices are declining, the upfront cost remains higher than traditional ICE vehicles, limiting accessibility for some consumers.

Grid Readiness Increased EV adoption places additional demand on power grids, requiring upgrades to ensure reliable energy distribution.

Key Players in the Market Automakers:

Tesla, BYD, Nissan, General Motors, and Volkswagen are among the leaders in the EV market. Traditional automakers are transitioning their portfolios to include more EVs.

Battery Manufacturers Companies like CATL, LG Chem, Panasonic, and Samsung SDI dominate the EV battery production market. Charging Infrastructure Providers ChargePoint, EV-go, and Ionity are expanding charging networks to meet the growing demand.

MARKET SEGMENTATION:

Market segmentation in the electric vehicle (EV) market enables manufacturers and marketers to identify and address the unique needs of different consumer groups, facilitating targeted strategies and efficient resource allocation. Demographically, several factors influence EV adoption. Income level remains a key determinant, with higher-income consumers gravitating toward premium EV brands such as Tesla, Lucid Motors, and Rivian, known for their luxurious features and cutting-edge technology. On the other hand, middle-income households often opt for more budget-friendly models like Hyundai Ioniq, Chevrolet Bolt, or the Nissan Leaf, which offer a balance between affordability and performance.

Geographic Segmentation

Geographical- EV adoption varies based on infrastructure development and regional policies. Urban areas with robust charging networks and government-supported incentives witness higher EV penetration compared to rural regions, where limited access to charging stations can hinder adoption. Countries with strict emission regulations and financial benefits, such as subsidies and tax rebates for EV buyers, lead the market, with regions like Europe, China, and parts of North America driving global growth. Climate also plays a critical role, as colder regions often experience reduced battery efficiency, which can deter potential buyers unless cold-weather battery solutions are provided.

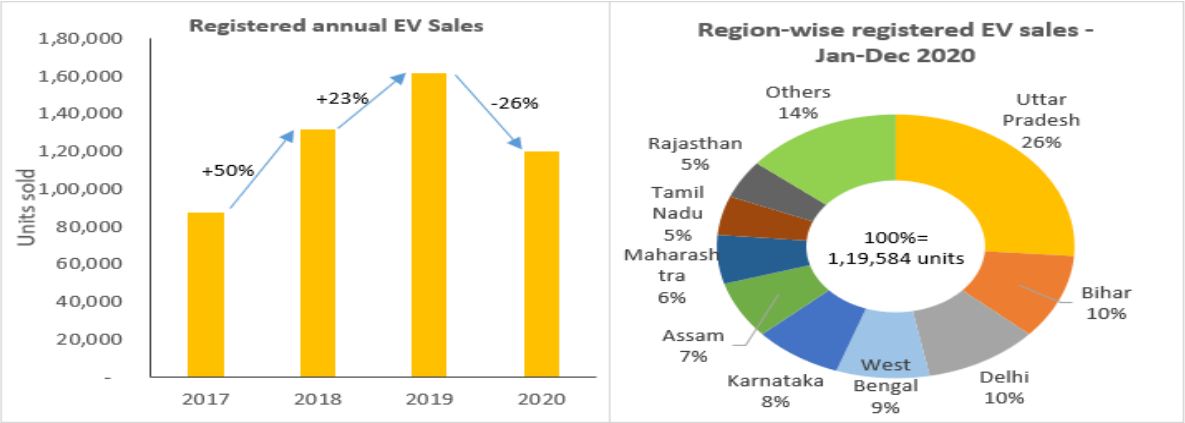
Psychographic Segmentation:

Psychographic factors highlight the importance of consumer values, lifestyles, and attitudes toward sustainability. Eco-conscious individuals who are motivated by environmental responsibility are naturally inclined toward EVs, viewing them as a way to reduce their carbon footprint. Tech enthusiasts are another crucial segment, drawn to innovative features like autonomous driving capabilities, AI-assisted driving aids, and over-the-air updates. These consumers value the advanced technological ecosystem EVs often offer, including smart charging apps and integration with home energy systems.

Behavioural Segmentation:

Behavioural segmentation sheds light on consumer habits, such as usage patterns, loyalty, and purchase motivations. Long-distance drivers and road-trip enthusiasts prioritize vehicles with extended range and access to a fast-charging network, while urban dwellers seek compact, cost-efficient models suited to city driving. Additionally, early adopters and brand-loyal customers form a crucial segment,

often influencing broader consumer trends and promoting trust in new EV technologies. Motivations for purchasing EVs vary, from saving on fuel costs and accessing government incentives to achieving social recognition and fulfilling personal commitments to sustainability**.**



Price-based segmentation:

Price-based segmentation is another critical factor in understanding the EV market. Consumers range from luxury buyers, who invest in high-end brands like Porsche Taycan or Tesla Model S, to cost-conscious individuals seeking affordable electric cars for everyday use. Fleet operators represent a separate segment, focusing on total cost of ownership, efficiency, and reliability. Companies in ride-hailing, logistics, and public transportation sectors are increasingly adopting EVs to reduce operational costs and meet sustainability goals.

Deep Learning:

Deep learning is a subset of machine learning that uses neural networks to automatically learn patterns from large datasets. It is widely used for tasks like image recognition, NLP, and speech processing. For example, in an image classification task, the model might use a Convolutional Neural Network (CNN) with layers like convolutional, pooling, and fully connected layers to predict labels based on input images. During training, loss functions like cross-entropy and optimization methods such as Adam are used. Results are evaluated using metrics like accuracy and confusion matrices.

For example, in an image classification task, a model might use a Convolutional Neural Network (CNN) with layers like convolutional, pooling, and fully connected layers to predict labels based on input images. The model could be trained to classify animals, distinguishing between categories like cats and dogs. During training, a loss function such as cross-entropy would be used, and an optimizer like Adam would adjust weights to minimize this loss.

To evaluate the model's performance, metrics like accuracy and confusion matrices would be used. For instance, after testing the model, we could measure how accurately it classifies a cat as "cat" and a dog as "dog" in a set of images, and the confusion matrix would show how often it misclassifies one animal for another. This helps identify areas of improvement, such as addressing specific misclassifications or increasing the dataset size.

Problem Statement:

The electric vehicle (EV) market is currently limited by several factors that hinder its widespread adoption. These challenges include the high initial purchase cost, inadequate charging infrastructure, and concerns about battery life and range. As a result, many consumers are hesitant to switch from traditional gasoline-powered vehicles, slowing down the transition to cleaner, more sustainable transportation options. Addressing these barriers is crucial for accelerating the adoption of EVs and achieving environmental sustainability goals.

Data Collection:

Data collected from various online sources, including platforms like **Kaggle**, **data.gov.in**, and Google Dataset Search which offer a wide range of datasets across different domains.

https://www.kaggle.com/datasets

https://www.data.gov.in/

https://datasetsearch.research.google.com/

```
import pandas as pd
import numpy as nd
import matplotlib.pyplot as plt
import tensorflow as tf
```

✓ 0.0s

```
data=pd.read_csv('data.csv',index_col=False)
data.head()
```

Data Pre-Processing

Preprocessing involves preparing raw data for analysis by cleaning and transforming it into a format suitable for modelling. This step includes handling missing values, correcting errors, removing duplicates, and standardizing or normalizing data to ensure consistency. Additionally, categorical variables might be encoded, and features may be scaled to improve model performance. The goal of preprocessing is to ensure the data is accurate, complete, and ready for analysis, enhancing the quality of insights drawn from the model.

```
data.info()
data.isnull().sum()
data.describe()
```

```
from sklearn.preprocessing import LabelEncoder
le=LabelEncoder()
data['RapidCharge']=le.fit_transform(data['RapidCharge'])
```
✓ 0.0s

```
data.drop(columns=['Segment'],axis=1,inplace=True)
```
✓ 0.0s

```
data.drop(columns=['Brand'],axis=1,inplace=True)
```
✓ 0.0s

```
data.drop(columns=['RapidCharge'],axis=1,inplace=True)
```

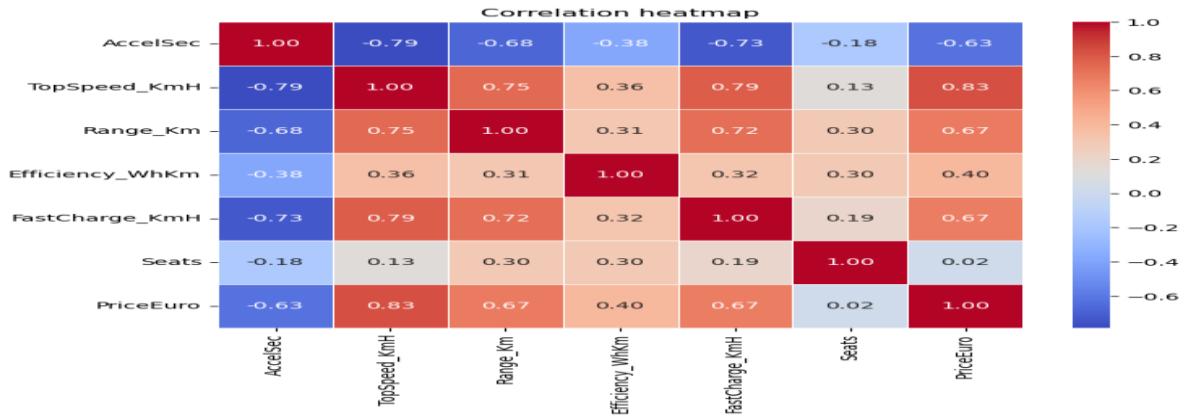
```
data1=pd.get_dummies(data,columns=['Model','PowerTrain','PlugType','BodyStyle']).astype(int)
```

Data Visualization:

Data visualization is the process of representing data in graphical or visual formats such as charts, graphs, and plots. It helps to uncover patterns, trends, and relationships within the data, making it easier to understand and interpret. Common tools for data visualization include bar charts, line graphs, histograms, scatter plots, and heatmaps. By using visualizations, complex datasets can be presented in an intuitive and engaging way, aiding decision-making, identifying anomalies, and communicating insights effectively to stakeholders.

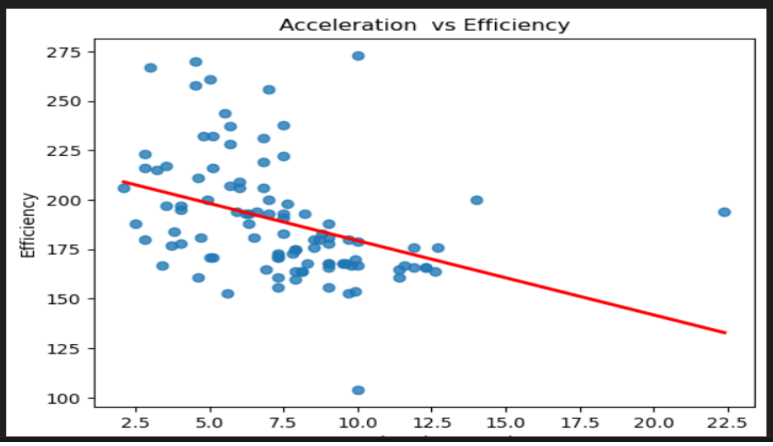
I focused on key factors such as top speed and range of electric vehicles. I performed a correlation analysis to examine how these factors relate to each other and other variables in the dataset. To visually represent these relationships, I used a heatmap to display the correlation matrix, allowing for easy identification of strong or weak correlations between variables.

```
data_numeric=data.select_dtypes(include=['number'])
cor=data_numeric.corr()
plt.figure(figsize=(8, 6))
sns.heatmap(cor, annot=True, cmap='coolwarm', fmt='.2f', linewidths=0.5)
plt.title('Correlation heatmap')
plt.show()
```



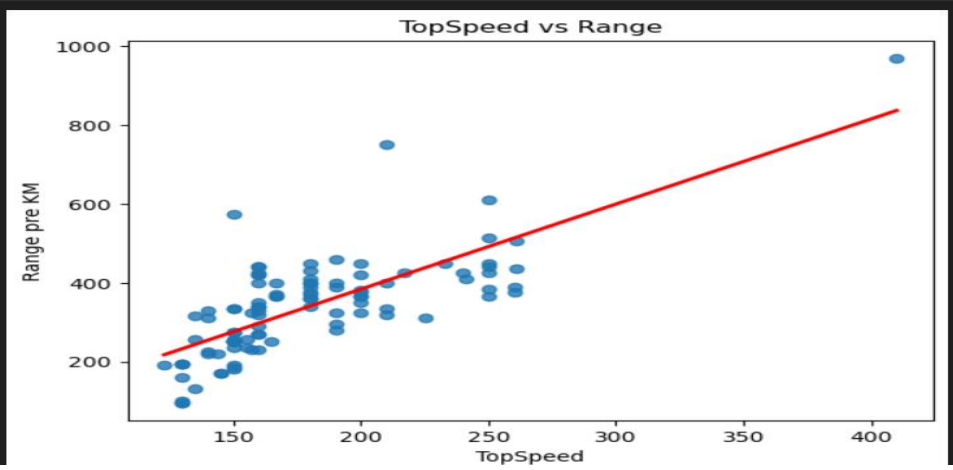

```
import seaborn as sns
sns.regplot(x=data['AccelSec'], y=data['Efficiency_WhKm'], ci=None, line_kws={"color": "red"})
plt.title('Acceleration  vs Efficiency')
plt.xlabel('Acceleration speed')
plt.ylabel('Efficiency')
plt.show()
```

✓ 0.1s




```
sns.regplot(x=data['TopSpeed_KmH'], y=data['Range_Km'], ci=None, line_kws={"color": "red"})
plt.title('TopSpeed vs Range')
plt.xlabel('TopSpeed')
plt.ylabel('Range pre KM')
plt.show()
```

✓ 0.1s



Feature Scaling And Train_Test:

Feature scaling is a technique used to standardize or normalize the range of independent variables (features) in a dataset. It ensures that no single feature dominates others due to differences in scale. Common methods include min-max scaling, which resizes the data to a fixed range (usually 0 to 1), and standardization, which transforms data to have a mean of 0 and a standard deviation of 1. Feature scaling is particularly important for algorithms that rely on distance calculations, like k-nearest neighbours or gradient descent-based models, as it helps improve model performance and convergence.

```
from sklearn.model_selection import train_test_split
X_train,X_test,y_train,y_test=train_test_split(X,y,test_size=0.2,random_state=0)
```

✓ 0.0s

```
from sklearn.preprocessing import StandardScaler
st=StandardScaler()
X_train=st.fit_transform(X_train)
X_test=st.transform(X_test)
```

✓ 0.0s

Model Processing:

In this project, a deep learning model was built and trained using the dataset, where the model learned patterns and relationships from the data. The training process included selecting an appropriate architecture, configuring hyperparameters, and optimizing the model using techniques like backpropagation. Once trained, the model was evaluated on its performance using metrics such as accuracy or loss, ensuring it could generalize well to new, unseen data.

```
ann=tf.keras.models.Sequential()
```

✓ 0.0s

```
ann.add(tf.keras.layers.Dense(units=128, activation='relu')) #input layer
ann.add(tf.keras.layers.Dense(units=64, activation='relu'))
ann.add(tf.keras.layers.Dense(units=1, activation='linear'))#output layer
```

✓ 0.0s

```
ann.compile(optimizer='adam',loss='mse',metrics=['mae'])
```

✓ 0.0s

```
ann.fit(X_train,y_train,batch_size=10,epochs=1500)
```

✓ 1m 15.1s

Model Prediction:

Model prediction involves using the trained deep learning model to make forecasts or classifications based on new, unseen data. After the model has been trained and validated, it is applied to predict

outcomes for test data or real-world input. The predictions are compared to actual values to evaluate the model's performance, and adjustments can be made to improve accuracy

```
# Reshaping y_test to a 2D array
y_test = nd.array(y_test)  # Convert y_test to NumPy array if it's a pandas Series
y_pred = ann.predict(X_test)

# Concatenate predictions and actual values
result = nd.concatenate((y_pred.reshape(len(y_pred), 1), y_test.reshape(len(y_test), 1)), axis=1)

print(result)
```

✓ 0.0s

Model Evaluation:

Model evaluation is the process of assessing the performance of a trained model using various metrics and techniques. It involves comparing the model's predictions against actual outcomes to measure its accuracy, precision, recall, or other relevant metrics. Common evaluation methods include using test datasets, cross-validation, and confusion matrices. This step helps identify how well the model generalizes to new data and whether it meets the desired performance criteria. Based on the evaluation results, the model can be refined or tuned to improve its accuracy and robustness.

```
from sklearn.metrics import mean_absolute_error, mean_squared_error, r2_score

# Calculate MAE, MSE, and R^2
mae = mean_absolute_error(y_test, y_pred)
mse = mean_squared_error(y_test, y_pred)
r2 = r2_score(y_test, y_pred)

print(f'Mean Absolute Error: {mae}')
print(f'Mean Squared Error: {mse}')
print(f'R-squared: {r2}')
```

✓ 0.0s

```
ean Absolute Error: 28494.83519345238
ean Squared Error: 1363120407.103779
-squared: 0.46426496542519646
```

Conclusion:

Deep learning model built for this project effectively learned patterns from the dataset and provided valuable predictions. Through preprocessing, feature scaling, and model training, we were able to optimize the model to handle key factors like top speed and range of electric vehicles. The model was evaluated using various metrics, ensuring it performed well on unseen data. While the model showed promising results, there may still be room for improvement through further tuning or exploring alternative architectures. Overall, the model demonstrates potential for making accurate predictions and providing insights into electric vehicle performance.

Analysing Market Segments

- Nikhil Joshi

There are several different variables by which segmentation is done:

Geographic segmentation Geographic segmentation consists of creating different groups of customers based on geographic boundaries. The needs and interests of potential customers vary according to their geographic location, climate and region, and understanding this allows you to determine where to sell and advertise a brand, as well as where to expand a business.

● Charging station by State wise: State wise charging station will become a significant effect on consumer purchasing decisions. Those states with more charging stations may prefer to buy an EV and vice versa.

Demographic segmentation consists of dividing the market through different variables such as age, gender, nationality, education level, family size, occupation, income, etc. This is one of the most widely used forms of market segmentation, since it is based on knowing how customers use your products and services and how much they are willing to pay for them.

● Income: Income levels have a significant effect on consumer purchasing decisions. Those with higher-income levels may prefer luxury vehicles. Conversely, individuals with lower income levels may prefer to get vehicles at the best deal and are likely to choose inexpensive products/services.

● Family size: Family size also determines consumers' purchase decisions. Those who have large family members may choose four wheelers and those who have less family members will choose two wheelers.

Psychographic segmentation Psychographic segmentation consists of grouping the target audience based on their behavior, lifestyle, attitudes and interests. To understand the target audience, market research methods such as focus groups, surveys, interviews and case studies can be successful in compiling this type of conclusion.

● Lifestyle: A consumer whose profession is more time consuming than other average consumers , that consumer may select a vehicle who takes less time to charge a vehicle. This group of consumers only focus on the time required to charge an EV.

● Interests : Some consumers may have interest in particular manufacturing companies. Some consumers may like only vehicles made by the Tata company.

● Behavior : Behavior of consumers is the most important factor in the market segment. It shows what exactly consumers want from us?. Some consumers may want an EV who will cover far distance per a charging. Customizing the Market Mix The marketing mix refers to the set of actions, or tactics, that a company uses to promote its brand or product in the market.

The 4Ps make up a typical marketing mix - Price, Product, Promotion and Place.

● Price: Refers to the value that is put for a product. It depends on costs of production, segment targeted, ability of the market to pay, supply - demand and a host of other direct and indirect factors. There can be several types of pricing strategies, each tied in with an overall business plan.

● Product: Refers to the item actually being sold. The product must deliver a minimum level of performance; otherwise even the best work on the other elements of the marketing mix won't do any good.

● Place: Refers to the point of sale. In every industry, catching the eye of the consumer and making it easy for her to buy it is the main aim of a good distribution or 'place' strategy. Retailers pay a premium for the right location. In fact, the mantra of a successful retail business is 'location, location, location'.

● Promotion: This refers to all the activities undertaken to make the product or service known to the user and trade. This can include advertising, word of mouth, press reports, incentives, commissions and awards to the trade. It can also include consumer schemes, direct marketing, contests and prizes.

All the elements of the marketing mix influence each other. They make up the business plan for a company and handle it right, and can give it great success. The marketing mix needs a lot of understanding, market research and consultation with several people, from users to trade to manufacturing and several others.

Recommendations and Learnings

The penetration of EV in India has Increased Significantly in the last five years as they are more efficient. In addition, growing fuel prices are further helping to boost substantial growth in the product adoption, mainly due to their extended range and efficiency.

The global Electric Vehicle Market size is projected to grow from 8,151 thousand units in 2022 to 39,208 thousand units by 2030, at a CAGR of 21.7%. Factors such as growing demand for low emission commuting and governments supporting long range, zero emission vehicles through subsidies & tax rebates have compelled the manufacturers to provide electric vehicles around the world.

Increasing investments by governments across the globe to develop EV charging stations and Hydrogen fueling stations along with incentives offered to buyers will create opportunities for OEMs to expand their revenue stream and geographical presence.

From this analysis we create different types of segments to affect consumers' purchasing decisions. Geographic segmentation is about places, cities, states that where consumers live will affect market sales. Like if a consumer lives in a rural area there may be less possibility of having charging stations and vice versa in urban areas. Now in 2022 yet we have only 1742 public charging stations available.

So if a consumer is from those states who have more available charging stations ,the probability of buying is more as compared to others who have less charging stations in their states. Demographic segmentation focuses on education level, family size, occupation, income, etc.

since it is based on knowing how customers use your products and services and how much they are willing to pay for them.

That depends on consumers' education, Financial status and purpose of buying EV’s. If a customer's purpose is to buy an EV for transporting goods in different cities or states, that customer will focus on the boot space and maximum range of a vehicle. On a psychological segment some customers may go for a product which gives them satisfaction and others may go with a product who is cheaper in cost and their other factors are average.

ELECTRIC VEHICLE MARKET SEGMENTATION ANALYSIS

Shaily Singh

Abstract

This project analyzes India's electric vehicle (EV) ecosystem, focusing on sales trends, market dynamics, and infrastructure development between 2015 and 2024. Using multiple datasets, the analysis covers key aspects such as EV sales by manufacturers, state-wise market presence, charging infrastructure, and vehicle categories. Key insights include year-over-year sales growth, overall market expansion, top-performing manufacturers, and market shares. The analysis highlights significant growth in EV adoption, with leading manufacturers like Ola Electric and TVS Motors dominating the market. Additionally, states such as Maharashtra emerge as leaders in EV manufacturing and public charging infrastructure. This comprehensive evaluation provides actionable insights into India's evolving EV landscape and its readiness to meet the increasing demand for sustainable transportation solutions.

1. Introduction

The global push for sustainable development and reduction in carbon emissions has driven the rapid adoption of electric vehicles (EVs) worldwide. India, as a key developing economy, has also seen a surge in EV adoption over the last decade. This study examines India's EV landscape by analyzing sales trends, leading manufacturers, and supporting infrastructure from 2015 to 2024. The objective is to evaluate the progress and challenges of transitioning to sustainable mobility in India.

2. Methodology

This analysis utilized multiple datasets containing information on EV sales, state-wise production data, market shares of manufacturers, and availability of public charging stations in India. The steps involved include:

- **Data Collection**

  The dataset used for the analysis was obtained from Kaggle, a trusted platform for open-source datasets.

  About Dataset

  This dataset provides a detailed overview of the electric vehicle (EV) market in India from 2001 to 2024. It includes monthly sales data, sales data categorized by manufacturer, and vehicle class-wise sales data for different manufacturers. This dataset

is ideal for market analysis, trend forecasting, and research on the adoption and growth of electric vehicles in India.

1. **EV Maker by Place**
    - List of popular EV Makers and their location of Manufacturing Plant.
2. **Operational PC**
    - Total Operational Public Charging Station for EV available in each state
3. **Vehicle Class**
    - Total vehicles (includes electric and all other fuels) registered (manufactured) by category from 2001 - Aug 2024
4. **v_cat_01-24**
    - Total electric vehicles manufactured from 2001 - Aug 2024 and vehicle category
5. **ev_sales_by_makers_and_cat_15-24**
    - Total electric vehicles manufactured by makers from 2015 - Aug 2024 with the vehicle class

- **Data Preprocessing**
    1. **Import Necessary Libraries**
        - **pandas:** For data manipulation and analysis.
        - **numpy:** For numerical operations and handling arrays.
        - **matplotlib.pyplot and seaborn:** For data visualization
    2. **Load the Dataset**

        The dataset is read from a CSV file using the pandas function read_csv().
    3. **Inspect the data**
        - **evsales.info():** to check the data types and identify missing values.
        - **evsales.isnull().sum():** command is used to detect the missing (null) values in the DataFrame evsales.
- **Exploratory Data Analysis (EDA)**

  Visualizing key trends in sales growth, manufacturer performance, and state-wise adoption.
    1. **Total Sales by Year**

We calculated the total sales across all categories for each year from 2015 to 2024.

Total Sales by Year

```
[37]: year_total = evsales.iloc[:,2:].sum()
      year_total
```

t[37]:

	0
2015	7752
2016	49249
2017	87019
2018	129763
2019	165786
2020	123770
2021	328854
2022	1020533
2023	1529234
2024	978943

2. **Year Over Year Growth**

   This calculates the Year Over Year (YoY) growth rate. The results show fluctuating growth rates, with some years experiencing a decline (e.g., 2020), while others show rapid growth (e.g., 2021-2022).

```
#calculate year over year growth
yoy_growth = year_total.pct_change()*100
yoy_growth
```

	0
2015	NaN
2016	535.307018
2017	76.691913
2018	49.120307
2019	27.760610
2020	-25.343515
2021	165.697665
2022	210.330116
2023	49.846600
2024	-35.984748

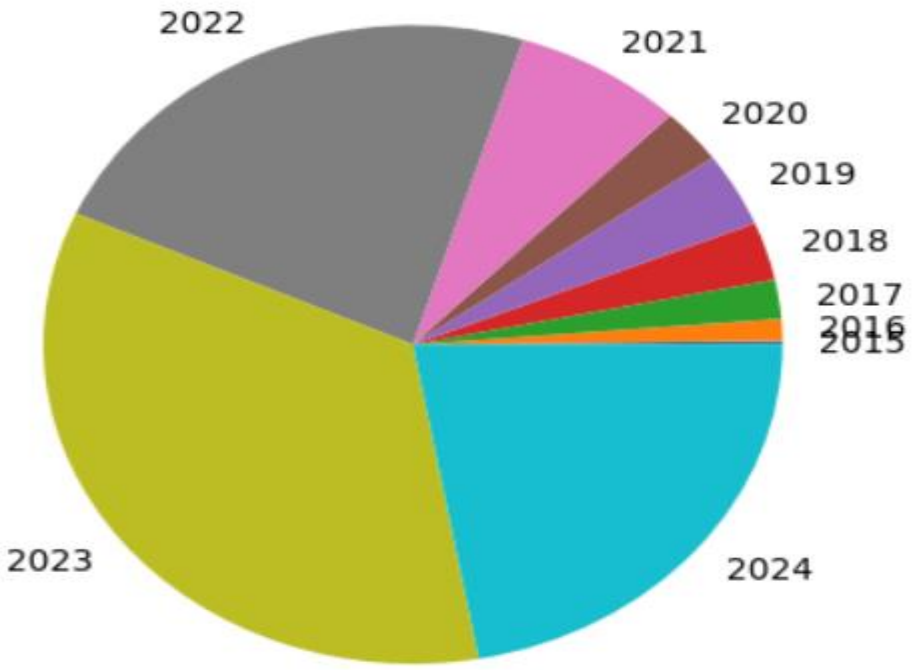
dtype: float64

3. **Plot Yearly Sales**

Plot Yearly Sales

```
year_total.plot(kind = 'pie')
```

```
<Axes: >
```



4. **Overall Growth from 2015 to 2024**

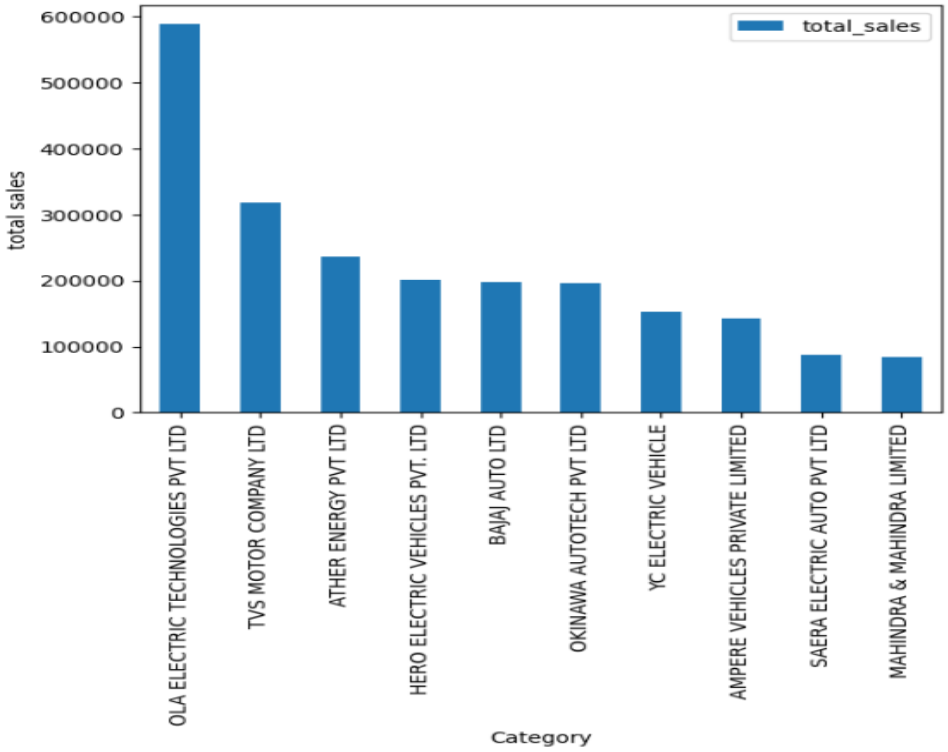
   The overall growth between 2015 and 2024 is an impressive **12,628%**.

5. **Manufacturer Performance: Total Sales per Manufacturer**
   - A new column total_sales is created by summing up the sales for each manufacturer over the years.
   - We group the data by manufacturer (Maker) and calculate their total sales.
6. **Top 10 Manufacturers**

Top 10 Manufacturers

```
#bar representation for top ten companies
df = Manufacturers_sales.iloc[:10,:]
df.plot(kind='bar', x='Maker', y='total_sales')
plt.xlabel('Category')
plt.ylabel('total sales')
```

```
Text(0, 0.5, 'total sales')
```



7. Market Share Calculation

The market share for each manufacturer is calculated by dividing their total sales by the total market sales.

```
Manufacturers_sales['market share(%)'] = (Manufacturers_sales['total_sales'] /total_market_sales)*100
```

```
Manufacturers_sales
```

	Maker	total_sales	market share(%)
738	OLA ELECTRIC TECHNOLOGIES PVT LTD	588266	13.306467
1056	TVS MOTOR COMPANY LTD	318445	7.203166
100	ATHER ENERGY PVT LTD	236387	5.347030
411	HERO ELECTRIC VEHICLES PVT. LTD	201785	4.564339
126	BAJAJ AUTO LTD	198498	4.489988
...	...	...	...
886	SAN MOTORS LIMITED	1	0.000023
443	IDEAL JAWA INDIA PVT LTD	1	0.000023
46	AKSMD RECHARGEABLE VEHICLES PVT LTD	1	0.000023
881	SAKTHI VIJAY INDUSTRIES	1	0.000023
944	SHRI RAM INDUSTRIES	1	0.000023

196 rows × 3 columns

8. Geographical Data Analysis

Count the number of EV makers operating in each state.

```
#count number of ev manufacturing by state
absev_market_by_state =ev_market_place.groupby('State')['EV Maker'].count().reset_index()
absev_market_by_state
```

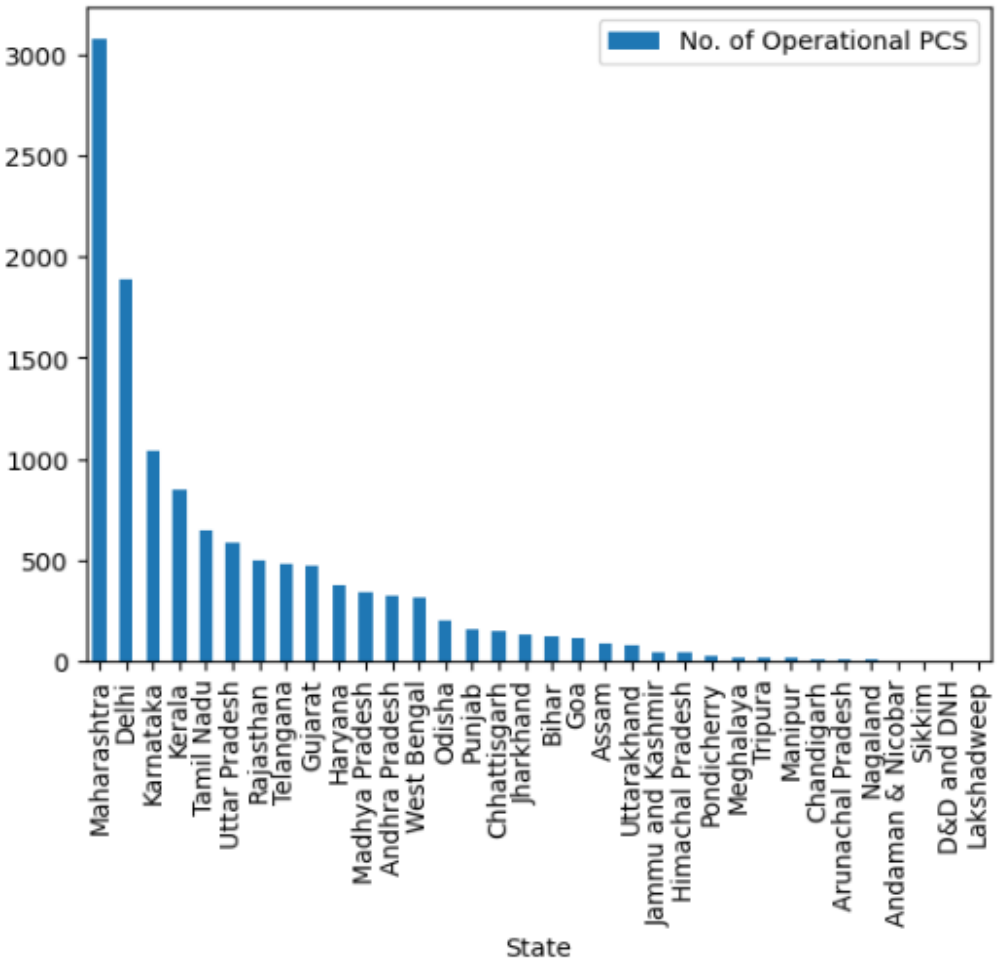
	State	EV Maker
0	Andhra Pradesh	1
1	Delhi	4
2	Gujarat	5
3	Haryana	6
4	Karnataka	6
5	Madhya Pradesh	1
6	Maharashtra	15
7	Punjab	1
8	Rajasthan	4
9	Tamil Nadu	11
10	Telangana	3
11	Uttarakhand	2
12	West Bengal	3

9. EV Charging Stations by State

The number of EV charging stations by state is visualized using a bar chart.

```
evcharging_station.plot(kind = 'bar' ,x ='State' ,y ='No. of Operational PCS' )
```

```
<Axes: xlabel='State'>
```



10. Segmentation Based on EV Sales

Manufacturers are categorized into **high**, **medium**, and **low** sales segments based on their total sales.

This categorizes manufacturers into high, medium, and low sales segments.

```
]: high_sales = Manufacturers_sales[Manufacturers_sales['total_sales'] > 100000]
   medium_sales = Manufacturers_sales[(Manufacturers_sales['total_sales'] <= 100000) & (Manufacturers_sales['total_sales'] > 5
   low_sales = Manufacturers_sales[Manufacturers_sales['total_sales'] <= 50000]

   print(f"High Sales Manufacturers:\n{high_sales}")
   print(f"Medium Sales Manufacturers:\n{medium_sales}")
   print(f"Low Sales Manufacturers:\n{low_sales}")
```

```
High Sales Manufacturers:
                                Maker  total_sales  market share(%)
738   OLA ELECTRIC TECHNOLOGIES PVT LTD       588266        13.306467
1056              TVS MOTOR COMPANY LTD       318445         7.203166
100                ATHER ENERGY PVT LTD       236387         5.347030
411     HERO ELECTRIC VEHICLES PVT. LTD       201785         4.564339
126                      BAJAJ AUTO LTD       198498         4.489988
737            OKINAWA AUTOTECH PVT LTD       196182         4.437600
1170                YC ELECTRIC VEHICLE       152951         3.459723
63      AMPERE VEHICLES PRIVATE LIMITED       141805         3.207603
Medium Sales Manufacturers:
                                  Maker  total_sales  market share(%)
869             SAERA ELECTRIC AUTO PVT LTD        87481         1.978804
640             MAHINDRA & MAHINDRA LIMITED        84794         1.918024
1033  TATA PASSENGER ELECTRIC MOBILITY LTD         74410         1.683140
231             DILLI ELECTRIC AUTO PVT LTD        69966         1.582618
751                               OTHERS           68108         1.540590
176                    CHAMPION POLY PLAST         53493         1.210002
1032    TATA MOTORS PASSENGER VEHICLES LTD         52520         1.187993
Low Sales Manufacturers:
                                  Maker  total_sales  market share(%)
645       MAHINDRA LAST MILE MOBILITY LTD        46534         1.052590
677                   MINI METRO EV L.L.P        44250         1.000927
769              PIAGGIO VEHICLES PVT LTD        43783         0.990363
368     GREAVES ELECTRIC MOBILITY PVT LTD        42879         0.969915
1072                 UNIQUE INTERNATIONAL        41615         0.941324
...                                   ...          ...              ...
886                    SAN MOTORS LIMITED            1         0.000023
443              IDEAL JAWA INDIA PVT LTD            1         0.000023
46    AKSMD RECHARGEABLE VEHICLES PVT LTD            1         0.000023
881                SAKTHI VIJAY INDUSTRIES            1         0.000023
944                    SHRI RAM INDUSTRIES            1         0.000023

[1181 rows x 3 columns]
```

3. Result

1. **Sales Growth:** EV sales grew dramatically (12,628%) from 2015 to 2024. However, the YoY growth fluctuated, with significant drops in 2020 and 2024.
2. **Top Manufacturers:**
    - Ola Electric leads the market with ~13.3% share.
    - TVS Motor Company and Ather Energy are the next top contributors.
3. **Geographical Concentration:**
    - Manufacturing Hubs: Maharashtra (15 EV makers), Tamil Nadu (11 EV makers).
    - Top Charging Infrastructure: Maharashtra, Delhi, and Karnataka have the highest number of public charging stations.

4. Conclusion

Overall, the EV industry in India is on an upward trajectory, with rapid growth in both sales and infrastructure. The government's continued support, along with the efforts of manufacturers and service providers, will be crucial in shaping the future of this sector. Continued innovation, along with a robust charging network, will be essential in ensuring the widespread adoption of electric vehicles across the country.

5. Reference

1. **https://www.kaggle.com/datasets/srinrealyf/india-ev-market-data/data**
2. **https://www.kaggle.com/code/fireeagle123/indian-ev-data-analusise**
3. **https://www.kaggle.com/code/kavyachippada/mini-hackathon2-0**

Project Report: Electric Vehicle Market Segmentation

By Mohammed Ehtesham Aleem

Abstract: The Indian automotive market is at a pivotal juncture with increasing interest in sustainable mobility. This report uses segmentation analysis to identify and target market segments most likely to adopt electric vehicles (EVs). By leveraging clustering techniques, we provide insights into customer profiles and propose a feasible market entry strategy.

---

1. Introduction

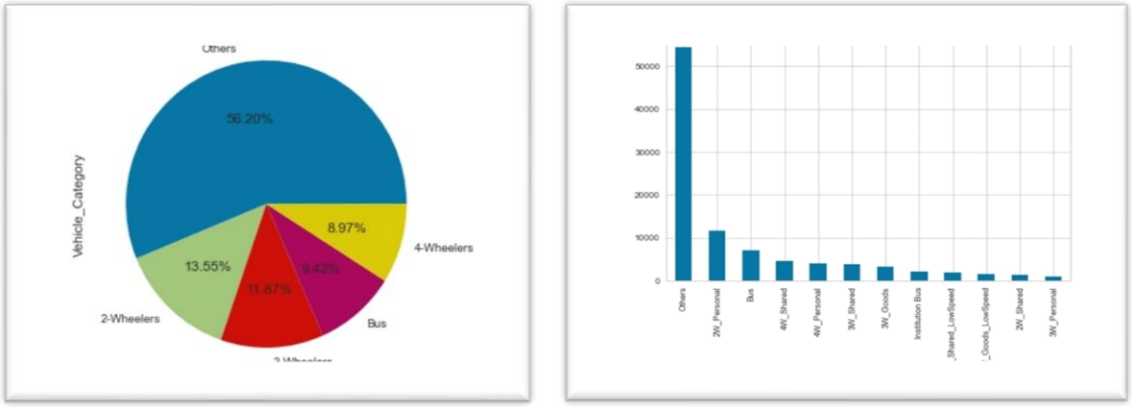
The global push towards sustainability and the rising fuel costs have made EVs a promising alternative in India. However, the diversity in consumer demographics and purchasing behaviours necessitates a targeted approach. This report analyzes the Indian EV market using segmentation analysis to identify optimal target segments.

2. Methodology

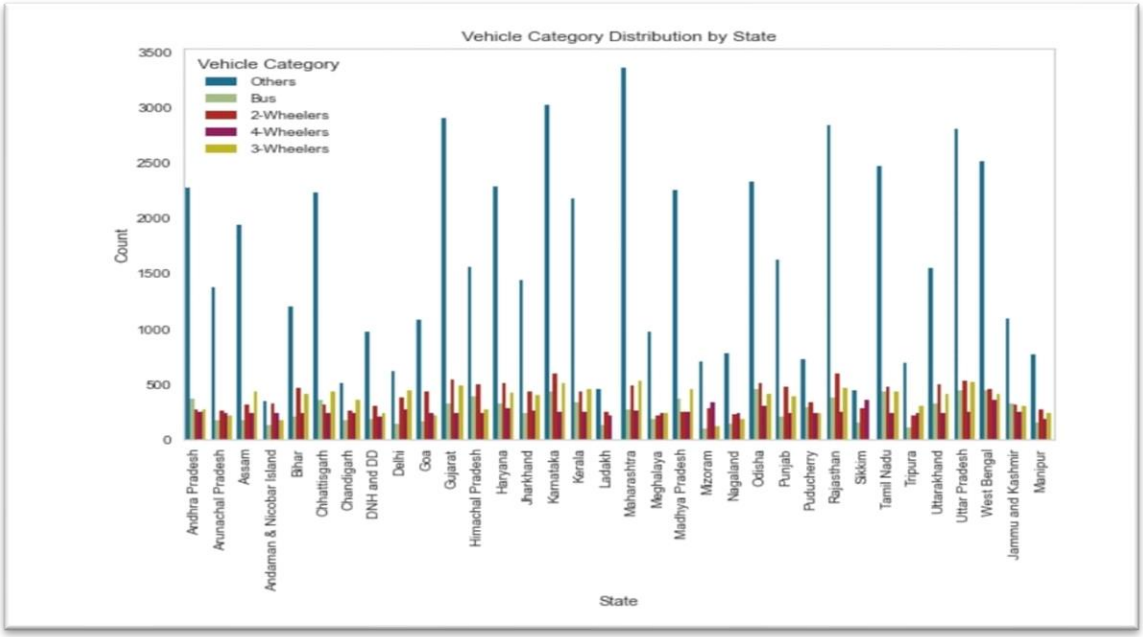
The analysis employs:

- **Data Collection:** Data includes demographics, income levels, geographic distribution, and preferences for EV adoption.
- **Clustering Algorithm:** The K-Means algorithm, with preprocessing steps like scaling and PCA, was used to identify clusters.
- **Cluster Validation:** The Elbow Method and silhouette scores ensured robust cluster formation.

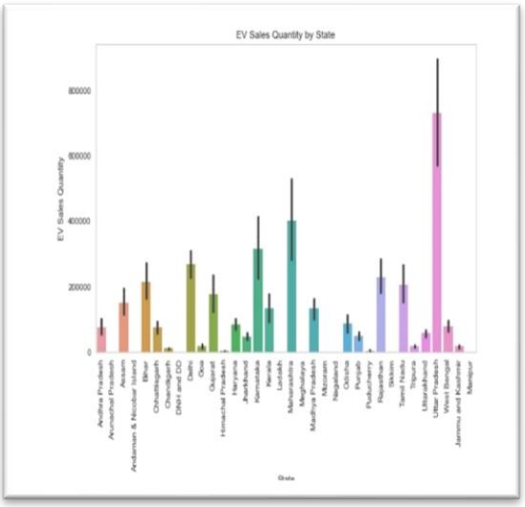
Market Overview

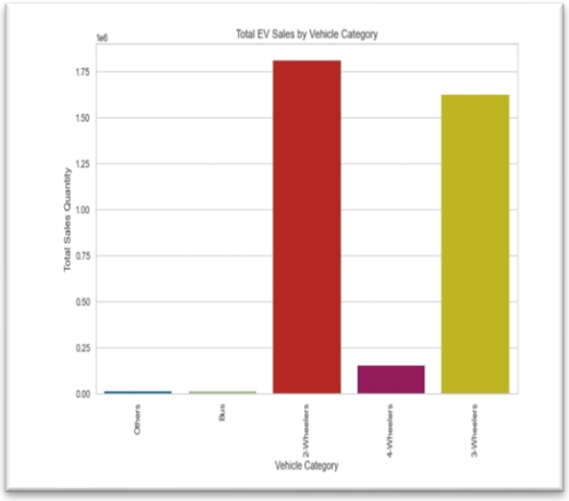


Distribution of Vehicle by Category



Distribution of Vehicle Category by State





Sales of EV by State and Category

3. Key Findings

3.1 Optimal Clustering: Using the Elbow Method, the ideal number of clusters was determined to be four. Each cluster represents a distinct consumer group.

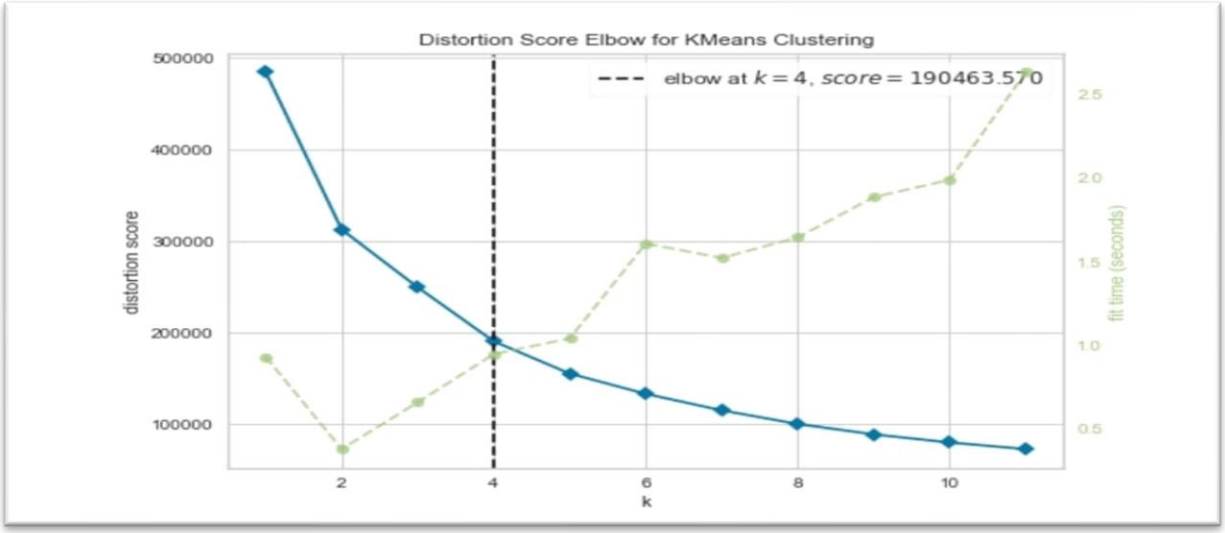
3.2 Cluster Profiles: The segmentation analysis revealed five distinct consumer groups, each with unique characteristics, purchasing behaviours, and motivations for EV adoption.

Cluster 0 comprises high-income, urban early adopters who possess significant purchasing power and strong environmental awareness. This group is concentrated in metropolitan cities and is drawn to premium EV models that offer advanced technology, luxury features, and superior performance. Their willingness to pay a premium for sustainable options makes them an ideal target for high-end EVs.

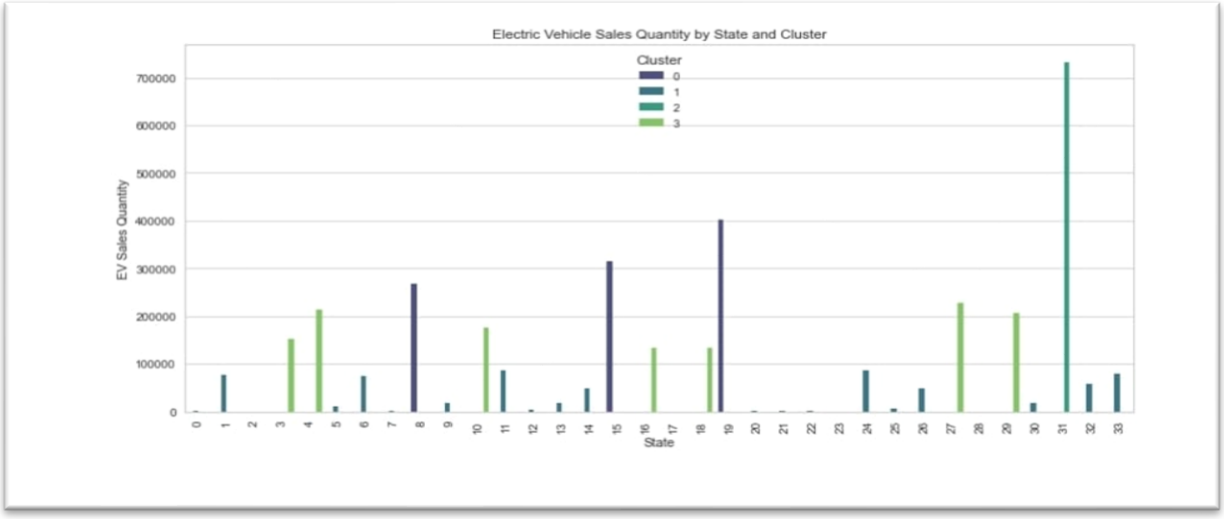
Cluster 1 includes mid-income, urban, environmentally conscious individuals who are moderately price-sensitive. This group values sustainability but operates within a constrained budget. Members of this cluster are primarily professionals and small business owners residing in urban areas. They are likely to adopt mid-range EV models if supported by government subsidies or attractive financing options. Marketing efforts for this segment should emphasize cost-effectiveness and long-term savings.

Cluster 2 consists of low-income, rural, price-sensitive consumers. This segment has limited disposable income and low awareness of the environmental and economic benefits of EVs. They primarily rely on two-wheelers or three-wheelers for their daily commute. Affordable EV options, such as low-cost scooters or shared transportation solutions, can address the needs of this group. Education campaigns and incentives will play a critical role in fostering adoption within this cluster.

Cluster 3 represents family-oriented, suburban residents who prioritize practicality, long-term savings, and reliability. This group typically comprises middle-aged individuals with families who need spacious and cost-efficient vehicles for daily commuting and occasional long drives. Marketing strategies for this segment should highlight the affordability of ownership, safety features, and family-friendly design elements.



Distribution Score Elbow for K-Means Clustering



EV Sales Quantity by State and Clusters using K-Means Clustering

---

4. Feasible Market Entry Strategy

4.1 Market Segmentation Focus: Based on the analysis, Clusters 1 and 2 should be prioritized for the initial market entry. These segments demonstrate a combination of readiness for EV adoption, financial capability, and alignment with sustainability goals.

4.2 Strategic Recommendations:

1. **Product Offering:**
    - Develop a diverse product line to cater to the unique needs of different clusters. For Cluster 1, focus on premium EV models with high-end features and luxury branding. For Cluster 2, introduce mid-range EVs that balance quality and affordability. Expand offerings to include low-cost two-wheelers and three-wheelers for Cluster 3, enabling rural penetration.
2. **Marketing and Awareness:**
    - Implement targeted digital campaigns aimed at tech-savvy and environmentally conscious individuals in Clusters 1 and 4. Highlight the luxury, innovation, and environmental benefits of EVs. For Cluster 3, conduct awareness drives in rural areas to educate potential buyers about the economic and environmental advantages of EVs. Leverage traditional media and community programs to build trust and interest.
3. **Incentives and Partnerships:**
    - Collaborate with the Indian government to offer attractive subsidies and tax benefits for EV buyers, particularly targeting mid-range and low-cost models. Partner with financial institutions to provide affordable financing solutions, including low-interest loans and flexible payment plans. Develop strategic alliances with technology companies to enhance connectivity features and improve user experience.
4. **Infrastructure Development:**

- Prioritize the expansion of EV charging infrastructure in urban and suburban areas to reduce range anxiety among potential buyers. Work with local governments and private players to establish a comprehensive network of charging stations. Offer home charging solutions and installation services to enhance convenience for residential buyers.

5. Recommendations for the Startup Company for Market Entry

Focus on Segments with High Adoption Potential:

- **Target Clusters 1 and 2 Initially:**
  - Cluster 1 (mid-income urban professionals): Develop mid-range EVs emphasizing affordability, long-term savings, and sustainability. Highlight benefits like cost-efficiency and government subsidies.
  - Cluster 2 (low-income rural users): Offer low-cost two-wheelers or three-wheelers tailored to rural commuting needs. Provide incentives and education on EV benefits.

Product Development Strategy:

- **Affordable Range**: Design low-cost vehicles with essential features for rural markets.
- **Mid-Range Solutions**: Focus on quality, affordability, and innovative financing options to appeal to urban middle-income users.
- **Premium Options**: Introduce high-tech, luxury EV models for high-income urban users (Cluster 0) in later phases.

Marketing Approach:

- Leverage digital campaigns targeting environmentally conscious urban consumers.
- Conduct rural education campaigns to build awareness and interest in affordable EV solutions.

Phased Expansion:

- Begin with urban and suburban markets where infrastructure and purchasing power are more robust.
- Gradually extend into rural areas with an emphasis on affordability and accessibility.

6. Conclusion

The Indian EV market presents immense opportunities for growth and innovation. By focusing on the identified clusters and tailoring products and marketing strategies to meet their specific needs, businesses can establish a competitive edge in the market. Addressing critical challenges, such as infrastructure gaps and affordability, will further accelerate EV adoption and ensure long-term success. A phased approach targeting urban and suburban markets initially, followed by rural penetration, will enable sustainable growth and maximize market share.

EV MARKET SEGMENTATION ANALYSIS

-UDDHAV SALLA

Abstract

The Indian electric vehicle (EV) market presents a diverse landscape, characterized by a range of models with varying performance metrics, affordability, and technological capabilities. This study analysis key parameters such as acceleration, top speed, range, efficiency, and price to segment the market and uncover actionable insights. The findings highlight significant trends, including the affordability-driven adoption of compact EVs, increasing interest in efficient and high-range vehicles, and the dominance of the SUV body style. With an average range of 338 km and an average price of €55,811, the study identifies opportunities for cost-optimized models to cater to the Indian market's price-sensitive consumers. This segmentation serves as a foundation for policymakers and businesses to address infrastructural challenges and align offerings with consumer needs, ultimately driving India's transition to sustainable mobility.

Introduction

India’s electric vehicle (EV) market is witnessing unprecedented growth as environmental concerns, government incentives, and advancements in technology converge to redefine mobility. With a diverse population and varying economic strata, market segmentation plays a critical role in identifying consumer preferences, optimizing offerings, and addressing challenges unique to the Indian automotive landscape.

This study examines key performance indicators from a dataset of EV models, including range, efficiency, acceleration, and price, to segment the market and understand emerging trends. Key statistics reveal that the average EV offers a range of 338 km, with prices ranging from €20,129 to €215,000, reflecting a broad spectrum of affordability and performance. While SUVs dominate the market, compact and mid-segment EVs show potential for mass adoption, given their practicality and cost efficiency.

The Indian EV market is currently shaped by the dominance of two- and three-wheelers, which address urban mobility needs, and a gradual rise in four-wheeler adoption among eco-conscious consumers. This analysis identifies gaps in affordability, infrastructure, and performance that need to be addressed to unlock the full potential of the EV market. By understanding market segmentation, stakeholders can better align strategies to accelerate the adoption of EVs in India.

Columns:

1. **Brand**: Vehicle manufacturer (e.g., Tesla, Volkswagen).
2. **Model**: Specific vehicle model.
3. **AccelSec**: Acceleration in seconds (0-100 km/h).
4. **TopSpeed_KmH**: Top speed in kilometers per hour.
5. **Range_Km**: Driving range in kilometers.
6. **Efficiency_WhKm**: Energy efficiency in watt-hours per kilometer.
7. **FastCharge_KmH**: Fast-charging speed (km of range added per hour).

8. **RapidCharge**: Whether the car supports rapid charging (Yes/No).
9. **PowerTrain**: Drivetrain type (e.g., AWD, RWD).
10. **PlugType**: Charging port type (e.g., Type 2 CCS).
11. **BodyStyle**: Vehicle design (e.g., Sedan, SUV).
12. **Segment**: Vehicle segment (e.g., B, C, D).
13. **Seats**: Number of seats.
14. **PriceEuro**: Price in Euros.

Key Metrics:

- **Performance:**
    - **Acceleration (0-100 km/h):** Ranges from 4.6 seconds (e.g., Tesla Model 3) to 10 seconds (e.g., VW ID.3).
    - **Top Speed:** Ranges from 145 km/h to 233 km/h.
    - **Energy Efficiency:** Varies between 161 Wh/km to 206 Wh/km, indicating a mix of highly efficient and less efficient vehicles.
- **Range and Charging:**
    - **Driving Range:** The range extends from 170 km (e.g., Honda e) to 450 km (e.g., Tesla Model 3).
    - **Fast Charging Speed:** Varies widely from 190 km/h (slow) to 940 km/h (fast).
    - **Rapid Charging Support:** Majority of vehicles support rapid charging, while a few do not.
- **Market Segmentation:**
    - **Price:** Prices range from €30,000 to €68,000, targeting mid-range to premium market segments.
    - **Body Style:** Includes Sedans, SUVs, Hatchbacks, and Liftbacks.
    - **Seats:** Most vehicles are 5-seaters, with some compact models offering 4 seats.
- **Segment Distribution:**
    - Segment B (Compact): Includes smaller cars like Honda e.
    - Segment C (Mid-size): Includes practical vehicles like VW ID.3.
    - Segment D (Premium): Features higher-performance models like Tesla Model 3 and Polestar 2.

Segmentation:

1. By Price:

- **Affordable (<€35,000):**
    - Vehicles like Honda e and VW ID.3 target budget-conscious buyers.
- **Mid-range (€35,000–€55,000):**
    - Includes Polestar 2 and Tesla Model 3.
- **Premium (>€55,000):**
    - BMW iX3 and similar luxury models.

2. By Range:

- **Short-range (<250 km):**
    - Focus on urban commuters (e.g., Honda e).
- **Medium-range (250–400 km):**
    - Balances daily use and occasional trips (e.g., VW ID.3).
- **Long-range (>400 km):**
    - Ideal for long-distance travelers (e.g., Tesla Model 3).

3. By Energy Efficiency:

- **Highly Efficient (<170 Wh/km):**
    - Economical vehicles with low energy consumption.
- **Moderately Efficient (170–190 Wh/km):**
    - Balanced performance and efficiency.
- **Less Efficient (>190 Wh/km):**
    - Power-focused or larger vehicles.

4. By Body Style:

- **Sedans:** Target professionals and long-distance drivers.
- **SUVs:** Focus on families or outdoor enthusiasts.
- **Hatchbacks:** Designed for urban and compact spaces.

Data Collection:

The data is collected from different online sources which includes Kaggle , data.gov.in , Chatgpt , Google ,GitHub

https://www.bing.com/ck/a?!&&p=7dfae9154b841ba3a63f264874f1e6039169aa98b1bbaae02357707a9f5dc192JmltdHM9MTczNzY3NjgwMA&ptn=3&ver=2&hsh=4&fclid=17bceccb-bb21-6659-38c9-fd70bac96726&psq=chat+gpt&u=a1aHR0cHM6Ly9jaGF0Z3B0LmNvbS8&ntb=1.

https://github.com/

https://www.kaggle.com/datasets

https://www.data.gov.in/

https://datasetsearch.research.google.com/

Data Representation:

Image 1 (Imports and Loading Data):

```
import pandas as pd
import numpy as nd
import matplotlib.pyplot as plt
import seaborn as sb
```

```
data=pd.read_csv("Ev data 1.zip")
```

- The code imports essential Python libraries for data analysis and visualization:
    - pandas for data manipulation.
    - numpy for numerical operations.
    - matplotlib.pyplot and seaborn for data visualization.
- The pd.read_csv() function is used to load a dataset from a compressed .zip file named "Ev data 1.zip". This dataset is likely related to electric vehicles (EVs).

Image 2 (Filter: TopSpeed > 200 Km/H):

```
data[data['TopSpeed_KmH']>200]
```

	Unnamed: 0	Brand	Model	AccelSec	TopSpeed_KmH	Range_Km	Efficiency_WhKm	FastCharge_KmH	RapidCharge	PowerTrain	PlugType	BodyStyle	Segr
0	0	Tesla	Model 3 Long Range Dual Motor	4.6	233	450	161	940	Yes	AWD	Type 2 CCS	Sedan	
2	2	Polestar	2	4.7	210	400	181	620	Yes	AWD	Type 2 CCS	Liftback	
5	5	Lucid	Air	2.8	250	610	180	620	Yes	AWD	Type 2 CCS	Sedan	
8	8	Tesla	Model 3 Standard Range Plus	5.6	225	310	153	650	Yes	RWD	Type 2 CCS	Sedan	
16	16	Porsche	Taycan	2.8	260	375	223	780	Yes	AWD	Type 2	Sedan	

- The dataset is filtered to display rows where the TopSpeed_KmH column exceeds 200 km/h.
- Key observations:
  - The filtered data shows high-performance EVs from brands like Tesla, Polestar, Lucid, and Porsche.
  - These cars have top speeds ranging from 210 to 260 km/h, demonstrating the capability of premium EVs in terms of speed.
  - Models include Tesla's Model 3 (Long Range Dual Motor and Standard Range Plus), Polestar 2, Lucid Air, and Porsche Taycan.

Image 3 (Filter: Price > €50,000):

```
data[data['PriceEuro']>50000]
```

2	2	Polestar	2	4.7	210	400	181	620	Yes	AWD	Type 2 CCS	Liftback
3	3	BMW	iX3	6.8	180	360	206	560	Yes	RWD	Type 2 CCS	SUV
5	5	Lucid	Air	2.8	250	610	180	620	Yes	AWD	Type 2 CCS	Sedan
9	9	Audi	Q4 e-tron	6.3	180	400	193	540	Yes	AWD	Type 2 CCS	SUV
10	10	Mercedes	EQC 400 4MATIC	5.1	180	370	216	440	Yes	AWD	Type 2 CCS	SUV
13	13	BMW	i4	4.0	200	450	178	650	Yes	RWD	Type 2 CCS	Sedan

- This filter extracts rows where the PriceEuro column exceeds €50,000.
- Key observations:
  - High-priced EVs include models from luxury brands such as Polestar, BMW, Lucid, Audi, and Mercedes.

- These vehicles typically offer premium features, longer ranges (up to 610 km for the Lucid Air), and advanced performance metrics (e.g., acceleration under 3 seconds for some).
- Body styles vary from sedans (Lucid Air, Tesla Model 3) to SUVs (BMW iX3, Audi Q4 e-tron).

Image 4 (Filter: Price < €50,000):

```
data[data['PriceEuro']<50000]
```

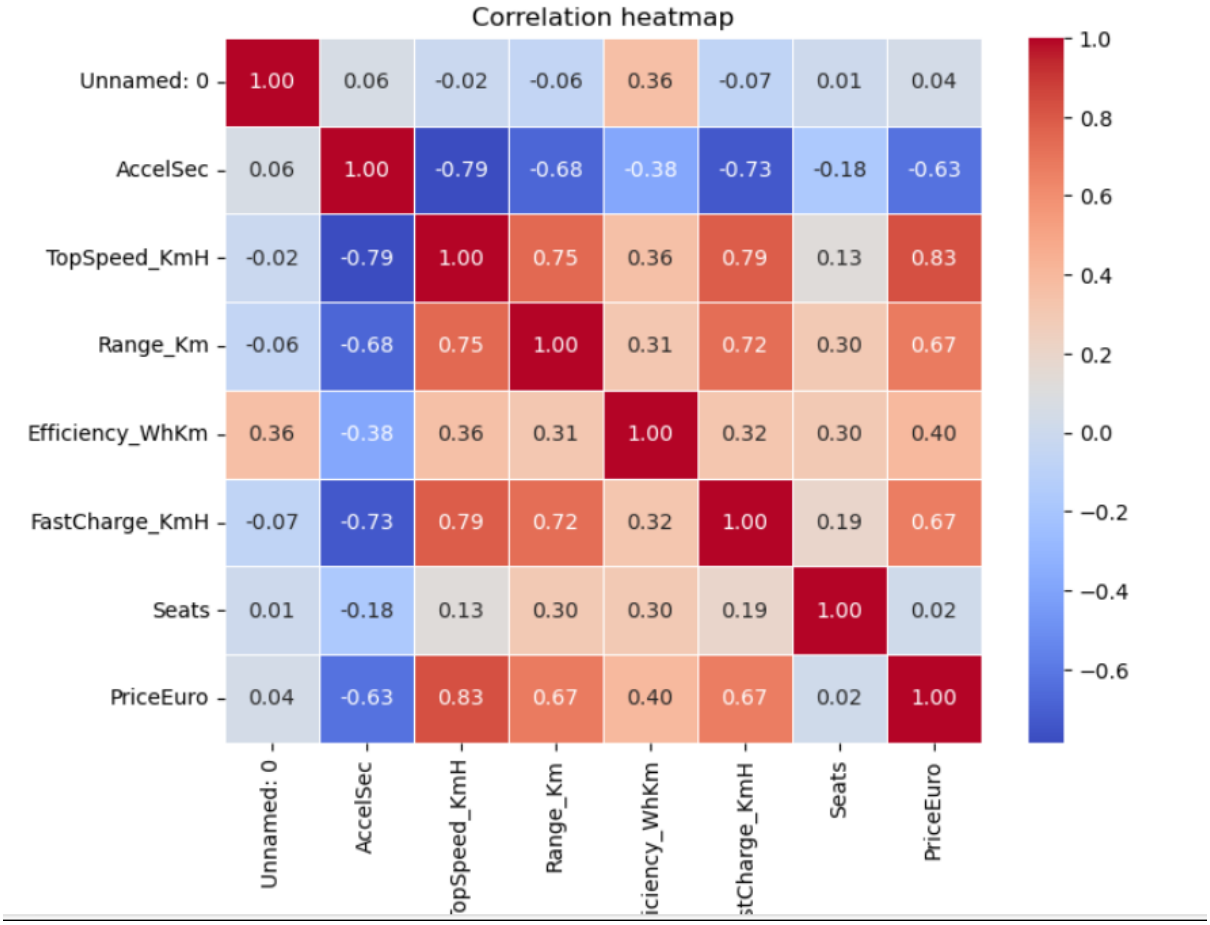
	Unnamed: 0	Brand	Model	AccelSec	TopSpeed_KmH	Range_Km	Efficiency_WhKm	FastCharge_KmH	RapidCharge	PowerTrain	PlugType	BodyStyle
1	1	Volkswagen	ID.3 Pure	10.0	160	270	167	250	No	RWD	Type 2 CCS	Hatchback
4	4	Honda	e	9.5	145	170	168	190	Yes	RWD	Type 2 CCS	Hatchback
6	6	Volkswagen	e-Golf	9.6	150	190	168	220	No	FWD	Type 2 CCS	Hatchback
7	7	Peugeot	e-208	8.1	150	275	164	420	No	FWD	Type 2 CCS	Hatchback
8	8	Tesla	Model 3 Standard Range Plus	5.6	225	310	153	650	Yes	RWD	Type 2 CCS	Sedan

- This filter retrieves rows where the PriceEuro column is less than €50,000.
- Key observations:
  - More affordable EVs are listed, including Volkswagen ID.3 Pure, Honda e, Volkswagen e-Golf, and Peugeot e-208.
  - These models typically have lower top speeds (145-225 km/h) and shorter ranges (170-310 km) compared to the higher-priced EVs.
  - They are well-suited for city commuting and budget-conscious consumers.
  - Most of the vehicles are compact hatchbacks, except for Tesla's Model 3 Standard Range Plus (sedan).

Data Visualization:

Image 1: Correlation Heatmap

```
data_numeric=data.select_dtypes(include=['number'])
cor=data_numeric.corr()
plt.figure(figsize=(8, 6))
sb.heatmap(cor, annot=True, cmap='coolwarm', fmt='.2f', linewidths=0.5)
plt.title('Correlation heatmap')
plt.show()
```

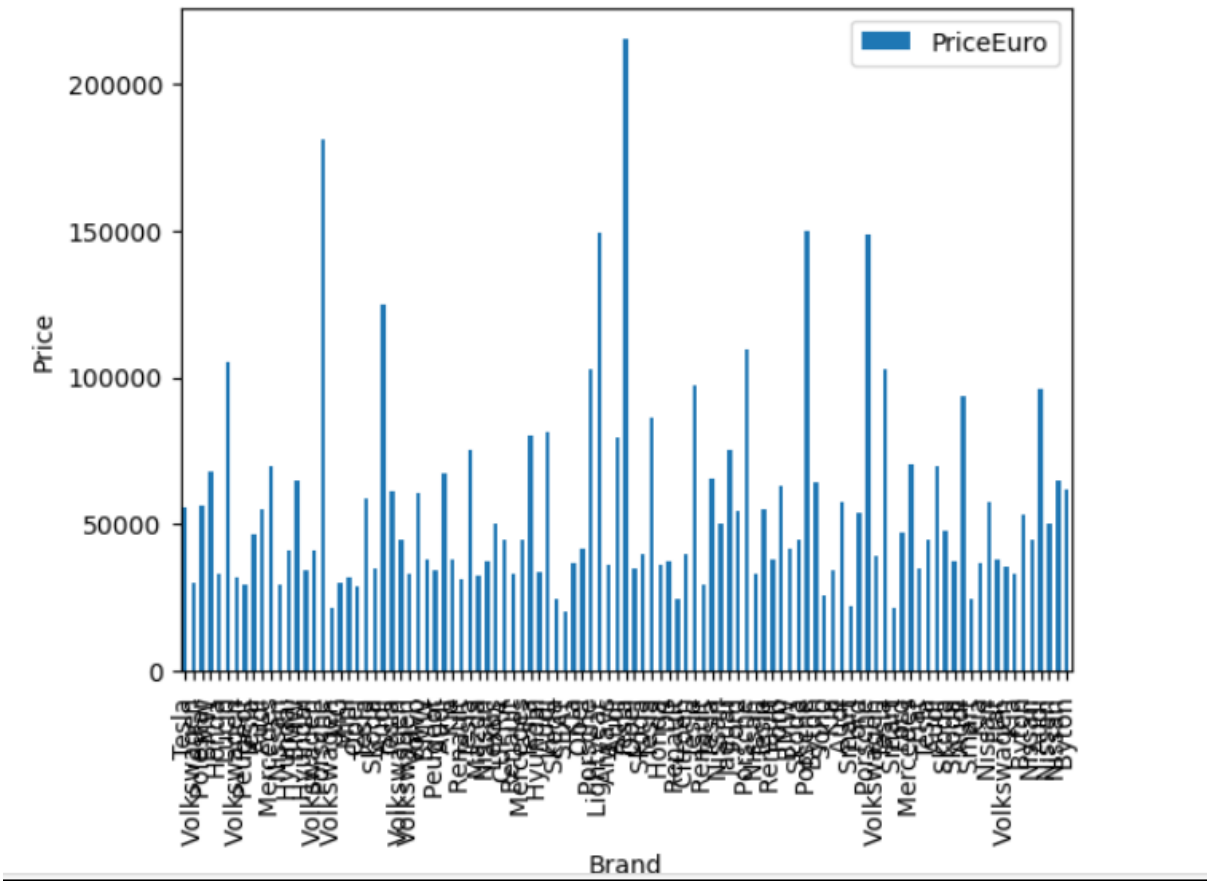


- A strong positive correlation (0.83) exists between TopSpeed_KmH and PriceEuro, indicating that vehicles with higher top speeds tend to be more expensive.
- Range_Km also correlates positively with PriceEuro (0.67), suggesting vehicles with higher ranges are pricier.
- A strong negative correlation (-0.79) exists between AccelSec and TopSpeed_KmH, meaning vehicles with faster acceleration (lower seconds) tend to have higher top speeds.
- Other notable relationships include Efficiency_WhKm negatively correlating with Range_Km (-0.68) and FastCharge_KmH positively correlating with TopSpeed_KmH.

Image 2: Bar Plot (Brand vs PriceEuro)

```
data.plot(kind='bar',x='Brand',y='PriceEuro')
plt.xlabel('Brand')
plt.ylabel('Price')
```

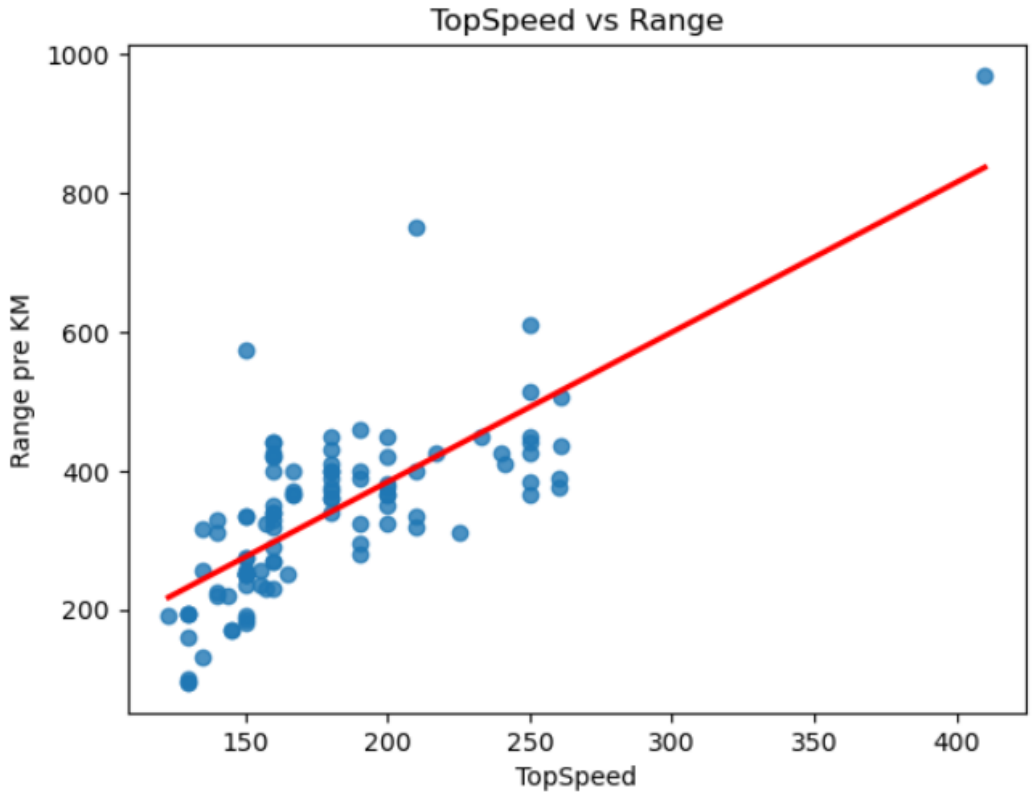
```
Text(0, 0.5, 'Price')
```



- The bar plot displays the PriceEuro distribution across different brands.
- Key Observations:
    - Prices vary widely between brands, with some brands offering premium vehicles priced above €200,000.
    - Many brands show a consistent pricing trend, while a few have large outliers, possibly indicating luxury or specialty vehicles.
    - The x-axis (Brand names) is cluttered due to the large number of brands, which could benefit from aggregation or filtering for clarity.

Image 3: Scatter Plot (TopSpeed vs Range)

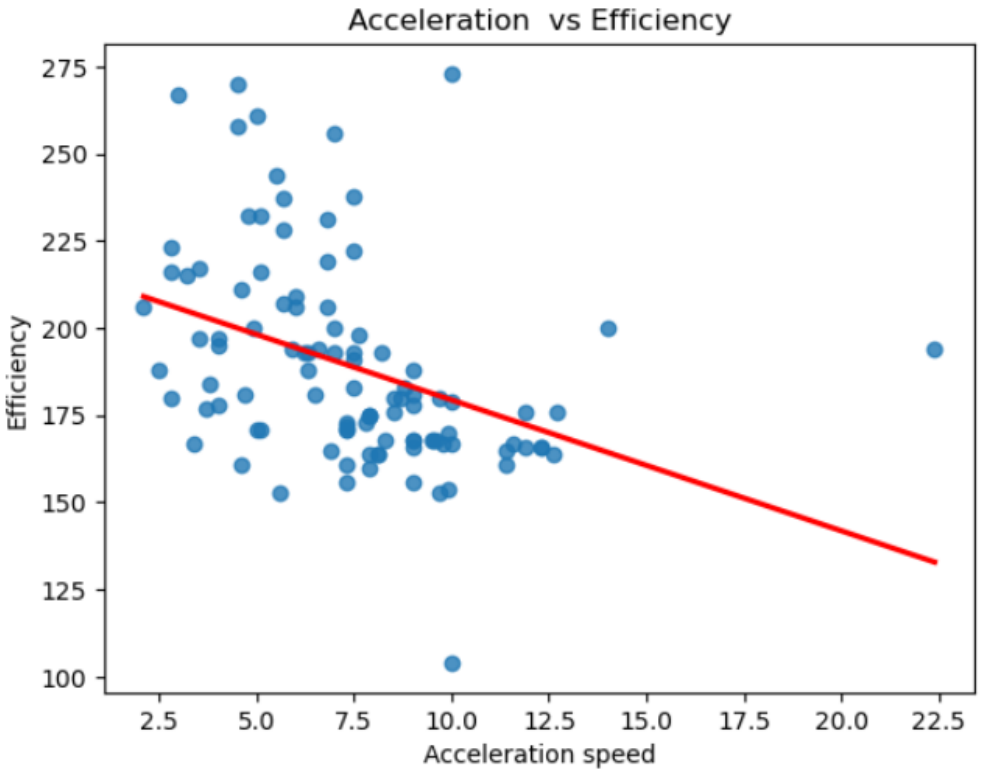
```
sb.regplot(x=data['TopSpeed_KmH'], y=data['Range_Km'], ci=None, line_kws={"color": "red"})
plt.title('TopSpeed vs Range')
plt.xlabel('TopSpeed')
plt.ylabel('Range pre KM')
plt.show()
```



- This scatter plot with a regression line shows the relationship between TopSpeed_KmH and Range_Km.
- Key Observations:
    - There is a positive trend between top speed and range, as vehicles with higher top speeds tend to have longer ranges.
    - However, some outliers with extremely high ranges or top speeds deviate from the trend.
    - The regression line visually confirms this positive correlation, which aligns with the correlation value (0.75) seen in the heatmap.

Image 4: Scatter Plot (Acceleration vs Efficiency)

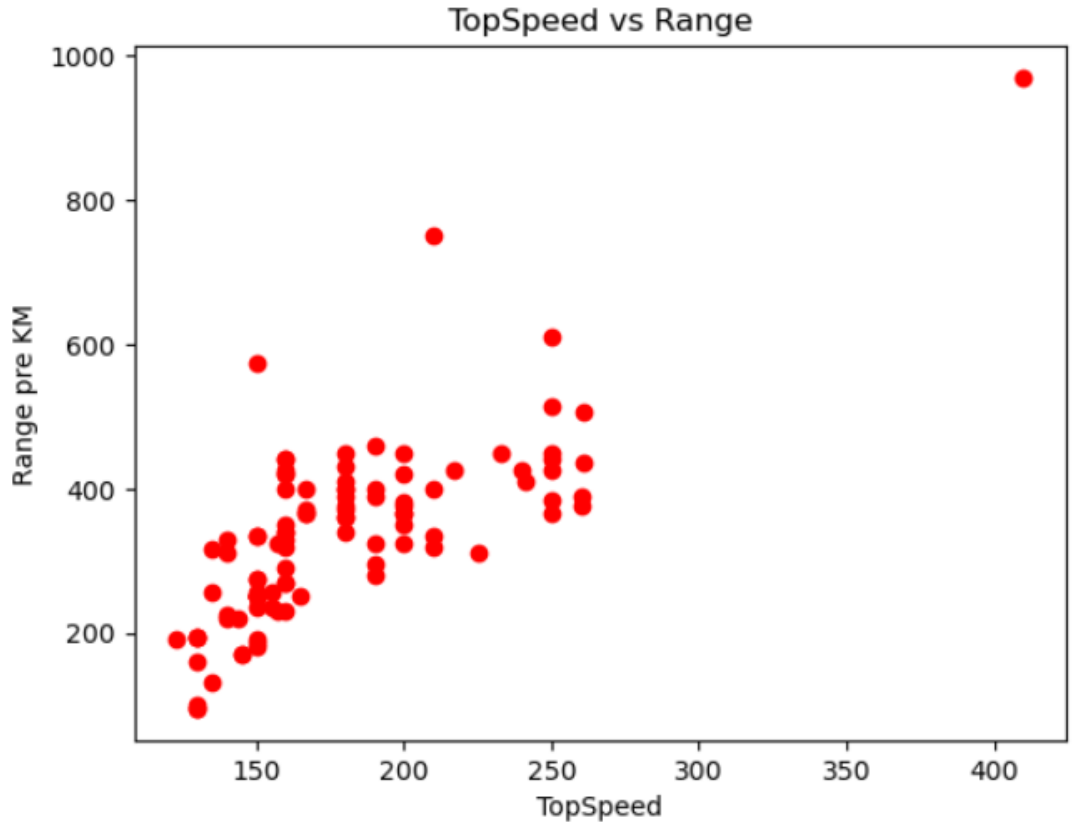
```
sb.regplot(x=data['AccelSec'], y=data['Efficiency_WhKm'], ci=None, line_kws={"color": "red"})
plt.title('Acceleration  vs Efficiency')
plt.xlabel('Acceleration speed')
plt.ylabel('Efficiency')
plt.show()
```



- This plot examines the relationship between AccelSec (acceleration time) and Efficiency_WhKm.
- Key Observations:
    - There is a negative trend, where vehicles with faster acceleration (lower seconds) tend to have lower efficiency (higher WhKm values).
    - The negative correlation reflects a trade-off between performance and energy efficiency.
    - This trend aligns with the correlation value (-0.38) from the heatmap, though the relationship is weaker compared to other variables.

Image 5: Scatter Plot (TopSpeed vs Range - Simplified)

```
plt.scatter(data['TopSpeed_KmH'],data['Range_Km'],color='red')
plt.title('TopSpeed vs Range')
plt.xlabel('TopSpeed')
plt.ylabel('Range pre KM')
plt.show()
```



- A simpler version of the third plot, this scatter plot omits the regression line and focuses solely on data points.
- Key Observations:
    - The positive relationship between TopSpeed_KmH and Range_Km is evident.
    - Clusters of data points suggest that most vehicles fall within a specific range of speeds and ranges, with a few outliers.

Conclusion:

The Indian EV market is highly dynamic, offering a wide spectrum of vehicles tailored to diverse consumer needs. By analysing metrics such as range, efficiency, price, and performance, the study identifies the following critical insights:

1. **Market Trends:**
    - The SUV body style dominates, appealing to family and adventure-oriented buyers.
    - Compact and mid-segment EVs show high potential for mass adoption due to their affordability and practicality.

- An increasing preference for vehicles with efficient energy consumption and longer ranges highlights consumer demand for sustainability and performance.

2. **Price Sensitivity:**
    - The market is segmented across affordable (<€35,000), mid-range (€35,000–€55,000), and premium (>€55,000) vehicles.
    - Despite the average price being €55,811, cost-effective models targeting the lower end of the price spectrum are essential to meet the needs of India's price-sensitive consumers.
3. **Technological Insights:**
    - High-speed and high-range EVs, such as the Tesla Model 3, cater to performance-focused consumers.
    - Rapid charging and energy efficiency are emerging as critical decision factors for EV buyers, emphasizing the need for advanced charging infrastructure.
4. **Gaps and Opportunities:**
    - Addressing affordability gaps is crucial to encourage widespread adoption among middle-income groups.
    - Infrastructure enhancements, particularly in charging networks, are necessary to support long-distance EV use.
    - Market players have opportunities to develop cost-optimized models and expand options in the compact and medium-range vehicle categories.
5. **Future Outlook:**
    - The strong positive correlation between price and performance metrics (e.g., range, top speed) indicates a growing market for premium vehicles. However, for mass adoption, manufacturers must prioritize affordable and practical EVs.
    - Collaboration between policymakers and industry stakeholders will be pivotal to overcoming infrastructural challenges and driving the transition to sustainable mobility.