Future of EV Market in India

SCOPE　　CHALLENGES　　MARKET SEGMENTATION

ELECTRIC VEHICLE MARKET ADAPTION AND SEGMENTATION REPORT

This Report will help us pinpoint the precise market segments Using Machine Learning techniques, that have the highest propensity for adapting electric vehicles. By steering our attention towards these particular segments, we can formulate a viable and efficient approach for a sustainable market debut.

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Abstract

This report is aimed to identify specific groups of potential costumers for EV adaption. We have used Socio-Demographic, Psycho-graphic, Behavioural and Geographical variables in a questionnaire to identify specific market segments and adaption trends. This report studies suitability of current infrastructure and future scope in context of Electric vehicle's adaption as a primary mode of transport. Results show that how consumer attitude towards Electric vehicle's compatibility, perceived advantages, personal traits, environmental concerns and background variables like gender, income, social status play key roles in their decision to go for an Electric vehicle. Based on these responses different marketing segments were distinguished to assist stakeholder come up with effective and targeted marketing strategies and overcome current barriers in EV adaption. It's time to go GREEN!

Introduction:

Albeit appearing the hotshot technology of 21st Century, Electric vehicles actually came in existence in the beginning of 20th century by **Thomas Davenport** in 1834 while the first Gasoline-powered automobile was still far from existence and interest in this technology has been rising time and again since then, especially since the Oil crisis in the 1970's.

Their have been many reasons for positive outlook at this technology, top three being: Exponentially rising Air pollution, Concerns for Reduced CO2 emissions and roller coaster ride of petroleum fuel prices and it's finiteness.

In context of above-mentioned primary concerns, Electric vehicles should be very promising as a primary mode of transport as there are wide range of sources of electricity and parallelly rising nuclear fusion technology can promise an endless and clean source of electricity. However, there are still many barriers which keep this wonderful technology from being adapted by general public, Like unavailability of optimal battery technology, high long term maintenance cost low confidence of general population from lack of understanding of this technology.

Overview

In present primary mode of transport is IC engine powered automobiles.

About more than 80 % of all mode of transport be it personal or public heavily depends on this extremely limited source of fuel even though there has been aggressive adaption of electricity as fuel by different governments in Public transports like Electric trains, Metros and public buses. This heavy dependence on Carbon fuel comes at a cost of degrading environment resulting in increasing global temperature and rising lung diseases.

However, people and governments are showing positive shift of attitudes towards alternative fuel powered vehicles and EVs has been very promising at this point.

High paced development in battery technology, Government encouragement to key players in this field, Environmental concerns has spurred EV technology and it's popularity is steadily increasing.

Electric vehicles provide many advantages over traditionally IC engines. In EVs a highly efficient Electric motor powered by Batteries provides instant torque and high acceleration over IC engines at no cost of Carbon emission and runs almost silently which makes them a potential replacement for conventional mode of transport.

Why EV is a necessity for sustainable future?

Ceaselessly growing air pollution has started showing it's effect worldwide. In 2023 Global average temperature was all time high with July being the hottest month ever. No-one remains untouched from this concurrent damage. Their has been rising concerns about finding an alternate source of fuel and EV has been very promising. However, no industry can grow without suitable infrastructure and supportive policies from Governments.

India hosts largest population on earth and even though major population is living at low-income, there is still huge demand for vehicles and resultantly Air pollution is rising at concerning level, so much so that more than 5 cities of Top 10 polluted cities in world are in India. This rising concern is pushing governments to implement policies to control this pollution and developing EV industry is one of them.

At present there are many models of EV in 4-wheeler and 2 wheeler segments available in the Indian market most of them produced by Startups. Supporting policies from government is reflecting in foundation of many startups in recent years dedicated to develop innovative technologies in this industry. Presently Electric vehicles market share in India stands at nearly 1% and large population still depends on conventional IC engines.

What EVs will be replacing:

- Large consumption of Petrol, Diesel and CNG consumed by transport sector estimating 600 million tons , major portion of which is being imported costing huge amounts on economy. EV will replace this dependence on costly fuel.
- Since Electric vehicle do not use as much part as conventional vehicle , sustainable development in this technology can bring down production cost and within reach of general population, current Vehicle to people ration stands at 1 : 60
- EV will bring down Carbon footprint of average Indian up to 60% which considering huge population, will be a significant achievement.
- Adaption of EV will also bring down emission of Greenhouse Gases significantly which at present stands at about 1.8 billion tons.

EV advantages over ICE :

- EV powertrains are very efficient at lower speeds than ICE which consumes significant amount of fuel even when idling.
- EVs produce higher torque than ICE at lesser expense of energy.
- Using Regenerative braking system EV recover energy lost in braking in case of traditional IC engine vehicle.
- EV are highly practical in smaller travel range.
- Lesser short term maintenance cost.

Market Overview

There are various segments of Electric Vehicles in Indian market based on their use and power source etc.

Usage :

- **Passenger Vehicles** : Used by general public forms most of the sector, such as Cars Motorcycles etc
- **Commercial Vehicles** : Used for carrying goods and mass , such as Trucks, Buses etc.

Power source:

- **Battery** : This segment of EV runs completely on power stored in rechargeable batteries.
- **Hybrid Electric vehicle:** This class of EV primary runs on ICE in combination of one or more Electric motor that use energy stored in batteries. In such vehicle Batteries are charged by ICE/Alternator instead of external charging equipment and Regenerative braking system. HEVs combine the benefits of high fuel economy and low tailpipe emissions with the power and range of conventional vehicles.
- **PHEV :** Plug-in Hybrid electric vehicle use batteries to power an electric motor, as well as another fuel, such as gasoline or diesel, to power an internal combustion engine or other propulsion source. PHEVs are different than HEV as they can charge their batteries through charging equipment and regenerative braking.
- **Fuel cell Electric vehicle**: Fuel cell electric vehicle are early stage technology in EV which uses Hydrogen as a fuel to generate Electricity internally by fuel cells ,emitting Water vapours as by-product. Safe storage and low efficiency of fuel cells are current challenges for this segment.

Technology adoption life cycle in context of EV market

Innovators:

Innovators are the first to adopt new technologies.

In the context of EV markets, these are the early adopters who are excited about the new technology and its potential benefits.

They are willing to take risks and are often attracted to the novelty and innovation of electric vehicles.

Early Adopters:

Early adopters follow the innovators and embrace new technologies before they become mainstream.

In the EV market, early adopters might be interested in the environmental benefits of EVs or the potential cost savings over time.

Their adoption helps create initial demand and build momentum.

Early Majority:

The early majority represents a larger segment of the population that starts adopting the technology as it becomes more established.

In the EV market, these are consumers who are motivated by practical benefits, such as lower operating costs and government incentives.

They may still have some reservations about EVs but are willing to give them a try.

Late Majority:

The late majority consists of skeptics who adopt the technology only after it has become well-established and widely accepted.

In the context of EVs, the late majority might be swayed by factors like increasing fuel prices, improved charging infrastructure, and a larger selection of EV models.

Laggards:

Laggards are the last to adopt new technologies and may do so reluctantly or out of necessity.

In the EV market, laggards might switch to EVs only when they have no other practical choice due to regulatory measures or market dynamics.

Note :- Rate of adoption based on factors such as culture, geography, government policies, and economic conditions.

Understanding the technology adoption life cycle can help stakeholders in the EV market tailor their strategies for marketing, infrastructure development, and policy-making to address the needs and concerns of each group.

As the market matures, the focus may shift from appealing to early adopters with innovative features to addressing the practical considerations of the majority and late adopters.

Market Dynamics and growth factors

The Indian electric vehicle (EV) sector is currently witnessing robust expansion and undergoing various transformations. In 2021, the market size of the EV industry in India was estimated at USD 1.45 billion. Projections suggest that the Indian electric vehicle industry's market size is expected to surge from USD 3.21 billion in 2022 to an impressive USD 113.99 billion by 2029.

Last 3 years E4W(Electric 4-wheeler) Sales

Sales and % Change Comparison

Last 3 years E2W (Electric 2-wheeler) Sales

Last 3 years E3W cargo (Electric 3-wheeler) Sales

EV sales trend in India over past years
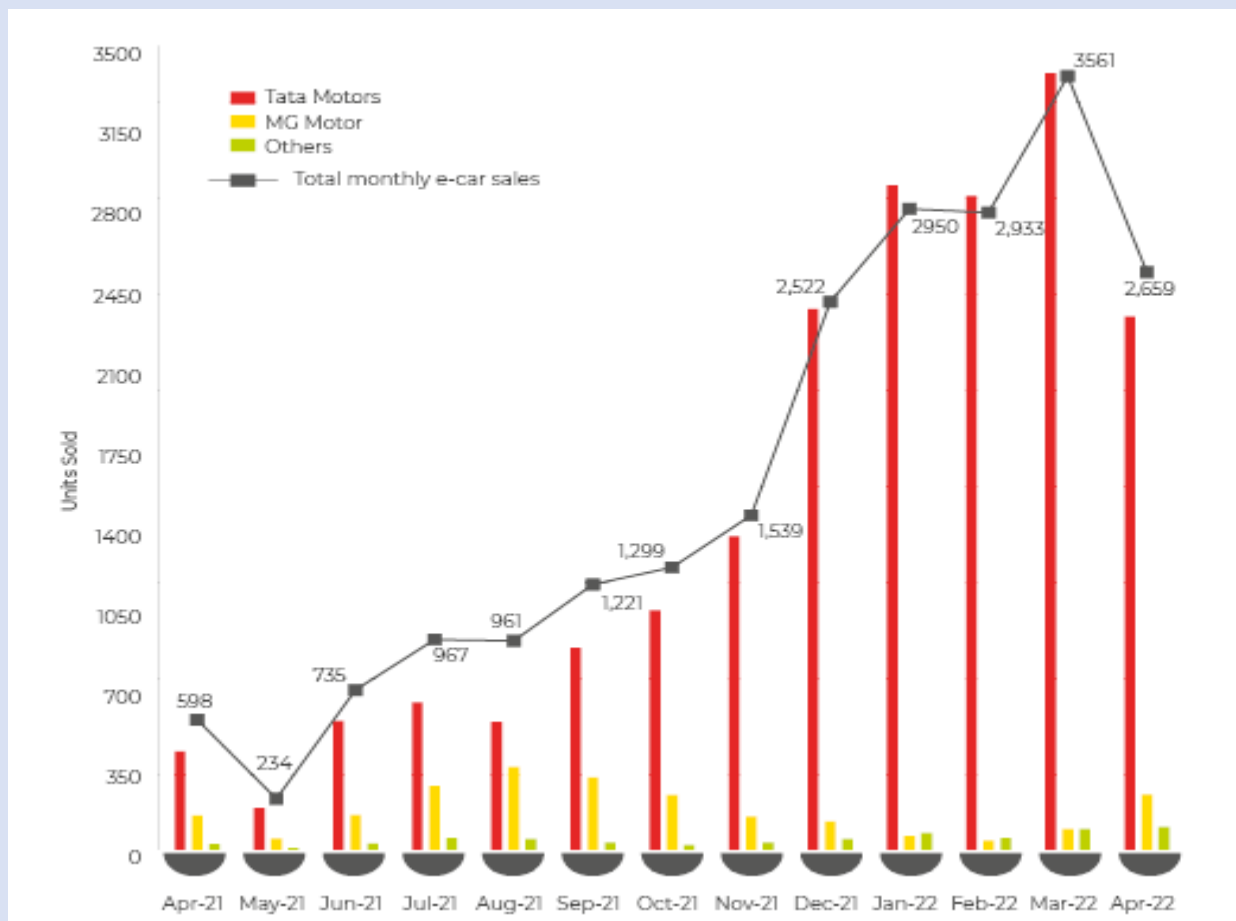

EV SALES TREND IN INDIA

EV Annual Sales Trend in India (FY2014 - FY2022)
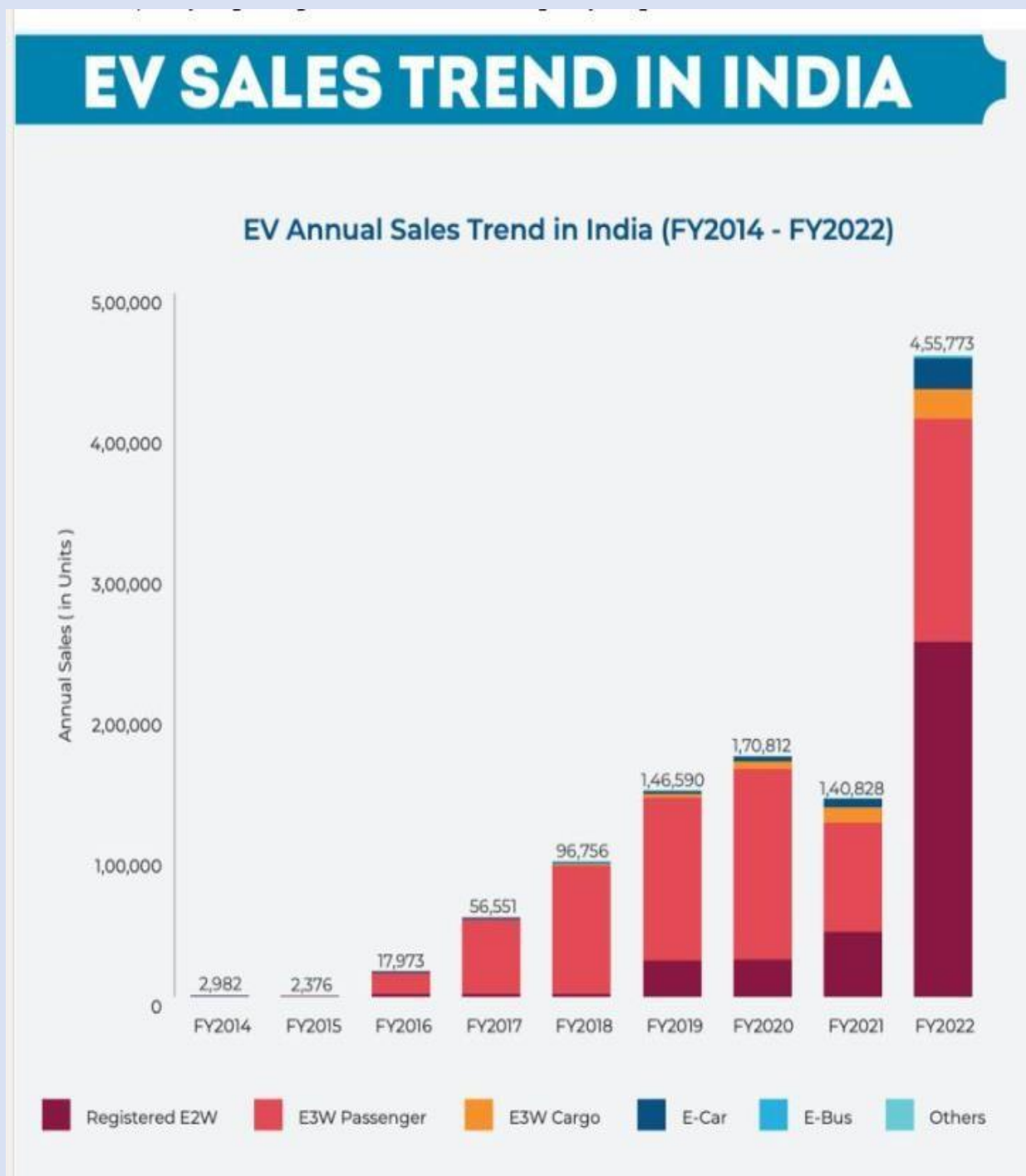
Source: Ohm Mobility

Tata Motors alone comprised 81.4 per cent of the Indian electric car market in FY23 and OLA Electric constituted the highest market share in the two-wheeler segment.

Source: Vahan Dashboard, Company Press Releases, JMK Research

As per industry estimates, the total EV sales in India stood at around 10 lakh units in 2022. Further, the survey said, "The EV industry will create 5 crore direct and indirect jobs by 2030. To support and nurture this development, the government has undertaken multiple steps"

Fig. 1.1: Actual and Projected EV Sales (Annual & Cumulative)
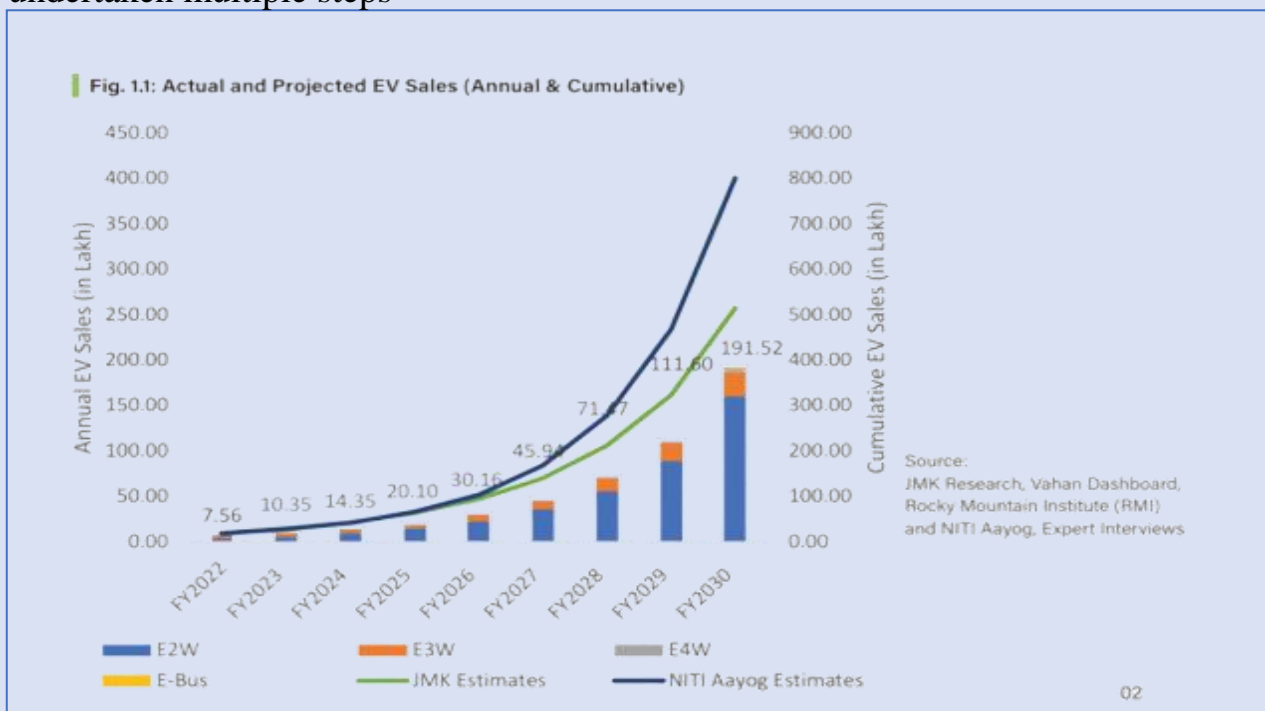
There are many factors shaping promising future for EVs :

1. **Government Initiatives:**

FAME INDIA SCHEME

STUDY IQ

Why in news?
The Government recently announced the revised FAME II subsidy for promoting EV usage in the country.

What is FAME?
Faster Adoption and Manufacturing of Hybrid and Electric Vehicles (FAME) was launched by Ministry of Heavy Industries & Public Enterprises to give a boost to development of Electric Vehicles.

Details
- FAME India is a part of the National Electric Mobility Mission Plan.
- Subsidy can be claimed by two wheelers, three wheelers, electric and hybrid cars and electric buses under the scheme.

Implementing Ways
- Establishing charging stations
- Incentivize buyers
- Publicizing benefits of Electric Vehicles

Benefits
- Demand for petrol and diesel is expected to reduce.
- Creation of new jobs in automobile sector.
- Reduction in pollution-induced health problems.

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FAME Scheme: The Indian government launched **the Faster Adoption and Manufacturing of Hybrid and Electric Vehicles (FAME)** scheme to promote the adoption of electric and hybrid vehicles. This scheme offered incentives, subsidies, and charging infrastructure development to encourage EV adoption.

- **Reduced GST Rates:** The government reduced the Goods and Services Tax (GST) rates on electric vehicles from 12% to 5%. This reduction in taxation aimed to make electric vehicles more affordable for consumers.

- **Income Tax Benefits:** To encourage individual buyers, the government provided income tax benefits to EV buyers under Section 80EEB of the Income

Tax Act. This included an additional deduction of up to INR 1.5 lakhs on the interest paid on loans taken to purchase electric vehicles.

- **Phasing Out Internal Combustion Engine (ICE) Vehicles:** Some states and cities in India announced plans to phase out the use of internal combustion engine (ICE) vehicles in a phased manner. This policy aimed to accelerate the shift towards electric and cleaner mobility options.

- **Public Awareness Campaigns:** The government conducted public awareness campaigns to educate consumers about the benefits of electric vehicles, including reduced emissions and lower operating costs.

2. **Rising demand as result of increasing Environmental concerns:**

The Indian EV market was on an upward trajectory, with increasing awareness of environmental concerns and a desire for cleaner transportation options.

3. **Key Players:**

Several domestic and international automakers entering the Indian EV market, offering a range of electric vehicles, from compact cars to electric two-wheelers.

- Tesla, one of the most prominent global EV manufacturers, announced its entry into the Indian market, generating significant interest.
- OLA has revolutionised electric 2 wheeler segment by introducing their highly efficient and equipped with state-of-the art technology scooters.
- E-commerce companies, like Amazon ,Zepto, Zomato etc are actively initiating e-mobility for deliveries and reducing carbon footprints.
- Even Governments has started integrating E-mobility in public transportation by deploying Electric buses for intra-city travel.

4. **Commerce of Electric Vehicles:**

Electric two-wheelers and electric three-wheelers are among the most popular categories due to their affordability and suitability for Indian conditions.
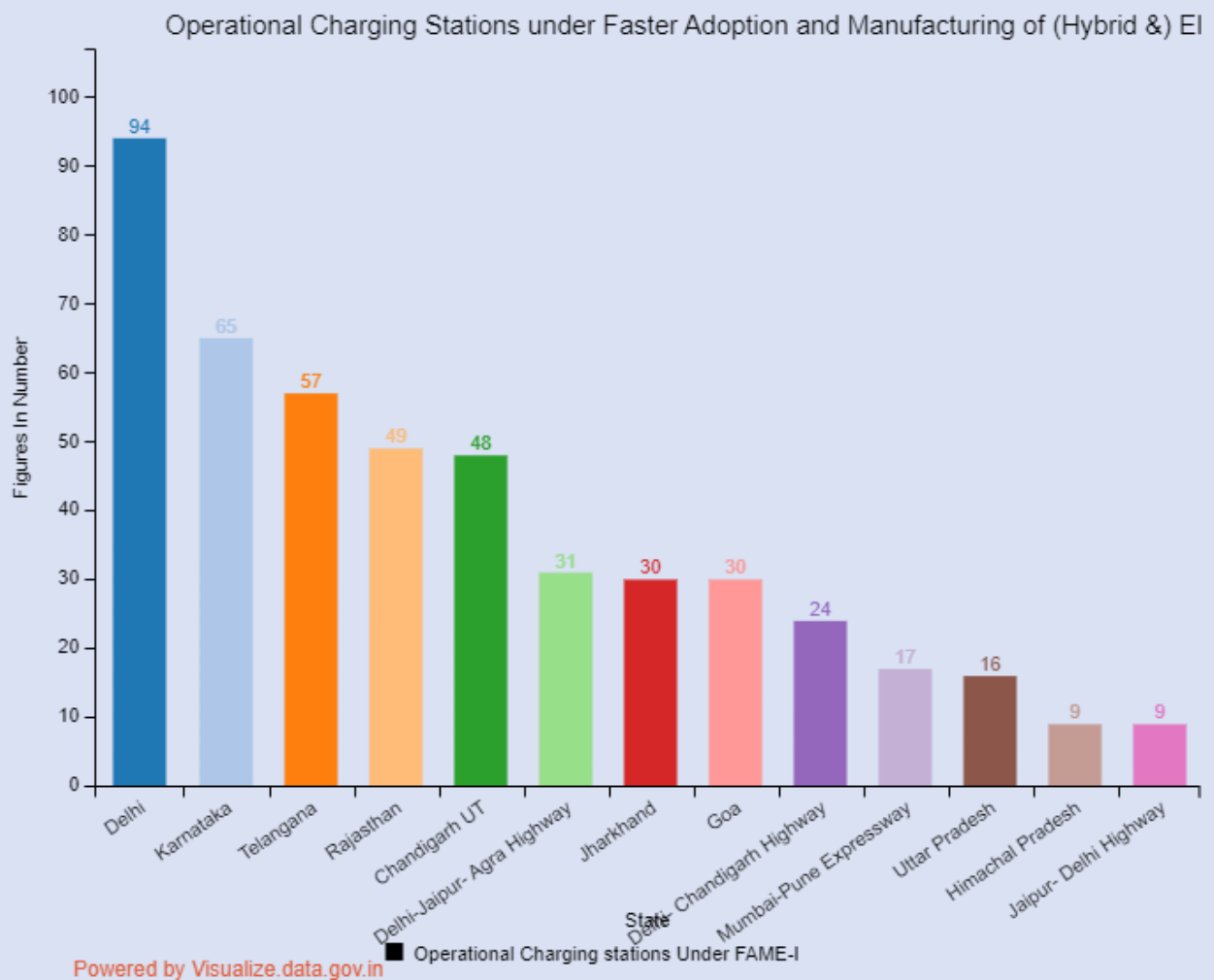
Electric cars, including compact and luxury models, are also available.

5. **Charging Infrastructure:**

Public Charging Infrastructure: The government aimed to boost the development of electric vehicle charging infrastructure across the country. Under the FAME scheme, incentives were provided to set up public charging stations, especially in urban areas.

Expansion of charging infrastructure are underway, with more public charging stations being set up in cities and along major highways.

Home charging solutions are becoming increasingly accessible to EV owners.

Operational Charging Stations under Faster Adoption and Manufacturing of (Hybrid &) El

Powered by Visualize.data.gov.in

6. Battery Manufacturing:

Initiatives were underway to encourage the establishment of lithium-ion battery manufacturing facilities in India. This was aimed at reducing dependence on imported batteries and lowering the overall cost of electric vehicles.

7. Government Procurement:

Some state governments in India were actively procuring electric buses for public transportation to reduce emissions and promote clean mobility.

Market Challenges

In Indian electric vehicle (EV) market there are many barriers against smooth adaption. EV industry faces several challenges that are affecting its technological development and market demands. These challenges are diverse and include technological, economic, and infrastructural factors. Various stakeholders, including the government, automakers, and infrastructure providers, are actively working to address these challenges and promote the adoption of electric vehicles in India. Here are some key challenges facing the Indian EV market:

1. **High Initial Cost:** Electric vehicles tend to have a higher upfront purchase price compared to traditional internal combustion engine vehicles. This cost differential can be a significant barrier for many potential buyers.
2. **Limited Charging Infrastructure**: A lack of widespread and easily accessible charging infrastructure is a major challenge. This "range anxiety" makes potential EV buyers hesitant, particularly in regions with inadequate charging stations like Rural areas. Also there is lack of affordable and consistent electricity supply to households in many states.
3. **Charging Speed:** Even where charging infrastructure exists, the speed of charging (slow vs. fast charging) could be a limitation. Fast-charging infrastructure are relatively scarce, making long-distance travel less convenient.
4. **Optimal Battery technology :** Presently Lithium ion type batteries are being used for EVs which albeit more efficient but have still limited potential and even though they are cleaner than Petrol/Diesel Extraction, handling and lack of recycling technology of Lithium still produces second hand pollution.
5. **Battery Degradation:** Concerns about battery life and degradation over time are common. Replacement costs for EV batteries could be significant.
6. **Consumer Awareness:** Despite efforts to raise awareness, many consumers in India have limited knowledge about EVs, their benefits, and how they worked. This lack of awareness could slow adoption.
7. **Technological Challenges:** Developing advanced electric vehicle technology and manufacturing capabilities in country like India is a complex process that requires substantial investments and expertise.
8. **Supply Chain Issues:** A robust supply chain for electric vehicle components, including batteries and motors, is still under development in India and currently there is heavy dependency on Imports.
9. **Economic Factors:** The total cost of ownership, including purchase price, operating costs, and resale value, need to be competitive with traditional vehicles to attract more buyers.

Methodology :

- **Breakdown Problem Statements :**
  Problem Statement is broken down in set of Question needed to ask from Data for in-depth understanding and analysis.

- **Data Collection**
  Relevant data is collected from various Data set hosts in public domain

- **Data Pre-processing**
  Dataset contain both Catagorical and Numerical Data. Catagorical Data need to be convert in numerical data to implement ML algorithms.

- **Data Exploration**
  Data is explored for capturing insights and trends based on problem statements.

- **Extracting Segments**
  Various segments having similar features and traits are extracted from dataset

- **Target Segment Profiling**
  Segment is profiled describing their traits and features for developing efficient and targeting market strategies by stakeholders

Breaking Down problem statements

To explore data effectively for capturing insights it is essential that we have clear understanding of the problem. To get that understanding we can make set of relevant questions which can get us relevant answers.

1. What is the age distribution of potential EV buyers? Which Age group is more likely to adopt EV ?
2. Does type of employment play a role in EV adoption?
3. Are urban dwellers more likely to consider EVs due to shorter commutes and better charging infrastructure?
4. Does income level play a role in the adoption of EVs?
5. Which regions have the highest adoption rates for EVs?
6. Which areas have highest Charging station densities?
7. What are the personality traits of early adopters of EV technology?
8. To whom it will be sell (Target Customer)?
9. What type of EV should we produce?
10. What features should we offer ?

Data Collection

Based on problem statements we generated keywords to explore relevant datasets in public domain.

Data Sources :

Charging Station in India :

https://data.gov.in/resource/expressways-and-highway-wise-electric-vehicles-ev-charging-stations-across-reply-unstarred

https://www.kaggle.com/datasets/saketpradhan/electric-vehicle-charging-stations-in-india

https://www.kaggle.com/datasets/a2162014/electrical-vehicle-datasets?select=charging_station_data.xlsx

Electric Vehicle User Reviews :

https://www.kaggle.com/datasets/deadprstkrish/ev-cars-user-reviews-india?select=4-wheeler-EV-carwale.csv

Electric Vehicle Consumer car purchasing behaviour :

https://www.kaggle.com/datasets/a2162014/electrical-vehicle-datasets?select=behavioural_segment_data.csv

https://www.kaggle.com/datasets/karivedha/indian-consumers-cars-purchasing-behaviour

Cars Specification :

https://www.kaggle.com/datasets/medhekarabhinav5/indian-cars-dataset?select=cars_ds_final_2021.csv

https://www.kaggle.com/datasets/krishnendubarman/indian-ev-segmentation

Visualization sources :

https://e-vehicleinfo.com/ev-sales-report/

https://community.data.gov.in/operational-charging-stations-under-faster-adoption-and-manufacturing-of-hybrid-electric-vehicles-of-india-scheme-phase-i-as-on-15-07-2022

Data Pre-processing

First we cleaned dataset by handling missing values and slicing out irrelevant columns.

Converting Categorical data to Numerical data : To convert Catagorical data into numerical data we used **LabelEncoder()** module of **SKleran.preprocessing** module in python programming language

```
catg_df = buy_beh_data[['Education','Profession','Marrital Status','Personal loan','House Loan','Wife Worki
# Create a LabelEncoder instance to convert Catagorical data into numerical
label_encoder = LabelEncoder()
cols = ['Education','Profession','Marrital Status','Personal loan','House Loan','Wife Working']
for column in cols:
    catg_df[column] = label_encoder.fit_transform(buy_beh_data[column])

# Display the encoded DataFrame
catg_df.head()
```

Feature scaling : Feature scaling is the process of normalizing the range of features in a dataset. Real-world datasets often contain features that are varying in degrees of magnitude, range, and units. Therefore, in order for machine learning models to interpret these features on the same scale, we need to perform feature scaling.

We used **MinMaxscaler()** of **SKleran.preprocessing** module in python programming language

```
features_to_norm= buy_beh_data[['Age', 'Salary','Wife Salary' ,'Total Salary','Price']]

scaler = MinMaxScaler()        #Normalising Data

# Fit the scaler on the data and transform the features
scaled_features = scaler.fit_transform(features_to_norm)

# Create a new DataFrame with the scaled features
num_df = pd.DataFrame(scaled_features, columns=features_to_norm.columns)

# Now, scaled_df contains the scaled features
num_df
```

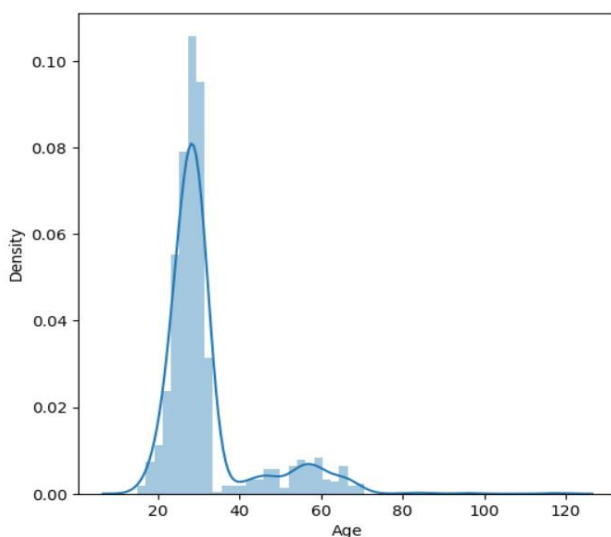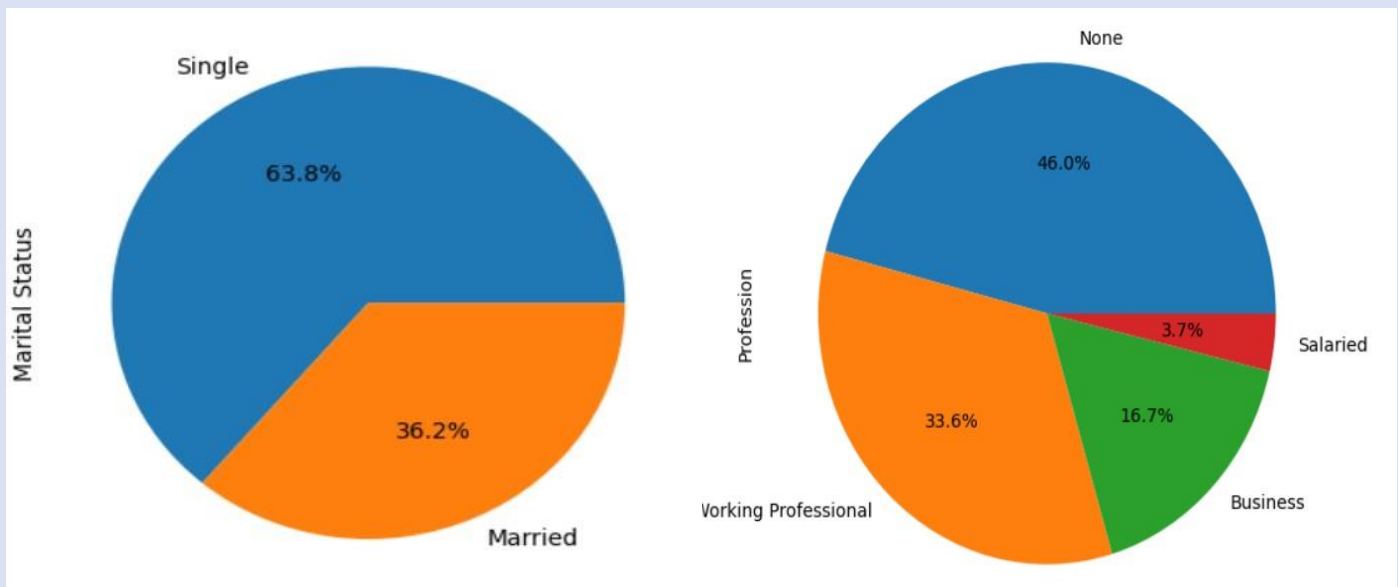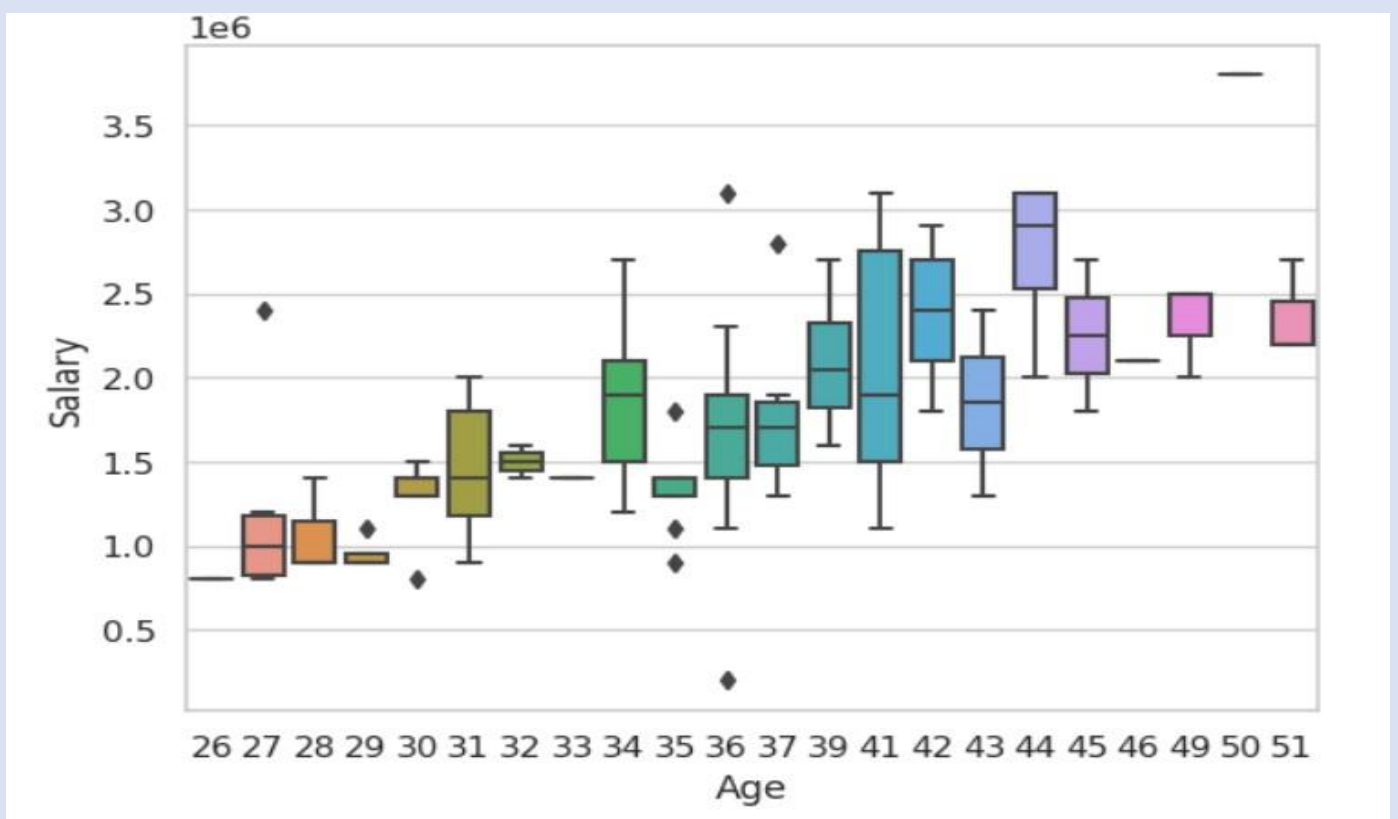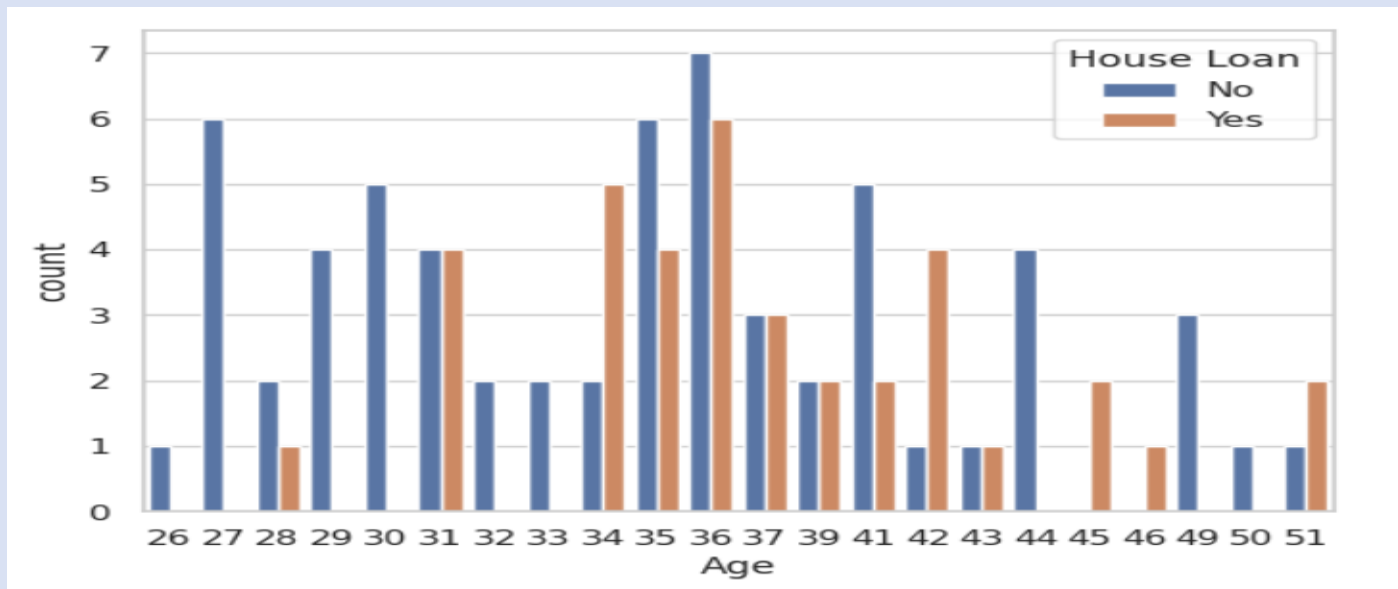|	Age	Salary	Wife Salary	Total Salary	Price
0	0.04	0.166667	0.000000	0.12	0.238754
1	0.36	0.333333	0.285714	0.36	0.307958
2	0.76	0.444444	0.000000	0.32	0.377163
3	0.60	0.388889	0.285714	0.40	0.377163
4	0.20	0.444444	0.380952	0.48	0.515571
...	...	...	...	...	...

Market Segmentation

Because the Electric Vehicle (EV) market in India is still in its early stages, obtaining thorough and specific consumer data related to EVs is challenging. Consequently, our strategy pivoted towards examining consumer data related to conventional fuel-based vehicles. By conducting straightforward Demographic, Psychological/behavioural and Geological assessments of this data, our objective was to extract valuable market insights. To deepen our comprehension of regional preferences, we harnessed state-level data to pinpoint potential markets suitable for various categories of EVs.
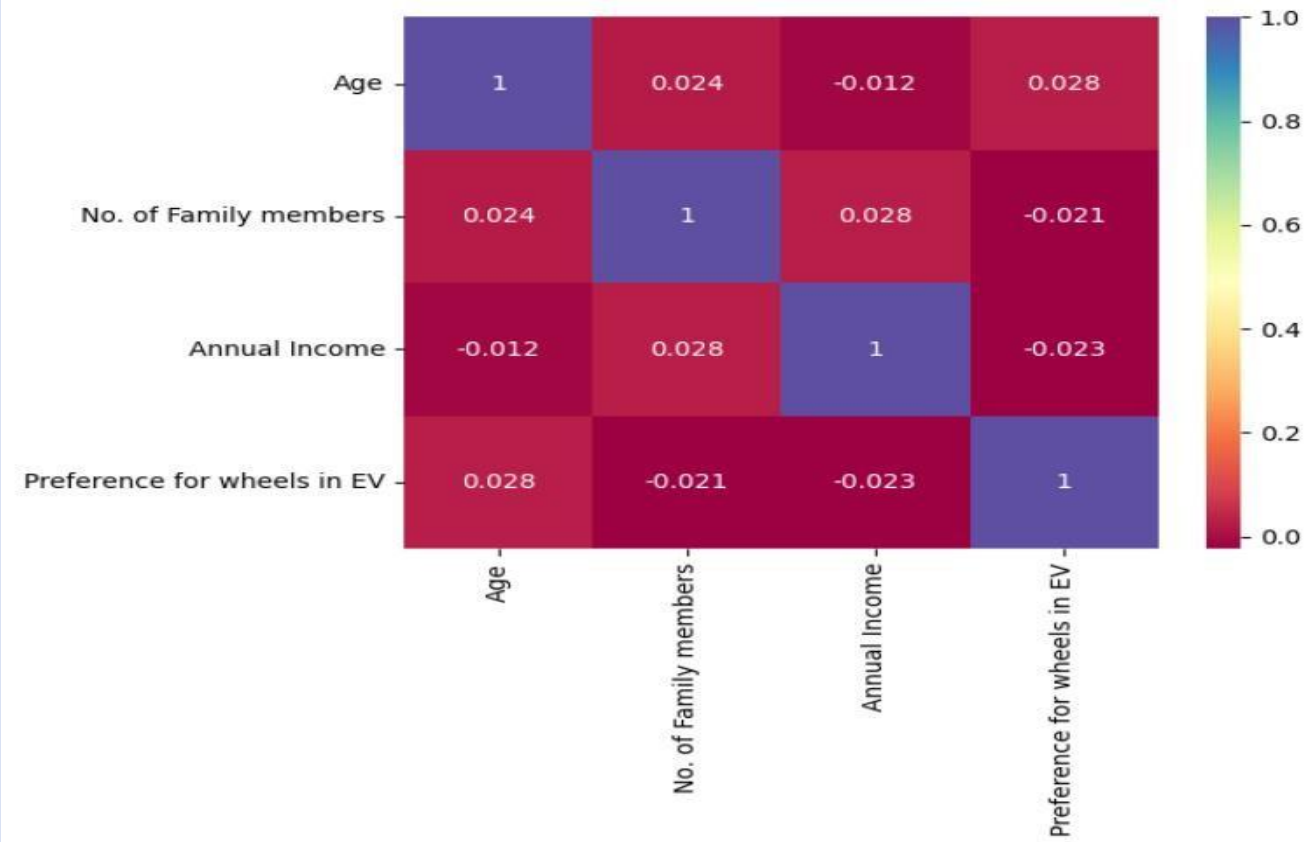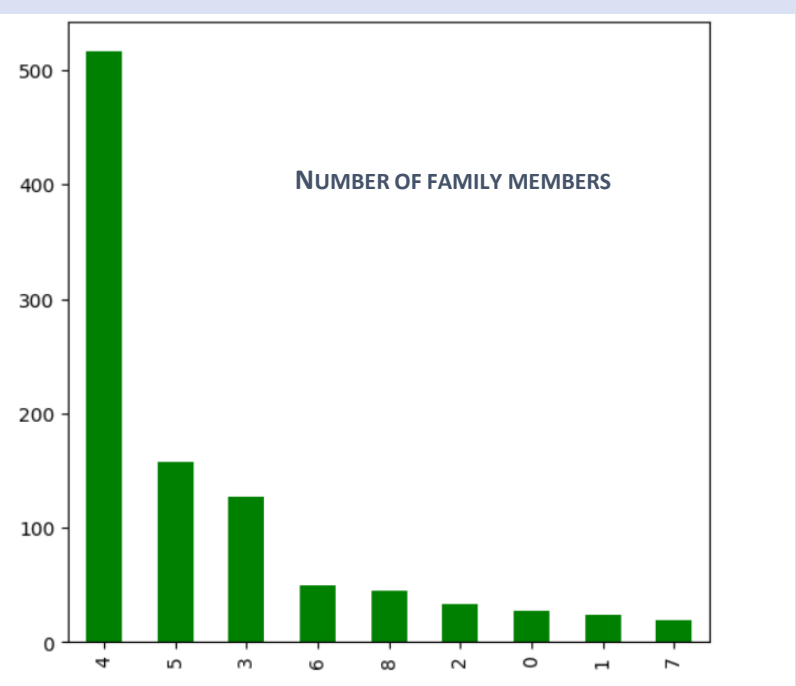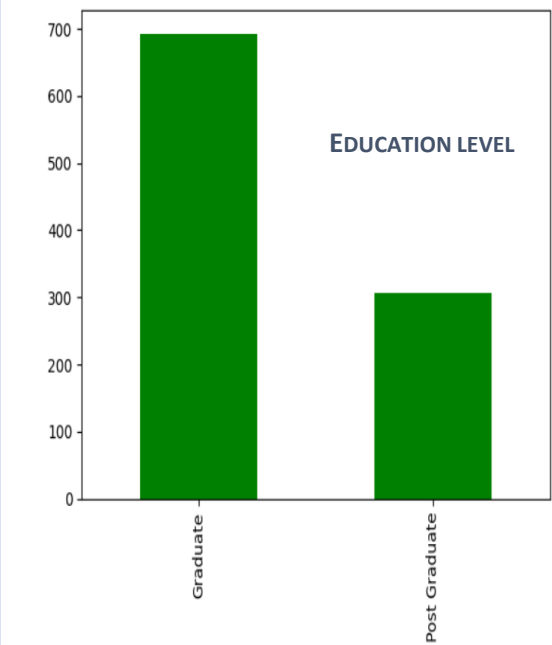
This analysis enabled us to pinpoint key characteristics within the target demographic, which could be harnessed for market segmentation using model-based algorithms.

Demographic Analysis :

Demographic segmentation explores trends in Age, Income, Education, Marital status

And other variables

EDUCATION LEVEL

NUMBER OF FAMILY MEMBERS

|	Age	No. of Family members	Annual Income	Preference for wheels in EV
Age	1	0.024	-0.012	0.028
No. of Family members	0.024	1	0.028	-0.021
Annual Income	-0.012	0.028	1	-0.023
Preference for wheels in EV	0.028	-0.021	-0.023	1
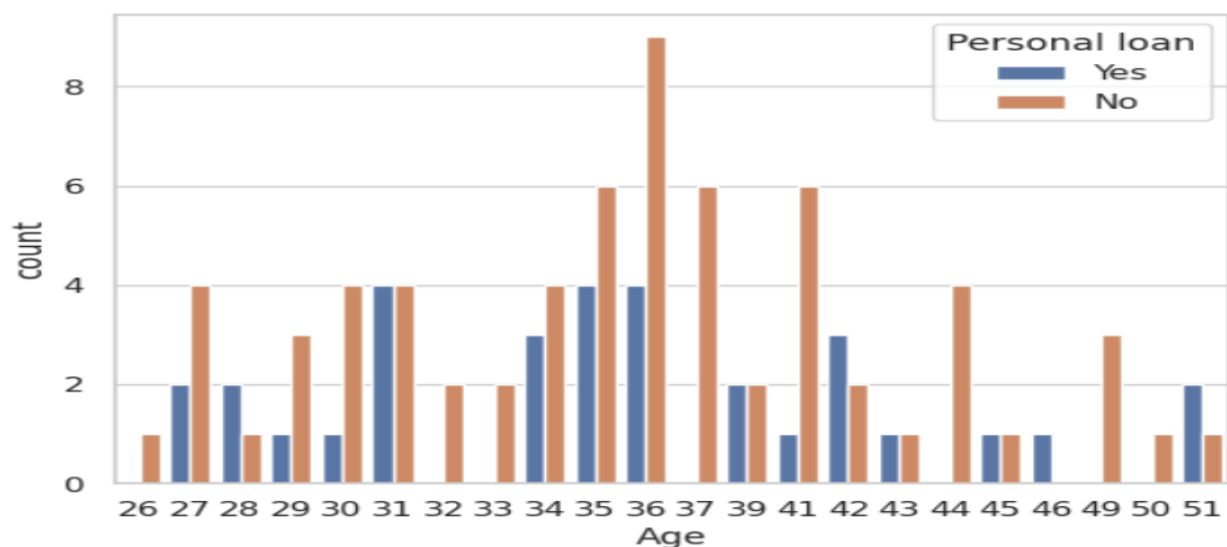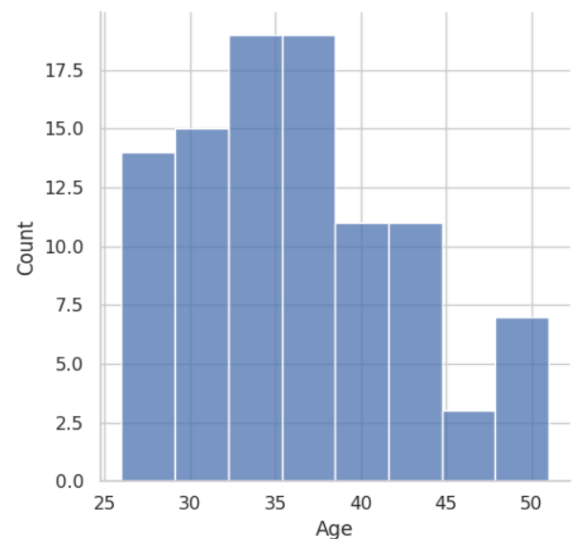
Observations :

- Younger people are adapting to EVs more than Older people. Which is not surprising as Younger people are generally more tech-savvy than older generations.
- Major proportion of EV consumers are in their early 30s with no Personal or Home loans
- Highest income group are in their early 40s
- Average income level increases with age.
- Single and Graduate people are major fragment of EV consumers.
- Number of family memebrs does not correlate with EV adaption.
- Overall there appears no significant correlation between demographic variables.
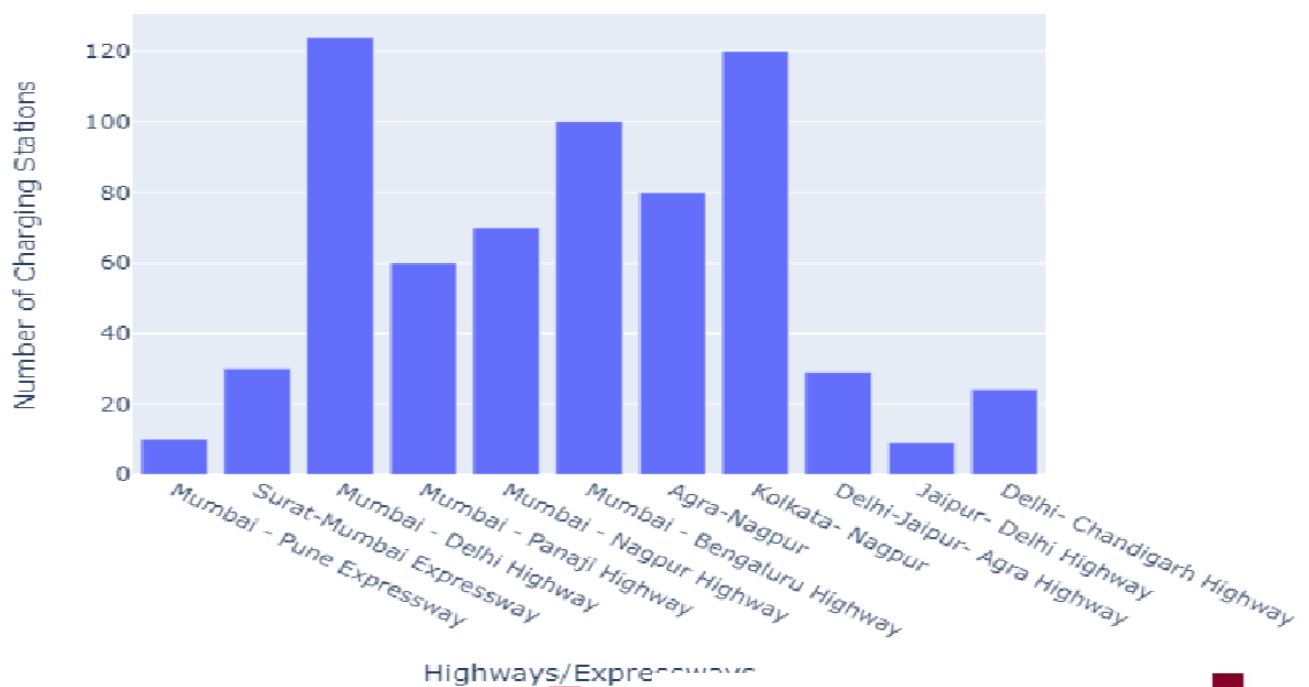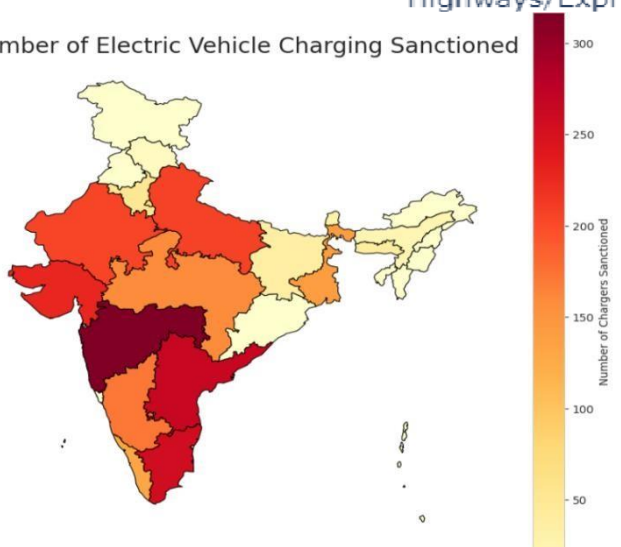
Geographical Analysis :

Electric Vehicle Adoption by State
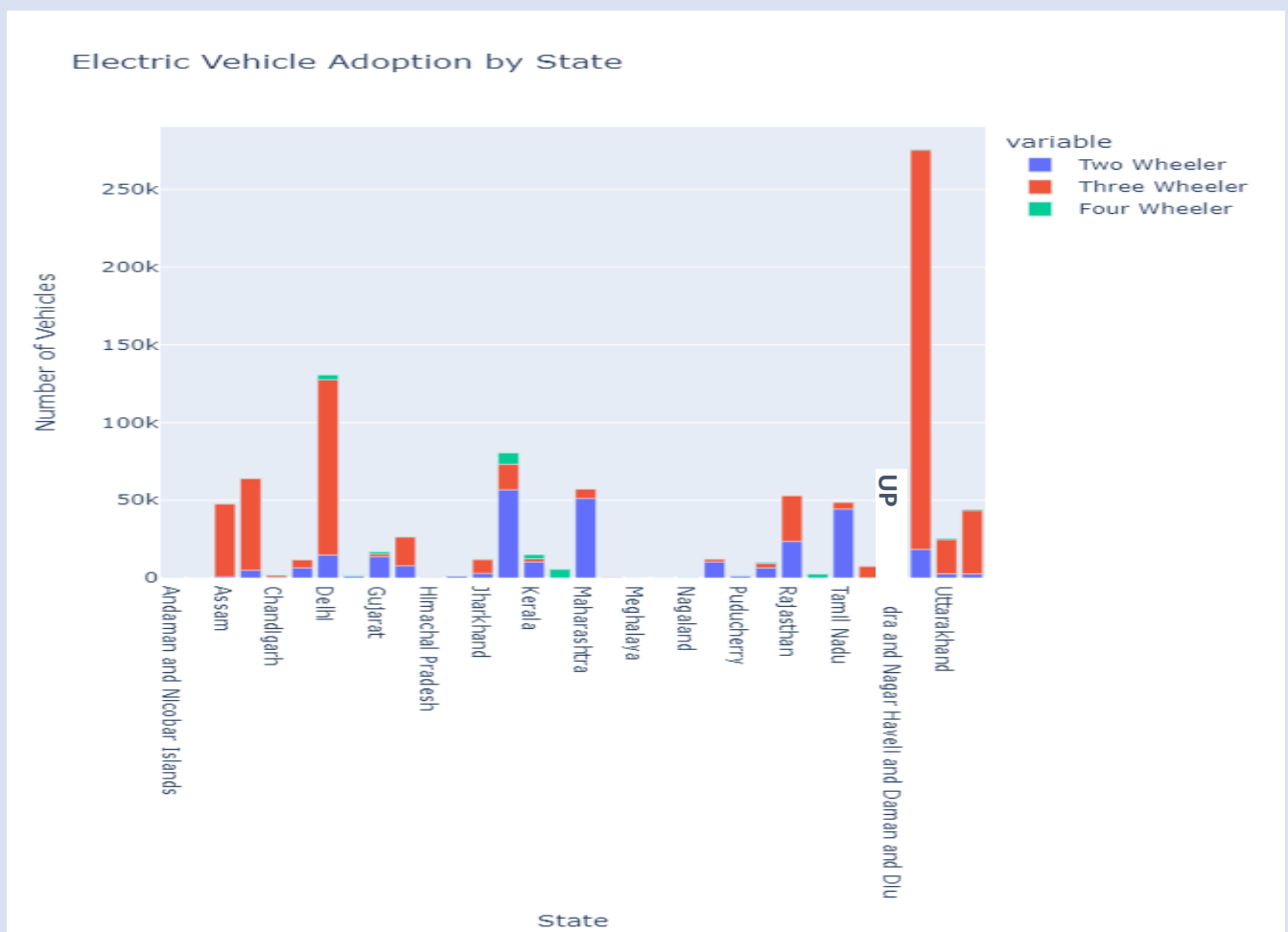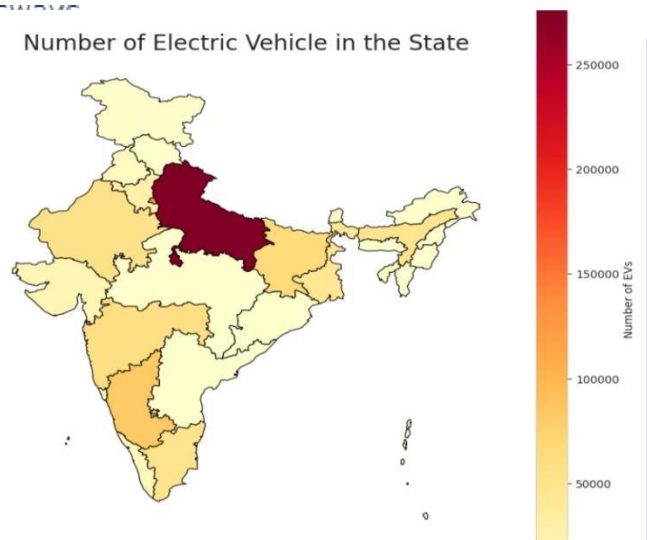
Charging Stations by State
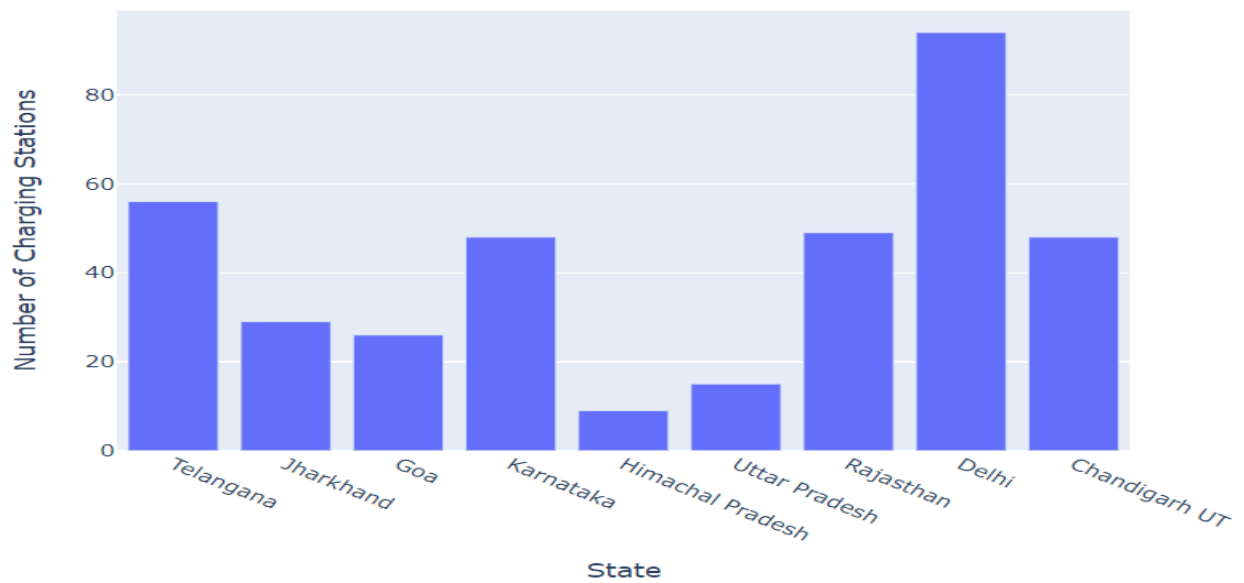
Charging Stations on Highways/Expressways

Number of Electric Vehicle Charging Sanctioned

Number of Electric Vehicle in the State

Observations :

States/UT With High Electric Vehicle Adoption:

A. Two Wheeler:
- Karnataka
- Maharastra

B. Three Wheeler:
- Uttar Pradesh
- Delhi

C. Four Wheeler:
- Karnataka
- Ladakh

States/UT and Highways with good infrastructure :

- Delhi
- Telangana
- Rajasthan
- Mumbai-Delhi Highway
- Kolkata-Nagpur Highway

State/UT with most sanctioned Charging stations :
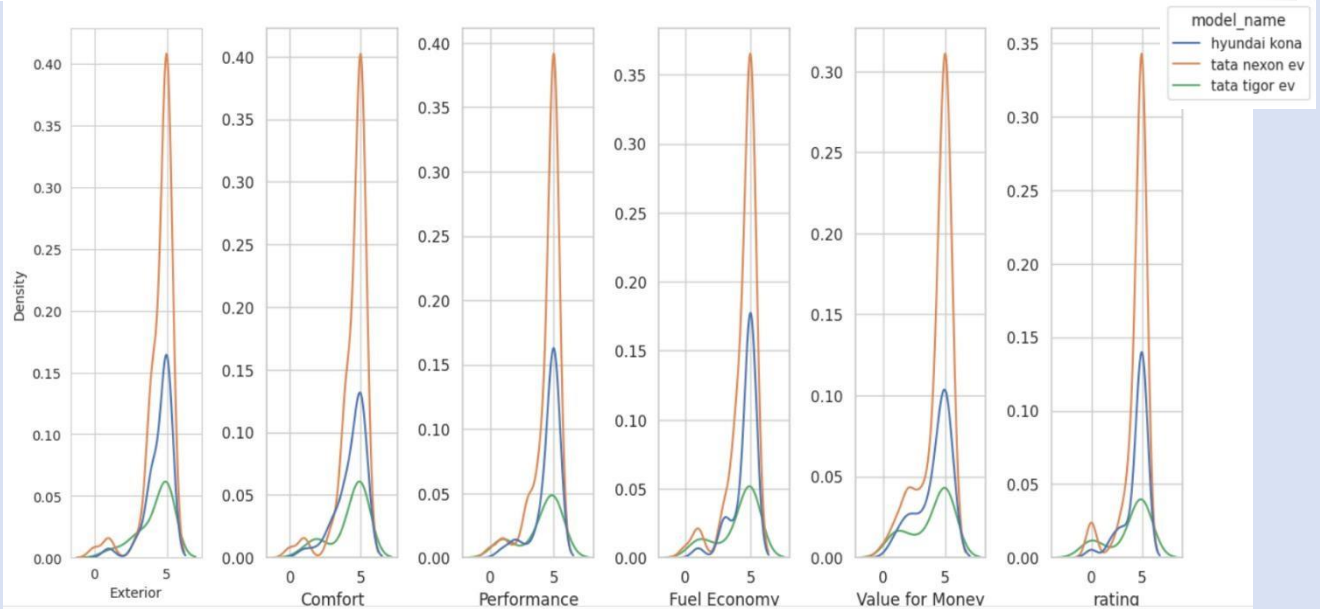
- Maharastra
- Gujarat
- Andhra pradesh
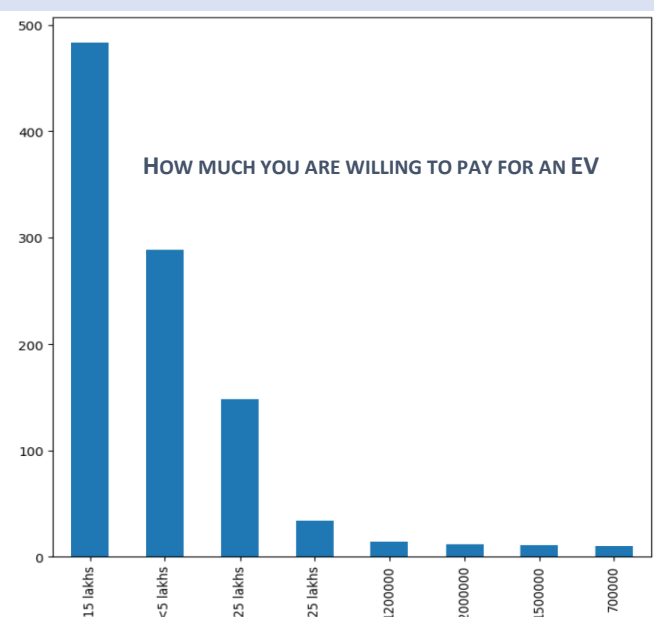- Uttar Pradesh

Psychological/Behavioural Analysis

- **Psychological profile Customer review analysis:**

```
review.describe()
```

	Exterior	Comfort	Performance	Fuel Economy	Value for Money	rating
count	129.000000	129.000000	129.000000	129.000000	129.000000	129.000000
mean	4.472868	4.418605	4.418605	4.418605	4.162791	4.341085
std	0.968871	1.036051	1.150392	1.122899	1.345076	1.389110
min	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
25%	4.000000	4.000000	4.000000	4.000000	4.000000	4.000000
50%	5.000000	5.000000	5.000000	5.000000	5.000000	5.000000
75%	5.000000	5.000000	5.000000	5.000000	5.000000	5.000000
max	5.000000	5.000000	5.000000	5.000000	5.000000	5.000000

model_name	Exterior	Comfort	Performance	Fuel Economy	Value for Money
hyundai kona	4.500000	4.323529	4.529412	4.558824	4.088235
tata nexon ev	4.533333	4.520000	4.493333	4.453333	4.293333
tata tigor ev	4.200000	4.200000	3.950000	4.050000	3.800000

Pie chart 1: EV model preference
- tata nexon ev: 58.1%
- hyundai kona: 26.4%
- tata tigor ev: 15.5%

Pie chart 2: Driving experience
- Did a short drive once: 28.7%
- Few thousand kilometers: 26.4%
- Few hundred kilometers: 24.0%
- Haven't driven it: 19.4%
- Its my mate since ages: 1.6%

PCA biplot with PC1 (83.89%) and PC2 (6.29%): Exterior, Comfort, Performance, Fuel Economy, Value for Money

Bar chart: Do you think Electronic Vehicles are economical? (Yes / No / Maybe) by Education (Graduate, Post Graduate)

Bar chart: HOW MUCH YOU ARE WILLING TO PAY FOR AN EV
- <15 lakhs, <5 lakhs, <25 lakhs, >25 lakhs, 1200000, 2000000, 1500000, 700000
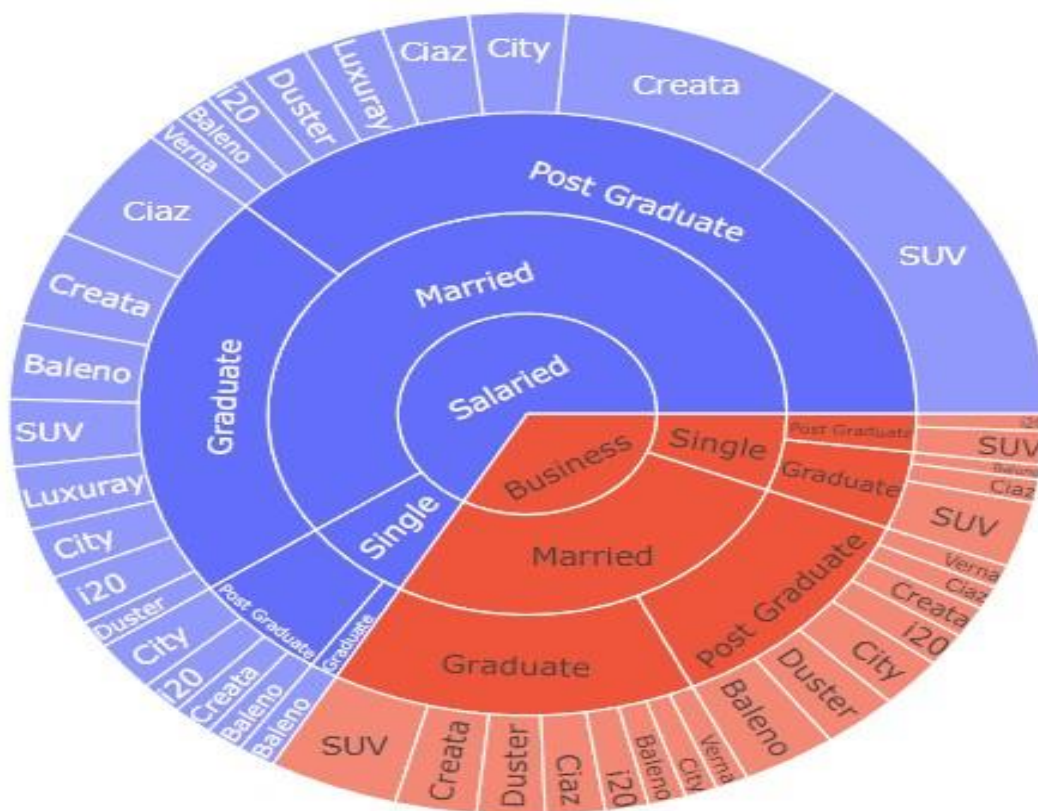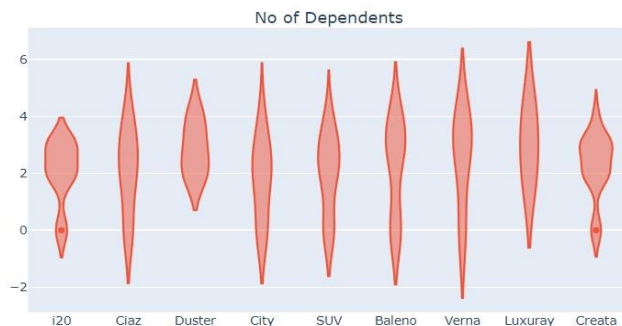
Observations :

- **From Reviews :-**

1. Reviews implies Consumers are satisfied with all attributes. Consumers are more satisfied with Appearance of EV than **Value for money** it provides
2. There is high correlation between Appearance and Comfort
3. Ratings given is not correlated with fuel economy of vehicle
4. Value for money awards higher Ratings
5. Performance and Value for money Plays important role in consumer satisfaction
6. EV are mostly being used for Short to mid distance travel - 28.7%
7. There are significant amount of users who are using it for large distance 26.4%
8. There are still large population who haven't purchased EV yet but may have driven it and satisfied and comparing with ratings given It appears they are willing to adopt- 35.7 %
9. Tata nexon EV has largest market presence and best performing vehicle achieving highest average ratings over all
10. Tata Tigor EV has lowest market presence and poorest performer in consumer satisfaction
11. Most Graduate customers find EV to be economical.
12. Customers are willing to pay between 5 – 15 lakhs.

- **Buying Behaviour :**

	Age	Profession	Marrital Status	Education	No of Dependents	Personal loan	House Loan	Wife Working	Salary	Wife Salary	Total Salary	Make	Price
count	99.00	99	99	99	99.00	99	99	99	99.00	99.00	99.00	99	99.00
unique	NaN	2	2	2	NaN	2	2	2	NaN	NaN	NaN	9	NaN
top	NaN	Salaried	Married	Post Graduate	NaN	No	No	Yes	NaN	NaN	NaN	SUV	NaN
freq	NaN	64	84	56	NaN	67	62	52	NaN	NaN	NaN	19	NaN
mean	36.31	NaN	NaN	NaN	2.18	NaN	NaN	NaN	1736363.64	534343.43	2270707.07	NaN	1194040.40
std	6.25	NaN	NaN	NaN	1.34	NaN	NaN	NaN	673621.73	605444.96	1050777.41	NaN	437695.54
min	26.00	NaN	NaN	NaN	0.00	NaN	NaN	NaN	200000.00	0.00	200000.00	NaN	110000.00
25%	31.00	NaN	NaN	NaN	2.00	NaN	NaN	NaN	1300000.00	0.00	1550000.00	NaN	800000.00
50%	36.00	NaN	NaN	NaN	2.00	NaN	NaN	NaN	1600000.00	500000.00	2100000.00	NaN	1200000.00
75%	41.00	NaN	NaN	NaN	3.00	NaN	NaN	NaN	2200000.00	900000.00	2700000.00	NaN	1500000.00
max	51.00	NaN	NaN	NaN	4.00	NaN	NaN	NaN	3800000.00	2100000.00	5200000.00	NaN	3000000.00

|	Age	No of Dependents	Salary	Wife Salary	Total Salary	Price
Age	1	0.54	0.66	0.29	0.59	0.38
No of Dependents	0.54	1	0.27	0.1	0.23	0.089
Salary	0.66	0.27	1	0.35	0.84	0.55
Wife Salary	0.29	0.1	0.35	1	0.8	0.64
Total Salary	0.59	0.23	0.84	0.8	1	0.72
Price	0.38	0.089	0.55	0.64	0.72	1

Multiple Subplots with Titles

Observations about buying behaviour from purchase history

1. Price of car purchased is highly correlated with Total salary
2. No. of dependents play no role in deciding price of car to purchase or even make.
3. Age is somewhat related to Salary earned but not so much to the car price.
4. Younger people Mostly opt for Hatchbacks like Baleno or i20 and some go for Sedans, there is small population of youngsters who also go for SUV but none go for Luxury
5. Higher Age people mostly opt for Luxury of Premium Sedans like Ciaz.
6. People who Earn Higher salary go for SUVs or Luxury.
7. i20 and Baleno (Hatchbacks) are most popular vehicle of Lower income group.
8. When Wife's salary is also high and resultantly Total salary also hikes up, choice of vehicles becomes Luxury and SUVs
9. **SUVs** holds most of the market capital with their primary Customers being Post Graduate, High Income Married, Salaried Professionals with Working wife; Singles of this group prefer City or Creta (Sedan/Compact SUV).
10. Second Fav Vehicle in this segment is **Creta (Compact SUV)**
11. Highly Educated Married Businessmen Prefer Hatchback &sedan whereas Single of this category also prefer **SUV.**
12. Overall **Post graduates Salaried Professionals** prefer **SUV** and **Businessmen** prefer Baleno So we can say These two are most popular categories.
13. Overall **Graduates Salaried** Professionals prefer **Ciaz** and **Businessmen** prefer **SUV** So we can say These two are most popular categories.
14. Overall Most Popular vehicle segments in decreasing order are : **SUV** > Baleno**(Hatchback)** > CIAZ**(Premium sedan)**

Extracting Segments

Demographical clusters :

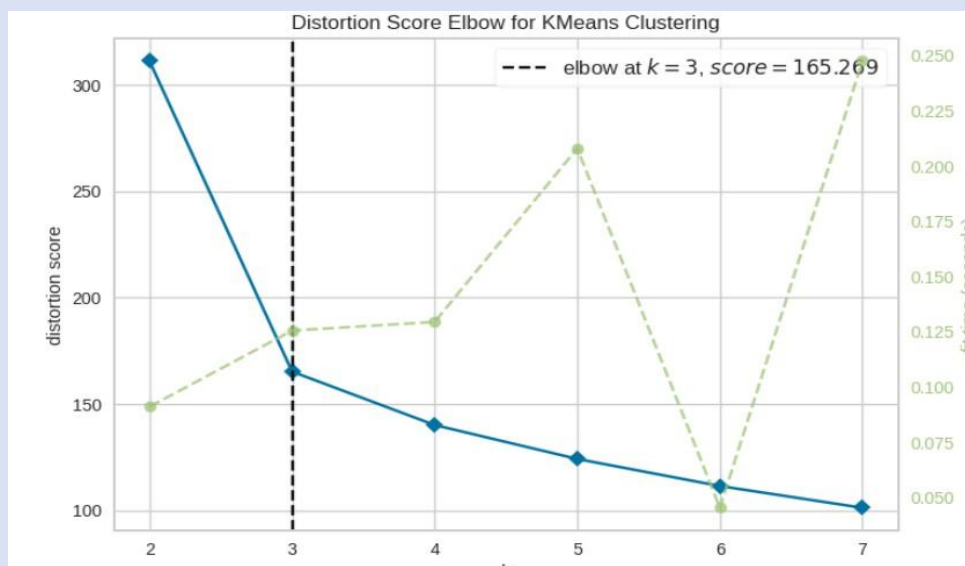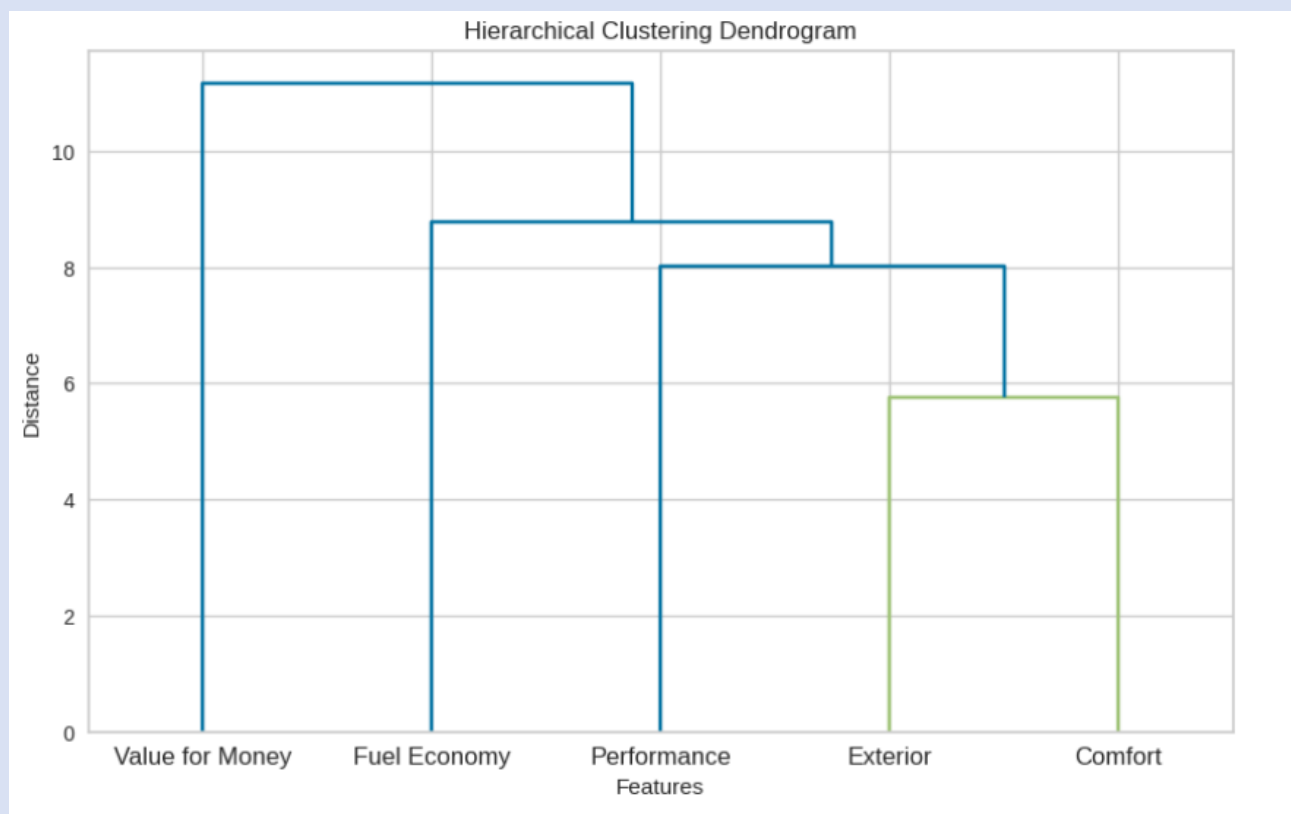EV Market Segmentation - Cluster Analysis
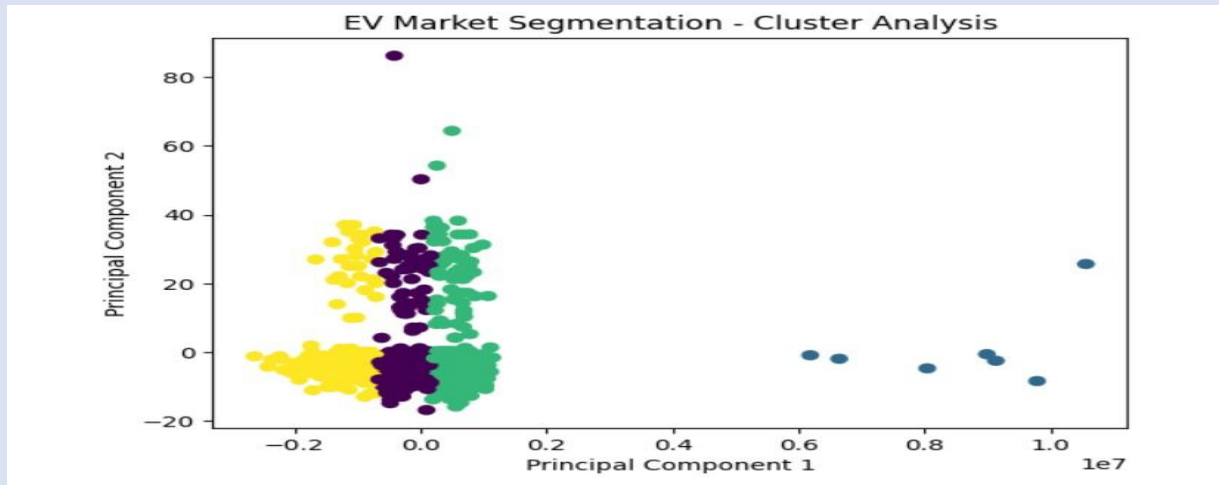
Geographical clusters :

Clustering of States Based on EV Adoption, Charging Infrastructure, and EV Charging Sanctions

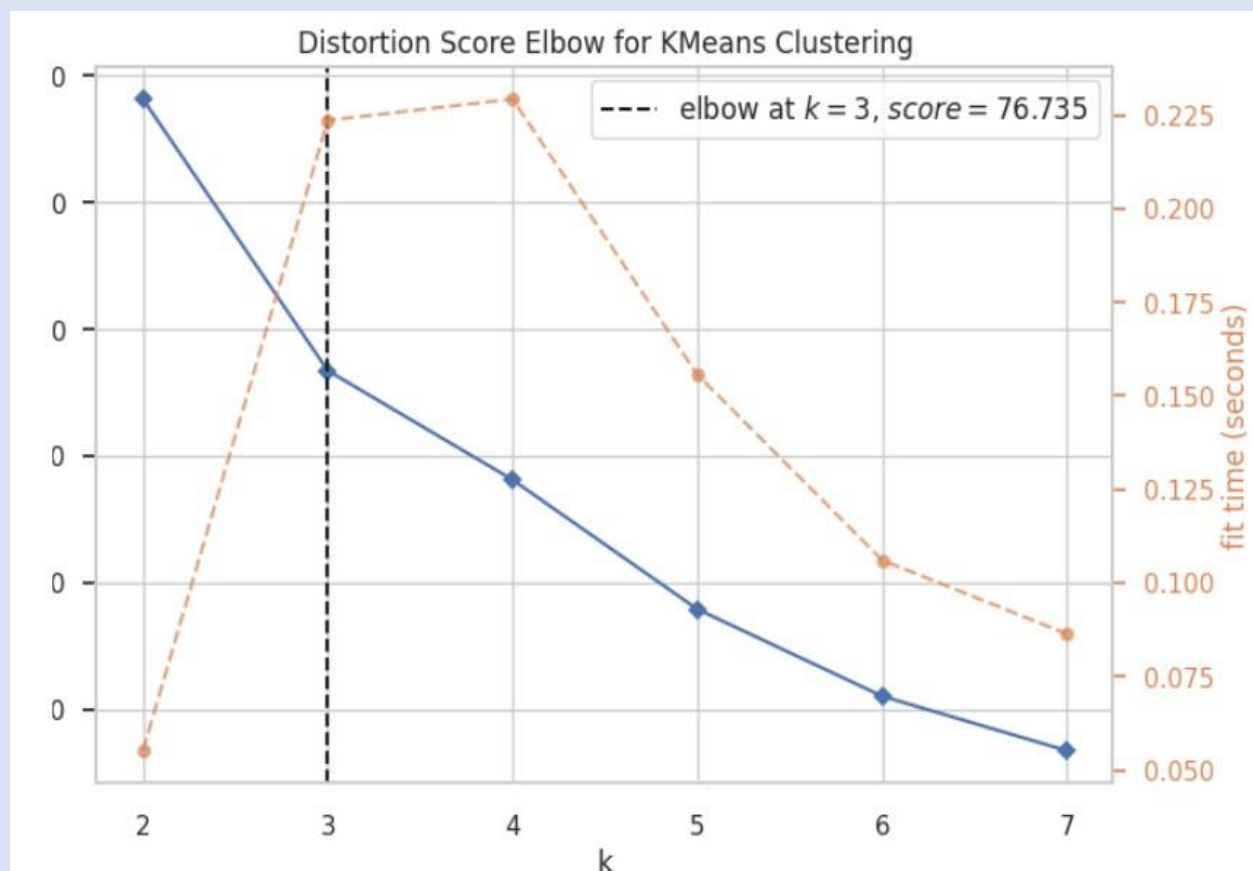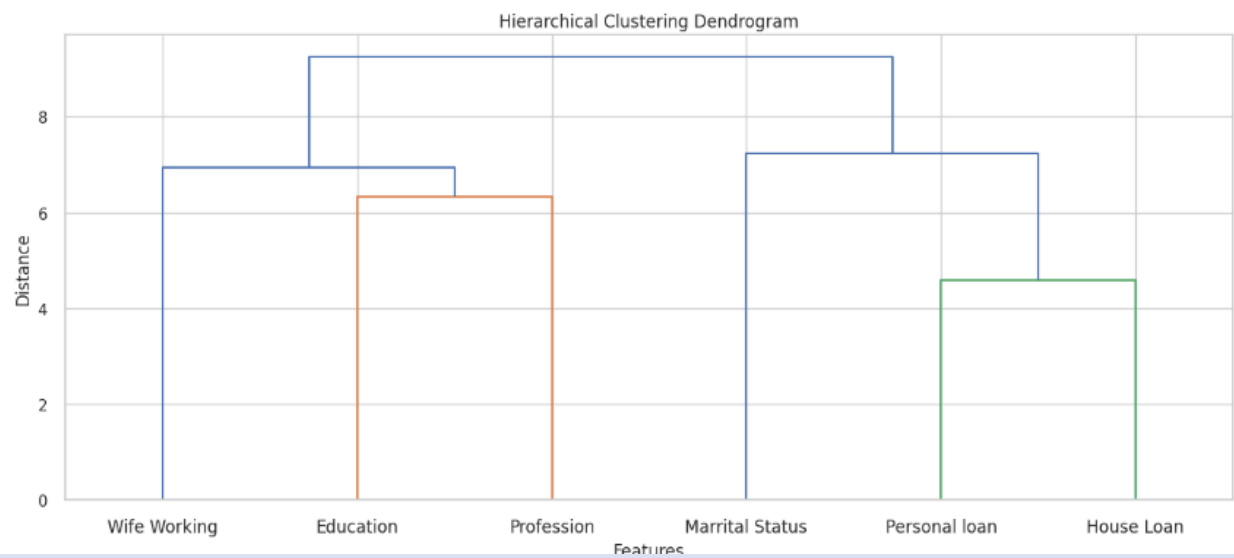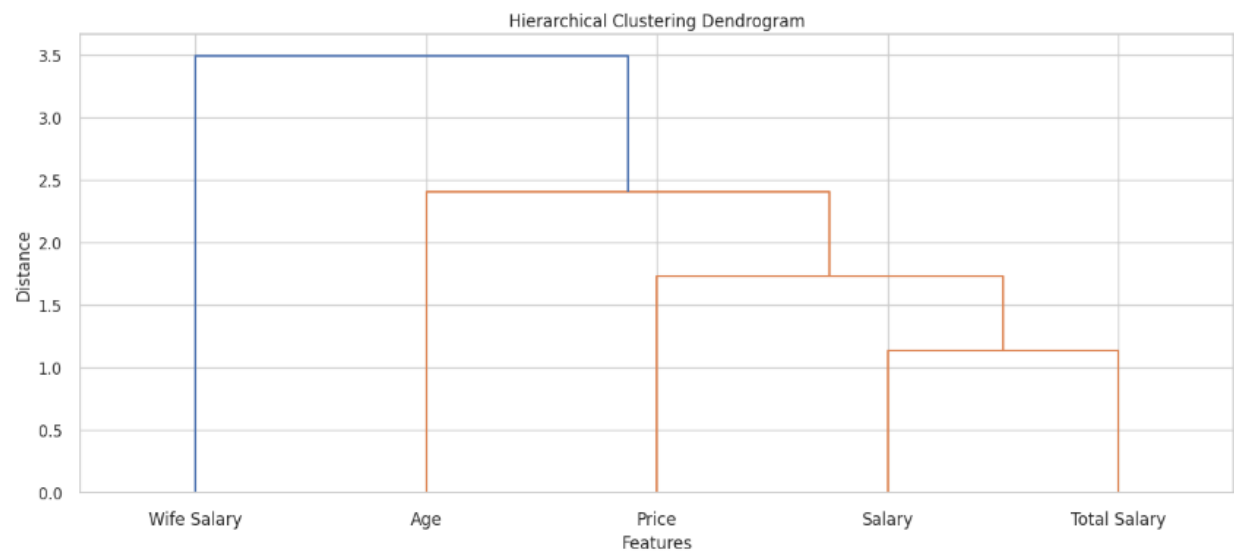**Psychological and buying behaviour clusters**

K-elbow approach to find optimal number of clusters for psychological profile

Distortion Score Elbow for KMeans Clustering

--- elbow at $k = 3$, $score = 165.269$

Hierarchical Clustering Dendrogram

K-elbow approach to find optimal number of clusters for Buying behavioural profile

Distortion Score Elbow for KMeans Clustering

--- elbow at $k = 3$, $score = 76.735$

Hierarchical Clustering Dendrogram

Hierarchical Clustering Dendrogram

Optimal Target profile:

Demographical profile:

Profile :

Cluster -0

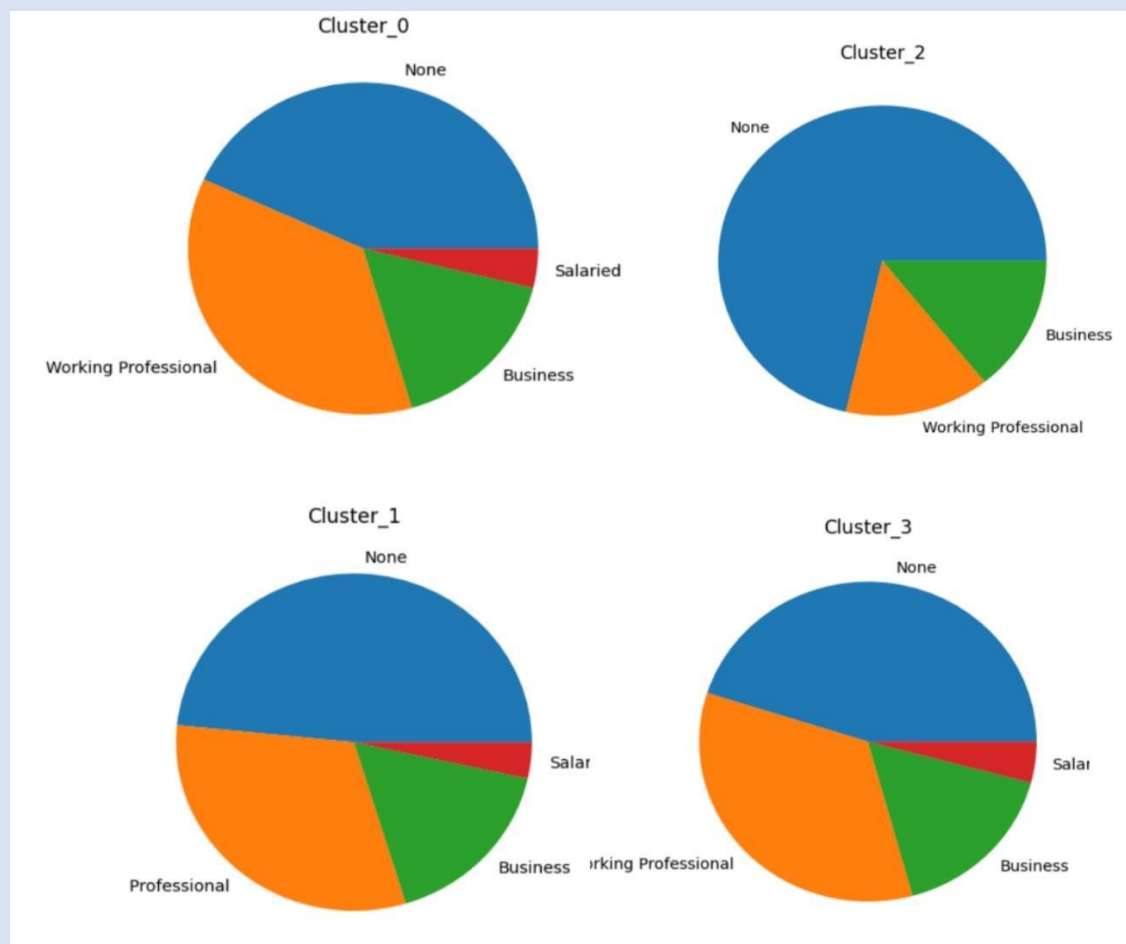- Young Age , No Business, Graduate, Single

Cluster -1

- Young age , working Professional, Graduate, Married.

Cluster – 2

- Middle aged(30+) , Businessmen, Post Graduate

Cluster – 3

- Middle aged, Salaried professional, Married

Geographical profile:

Cluster 0 - High EV Adoption, Moderate Charging Infrastructure, Moderate EV Charging Sanctions.

States - Tamil Nadu and Chhattisgarh

Cluster 1 - Low to Moderate EV Adoption, Low Charging Infrastructure, Low EV Charging Sanctions.

States - Odisha, Punjab, Bihar, Assam, Haryana, Ladhakh, Sikkim, Jharkhand, Puducherry, Goa, Jammu Kashmir

Cluster 2 - High EV Adoption, High Charging Infrastructure, High EV Charging Sanctions.

States: Karnataka And Delhi

Cluster 3 - Moderate EV Adoption, Moderate Charging Infrastructure, High EV Charging Sanctions.

States: Maharashtra, Rajasthan, West Bengal, Gujarat, Kerala

Cluster 4 - High EV Adoption (Mainly Three Wheelers and Four Wheelers), Low Charging Infrastructure, Low EV Charging Sanctions.

States: Uttar Pradesh

Psychological Profile :-

cluster_num	Exterior	Comfort	Performance	Fuel Economy	Value for Money
0	4.829787	4.819149	4.914894	4.882979	4.893617
1	1.666667	1.333333	1.000000	1.222222	0.888889
2	4.153846	4.038462	3.807692	3.846154	2.653846

Desirability of EV Models
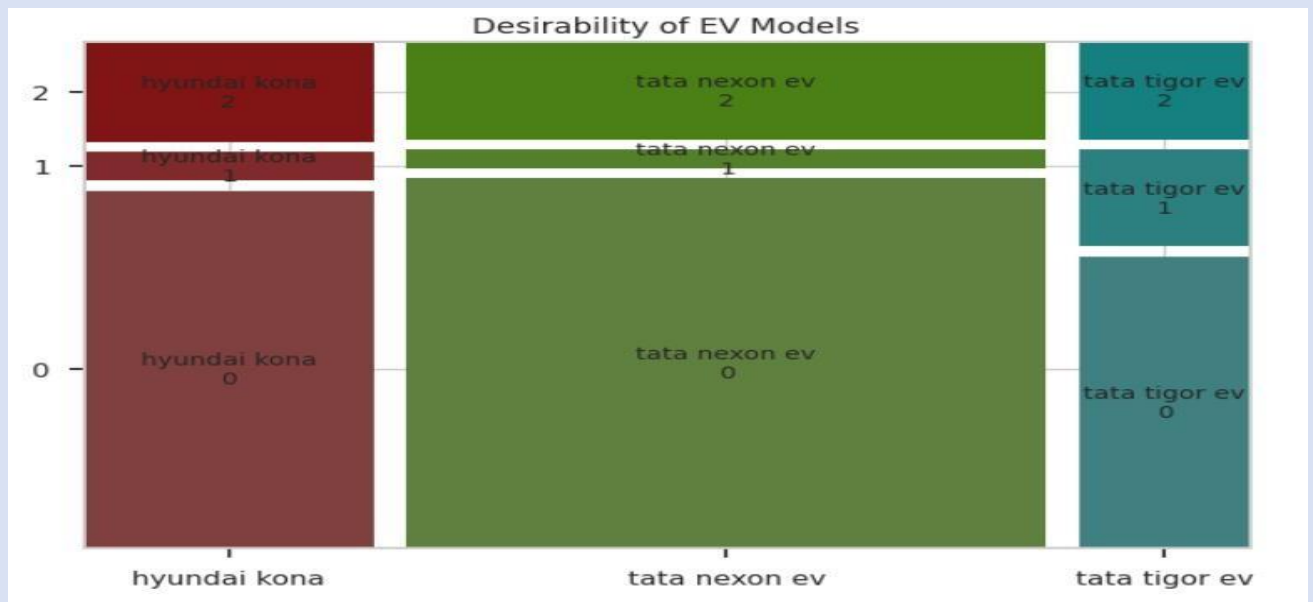
Segment 0 :

High satisfaction on every aspect ,indicates higher willing to adoption of EV,

forms most of the population - 72.9%

Most desired EV is Tata Nexon

These are Early majority

Segment 1 :

Unsatisfied on all aspects, didn't find EV to be value for money

forms 7% of population

Found Tata tigor EV ** to be most likeable

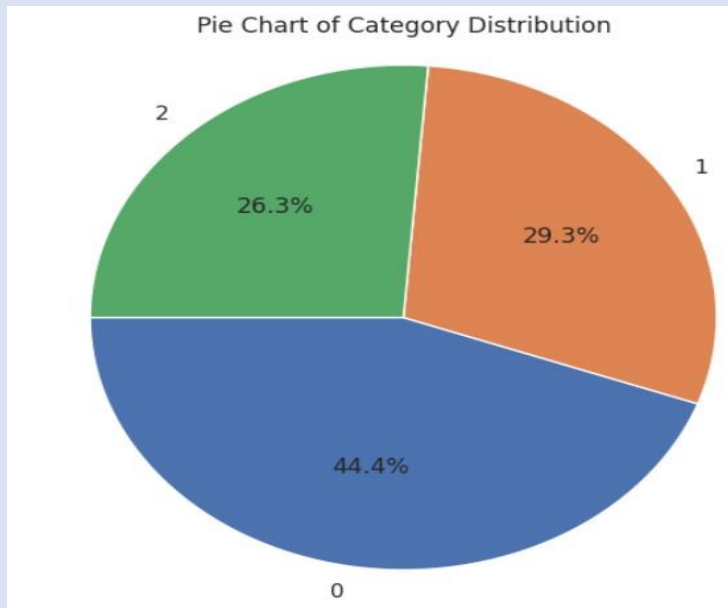can be considered **Late adapters.

Segment 2:

They liked Exterior and Comfort of EVs but didn't find it Value for money much;

form 20.2% population

Found each EV equally likeable

can be considered Early adaptors

Behavioural Profile :-

Segments Based on Social status :

Pie Chart of Category Distribution

Segment 0 :

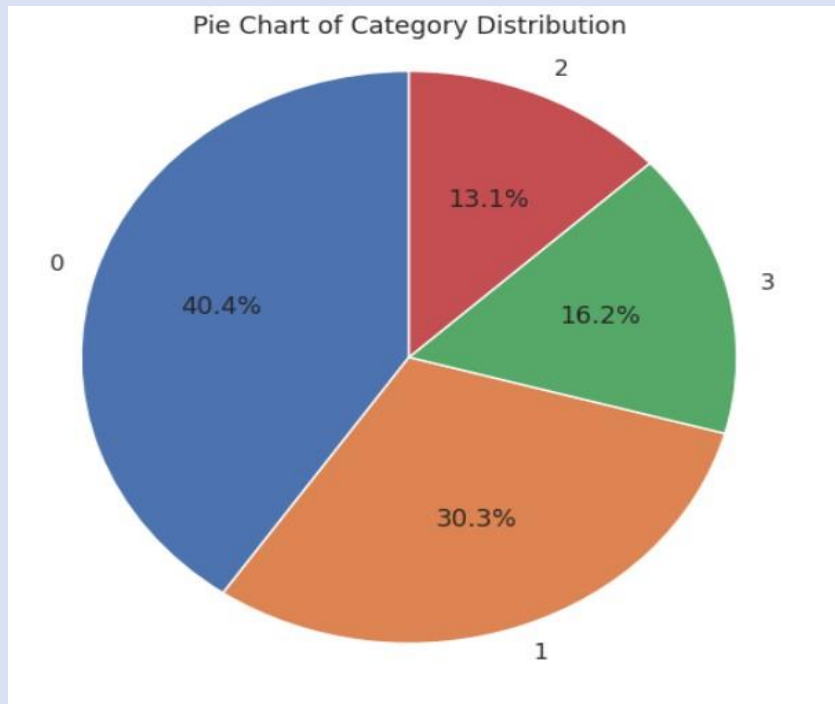Highly Educated Salaried Professional with Working wife :- 44.4 %

Segment 1 :

Highly Educated, Salaried Single professional with little Personal Loan. :- 29.3 %

Segment 2 :

Post graduate, Salaried professional , which have High personal and home loans but also a working wife. :- 26.3 %

Financial Status profile :-

Pie Chart of Category Distribution

Segments Based on Financial status :

Segment 0 :

Young age, Mid-level Total Salary Professional Looking for mid_range priced Car :- 40.4 %

Segment 1 :

People in their 30s,Above Average total Salary with Working wife Looking for Higher Price ranged cars :- 30.3 %

Segment 2 :

People in their 40's, Lower range Salaried with High wife's salary ,Looking for above mid-range of Cars :- 13.1 %

Segment 3 :

People in their 40's, Lower range Salaried with no wife's salary ,Looking for Cheaper range of Cars :- 16.2 %

What features should one offer in a EV SUV segment?

Features of Most popular EV model based on reviews:- Tata Nexon EV

	1006	1007	1008
Make	Tata	Tata	Tata
Model	Nexon Ev	Nexon Ev	Nexon Ev
Variant	Xm	Xz Plus	Xz Plus Lux
Ex-Showroom_Price	Rs. 13,99,000	Rs. 14,99,000	Rs. 15,99,000
Drivetrain	FWD (Front Wheel Drive)	FWD (Front Wheel Drive)	FWD (Front Wheel Drive)
Fuel_Type	Electric	Electric	Electric
Height	1607 mm	1607 mm	1607 mm
Length	3994 mm	3994 mm	3994 mm
Width	1811 mm	1811 mm	1811 mm
Body_Type	SUV	SUV	SUV
Doors	5.0	5.0	5.0
Ground_Clearance	205 mm	205 mm	205 mm
Front_Brakes	Ventilated Disc	Ventilated Disc	Ventilated Disc
Rear_Brakes	Solid Disc	Solid Disc	Solid Disc
Front_Suspension	Independent MacPherson Dual path Strut with co...	Independent MacPherson Dual path Strut with co...	Independent MacPherson Dual path Strut with co...
Rear_Suspension	Torsion beam with hydraulic shock absorbers	Torsion beam with hydraulic shock absorbers	Torsion beam with hydraulic shock absorbers
Front_Tyre_&_Rim	R16	R16	R16
Rear_Tyre_&_Rim	R16	R16	R16
Power_Steering	Electric Power	Electric Power	Electric Power
Power_Windows	All Windows	All Windows	All Windows
Keyless_Entry	Smart Key	Smart Key	Smart Key
Power	129PS	129PS	129PS
Torque	245Nm	245Nm	245Nm
Odometer	Digital	Digital	Digital
Speedometer	Digital	Digital	Digital
Tachometer	Analog	Analog	Analog
Tripmeter	Yes	Yes	Yes
Seating_Capacity	5.0	5.0	5.0
Seats_Material	Fabric	Fabric	Fabric

Average Range by PowerTrain
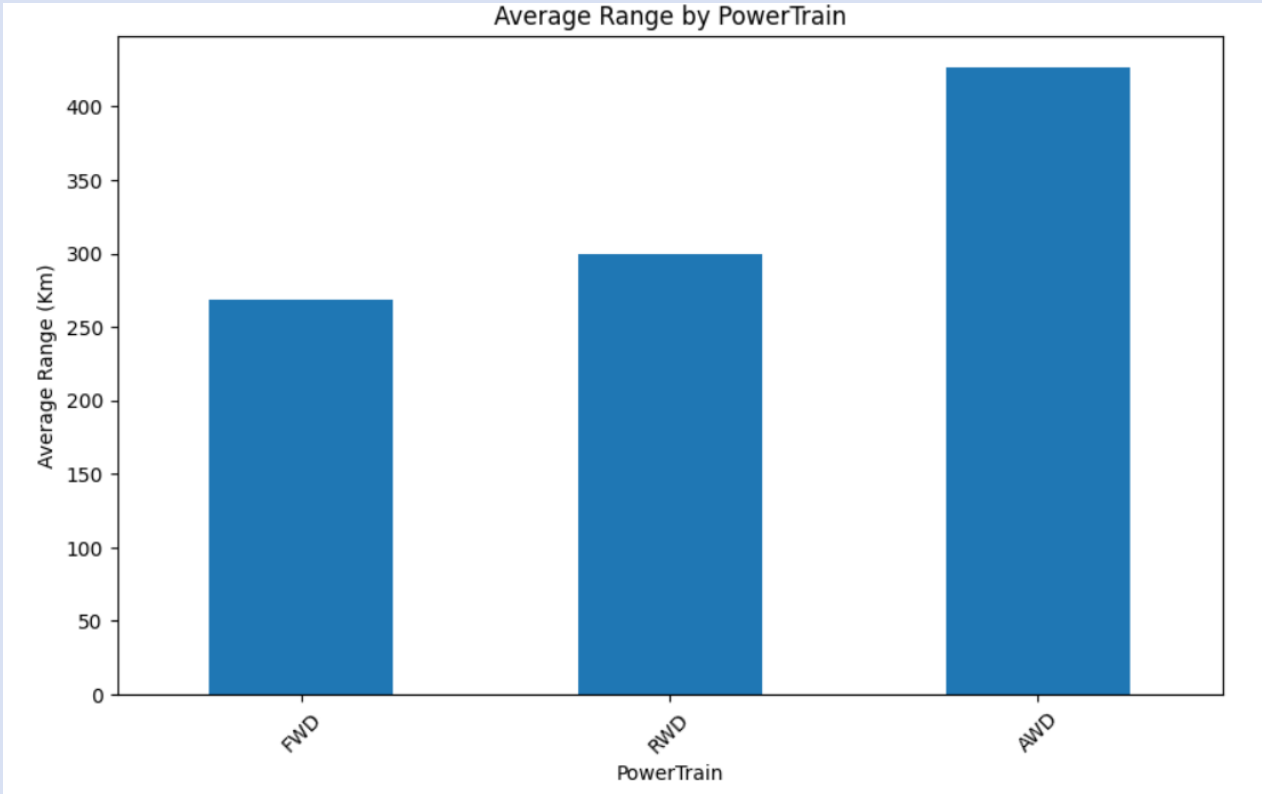
Conclusion :

This report deals with the issue of how a new and environment-friendly car technology may be diffused into the private car market.

It was found that adoption of the electric vehicle depends on how the vehicles specific product attributes are perceived, on personal traits, and on background variables. Further, it shows that those most interested in adopting an electric vehicle are those with the most favourable attitude towards the vehicle, which, in turn, mainly depends on the perception of the electric vehicle's usefulness and on the importance put on it's technical performance.

Application of machine learning in the segmentation of the electric vehicle (EV) market has yielded valuable insights and actionable strategies for market optimization. Through the analysis of comprehensive data, we have identified distinct customer segments and their preferences within the EV landscape.

By harnessing the power of machine learning algorithms, we've discerned key patterns and trends in consumer behaviour, allowing us to make informed decisions on product development, Infrastructure development, marketing strategies, and market positioning. This has not only improved our understanding of the EV market but also provided a solid foundation for targeted marketing efforts.

Analysing the dataset and the applying algorithms for market segmentation reveals substantial opportunities for achieving robust profitability within the realm of Electric vehicles. The primary catalyst that may influence this upward growth trajectory is the escalating costs associated with various other fuel types, thus positioning Electric vehicles advantageously for expansion due to their cost-efficiency and energy conservation.

By executing the market segmentation process on current Buying behaviour of Traditional vehicle we have identified most desirable body type, price range and most liked features which we can adapt in EVs to replace Conventional vehicle .

In conclusion, machine learning-driven market segmentation has empowered us to make data-driven decisions, fine-tune our marketing approaches, and unlock new opportunities for success in the dynamic and promising electric vehicle market.

Github links for Source codes:

NISHIL TAYAL

https://github.com/NishilTayal/Market-Segmentation/blob/main/EV_Geographic_Segmentation.ipynb

UTKARSH RAJ

https://github.com/uttoxi/Feynn-labs-project/tree/main/Electric%20Vehicle%20Market%20Segmentation

DEEKSHA REDDY

https://github.com/Deeksha-45/EV-SEGMENTATION/tree/main

PRASHANT KUMAR DATTATREY

https://github.com/iitkgpian/Electric_Vechile_Market_Segmentation/tree/main

RUCHA BHIDE

https://github.com/wabi-sabi-wasabi/EVMarketSEgmentationFeynn/tree/main