MARKET SEGMENTATION OF ELECTRIC VEHICLES IN INDIA

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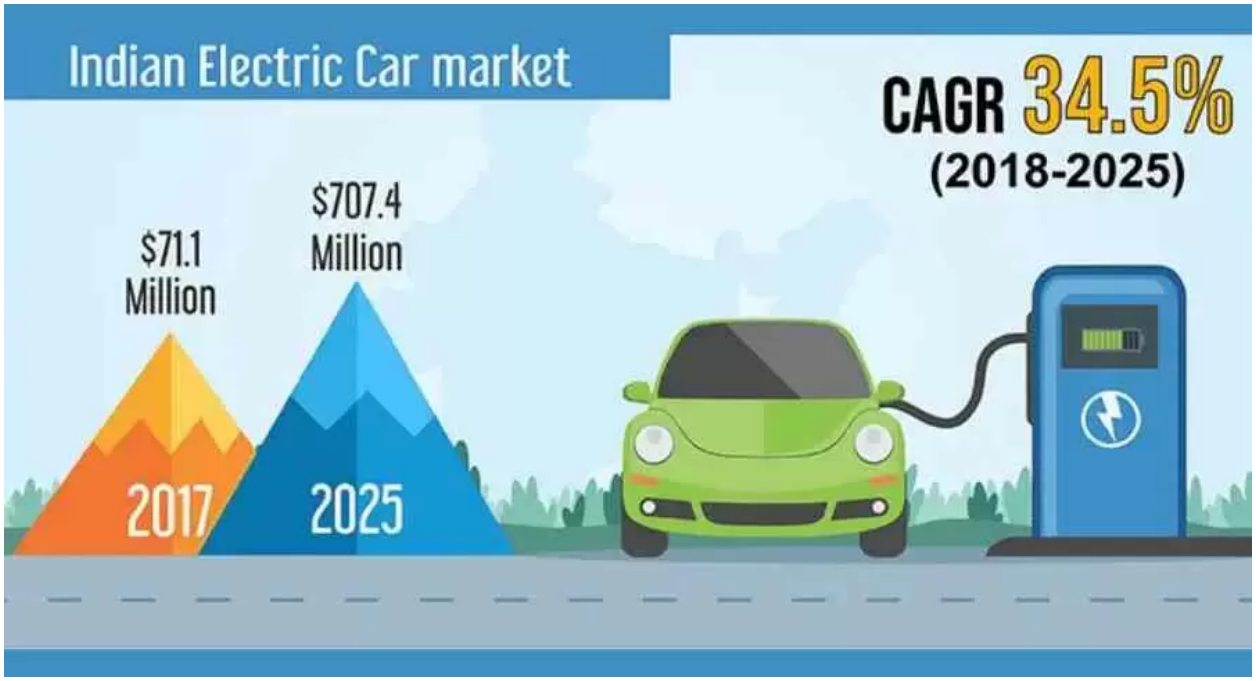


ABSTRACT

Electric vehicles (EVs) are vehicles that run on electric motors powered by rechargeable batteries instead of internal combustion engines that run on fossil fuels. They are considered a more environmentally friendly alternative to traditional gas-powered vehicles as they emit less greenhouse gasses and pollutants. There are different types of electric vehicles, including Battery Electric Vehicles (BEVs), which rely entirely on electric power and have no internal combustion engine; Hybrid Electric Vehicles (HEVs), which have both an electric motor and a gasoline engine; and Plug-in Hybrid Electric Vehicles (PHEVs), which are similar to HEVs but have larger batteries that can be recharged by plugging them in. The adoption of electric vehicles has been growing rapidly in recent years, driven by factors such as increasing environmental concerns, government incentives, and technological advancements in battery technology. However, there are still challenges that need to be addressed, such as the high cost of EVs, limited range, and lack of charging infrastructure in some areas. Efforts are being made to overcome these obstacles and accelerate the adoption of electric vehicles globally.

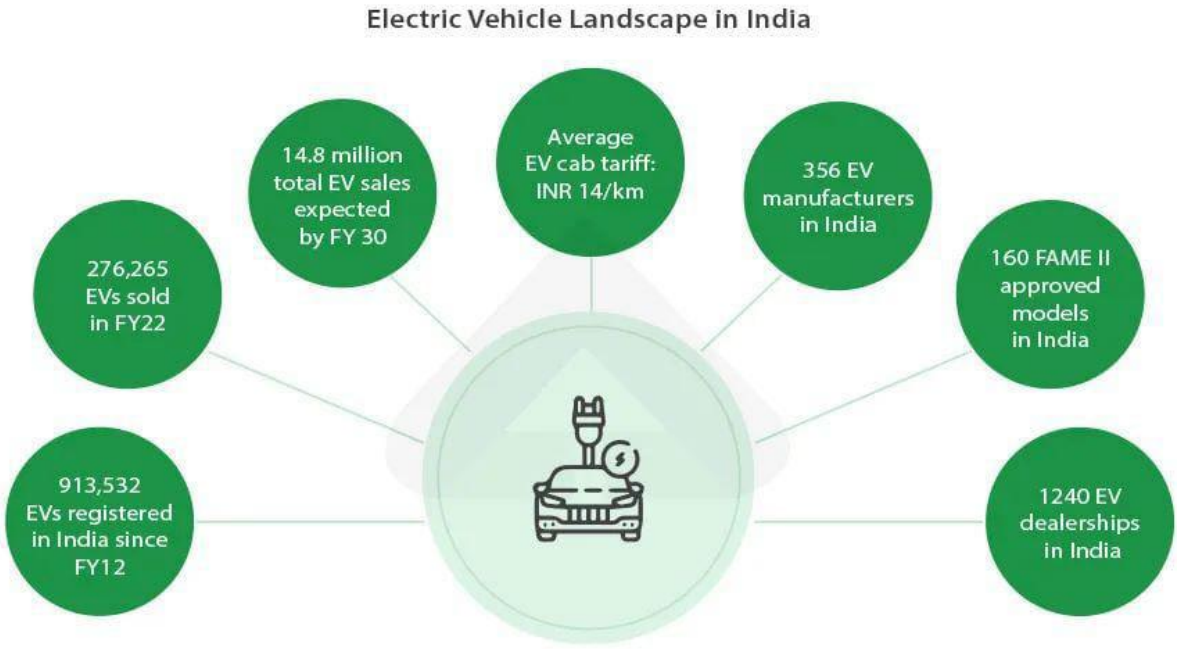
The Indian automobile market is rapidly evolving, and the government has set ambitious goals for electric vehicle adoption. However, there are several challenges to the widespread adoption of electric vehicles, including high prices, lack of charging infrastructure, and limited range. To overcome these challenges, it is essential to understand the different segments of the electric vehicle market in India. The proposed method analyzes the factors influencing the purchase of electric vehicles, including environmental concerns, fuel costs, and government incentives. Based on these factors, the market is segmented into various categories, including urban commuters, fleet operators, and high-end luxury buyers. It also discusses the potential for electric vehicles in the Indian market and the challenges that need to be addressed to promote their adoption. Ultimately, it provides insights into the market segmentation of electric vehicles in India.

The purpose of this study is to categorize the numerous EV market segments in India and comprehend their traits, preferences, and actions. To identify the important segments in the Indian EV market, the study combines qualitative and quantitative research techniques, including surveys, interviews, and secondary data analysis. Based on the findings, the study separates consumers into four main groups: early adopters, value seekers, eco-conscious consumers, and buyers who prioritize convenience. The demographics, psychographics, and behavioral characteristics of each segment are examined, and suggestions are produced for marketing plans that are specifically catered

to the requirements and preferences of each group. The study's findings suggest that in order for EV producers and marketers to successfully target their clients and encourage the adoption of EVs in India, it is imperative that they have a thorough awareness of the various categories in the Indian EV market.
In this study, we will use **Fermi Estimation** to analyze the data and resolve the issue.

INTRODUCTION

The electric vehicle (EV) market in India is still in its nascent stage, but it is growing rapidly. The Indian government has set a target of achieving 30% electric vehicle penetration by 2030, and several initiatives have been taken to promote the adoption of EVs in the country. Market size: According to a report by Niti Aayog, the EV market in India is projected to reach 30% of total vehicle sales by 2030. However, the market size is currently quite small, with only a few thousand EVs sold each year. the EV market in India has a lot of potential for growth, and the government is taking steps to promote the adoption of EVs. However, there are still several challenges that need to be addressed, such as the lack of charging infrastructure and consumer awareness, before the market can reach its full potential.



Market segmentation is the process of dividing a market into smaller groups of consumers with similar needs or characteristics. This approach helps businesses tailor their marketing strategies and products to specific target audiences. The market

segmentation of electric vehicles (EVs) is an important consideration for automakers and other stakeholders in the EV industry. There are several ways to segment the market for EVs. One common approach is to divide the market based on consumer preferences, such as vehicle size, range, and price. For example, some consumers may be interested in purchasing a smaller, more affordable EV for commuting purposes, while others may be interested in a larger, more expensive EV with a longer range for family trips.

Another way to segment the EV market is by geographic location. EV adoption rates can vary greatly depending on the region, with factors such as government incentives, charging infrastructure, and climate affecting consumer demand. For example, EVs may be more popular in areas with high gasoline prices, strict emissions regulations, or abundant renewable energy resources. Additionally, the EV market can be segmented by consumer demographics, such as age, income, and lifestyle. For instance, younger consumers may be more likely to adopt EVs due to their interest in sustainable living and technology, while wealthier consumers may be more attracted to premium EV models.
Market segmentation is an important tool for businesses looking to succeed in the rapidly growing EV industry. By understanding the unique needs and preferences of different consumer segments, automakers can develop EV models and marketing strategies that appeal to a wider range of customers and help accelerate the transition to a more sustainable transportation future.

PROBLEM STATEMENTS

As part of an Electric Vehicle Startup team, our task is to analyze the Indian Electric Vehicle market using segmentation analysis and devise a viable market entry strategy that focuses on the segments with the highest potential for Electric vehicle usage. The Startup is currently exploring the various vehicle and customer spaces to develop its EVs.
As part of an Online Vehicle Booking Product Startup team, your task is to analyze the Indian Vehicle market using segmentation analysis and devise a viable market entry strategy that focuses on segments with the potential to generate early traction and revenue. The Startup is exploring alternative segments due to stiff competition in the Cab booking space from Ola and Uber in India. Your goal is to identify segments with profit potential for offering vehicle booking services.
Any problem statement can be broken down into:

1. Who: A team working under an Electric Vehicle Startup
2. What: Analyze the Electric Vehicle market in India using Segmentation analysis
3. Why: To come up with a feasible strategy to enter the market

4. How: By targeting the segments most likely to use Electric vehicles
5. Additional information: The startup is still deciding in which vehicle/customer space it will develop its EVs.

MARKET CHALLENGES

- Despite the rapid surge in demand for electric vehicles (EVs) in India, sales figures do not reflect the market hype. This discrepancy can be attributed to several factors, including limited options in the passenger car segment, driving range limitations, affordability issues, and a lack of charging infrastructure.
- The primary consideration for a majority of vehicle buyers in India is the cost of the vehicle, which unfortunately makes EVs out of reach for a significant portion of the population. Affordability is a major hurdle in the growth of the EV market in India, particularly in a price-sensitive country like India.
- In addition to affordability issues, the charging infrastructure for EVs in India is still in its nascent phase compared to developed nations, where well-established charging stations are easily accessible for EV owners. Developing a reliable charging infrastructure is essential for creating a conducive ecosystem for EV growth in India.
- Furthermore, only a few EV models currently available in the market can provide a driving range of over 150 km per charge, which further limits their appeal to potential buyers.

COMPETITIVE LANDSCAPE

1. Electric Vehicles (EVs) in India face competition from several sources, including traditional gasoline and diesel vehicles as well as hybrid vehicles. Additionally, there are several new EV manufacturers entering the Indian market, which adds to the competition.
2. The two major competitors of EVs in India are gasoline and diesel vehicles. Despite the environmental concerns and increasing awareness about the impact of fossil fuels on the environment, gasoline and diesel vehicles remain the most popular choices for buyers due to their affordability, established infrastructure, and convenience.
3. Hybrid vehicles, which use a combination of gasoline or diesel engines and electric motors, are also growing in popularity in India. Hybrid vehicles offer improved fuel efficiency and lower emissions than traditional gasoline and diesel vehicles, making them an attractive option for eco-conscious buyers.
4. Furthermore, there are several established global automobile manufacturers entering the Indian EV market, including Tata Motors, Mahindra & Mahindra, and Hyundai Motors. These companies have a significant advantage in terms of brand recognition, manufacturing capabilities, and established sales and distribution networks.

Finally, new and upcoming Indian EV startups such as Ather Energy, Revolt Motors, and Ola Electric are also competing in the Indian EV market, bringing new and innovative products to the market. These startups often focus on creating unique features and affordable pricing to attract customers.

SITUATION ANALYSIS

Conducting a situational analysis is a crucial step in comprehending the market segmentation of electric vehicles (EVs) in India. This process involves evaluating the internal and external factors that influence the EV market in India.

- ➢ External factors encompass political, economic, social, technological, environmental, and legal factors that impact the growth of the EV industry in India. For instance, the Indian government's ambitious goal to have only electric vehicles on Indian roads by 2030, coupled with incentives and subsidies for EVs, has led to a surge in the number of EVs in India. Other drivers of the EV market

growth in India include the increasing awareness of environmental issues, rising fuel prices, and the need for sustainable transportation.

- ➢ On the other hand, internal factors involve strengths, weaknesses, opportunities, and threats (SWOT analysis) of the EV industry in India. Strengths of the EV industry in India include the presence of various domestic and international EV manufacturers, a growing market for EVs, and a supportive regulatory environment. However, there are also weaknesses such as a lack of charging infrastructure and high initial costs of EVs, which can act as a barrier to entry for potential customers.
- ➢ Opportunities for the EV industry in India include the potential for collaborations between domestic and international players to develop advanced technologies and lower costs, as well as the potential for Indian manufacturers to export EVs to other countries. However, threats to the EV industry in India include competition from established players in the automobile industry, potential delays in policy implementation, and fluctuating market demand.

DATA SOURCES

https://www.kaggle.com/datasets/geoffnel/evs-one-electric-vehicle-dataset
https://www.kaggle.com/datasets/deadprstkrish/ev-cars-user-reviews-india?select=4
https://www.kaggle.com/datasets/kkhandekar/cheapest-electric-cars
https://www.kaggle.com/datasets/kkhandekar/electric-vehicles-india
https://www.kaggle.com/datasets/deadprstkrish/ev-cars-user-reviews-india?select=2
https://www.kaggle.com/datasets/fathimaibrahimkunju/electric-vehicle-in-india-202
https://lorien-live.mordorintelligence.com/MEs/90618/India_Electric_Vehicle_Mark
https://www.kaggle.com/datasets/karivedha/indian-consumers-cars-purchasing-beha
https://www.kaggle.com/datasets/geoffnel/evs-one-electric-vehicle-dataset?select=El
https://www.niti.gov.in/sites/default/files/2022-06/ForecastingPenetration-ofElectri

https://pib.gov.in/PressReleasePage.aspx?PRID=1842704
https://pqals.nic.in/annex/1711/AU2113.pdf
https://lorien-live.mordorintelligence.com/MEs/90618/India_Electric_Vehicle_Mark
https://www.kaggle.com/datasets/rickymaisnam/cab

The several datasets are as follows:

1. Geographic data for the distribution of subsidies across different states.

Out[5]:

	state	capital	subsidy	road tax	petrol	diesel
0	Andhra Pradesh	Amaravati	0.0	1.00	111.65	99.41
1	Arunachal Pradesh	Itanagar	5000.0	0.00	95.89	84.81
2	Assam	Dispur	10000.0	1.00	96.34	84.24
3	Bihar	Patna	10000.0	1.00	109.17	95.82
4	Chhattisgarh	Raipur	5000.0	0.00	102.98	95.96
5	Goa	Panaji	8000.0	1.00	97.82	90.37
6	Gujarat	Gandhinagar	10000.0	0.50	96.49	92.23
7	Haryana	Chandigarh	0.0	0.00	97.24	90.08
8	Himachal Pradesh	Shimla	5000.0	0.00	95.74	81.99
9	Jharkhand	Ranchi	5000.0	0.00	100.09	94.88
10	Karnataka	Bengaluru	0.0	1.00	102.64	88.55
11	Kerala	Thiruvananthapuram	0.0	0.50	106.45	95.34
12	Madhya Pradesh	Bhopal	0.0	0.99	110.02	95.18

13	Maharashtra	Mumbai	5000.0	1.00	111.18	95.66
14	Manipur	Imphal	5000.0	0.00	101.22	87.16
15	Meghalaya	Shillong	4000.0	1.00	95.06	83.28
16	Mizoram	Aizawl	0.0	0.00	95.72	82.17
17	Nagaland	Kohima	5000.0	0.00	98.28	86.65
18	Odisha	Bhubaneswar	0.0	1.00	104.45	95.97
19	Punjab	Chandigarh	0.0	1.00	96.26	86.63
20	Rajasthan	Jaipur	0.0	0.00	108.07	93.35
21	Sikkim	Gangtok	0.0	0.00	102.85	98.90
22	Tamil Nadu	Chennai	0.0	1.00	103.62	95.24
23	Telangana	Hyderabad	0.0	1.00	111.97	99.97
24	Tripura	Agartala	5000.0	0.00	98.58	87.52
25	Uttar Pradesh	Lucknow	0.0	0.75	96.38	89.55
26	Uttarakhand	Dehradun	0.0	0.00	95.62	90.55
27	West Bengal	kolkata	10000.0	1.00	106.79	93.47
28	Andaman and Nicobar Islands	Port Blair	0.0	0.00	84.10	79.74
29	Chandigarh	Chandigarh	5000.0	1.00	96.20	84.26
30	Dadra and Nagar Haveli and Daman and Diu	Daman	5000.0	0.00	94.43	89.98
31	Delhi	Delhi	10000.0	1.00	96.72	89.62

2. This data encompasses various brands of electric cars available in India, along with details such as the charger type, number of seats, charging time, top speed, and other relevant information related to the cars.

Out[3]:

	Unnamed: 0	Brand	Model	AccelSec	TopSpeed_KmH	Range_Km	Efficiency_WhKm	FastCharge_KmH	RapidCharge	PowerTrain	PlugType
0	0	Tesla	Model 3 Long Range Dual Motor	4.6	233	450	161	940	Yes	AWD	Type 2 CCS
1	1	Volkswagen	ID.3 Pure	10.0	160	270	167	250	No	RWD	Type 2 CCS
2	2	Polestar	2	4.7	210	400	181	620	Yes	AWD	Type 2 CCS
3	3	BMW	iX3	6.8	180	360	206	560	Yes	RWD	Type 2 CCS
4	4	Honda	e	9.5	145	170	168	190	Yes	RWD	Type 2 CCS
...	...	...	...	...	...	...	...	...	...	...	...
98	98	Nissan	Ariya 63kWh	7.5	160	330	191	440	Yes	FWD	Type 2 CCS
99	99	Audi	e-tron S Sportback 55 quattro	4.5	210	335	258	540	Yes	AWD	Type 2 CCS
100	100	Nissan	Ariya e-4ORCE 63kWh	5.9	200	325	194	440	Yes	AWD	Type 2 CCS

100	100	Nissan	Ariya e-4ORCE 63kWh	5.9	200	325	194	440	Yes	AWD	Type 2 CCS
101	101	Nissan	Ariya e-4ORCE 87kWh Performance	5.1	200	375	232	450	Yes	AWD	Type 2 CCS
102	102	Byton	M-Byte 95 kWh 2WD	7.5	190	400	238	480	No	AWD	Type 2 CCS

103 rows × 15 columns

3. This data encompasses the behavior of Indian consumers when it comes to purchasing electric vehicles

Out[4]:

	Age	Profession	Marrital Status	Education	No of Dependents	Personal loan	Total Salary	Price
0	27	Salaried	Single	Post Graduate	0	Yes	800000	800000
1	35	Salaried	Married	Post Graduate	2	Yes	2000000	1000000
2	45	Business	Married	Graduate	4	Yes	1800000	1200000
3	41	Business	Married	Post Graduate	3	No	2200000	1200000
4	31	Salaried	Married	Post Graduate	2	Yes	2600000	1600000
...	...	...	...	...	...	...	...	...
94	27	Business	Single	Graduate	0	No	2400000	1600000
95	50	Salaried	Married	Post Graduate	3	No	5100000	1600000
96	51	Business	Married	Graduate	2	Yes	2200000	1100000
97	51	Salaried	Married	Post Graduate	2	No	4000000	1500000
98	51	Salaried	Married	Post Graduate	2	Yes	2200000	1100000

99 rows × 8 columns

4. The below dataset depicts the number of charging stations in all the states of India

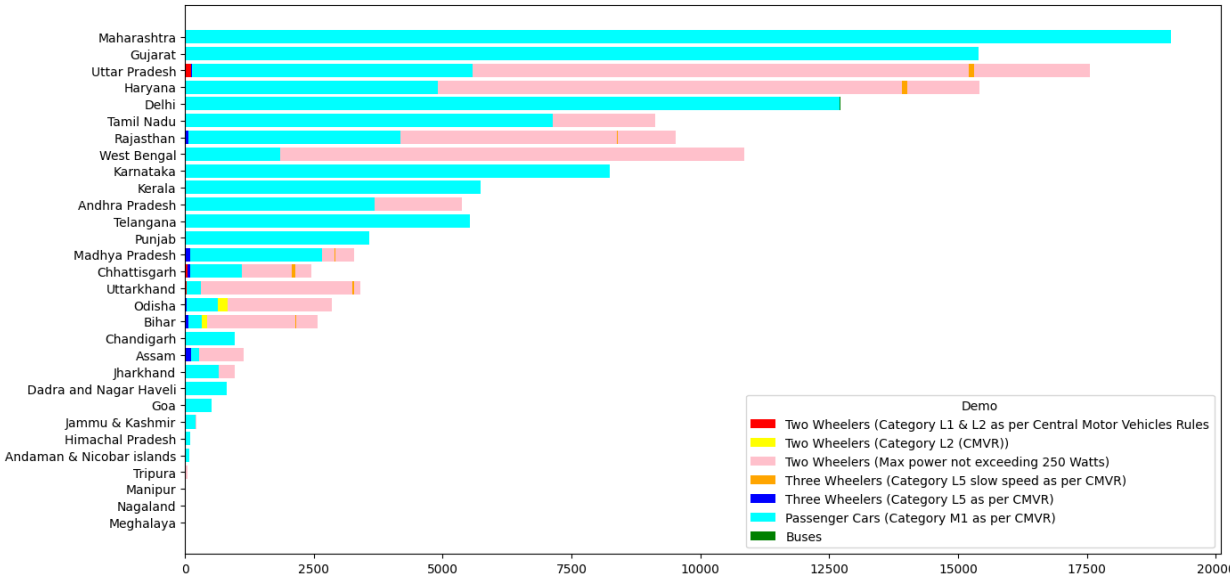
Out[10]:

	State Name	No.of Operational Public Charging Stations
0	Andaman & Nicobar	3
1	Andhra Pradesh	222
2	Arunachal Pradesh	9
3	Assam	48
4	Bihar	83
5	Chandigarh	6
6	Chhattisgarh	46
7	Delhi	1845
8	Goa	44
9	Gujarat	195
10	Haryana	232
11	Himachal Pradesh	27
12	Jammu & Kashmir	24
13	Jharkhand	60
14	Karnataka	704
15	Kerala	192
16	Lakshadweep	1
17	Madhya Pradesh	174
18	Maharashtra	660
19	Manipur	16
20	Meghalaya	19
21	Nagaland	6
22	Odisha	117
23	Puducherry	4
24	Punjab	126

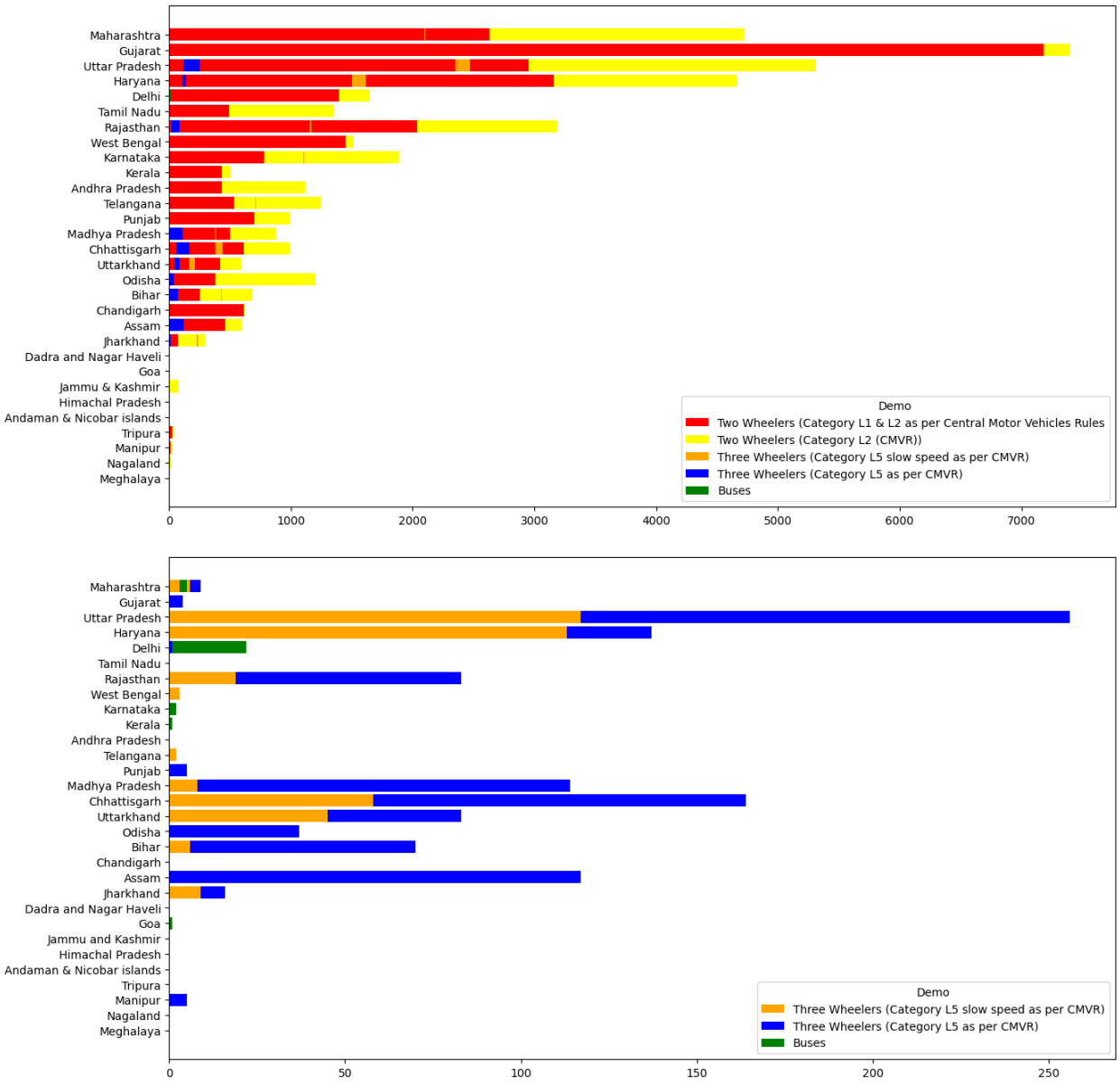
25	Raiasthan	254
26	Sikkim	1
27	Tamil Nadu	441
28	Telangana	365
29	Tripura	18
30	Dadar &Nagar Haveliand Daman &Diu	1
31	Uttar Pradesh	406
32	Uttarakhand	48
33	West Bengal	189

MARKET SEGMENT ANALYSIS

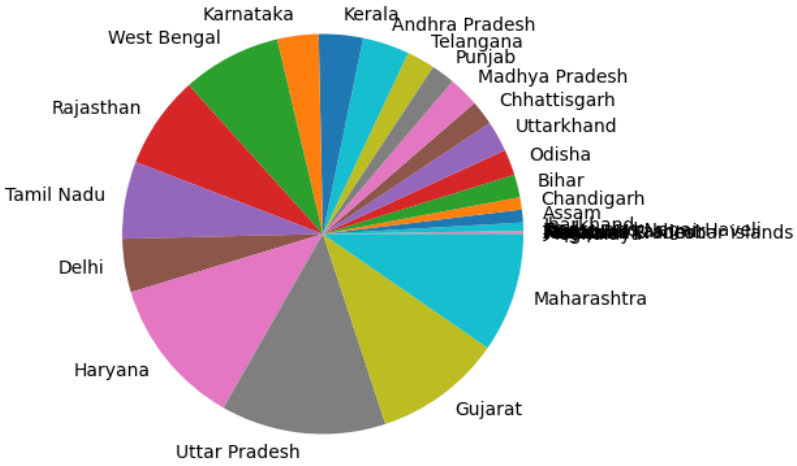
1. GEOGRAPHIC ANALYSIS:



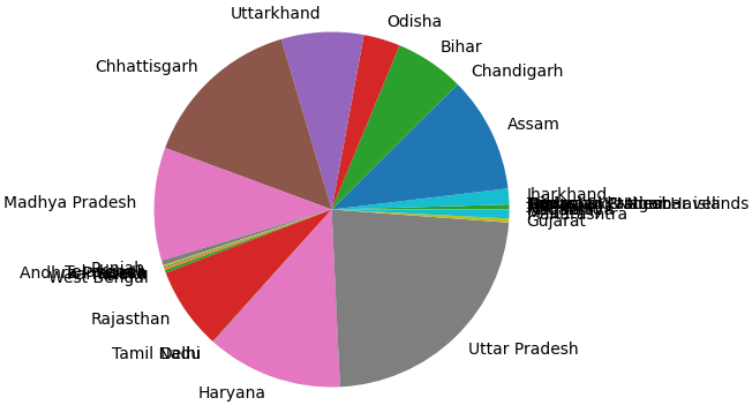
The graph above indicates that Maharashtra has recorded the highest number of electric vehicle sales. However, a closer analysis of the top states in EV sales reveals some significant findings.



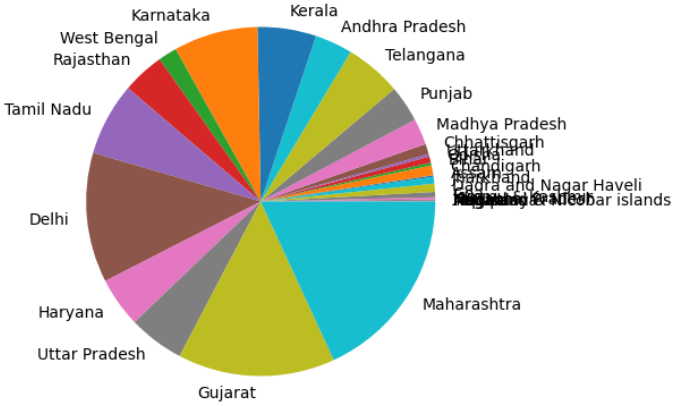
- Although Maharashtra leads in the total number of EV sales, most of the sales are in the passenger car segment.
- Gujarat has the highest proportion of two-wheeler (category L1 and L2) EV sales compared to the total sales in the state.
- Uttar Pradesh has the highest percentage of sales in two-wheelers (with maximum power not exceeding 250 watts) EVs of the total sales in the state.
- Similar observations can be made for other segments based on the percentage of sales.



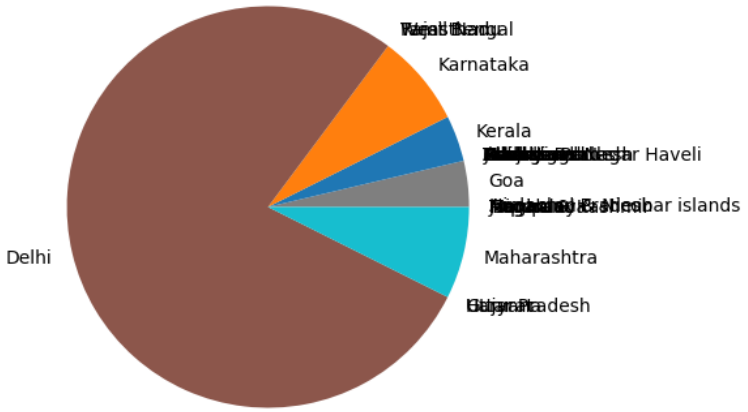
Number of two wheelers



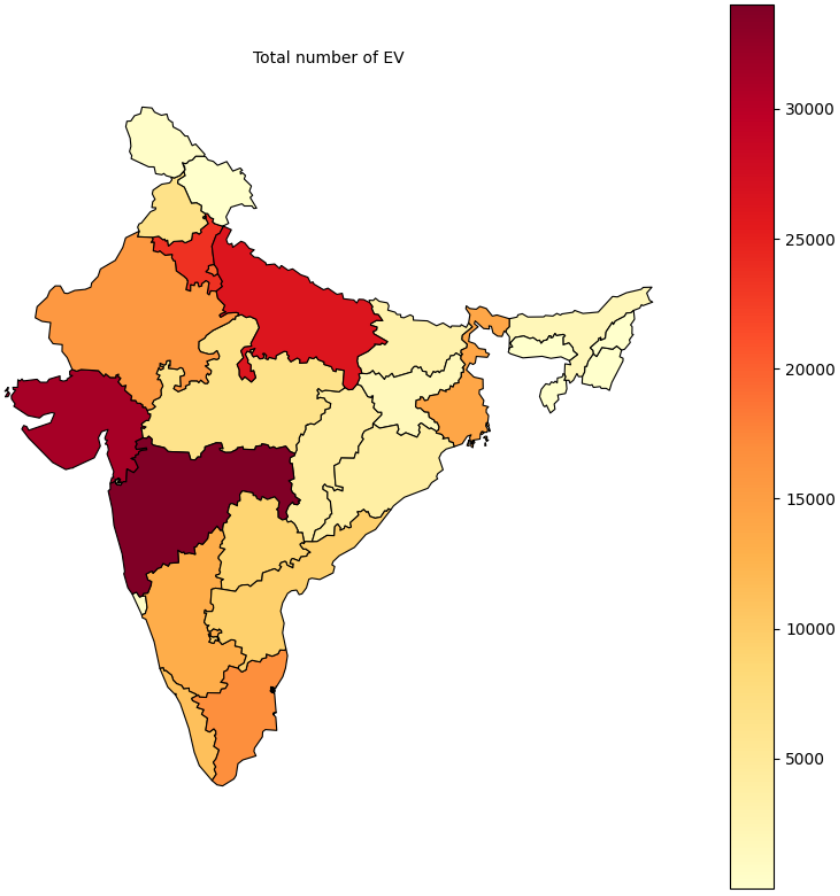
Number of three wheelers



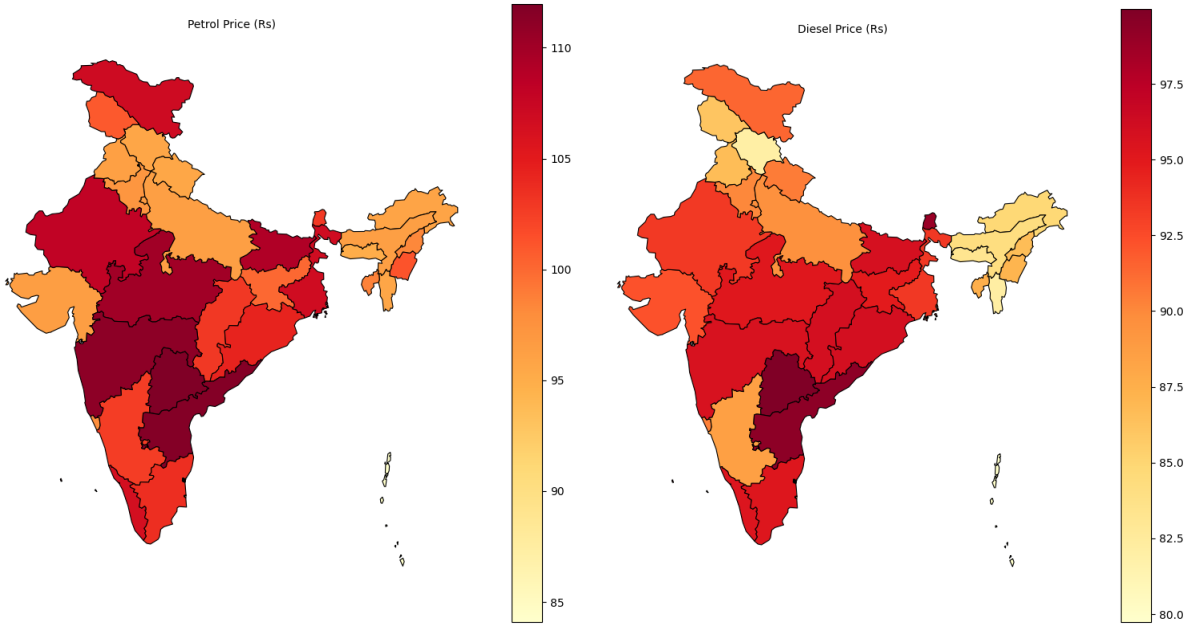
Number of passenger cars



Number of buses

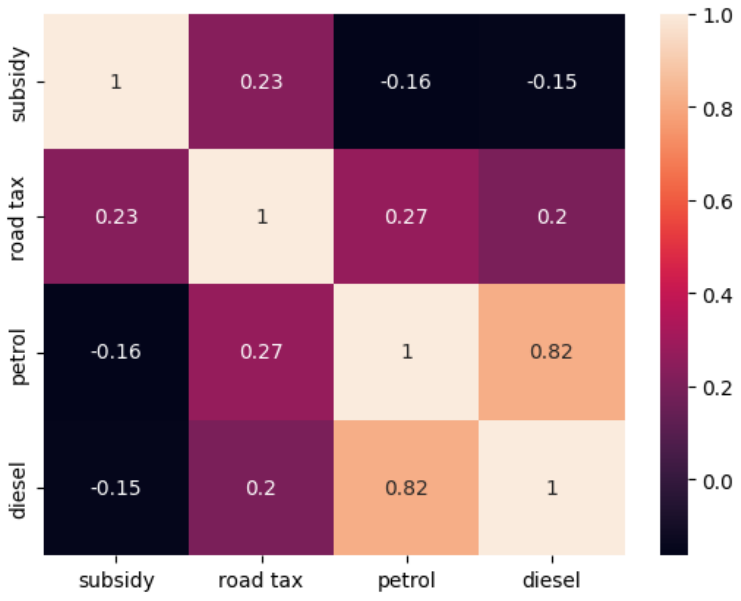


Total number of EV



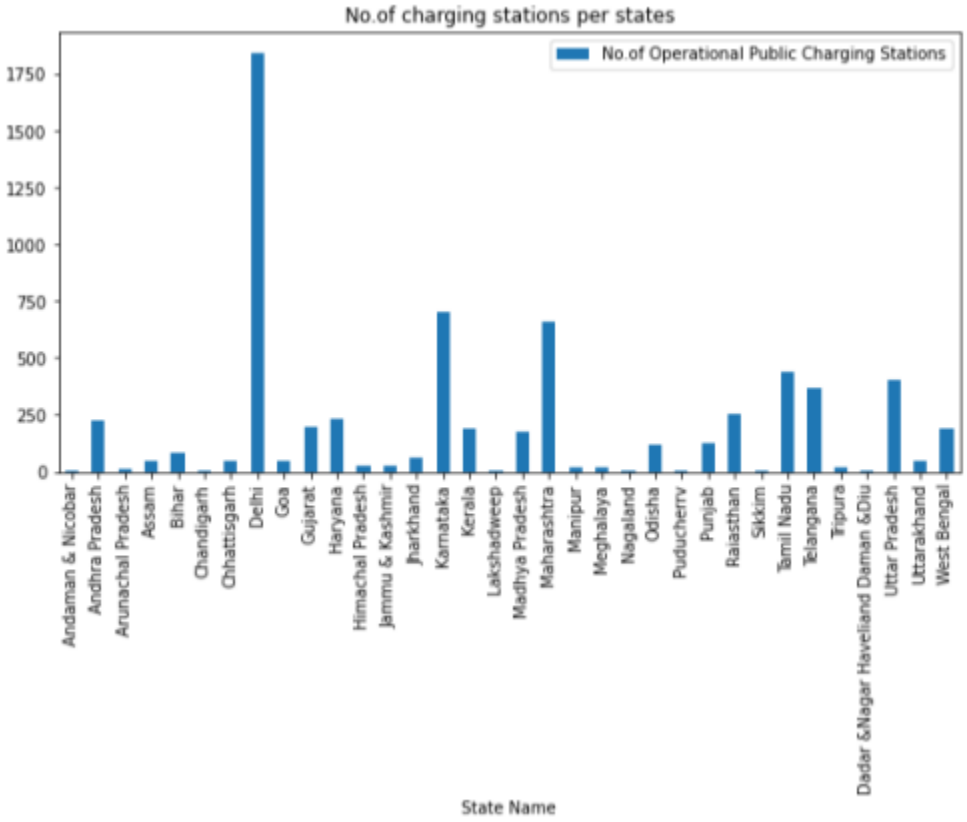
Petrol and Diesel prices in India

With rising petrol and diesel prices, electric vehicles are becoming a more cost-effective option compared to traditional petrol or diesel vehicles. Electric vehicles have lower running and maintenance costs, making them a more attractive alternative for consumers. As the price of petrol continues to increase, electric vehicles become even more appealing to consumers as they provide long-term cost savings and can reduce the consumer's dependence on traditional fuels.

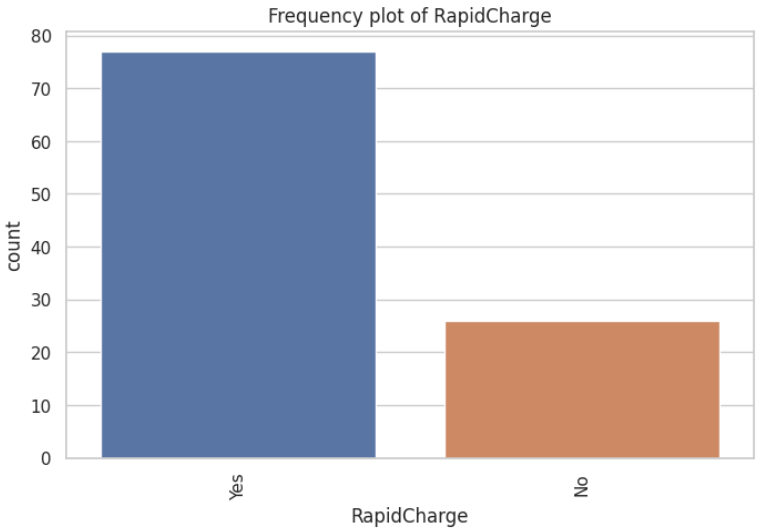


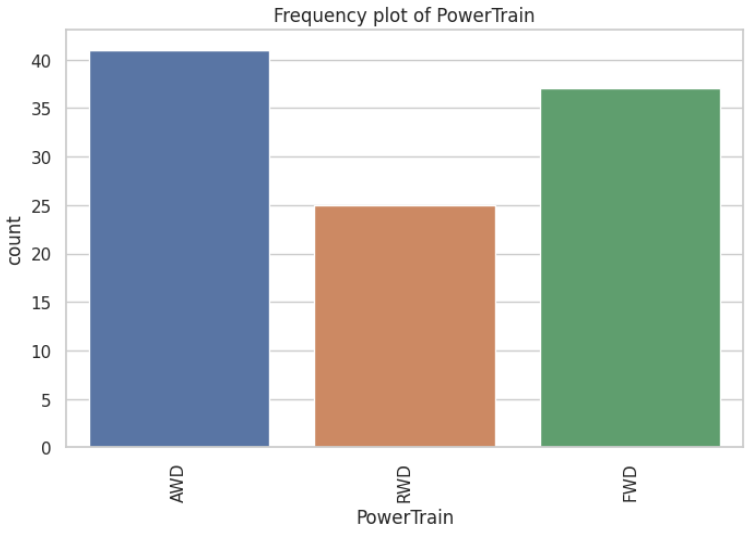
Correlation between petrol and diesel

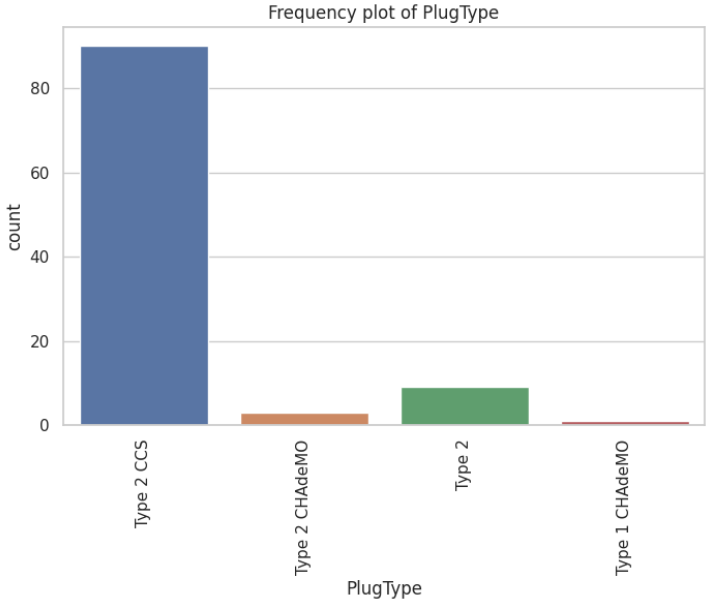
➢ **Charging Stations Analysis**

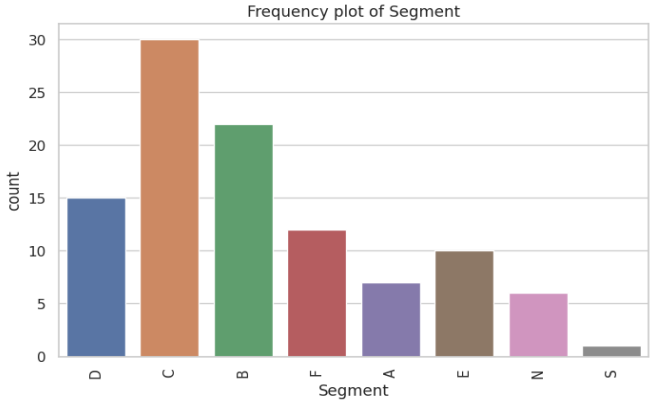


2. Behaioral Analysis of different Electric Vehicle Brands




Frequency plot of PowerTrain
count
PowerTrain
AWD
RWD
FWD
0
5
10
15
20
25
30
35
40


Frequency plot of PlugType
count
PlugType
Type 2 CCS
Type 2 CHAdeMO
Type 2
Type 1 CHAdeMO
0
20
40
60
80


Frequency plot of Segment
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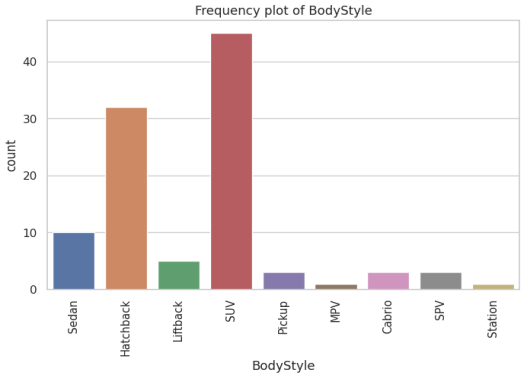
Segment
D
C
B
F
A
E
N
S
0
5
10
15
20
25
30


Frequency plot of BodyStyle
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BodyStyle
Sedan
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Liftback
SUV
Pickup
MPV
Cabrio
SPV
Station
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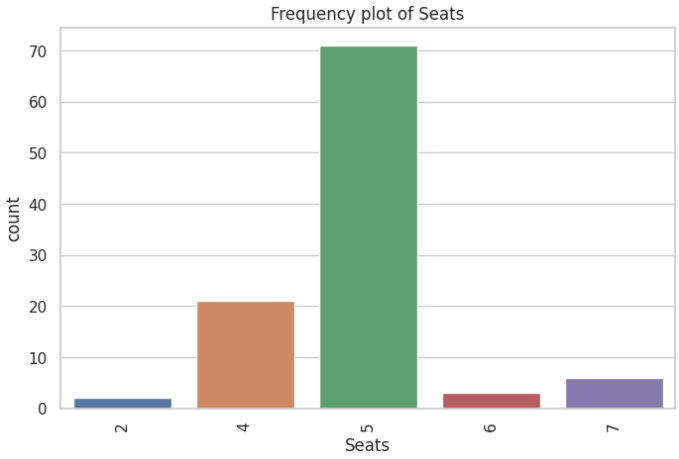
30
40


Frequency plot of Seats
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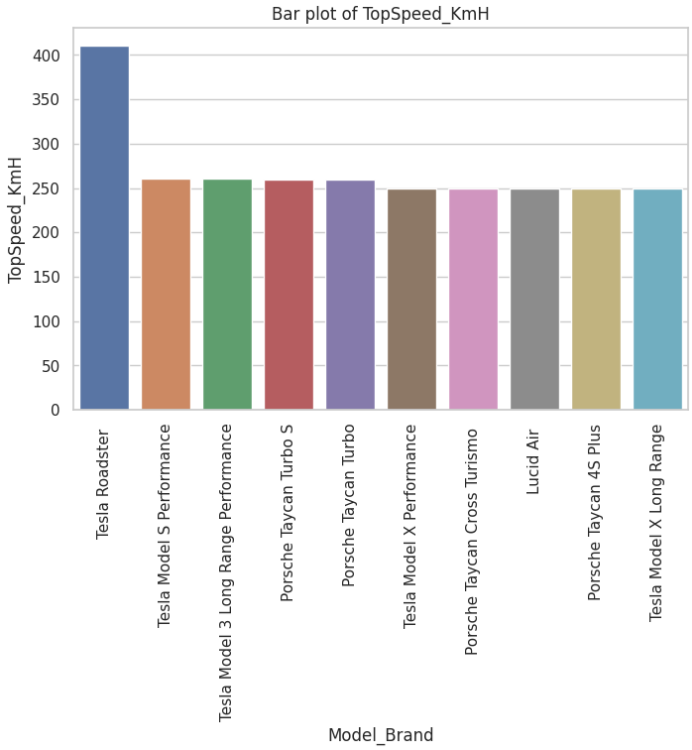
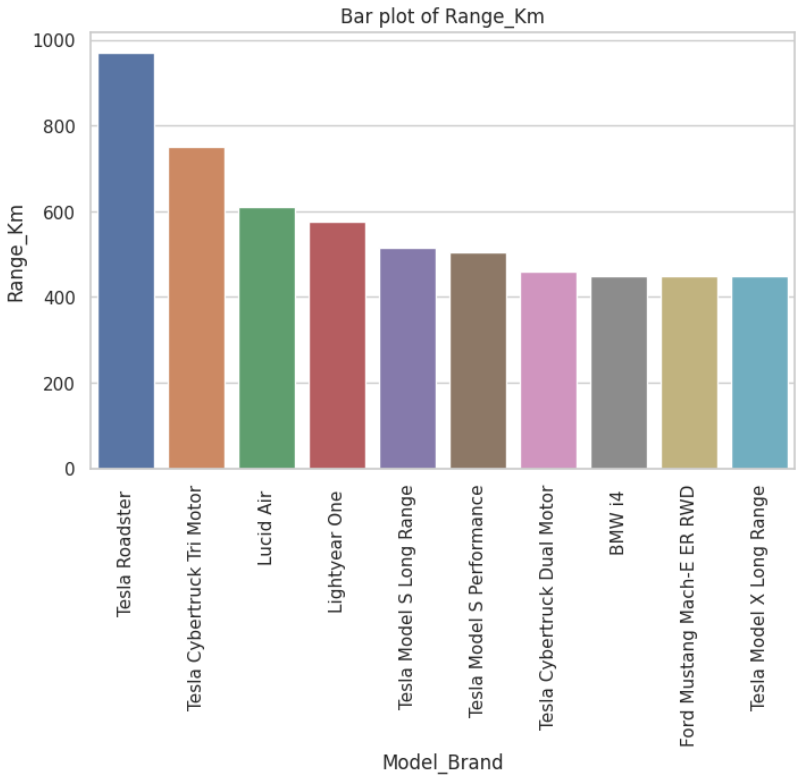
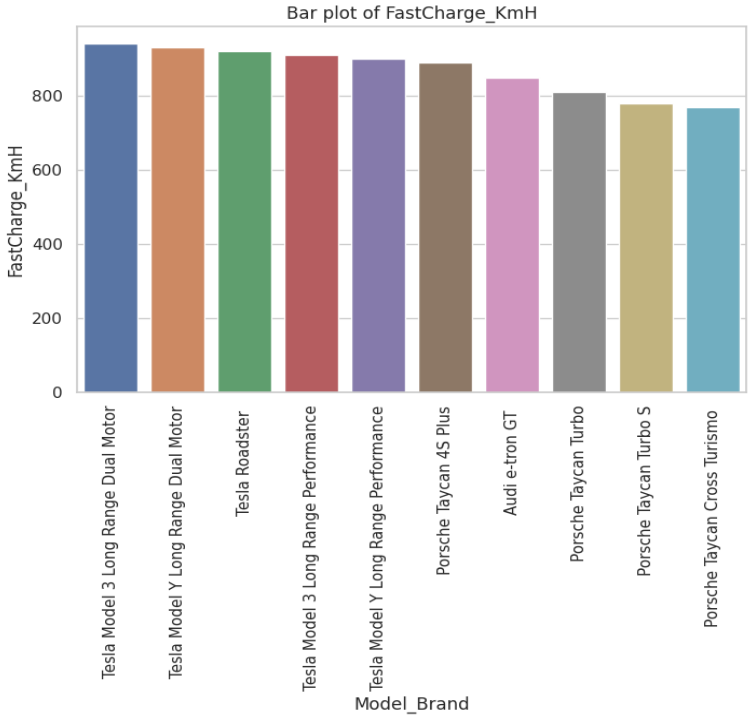
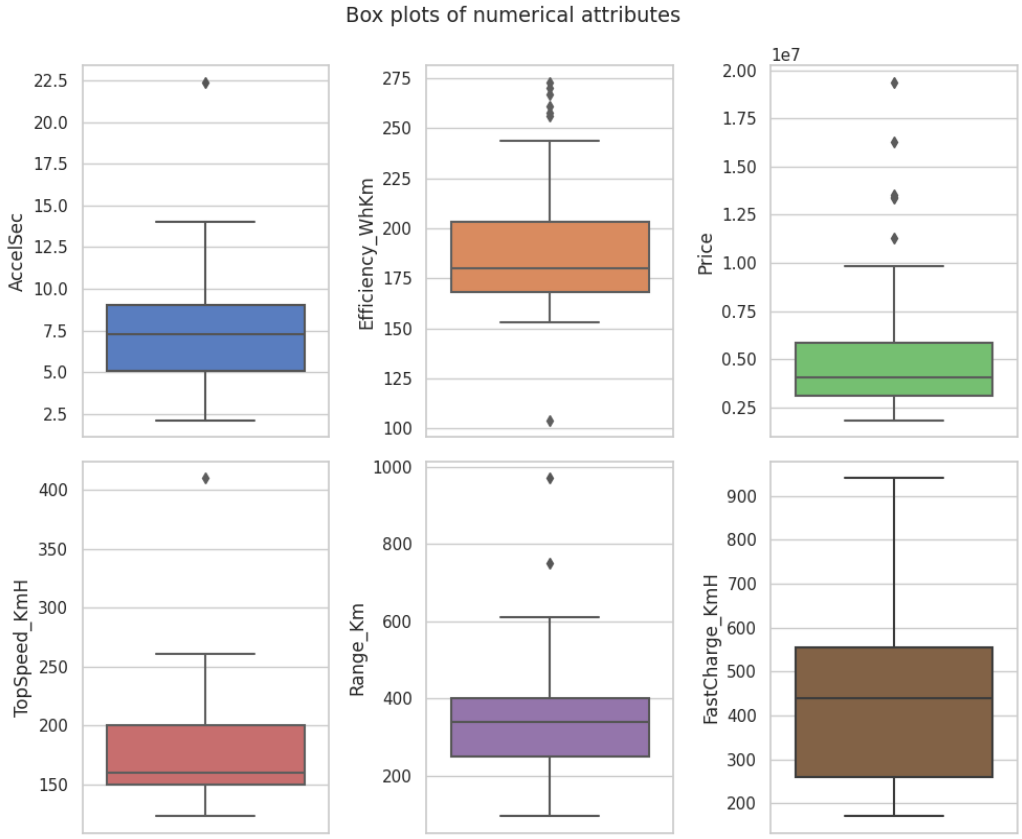
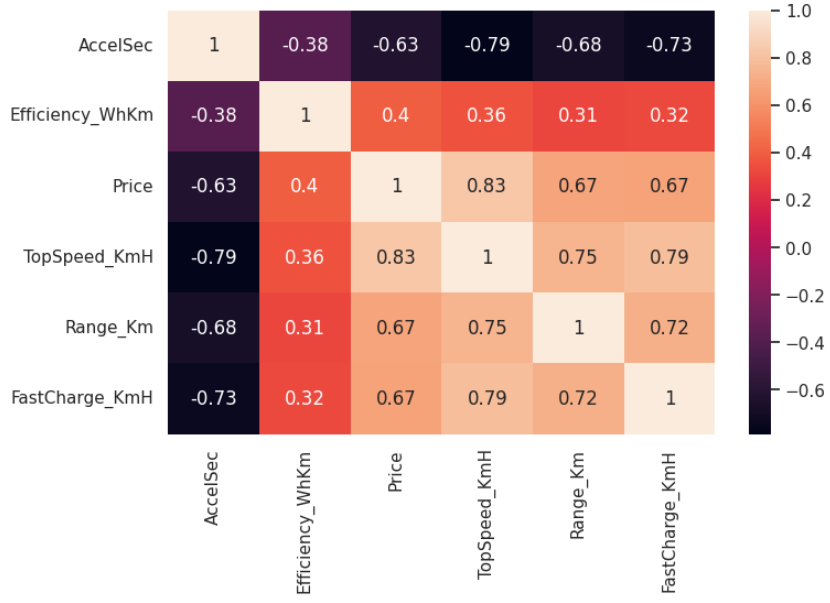
30
40
50
60
70
2
4
5
6
7
Seats


Bar plot of TopSpeed_KmH
TopSpeed_KmH
0
50
100
150
200
250
300
350
400
Tesla Roadster
Tesla Model S Performance
Tesla Model 3 Long Range Performance
Porsche Taycan Turbo S
Porsche Taycan Turbo
Tesla Model X Performance
Porsche Taycan Cross Turismo
Lucid Air
Porsche Taycan 4S Plus
Tesla Model X Long Range
Model_Brand

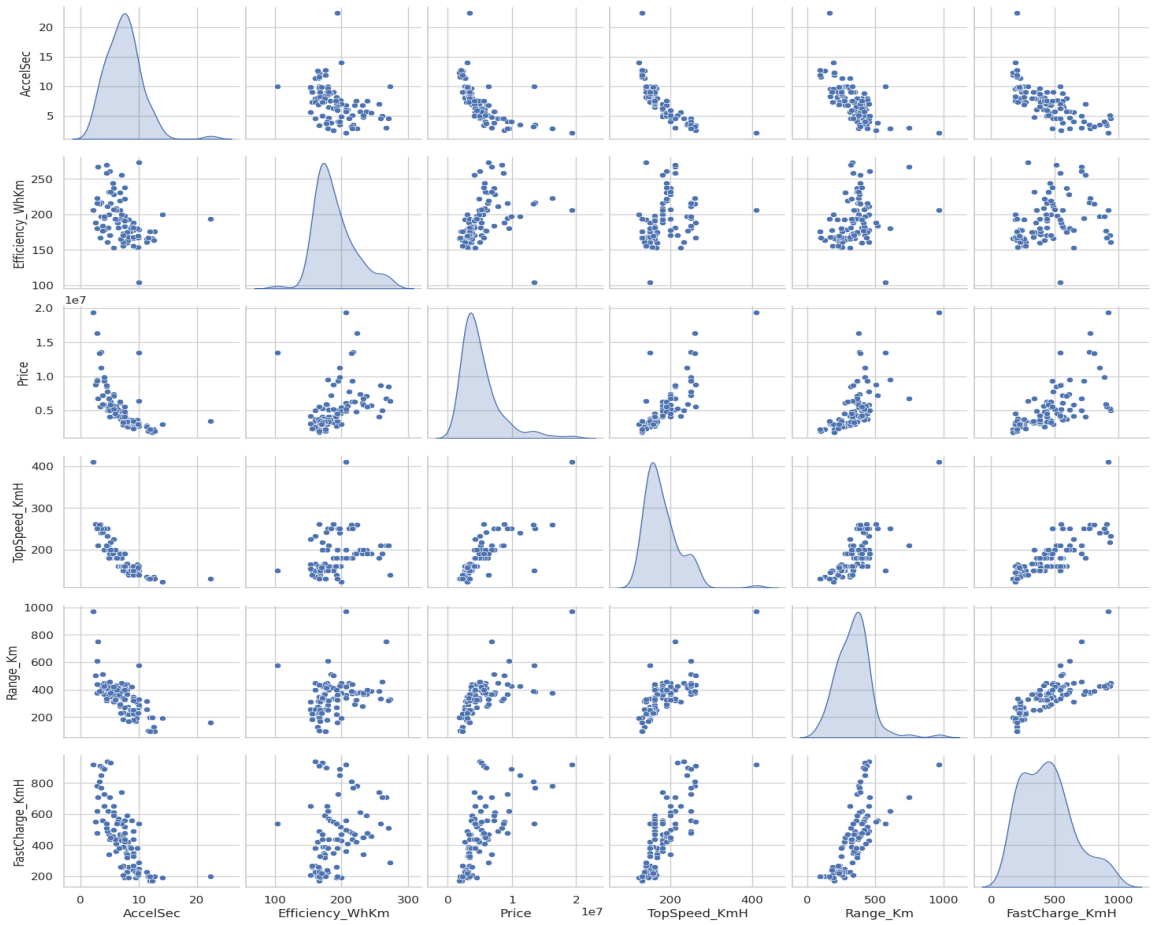

Bar plot of Range_Km
Range_Km
1000
800
600
400
200
0
Tesla Roadster
Tesla Cybertruck Tri Motor
Lucid Air
Lightyear One
Tesla Model S Long Range
Tesla Model S Performance
Tesla Cybertruck Dual Motor
BMW i4
Ford Mustang Mach-E ER RWD
Tesla Model X Long Range
Model_Brand

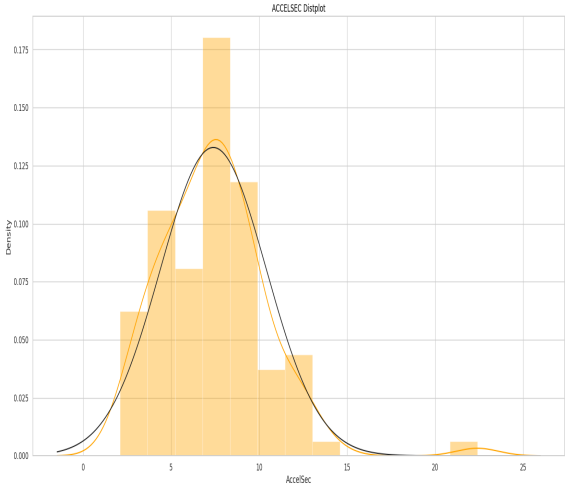

Bar plot of FastCharge_KmH
FastCharge_KmH
800
600
400
200
0
Tesla Model 3 Long Range Dual Motor
Tesla Model Y Long Range Dual Motor
Tesla Roadster
Tesla Model 3 Long Range Performance
Tesla Model Y Long Range Performance
Porsche Taycan 4S Plus
Audi e-tron GT
Porsche Taycan Turbo
Porsche Taycan Turbo S
Porsche Taycan Cross Turismo
Model_Brand

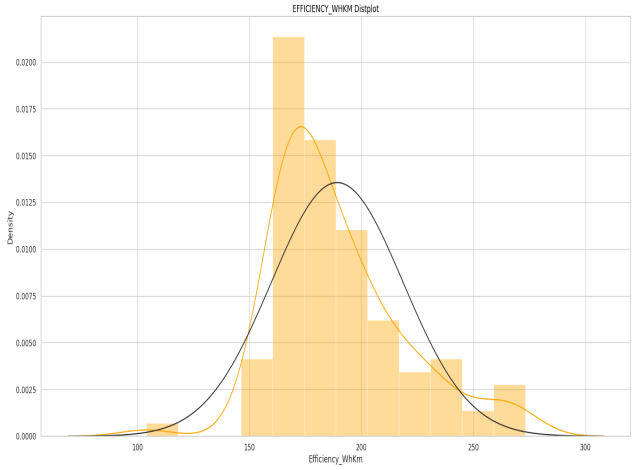


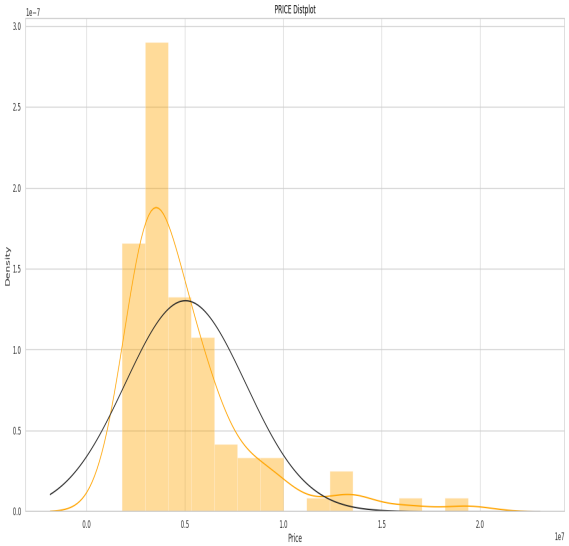


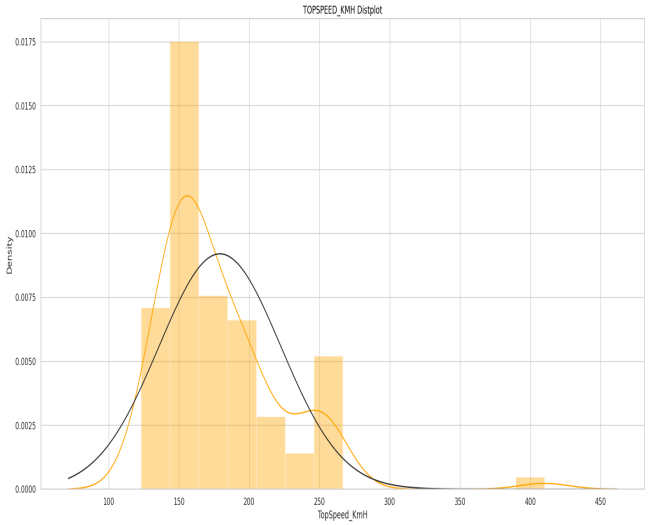
MULTIVARIATE ANALYSIS

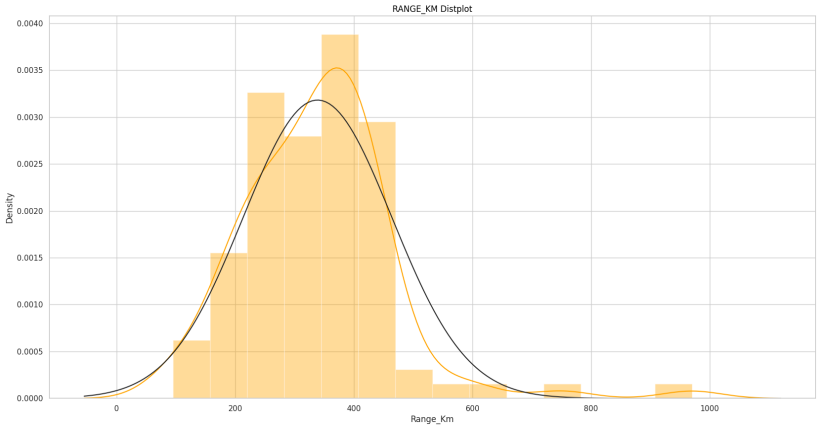

AccelSec
Efficiency_WhKm
Price
1e7
TopSpeed_KmH
Range_Km
FastCharge_KmH


ACCELSEC Distplot
Density
AccelSec

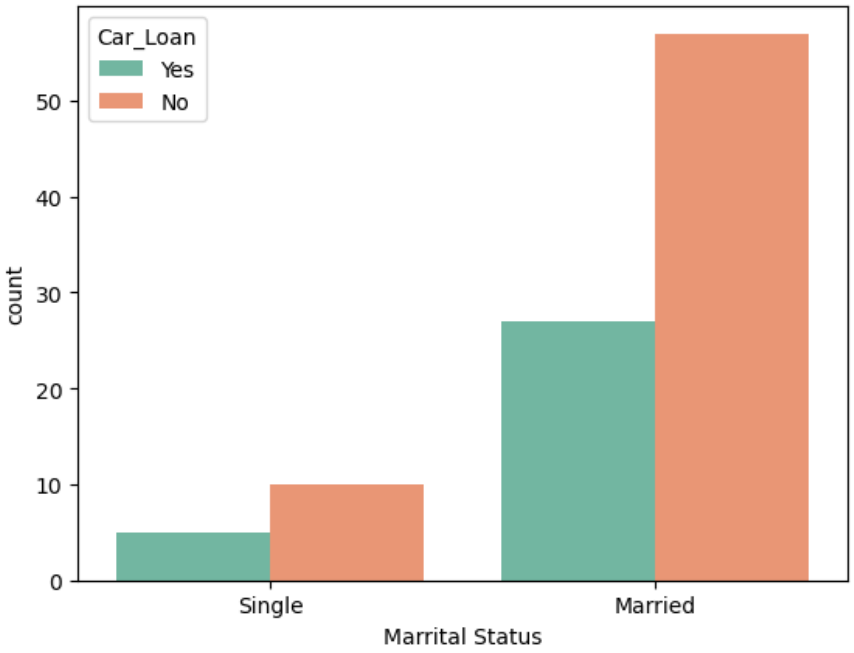

EFFICIENCY_WHKM Distplot
Density
Efficiency_WhKm

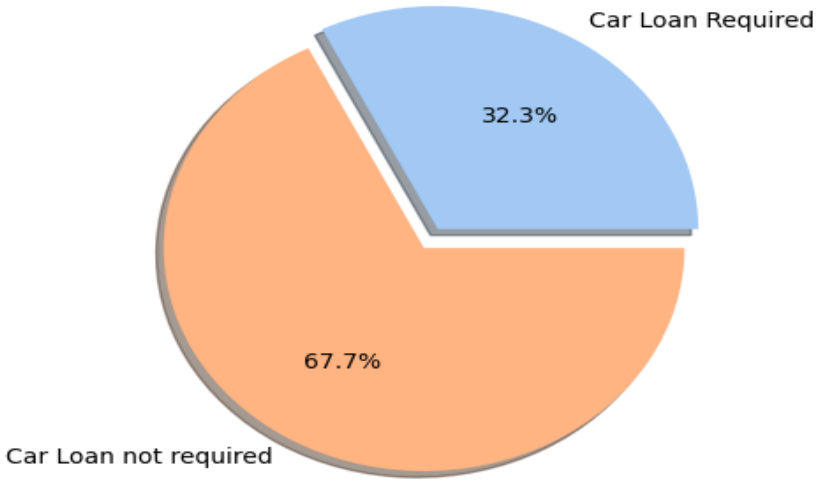

PRICE Distplot
1e−7
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Density
0.0
0.5
1.0
1.5
2.0
Price
1e7

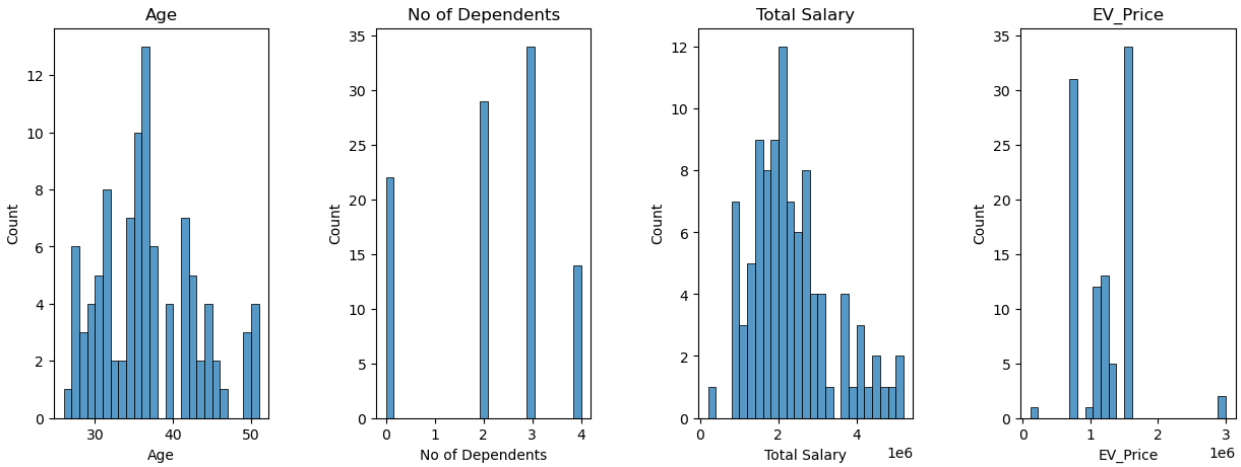

TOPSPEED_KMH Distplot
0.0175
0.0150
0.0125
0.0100
0.0075
0.0050
0.0025
0.0000
Density
100
150
200
250
300
350
400
450
TopSpeed_KmH

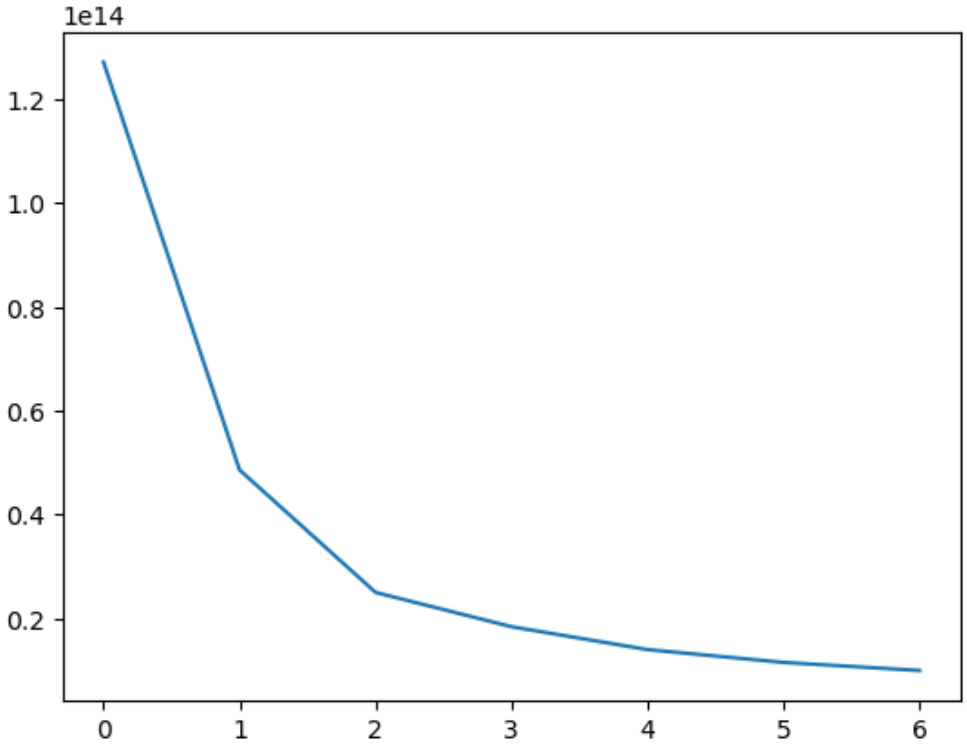

RANGE_KM Distplot
0.0040
0.0035
0.0030
0.0025
0.0020
0.0015
0.0010
0.0005
0.0000
Density
0
200
400
600
800
1000
Range_Km

3. DEMOGRAPHIC ANALYSIS









OPTIMAL NUMBER OF CLUSTERS

So, in conclusion

- ➢ The younger the consumer, the more likely they are to purchase a less expensive car.
- ➢ Consumers with more dependents tend to buy cars with more seats, which makes SUVs a popular choice.

➢ The average salary of consumers tends to align with the price range of the cars they purchase, creating a direct relationship between the two variables.

SEGMENT EXTRACTION

We will perform segment analysis for different types of data. For the same purpose we employ K Means Clustering and Linear Regression.

1. Linear Regression: is a statistical method that analyzes the relationship between a dependent variable and one or more independent variables. In the context of the electric vehicles market in India, linear regression can be used to analyze the factors that influence the sales of electric vehicles. The dependent variable in this case would be the sales of electric vehicles in a particular region or state, while the independent variables could be factors such as the price of electric vehicles, the availability of charging infrastructure, government subsidies, and the level of awareness about electric vehicles.

By performing linear regression analysis on the data, we can determine the extent to which each independent variable affects the sales of electric vehicles. This information can then be used to develop strategies to increase sales, such as offering discounts or subsidies on electric vehicles or investing in the development of charging infrastructure in areas with low sales.

Linear regression is a useful tool for understanding and predicting the electric vehicle market in India and can help stakeholders make informed decisions to promote the adoption of electric vehicles.

a. For geographical analysis:

	Sl. No	State	Two Wheelers (Category L1 & L2 as per Central Motor Vehicles Rules	Two Wheelers (Category L2 (CMVR))	Two Wheelers (Max power not exceeding 250 Watts)	Three Wheelers (Category L5 slow speed as per CMVR)	Three Wheelers (Category L5 as per CMVR)	Passenger Cars (Category M1 as per CMVR)	Buses	Total in state
0	1	Meghalaya	0	0	0	0	0	6	0	6
1	2	Nagaland	0	20	3	0	0	1	0	24
2	3	Manipur	16	8	11	0	5	12	0	52
3	4	Tripura	28	9	36	0	0	8	0	81
4	5	Andaman and Nicobar Islands	0	0	0	0	0	82	0	82

Merging the datasets:

	Unnamed: 0	State Name	No.of Operational Public Charging Stations	subsidy	road tax	petrol	diesel	Two Wheelers (Category L1 & L2 as per Central Motor Vehicles Rules	Two Wheelers (Category L2 (CMVR))	Two Wheelers (Max power not exceeding 250 Watts)	Three Wheelers (Category L5 slow speed as per CMVR)	Three Wheelers (Category L5 as per CMVR)	Passenger Cars (Category M1 as per CMVR)	Buses	Total in state
0	0	Andaman and Nicobar Islands	3	0.0	0.0	84.10	79.74	0.0	0.0	0.0	0.0	0.0	82.0	0.0	82.0
1	1	Andhra Pradesh	222	0.0	1.0	111.65	99.41	431.0	692.0	4689.0	0.0	0.0	3680.0	0.0	9492.0
2	2	Arunachal Pradesh	9	5000.0	0.0	95.89	84.81	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
3	3	Assam	48	10000.0	1.0	96.34	84.24	463.0	138.0	1006.0	0.0	117.0	151.0	0.0	1875.0
4	4	Bihar	83	10000.0	1.0	109.17	95.82	252.0	430.0	2148.0	6.0	64.0	271.0	0.0	3171.0

```
df = df.dropna()
```

```
[ ] #define predictor and response variables
    x = df[['No.of Operational Public Charging Stations', 'subsidy', 'road tax', 'petrol', 'diesel']]
    y = df['Total in state']

    #add constant to predictor variables
    x = sm.add_constant(x)

    #fit linear regression model
    model = sm.OLS(y, x).fit()

    #view model summary
    print(model.summary())
```

```
                            OLS Regression Results
==============================================================================
Dep. Variable:         Total in state   R-squared:                       0.397
Model:                            OLS   Adj. R-squared:                  0.253
Method:                 Least Squares   F-statistic:                     2.764
Date:                Fri, 12 May 2023   Prob (F-statistic):             0.0453
Time:                        04:08:11   Log-Likelihood:                -280.24
No. Observations:                  27   AIC:                             572.5
Df Residuals:                      21   BIC:                             580.3
Df Model:                           5
Covariance Type:            nonrobust
================================================================================================================
                                                   coef    std err          t      P>|t|      [0.025      0.975]
----------------------------------------------------------------------------------------------------------------
const                                       -3.311e+04   3.12e+04     -1.063      0.300   -9.79e+04    3.17e+04
No.of Operational Public Charging Stations     12.8994      5.071      2.544      0.019       2.353      23.446
subsidy                                        -0.0822      0.453     -0.181      0.858      -1.025       0.860
road tax                                     1044.5681   4339.713      0.241      0.812   -7980.359    1.01e+04
petrol                                       -484.8177    532.872     -0.910      0.373   -1592.985     623.350
diesel                                        968.0590    615.540      1.573      0.131    -312.026    2248.144
==============================================================================
Omnibus:                        9.682   Durbin-Watson:                   1.613
Prob(Omnibus):                  0.008   Jarque-Bera (JB):                8.065
Skew:                           1.260   Prob(JB):                       0.0177
Kurtosis:                       3.905   Cond. No.                     9.87e+04
==============================================================================
```

```
Notes:
[1] Standard Errors assume that the covariance matrix of the errors is correctly specified.
[2] The condition number is large, 9.87e+04. This might indicate that there are
strong multicollinearity or other numerical problems.
```

Now we can see that the coefficients of the columns "road tax" and "diesel" have the most correlation with number of EVs and the confidence score of "No.of Operational Public Charging Stations" is less than 0.05. So we use these features to cluster the states and address the EV markets accordingly.

	Unnamed: 0	State Name	No.of Operational Public Charging Stations	subsidy	road tax	petrol	diesel	Two Wheelers (Category L1 & L2 as per Central Motor Vehicles Rules	Two Wheelers (Category L2 (CMVR))	Two Wheelers (Max power not exceeding 250 Watts)	Three Wheelers (Category L5 slow speed as per CMVR)	Three Wheelers (Category L5 as per CMVR)	Passenger Cars (Category M1 as per CMVR)	Buses	Total in state
1	1	Andhra Pradesh	222	0.0	1.0	111.65	99.41	431.0	692.0	4689.0	0.0	0.0	3680.0	0.0	9492.0
3	3	Assam	48	10000.0	1.0	96.34	84.24	463.0	138.0	1006.0	0.0	117.0	151.0	0.0	1875.0
4	4	Bihar	83	10000.0	1.0	109.17	95.82	252.0	430.0	2148.0	6.0	64.0	271.0	0.0	3171.0
5	5	Chandigarh	6	5000.0	1.0	96.20	84.26	612.0	18.0	896.0	0.0	0.0	974.0	0.0	2500.0
7	7	Delhi	1845	10000.0	1.0	96.72	89.62	1395.0	251.0	5018.0	0.0	1.0	12695.0	21.0	19381.0
8	8	Goa	44	8000.0	1.0	97.82	90.37	0.0	0.0	0.0	0.0	0.0	513.0	1.0	514.0
14	14	Karnataka	704	0.0	1.0	102.64	88.55	784.0	1104.0	3252.0	2.0	0.0	8242.0	2.0	13386.0
18	18	Maharashtra	660	5000.0	1.0	111.18	95.66	2630.0	2097.0	10146.0	6.0	3.0	19129.0	2.0	34013.0
20	20	Meghalaya	19	4000.0	1.0	95.06	83.28	0.0	0.0	0.0	0.0	0.0	6.0	0.0	6.0

These states have high road tax, so these states are in the infrastructure construction phase and they can be a sink for a new EV market.

	Unnamed: 0	State Name	No.of Operational Public Charging Stations	subsidy	road tax	petrol	diesel	Two Wheelers (Category L1 & L2 as per Central Motor Vehicles Rules	Two Wheelers (Category L2 (CMVR))	Two Wheelers (Max power not exceeding 250 Watts)	Three Wheelers (Category L5 slow speed as per CMVR)	Three Wheelers (Category L5 as per CMVR)	Passenger Cars (Category M1 as per CMVR)	Buses	Total in state
0	0	Andaman and Nicobar Islands	3	0.0	0.0	84.10	79.74	0.0	0.0	0.0	0.0	0.0	82.0	0.0	82.0
11	11	Himachal Pradesh	27	5000.0	0.0	95.74	81.99	0.0	0.0	0.0	0.0	0.0	98.0	0.0	98.0
20	20	Meghalaya	19	4000.0	1.0	95.06	83.28	0.0	0.0	0.0	0.0	0.0	6.0	0.0	6.0
3	3	Assam	48	10000.0	1.0	96.34	84.24	463.0	138.0	1006.0	0.0	117.0	151.0	0.0	1875.0
5	5	Chandigarh	6	5000.0	1.0	96.20	84.26	612.0	18.0	896.0	0.0	0.0	974.0	0.0	2500.0
12	12	Jammu and Kashmir	24	0.0	0.0	100.94	86.09	2.0	76.0	152.0	0.0	0.0	208.0	0.0	438.0
24	24	Punjab	126	0.0	1.0	96.26	86.63	698.0	300.0	1968.0	0.0	5.0	3567.0	0.0	6538.0
21	21	Nagaland	6	5000.0	0.0	98.28	86.65	0.0	20.0	3.0	0.0	0.0	1.0	0.0	24.0

These states have high fuel prices, which bears the adjacent public sentiment of shifting to EVs, so, these can be a new market for EVs.

[ ]

	Unnamed: 0	State Name	No.of Operational Public Charging Stations	subsidy	road tax	petrol	diesel	Two Wheelers (Category L1 & L2 as per Central Motor Vehicles Rules	Two Wheelers (Category L2 (CMVR))	Two Wheelers (Max power not exceeding 250 Watts)	Three Wheelers (Category L5 slow speed as per CMVR)	Three Wheelers (Category L5 as per CMVR)	Passenger Cars (Category M1 as per CMVR)	Buses	Total in state
7	7	Delhi	1845	10000.0	1.00	96.72	89.62	1395.0	251.0	5018.0	0.0	1.0	12695.0	21.0	19381.0
14	14	Karnataka	704	0.0	1.00	102.64	88.55	784.0	1104.0	3252.0	2.0	0.0	8242.0	2.0	13386.0
18	18	Maharashtra	660	5000.0	1.00	111.18	95.66	2630.0	2097.0	10146.0	6.0	3.0	19129.0	2.0	34013.0
27	27	Tamil Nadu	441	0.0	1.00	103.62	95.24	491.0	863.0	8260.0	0.0	0.0	7132.0	0.0	16746.0
31	31	Uttar Pradesh	406	0.0	0.75	96.38	89.55	2954.0	2355.0	15199.0	117.0	139.0	5445.0	0.0	26209.0
28	28	Telangana	365	0.0	1.00	111.97	99.97	535.0	711.0	2256.0	2.0	0.0	5530.0	0.0	9034.0
10	10	Haryana	232	0.0	0.00	97.24	90.08	3162.0	1504.0	13908.0	113.0	24.0	4878.0	0.0	23589.0
1	1	Andhra Pradesh	222	0.0	1.00	111.65	99.41	431.0	692.0	4689.0	0.0	0.0	3680.0	0.0	9492.0
9	9	Gujarat	195	10000.0	0.50	96.49	92.23	7182.0	217.0	8476.0	0.0	4.0	15388.0	0.0	31267.0

These states have more charging stations, and for a new EV startup it will be easier to access the charging stations rather than building the stations from scratch.

```
x = set(road_tax1['State Name'])
y = set(diesel1['State Name'])
z = set(charging_station1['State Name'])

print(x.intersection(y))
print(y.intersection(z))
print(x.intersection(z))
```

```
{'Chandigarh', 'Assam', 'Meghalaya'}
set()
{'Maharashtra', 'Karnataka', 'Delhi', 'Andhra Pradesh'}
```

Targeting Chandigarh, Maharashtra, and Karnataka states would be a better entry point for an EV startup.

2. K Means Clustering: K Means Clustering is a popular unsupervised machine learning technique used for clustering similar data points into groups. In the context of Electric Vehicles Market Segmentation in India, K Means Clustering can be used to group consumers based on their preferences, needs, and characteristics related to EVs.

The algorithm will group data points based on their similarity to each other in terms of the variables used in the analysis. Analyze the clusters to identify common characteristics and preferences among the consumers in each cluster. This analysis can be used to develop targeted marketing strategies for each cluster.

K Means Clustering is a valuable tool for Electric Vehicles Market Segmentation in India as it can help EV startups and manufacturers identify and target specific segments of consumers with tailored marketing strategies.

a. For geographical analysis:

```
[ ]  df1.replace("Andaman & Nicobar", "Andaman and Nicobar Islands", inplace=True)
     df1.replace("Jammu & Kashmir", "Jammu and Kashmir", inplace = True)
     df1.head()
```

	State Name	No.of Operational Public Charging Stations
0	Andaman and Nicobar Islands	3
1	Andhra Pradesh	222
2	Arunachal Pradesh	9
3	Assam	48
4	Bihar	83

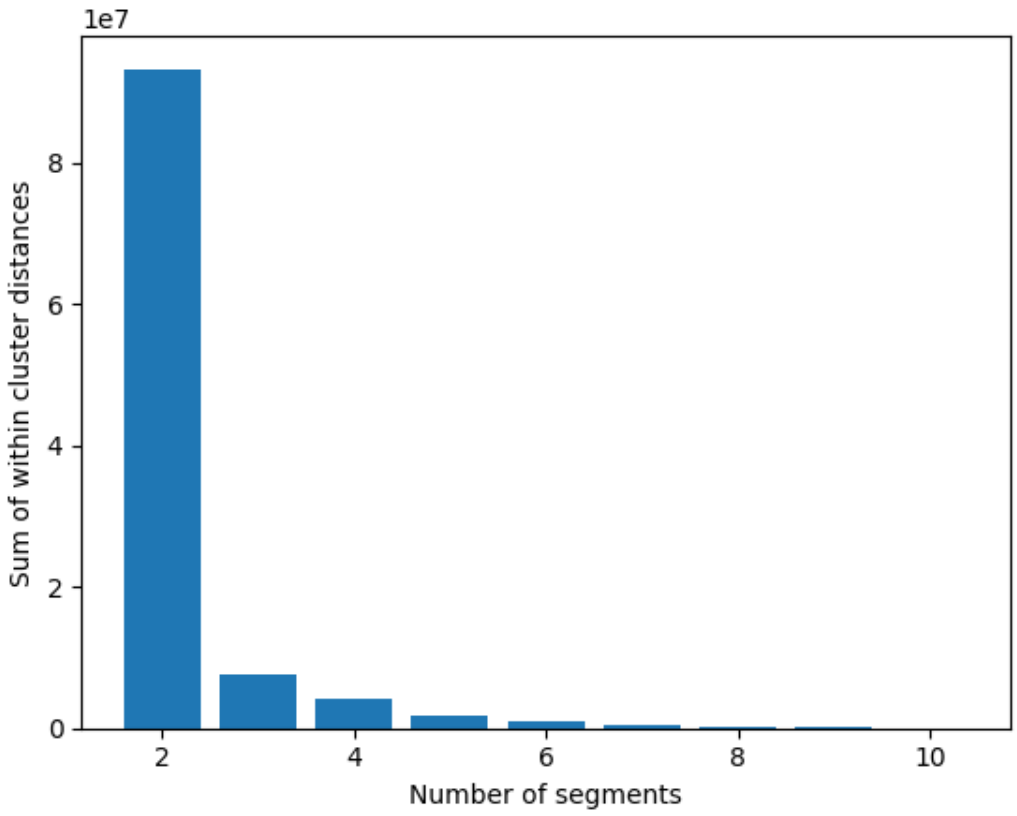
	state	capital	subsidy	road tax	petrol	diesel
0	Andhra Pradesh	Amaravati	0.0	1.0	111.65	99.41
1	Arunachal Pradesh	Itanagar	5000.0	0.0	95.89	84.81
2	Assam	Dispur	10000.0	1.0	96.34	84.24
3	Bihar	Patna	10000.0	1.0	109.17	95.82
4	Chhattisgarh	Raipur	5000.0	0.0	102.98	95.96

Merging the above datasets:

	State Name	No.of Operational Public Charging Stations	state	capital	subsidy	road tax	petrol	diesel
0	Andaman and Nicobar Islands	3	Andaman and Nicobar Islands	Port Blair	0.0	0.0	84.10	79.74
1	Andhra Pradesh	222	Andhra Pradesh	Amaravati	0.0	1.0	111.65	99.41
2	Arunachal Pradesh	9	Arunachal Pradesh	Itanagar	5000.0	0.0	95.89	84.81
3	Assam	48	Assam	Dispur	10000.0	1.0	96.34	84.24
4	Bihar	83	Bihar	Patna	10000.0	1.0	109.17	95.82

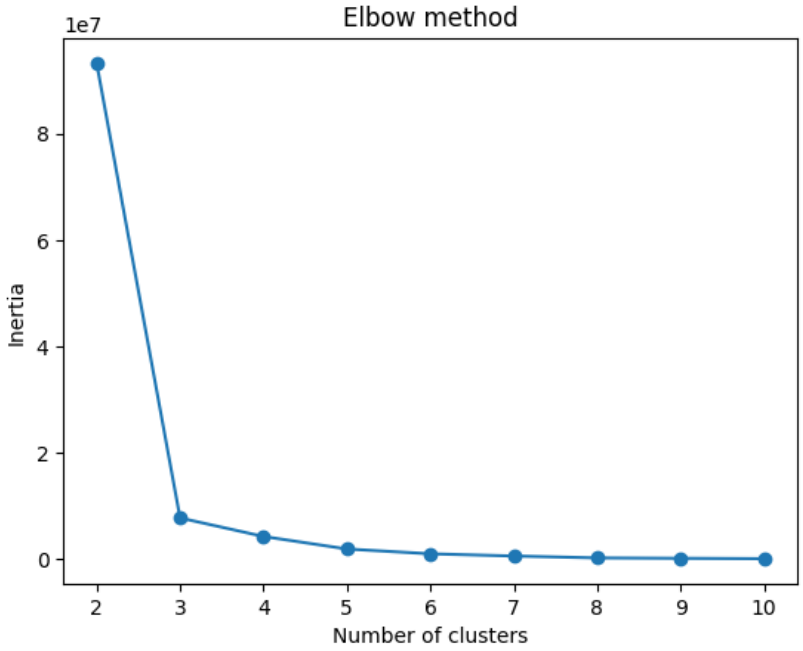
Applying the K-Means Clustering to the dataset:

```
[ ] from sklearn.cluster import KMeans
    from matplotlib import pyplot as plt
    distortions = []
    for k in range(2,11):
        kmeanModel = KMeans(n_clusters=k, random_state=1234, n_init=10)
        kmeanModel.fit(df[['No.of Operational Public Charging Stations', 'subsidy','road tax', 'petrol', 'diesel']].dropna())
        distortions.append(kmeanModel.inertia_)
    plt.bar(range(2,11), distortions)
    plt.xlabel('Number of segments')
    plt.ylabel('Sum of within cluster distances')
    plt.show()
```



i) Elbow method:

```
[ ]  inertias = []

     for i in range(2,11):
         kmeans = KMeans(n_clusters=i)
         kmeans.fit(df[['No.of Operational Public Charging Stations', 'subsidy','road tax', 'petrol', 'diesel']].dropna())
         inertias.append(kmeans.inertia_)

     plt.plot(range(2,11), inertias, marker='o')
     plt.title('Elbow method')
     plt.xlabel('Number of clusters')
     plt.ylabel('Inertia')
     plt.show()
```



The Clusters:

```
[ ]  print(cluster1['State Name'])
     cluster1.describe()
```

```
0     Andaman and Nicobar Islands
1                  Andhra Pradesh
10                        Haryana
12               Jammu and Kashmir
14                       Karnataka
15                          Kerala
16                     Lakshadweep
17                  Madhya Pradesh
22                          Odisha
24                          Punjab
26                          Sikkim
27                      Tamil Nadu
28                       Telangana
31                   Uttar Pradesh
32                     Uttarakhand
Name: State Name, dtype: object
```

	No.of Operational Public Charging Stations	subsidy	road tax	petrol	diesel
count	15.000000	15.0	15.000000	15.000000	15.000000
mean	203.733333	0.0	0.549333	102.126667	92.511333
std	201.468348	0.0	0.483003	7.407507	5.777981
min	1.000000	0.0	0.000000	84.100000	79.740000
25%	36.000000	0.0	0.000000	96.810000	89.050000
50%	174.000000	0.0	0.750000	102.850000	95.180000
75%	298.500000	0.0	1.000000	107.080000	96.220000
max	704.000000	0.0	1.000000	111.970000	99.970000

```
print(cluster2['State Name'])
cluster2.describe()
```

```
3           Assam
4           Bihar
7           Delhi
8             Goa
9         Gujarat
33    West Bengal
Name: State Name, dtype: object
```

	No.of Operational Public Charging Stations	subsidy	road tax	petrol	diesel
count	6.000000	6.000000	6.000000	6.000000	6.000000
mean	400.666667	9666.666667	0.916667	100.555000	90.958333
std	710.731642	816.496581	0.204124	5.823596	3.970760
min	44.000000	8000.000000	0.500000	96.340000	84.240000
25%	56.750000	10000.000000	1.000000	96.547500	89.807500
50%	136.000000	10000.000000	1.000000	97.270000	91.300000
75%	193.500000	10000.000000	1.000000	104.547500	93.160000
max	1845.000000	10000.000000	1.000000	109.170000	95.820000

```
print(cluster3['State Name'])
cluster3.describe()
```

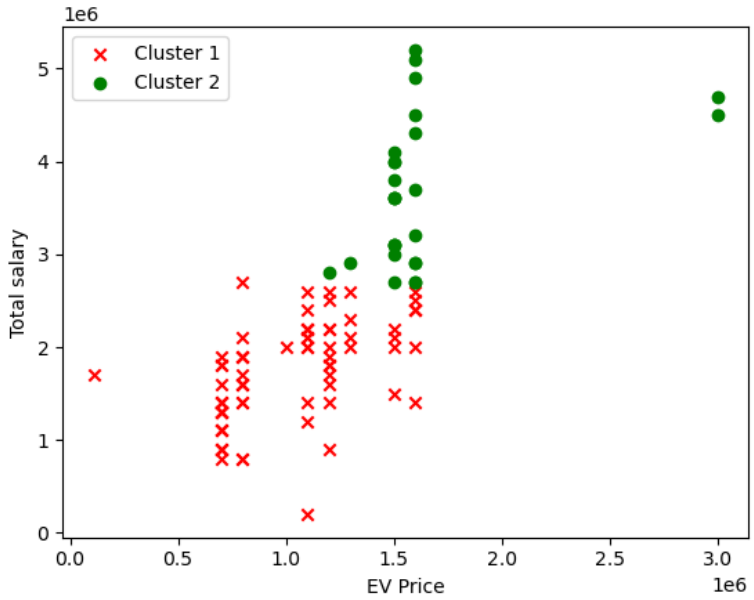
```
2     Arunachal Pradesh
5            Chandigarh
6          Chhattisgarh
11      Himachal Pradesh
13             Jharkhand
18           Maharashtra
19               Manipur
20             Meghalaya
21              Nagaland
29               Tripura
Name: State Name, dtype: object
```

	No.of Operational Public Charging Stations	subsidy	road tax	petrol	diesel
count	10.000000	10.000000	10.000000	10.000000	10.000000
mean	86.700000	4900.000000	0.300000	99.522000	88.217000
std	202.201797	316.227766	0.483046	4.852749	5.314774
min	6.000000	4000.000000	0.000000	95.060000	81.990000
25%	10.750000	5000.000000	0.000000	95.967500	84.397500
50%	18.500000	5000.000000	0.000000	98.430000	86.905000
75%	41.250000	5000.000000	0.750000	100.937500	93.040000
max	660.000000	5000.000000	1.000000	111.180000	95.960000

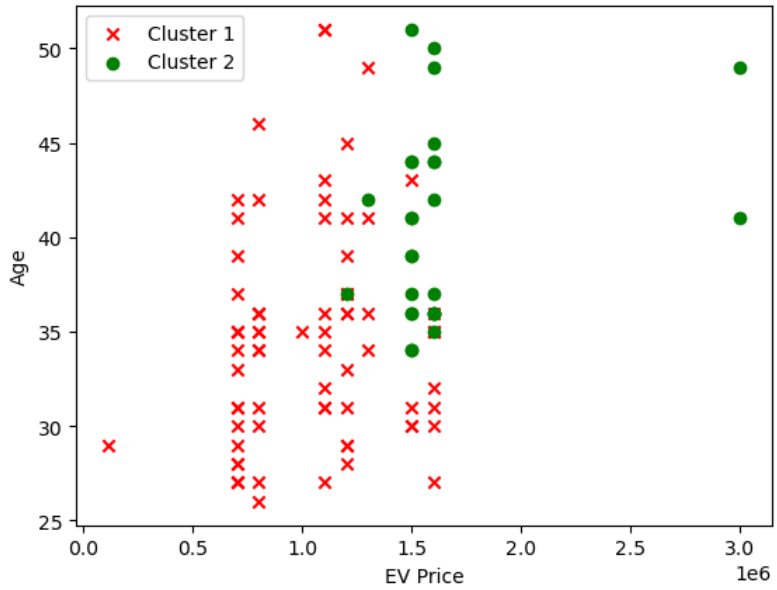
It can be observed that cluster 2 has a higher average number of charging stations, making it a more suitable target for the EV startup. Additionally, government subsidies are more prevalent in cluster 2, which can incentivize people to purchase EVs, further making these states ideal for the startup's entry point. On the other hand, cluster 3 has lower mean values for Road Tax, petrol price, and diesel price, which can potentially shift public sentiment towards electric vehicles.

ii) For behavioral analysis:

In [34]:
```
plt.scatter(Cluster_0.EV_Price, Cluster_0['Total Salary'],color='red', marker = 'x', label = 'Cluster 1')
plt.scatter(Cluster_1.EV_Price, Cluster_1['Total Salary'],color='green', label = 'Cluster 2')
plt.legend(loc="upper left")

plt.xlabel('EV Price')
plt.ylabel('Total salary')
plt.show()

```

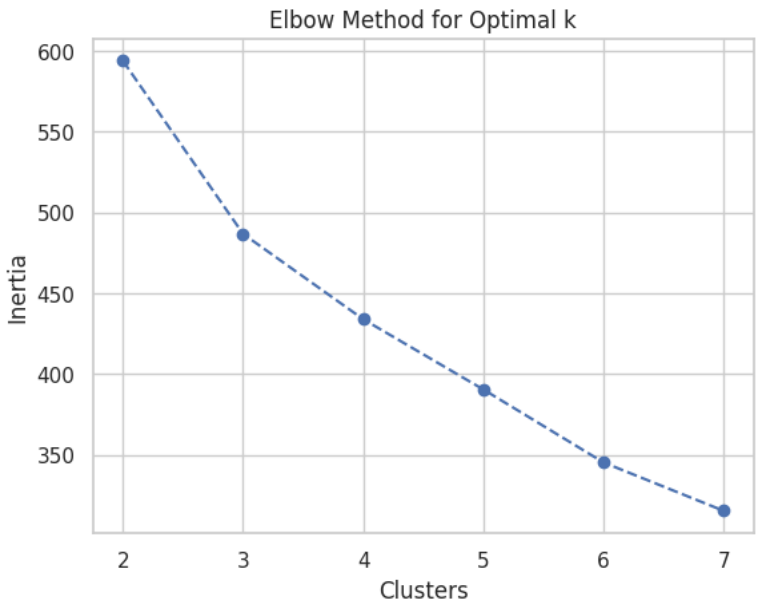


In [35]:
```
plt.scatter(Cluster_0.EV_Price, Cluster_0['Age'],color='red', marker = 'x', label = 'Cluster 1')
plt.scatter(Cluster_1.EV_Price, Cluster_1['Age'],color='green', label = 'Cluster 2')
plt.legend(loc = "upper left")

plt.xlabel('EV Price')
plt.ylabel('Age')
plt.show()
```



iii) K Means Clustering for demographic analysis:

```
elbow = dict()
preprocessor = ColumnTransformer(
    transformers=[
        ('num', StandardScaler(), [col for col in num_attributes]),
        ('cat', OneHotEncoder(), [col for col in cat_column])
    ])

for i in range(2,8):

    pipeline = Pipeline([
        ('preprocessor', preprocessor),
        ('estimator', KMeans(n_clusters=i))

    ])
    clusters = pipeline.fit_predict(df)
    kmeans_estimator = pipeline.named_steps['estimator']
    elbow[i] = kmeans_estimator.inertia_

#Plotting Elbow plot
plt.plot(*zip(*elbow.items()), marker='o', linestyle='--')
plt.title('Elbow Method for Optimal k')
plt.ylabel('Inertia')
plt.xlabel('Clusters');
```



ELBOW METHOD

➢ Finding the clusters:

```
pipeline = Pipeline([
            ('preprocessor', preprocessor),
            ('estimator', KMeans(n_clusters=4))
        ])

df['Labels'] = pipeline.fit_predict(df)
```

```
[ ]  df['RapidCharge']=df['RapidCharge'].map({1:'Yes',0:'No'})
```

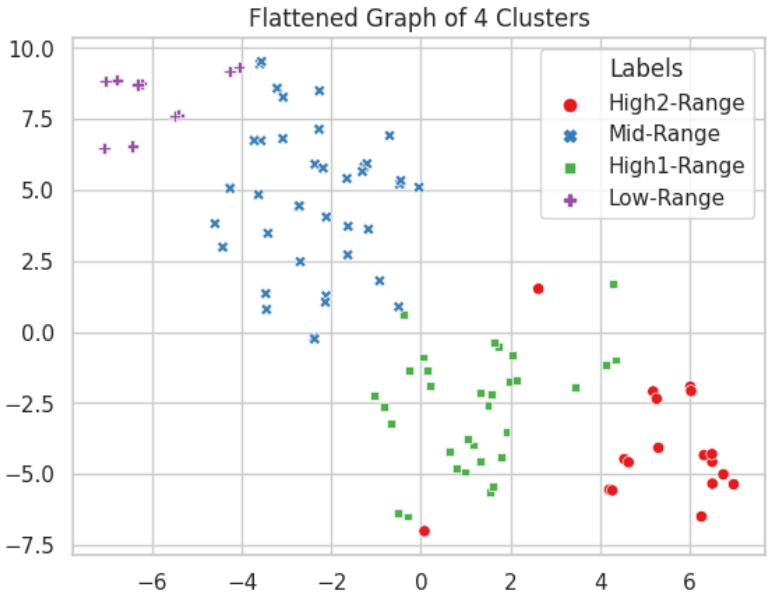
Studying Segments

```
[ ]  df['Seats']=df['Seats'].astype('int')
     df.groupby('Labels').mean()
```

Labels	AccelSec	TopSpeed_KmH	Range_Km	Efficiency_WhKm	FastCharge_KmH	Seats	Price
0	12.681818	132.545455	154.090909	173.727273	189.090909	4.000000	2.451013e+06
1	6.031250	188.593750	374.375000	214.562500	504.375000	5.125000	5.536359e+06
2	3.855556	249.611111	494.444444	193.111111	743.333333	5.111111	9.855480e+06
3	8.569048	154.071429	293.333333	172.166667	337.142857	4.833333	3.259083e+06

➢ Visualizing Clusters

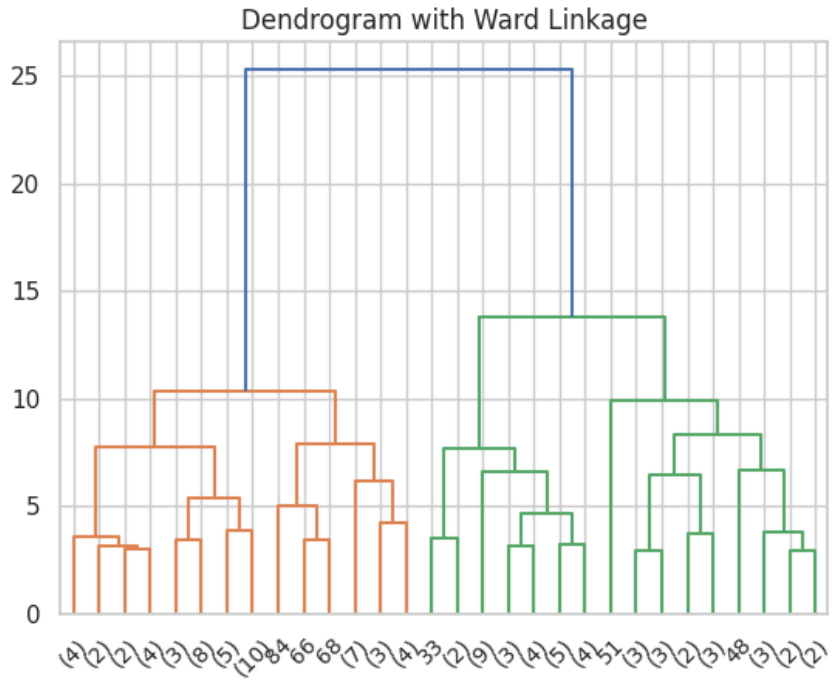
```
[ ]  from sklearn.manifold import TSNE
     def Visualise_cluster(data):

         model = TSNE(random_state=1)
         transformed = model.fit_transform(preprocessor.fit_transform(data))

         plt.title('Flattened Graph of 4 Clusters')
         sns.scatterplot(x=transformed[:,0], y=transformed[:,1], hue=data['Labels'], style=data['Labels'], palette="Set1")

     Visualise_cluster(df)
```



The market is predominantly occupied by mid-range and a combination of high and mid-level car models, while low-end and high-end vehicles are relatively scarce.

➢ **Ward Linkage**

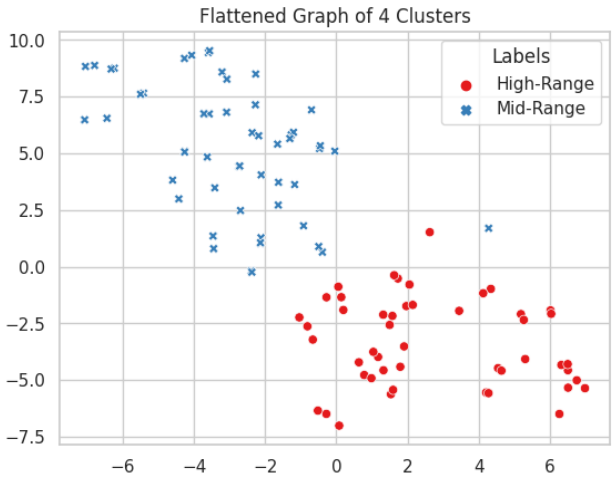
```
def plot_dendrogram(model, **kwargs):
    # create linkage matrix and then plot the dendrogram

    # create the counts of samples under each node
    counts = np.zeros(model.children_.shape[0])
    n_samples = len(model.labels_)
    for i, merge in enumerate(model.children_):
        current_count = 0
        for child_idx in merge:
            if child_idx < n_samples:
                current_count += 1  # leaf node
            else:
                current_count += counts[child_idx - n_samples]
        counts[i] = current_count

    linkage_matrix = np.column_stack([model.children_, model.distances_, counts]).astype(float)

    # plot the corresponding dendrogram
    dendrogram(linkage_matrix, **kwargs)
```




```
[ ]  df1['Seats']=df1['Seats'].astype('int')
     df1.groupby('Labels').mean()
```

Labels	AccelSec	TopSpeed_KmH	Range_Km	Efficiency_WhKm	FastCharge_KmH	Seats	Price
0	5.102083	213.083333	419.375000	205.958333	597.291667	5.083333	7.169506e+06
1	9.398182	149.618182	268.454545	174.509091	310.727273	4.709091	3.168518e+06

- The above labels suggest that label 0 are high end vehicles.
- The label 1 has vehicles that fall under mid-end section vehicles.



If we consider a two-cluster solution, the market is evenly divided between high-end and mid-range vehicles.

MARKETING MIX

The marketing mix comprises a set of tactics including product, price, promotion, and place (distribution) utilized by businesses to effectively reach their intended market segments.

Based on the earlier discussed segmentation of the Indian electric vehicle (EV) market, below is an example of a marketing mix:

- **Product:** EV manufacturers should provide a diverse product range to appeal to various psychographic segments. This includes luxury EVs for those with higher incomes, practical and reasonably priced EVs for consumers looking for value, and environmentally friendly EVs for those who prioritize sustainability.
- **Price:**The pricing strategy for EV manufacturers should consider the affordability and value preferences of different market segments. This may include providing financing options, incentives, and discounts on prices for each segment.
- **Promotion:** To effectively promote their EV products, manufacturers should customize their promotional activities to cater to the interests and preferences of different segments. This could involve implementing social media campaigns, influencer marketing, and hosting events that target specific psychographic segments. For instance, manufacturers can sponsor environmental events for eco-conscious consumers, tech fairs for tech-savvy buyers, and auto shows for early adopters.

- **Place:** To effectively reach the desired psychographic segments, the distribution strategy should be carefully designed. EV manufacturers could form partnerships with dealerships, establish charging infrastructure in urban areas, and offer home charging solutions to cater to convenience-oriented segments.

In order to succeed in the Indian EV market, companies should possess a thorough comprehension of the distinct requirements, inclinations, and drivers of diverse psychographic segments. This understanding can aid in the development of an effective marketing mix by tailoring product offerings, pricing strategies, promotional activities, and distribution channels to cater to the specific needs of each segment. By doing so, companies can effectively reach their desired audience and encourage widespread adoption of EVs in India.

CONCLUSION

In conclusion, the use of K Means Clustering and Linear Regression for market segmentation of electric vehicles in India can provide valuable insights for companies looking to enter the market. K Means Clustering helps to identify different clusters of states based on various attributes such as the number of charging stations, government subsidies, and road tax. This information can be used by companies to target specific states and develop marketing strategies tailored to the needs and preferences of each cluster. Linear Regression can also provide valuable insights into the market by identifying which attributes are most important in determining the price of an electric vehicle. This information can help companies to develop products that are priced appropriately for different segments of the market and offer financing options or price discounts to increase adoption. Overall, by combining the insights from both K Means Clustering and Linear Regression, companies can gain a deeper understanding of the Indian electric vehicle market and develop effective marketing strategies that target the needs and preferences of different psychographic segments. This can ultimately lead to increased adoption of electric vehicles in India and contribute to a more sustainable future.

REFERENCES

In addition to the data source links shared in page 7, here are some other documents that helped us in developing this project.

[1] https://analysis.technavio.org/electric-car-market-size-research
[2] https://www.mordorintelligence.com/industry-reports/india-electric-vehicle-market
[3] https://www.alliedmarketresearch.com/electric-vehicle-market#:~:text=The
[4] https://www.sciencedirect.com/science/article/pii/S0969698922000625
[5]https://www.google.com/search?q=market+segmentation+analysis+of+electric+vehicles+in+India&rlz=1C1UEAD_enIN1036IN1036&oq=market+segmentation+analysis+of+electric+vehicles+in+India&aqs=chrome..69i57j69i60l2.15009j0j7&sourceid=chrome&ie=UTF-8

GITHUB LINKS:

https://github.com/umamaheshwari20/Market-Segmentation-of-Electric-Vehicles-in-India

https://github.com/Divyan-shu-Singh/Ev_market_segmentation

https://github.com/Mriganka-github/EV-Market

https://github.com/Meenu2204/Meenakshi