Analysis on Adoption of Electric vehicle

Gokhale Education Society's

H.P.T. Arts and R.Y.K. Science College, Nashik-422005

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DEPARTMENT OF STATISTICS

This to certify that the project work entitled **"Analysis on Adoption of Electric Vehicles"** is a bonafide work carried out by

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With partial fulfilment for the Statistics project of the Savitribai Phule Pune University during the year **2021-22**. The project report has been approved as it satisfies the academic requirements in respect of Project Work prescribed for the said degree.

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We would like to extend the special thanks to our respondents who gave us fruitful information to analyse.

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Heartfelt gratitude to all of you!

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Introduction

Pollution of the environment is currently a global concern. Toxic emission from internal combustion engines is one of the primary air pollutants. In order to mitigate the effects of fossil fuel emission and address environmental concerns (EC's), electric vehicles (EV's) are being promoted aggressively all over the world. Various governments are encouraging people to switch to electric vehicles by incentivizing the transition. Previous studies indicate that the high cost of the electric car, non-availability of charging infrastructure, time and range anxiety act as impediments to consumer adoption. The Government of India has given a call for 'only Electric Vehicles' on Road by 2030. This article is contemporary and examines the different factors that affect a consumer adoption of an electric vehicles.

The over-a-century-old automobile industry is gearing up for transformation. The fossil fuel price spike and the impact of its emission on the environment have called for a change in individual transportation habits. The sector, propelled by internal combustion engines, is gravitating gradually towards electric vehicles (EV's).

Electric motors propel the electric vehicles and the rechargeable battery or other portable energy storage device maintains power supply. These vehicles are energy efficient, generating less greenhouse gas (GHG) emissions and reduced noise.

The government is examining the battery swapping option model to overcome the challenges in electric vehicle adoption. The swapping model was introduced in Israel and China met with partial success. The challenges are the battery size and power. These may vary according to manufacturer/models (e.g., Maruti Alto and Honda City). This complicated situation under this model demands a similar vehicle design to accommodate the same battery, which is difficult to achieve. Another alternative could be battery leasing that could reduce the ownership cost. However, the easy availability of charging points across different places in a city remains a significant challenge yet unresolved.

The shift towards electric vehicles in India is imperative in the near future, though not imminent. Several cities are victims of unplanned urbanization and high pollution. They suffer unqualified degradation, with vehicular emission as the primary source.

Objectives

- To study main factors affecting the adoption of electric vehicle and what is the impact of several other factors.
- To explore whether different characteristics have an impact on purchasing of an Electric vehicles.
- To know why electric vehicle couldn't get enough consumer attraction.
- To study the scope of electric vehicle in future.
- To know the benefits and advantages of electric vehicle.
- To spread awareness among people about the benefits of electric vehicle via comparison between electric vehicle and non-electric vehicle.

“Be Part of Solution not Pollution”

Go Green

Research Methodology

Way of collection of data and method of data collection is very important part of the project. We select the survey method for our project's data collection. For our project we have collected Primary data. Primary data means original data obtained by an investigator himself/herself. Primary data also called as raw data.

Our project deals with methodology adopted to fulfil the objectives of the study on electric vehicles. The data was collected from various cities in India.

- Sampling Techniques: Simple Random Sampling
- Sample Size : 280
- Sampling unit: All the customer’s using vehicles.
- Collection of data: Our data is primary data. It was collected from the respondents through google forms.
- Period of collection of data: 3 days
- Data Collected by questionnaire consisting of single and multiple choice questions.

Abstract

In India, electric vehicles are scarce on the road and are not available readily in the market. Potential adopters / users of electric vehicles may have never seen, driven or charged such vehicles. People have limited familiarity with the characteristics of these Vehicles.

The data collection was done through a structured questionnaire. The developed instrument contained information on constructs and their constituents. The designed questionnaire had two parts:

The first part focused on the data related to demographic characteristics of the respondents:

- Gender
- Age
- Educational qualification
- Occupation
- Annual income
- City they live in.

The second part of the questionnaire was again divided into two sub-parts:

- For fuel vehicles users
- For electric vehicle users.

The second part measures the model variables. There was one dependent variable 'will you prefer electric vehicle in future' consisting five independent variables:

- Low maintenance
- Eco-friendly
- Government subsidy
- Performance
- Can be charged anywhere

The four Independent variables in favour of 'not preferring electric vehicle in future':

- High price
- Low average
- Less charging stations
- Less service stations

The study aimed to examine factors that may influence electric vehicle adoption. To study the most favourable and unfavourable factors that affects the adoption of electric vehicles. As the data is collected only for a limited sample size, the results thus are reliable only for our project.

Questionnaire

1. Email ID: _____

2. Age:

- 18 - 28
- 28 - 38
- 38 – 48
- 48 – 58
- 58 & above

3. Which city do you live in? _____

4. Gender:

- Male
- Female

5. Qualification:

- 10^{th}
- 12^{th}
- Undergraduate
- Postgraduate
- Other

6. What is your occupation?

- Service
- Self-employed / Businessman
- Student
- Housemaker

7. What is your annual income?

- Below 3 lakhs
- 3 - 5 lakhs
- 5 - 7 lakhs
- 7 lakhs & above

8. Do you know about electric vehicles (EVs)?

- Yes
- No

9. Which type of vehicle are you using at present?

- Petrol / Diesel
- Electric

10. If you want to purchase a vehicle, which vehicle will you buy?

- 2 – wheeler
- 4 - wheeler

11. Which type of vehicle will you prefer?

- Petrol / Diesel
- Electric

12. Why do you prefer petrol/diesel vehicles?

- ☐ Average (in km)
- ☐ Reasonable Price
- ☐ Availability of Fuel pumps
- ☐ Availability of Service/repair Centre

13. Why don’t you prefer electric vehicles?

- ☐ High Price
- ☐ Low Average (in km)
- ☐ Less Charging Stations
- ☐ Less Service/repair Centre

14. For which purpose will you prefer petrol/diesel vehicles?

- City Driving
- Highway Driving

15. If chosen electric vehicle, which factor will you consider while buying?

- ☐ Low Maintenance
- ☐ Performance
- ☐ Eco-friendly
- ☐ Government Subsidy / Incentives
- ☐ Can Charge Anywhere

16. Where will you prefer to charge your electric vehicle?

- ○ Home
- ○ Work Place
- ○ Public Charging Stations

17. For which purpose will you prefer electric vehicles?

- ○ City Driving
- ○ Highway Driving

18. Do you have sufficient charging stations in your city?

- ○ Yes
- ○ No

19. Will you prefer electric vehicles over other vehicles in future?

- ○ Yes
- ○ No

20. Which factor you considered while buying electric vehicle?

- ☐ Low Maintenance
- ☐ Performance
- ☐ Eco-friendly
- ☐ Government Subsidy/Incentives
- ☐ Can Charge Anywhere

21. Why don’t you prefer petrol/diesel vehicles?

- ☐ Petrol / Diesel Prices
- ☐ Maintenance
- ☐ Pollution due to fuel vehicles

22. In your opinion, which factors can affect sales of electric vehicles?

- ☐ Less Charging Stations
- ☐ Low Average
- ☐ High Price
- ☐ Less Service / repair Centre

23. Where do you charge your vehicle?

- ○ Home
- ○ Workplace
- ○ Public Charging Stations

24. Where will you prefer to charge your electric vehicle?

- ○ Home
- ○ Workplace
- ○ Public Charging Stations

25. For which purpose will you prefer electric vehicles?

- ○ Highway Driving
- ○ City Driving

26. Do you have sufficient charging stations in your city?

- ○ Yes
- ○ No

27. Will you prefer electric vehicles over other vehicles in future?

- ○ Yes
- ○ No

Coding

Age	Coding
18-28	1
28-38	2
38-48	3
48-58	4
58&above	5

Gender	Coding
Male	1
Female	2

Qualification	Coding
Undergraduate	1
Postgraduate	2
Other	3
12^{th}	4
10^{th}	5

Occupation	Coding
Student	1
Service	2
Self-employed/Businessman	3
Housemaker	4

Q9	Coding
Yes	1
No	2

Annual Income	Coding
Below 3 lakhs	1
7 & above	2
5 - 7 lakhs	3
3 - 5 lakhs	4

Q11	Coding
Petrol/Diesel	1
Electric	2

Q8	Coding
Electric	1
Petrol/Diesel	2

Q10	Coding
4-Wheeler	1
2-Wheeler	2

For Fuel Section:

Q12	Coding
Availability of Fuel pumps	1
Average (in km)	2
Availability of Service/repair Centre	3
Reasonable Price	4

Q13	Coding
Less Charging Stations	1
High Price	2
Low Average (in km)	3
Less Service/repair Centre	4

Q15	Coding
Low Maintenance	1
Eco-friendly	2
Performance	3
Government Subsidy / Incentives	4
Can Charge Anywhere	5

Q14	Coding
Highway Driving	1
City Driving	2

Q17	Coding
City Driving	1
Highway Driving	2

Q16	Coding
Home	1
Public Charging Stations	2
Workplace	3

Q19	Coding
Yes	1
No	2

Q18	Coding
No	1
Yes	2

For Electric Section:

Q20	Coding
Eco-friendly	1
Low Maintenance	2
Performance	3
Can Charge Anywhere	4
Government Subsidy/Incentives	5

Q21	Coding
Pollution due to fuel vehicles	1
Petrol / Diesel Prices	2
Maintenance	3

Q22	Coding
Less Charging Stations	1
High Price	2
Less Service/repair Centre	3
Low Average (in km)	4

Q23	Coding
Home	1
Public Charging Stations	2
Workplace	3

Q25	Coding
City Driving	1
Highway Driving	2

Q24	Coding
Home	1
Public Charging Stations	2
Workplace	3

Q26	Coding
No	1
Yes	2

Q27	Coding
Yes	1
No	2

Coded Data Set

Age :	Gender :	City :	Qualification :	Occupation :	Annual Income :	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20	Q21	Q22	Q23	Q24	Q25	Q26	Q27
1	1	Mumbai	1	2	4	1	1	1	2	4, 1	2, 3	1	1, 3, 5	1	1	2	1	0	0	0	0	0	0	0	0
2	1	Mumbai	2	2	3	1	1	2	1	0	0	0	0	0	0	0	0	2, 3, 1	2, 3	1, 2	1	1	1	1	1
1	2	Nashik	1	1	1	2	1	2	1	0	0	0	0	0	0	0	0	2, 1, 5	1	4, 2	1	2	1	1	1
1	2	Nashik	1	1	1	1	1	2	2	1, 3	3, 4	1	1, 2, 4	1	1	1	1	0	0	0	0	0	0	0	0
2	2	Nashik	2	2	2	1	1	2	2	4, 3	2, 1	2	1, 2, 4	1	2	1	1	0	0	0	0	0	0	0	0
1	2	Aurangabad	1	1	1	1	1	2	1	0	0	0	0	0	0	0	0	3, 1, 4	1	1, 4	2	1	1	1	1
1	1	Nashik	1	1	1	1	2	2	1	0	0	0	0	0	0	0	0	2, 1, 4	2, 1	1, 2	1	1	1	2	1
5	2	Akas Ganga	3	4	2	1	1	1	2	2, 3	2, 1	1	2, 4, 5	3	1	1	2	0	0	0	0	0	0	0	0
1	1	Aurangabad	1	1	1	1	1	2	1	0	0	0	0	0	0	0	0	2, 3, 1	2, 1	1, 2	1	2	1	1	1
1	2	Pune	1	1	1	1	1	1	2	2, 3	3, 4	1	1, 2, 4	2	1	2	1	0	0	0	0	0	0	0	0
1	1	Nashik	1	1	1	1	1	1	2	2, 4	2, 1	1	1, 2, 4	2	1	1	1	0	0	0	0	0	0	0	0
1	1	Yavatmal	1	1	1	1	1	2	1	0	0	0	0	0	0	0	0	2, 1, 4	3, 1	1, 4	1	3	1	1	1
1	2	Nashik	1	1	1	1	1	2	1	0	0	0	0	0	0	0	0	2, 3, 1	2	4, 2	1	1	1	1	1
1	1	Nashik	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	2, 1, 5	2, 3	1, 2	1	1	1	2	1
2	1	Pune	2	2	2	1	1	1	2	1, 3	3, 1	1	1, 3, 2	1	1	2	1	0	0	0	0	0	0	0	0
1	1	Nagpur	1	1	1	1	1	2	1	0	0	0	0	0	0	0	0	3, 1, 5	2	1, 2	1	1	1	1	1
1	2	Aurangabad	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	3, 1, 4	2, 1	1, 4	1	1	1	1	1
1	1	Amravati	1	1	1	1	1	2	1	0	0	0	0	0	0	0	0	1, 5, 4	2, 1	1, 3	1	2	1	1	1
1	1	Nagpur	1	1	1	1	1	1	2	1, 3	1, 4	1	1, 3, 2	1	1	1	2	0	0	0	0	0	0	0	0
1	1	Nashik	1	1	1	1	1	1	2	4, 1	3, 1	1	3, 4, 5	1	1	1	1	0	0	0	0	0	0	0	0
1	1	Aurangabad	1	1	1	1	2	1	2	2, 1	2, 3	1	1, 3, 4	3	1	2	1	0	0	0	0	0	0	0	0
2	1	Nashik	2	1	1	2	1	1	1	0	0	0	0	0	0	0	0	2, 1, 5	2, 1	1, 2	1	1	2	1	1
1	2	Nagpur	1	1	1	1	1	2	2	4, 1	2, 3	2	3, 2, 4	3	2	2	1	0	0	0	0	0	0	0	0
1	1	Nashik	1	1	1	1	1	2	1	0	0	0	0	0	0	0	0	2, 5, 4	2, 1	1, 2	2	2	1	1	1
1	1	Amravati	1	1	1	1	2	2	1	0	0	0	0	0	0	0	0	3, 1, 5	1	4, 3	3	3	1	2	1
1	2	Amravati	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	3, 1, 5	2, 1	4, 2	3	3	1	1	1
5	1	Amravati	1	1	1	1	1	1	2	1, 3	2, 4	1	1, 3, 4	2	2	1	1	0	0	0	0	0	0	0	0
1	1	Nashik	1	1	1	1	1	2	2	2, 1	2, 1	1	1, 3, 5	1	1	1	1	0	0	0	0	0	0	0	0
1	2	Nashik	1	1	1	1	1	2	1	0	0	0	0	0	0	0	0	3, 1, 4	2, 1	1, 3	1	2	2	1	1
1	1	Amravati	4	1	1	1	1	1	1	0	0	0	0	0	0	0	0	2, 3, 1	2, 1	1, 2	1	2	1	1	1
1	2	Nashik	4	1	1	2	1	2	1	0	0	0	0	0	0	0	0	3, 1, 4	2	1, 2	1	1	1	1	1
1	1	Nashik	1	1	1	1	1	1	2	2, 1	3, 1	1	1, 3, 5	2	1	1	2	0	0	0	0	0	0	0	0
1	1	Nashik	4	1	1	1	1	1	1	0	0	0	0	0	0	0	0	2, 3, 5	2, 1	1, 3	2	2	1	1	1
3	1	Nashik	1	3	3	2	1	2	2	2, 1	3, 4	2	1, 3, 5	2	1	1	2	0	0	0	0	0	0	0	0
3	2	Nashik	5	4	1	1	1	1	1	0	0	0	0	0	0	0	0	2, 3, 1	2, 1	1, 4	1	1	1	2	2
1	1	Haryana	2	3	3	1	1	1	1	0	0	0	0	0	0	0	0	2, 1, 5	2, 1	1, 2	3	1	1	1	1
1	1	Surat	1	3	4	2	1	1	2	2, 1	1, 4	1	3, 2, 4	2	1	1	1	0	0	0	0	0	0	0	0
1	1	Amravati	1	1	1	1	1	2	1	0	0	0	0	0	0	0	0	3, 1, 4	2, 1	1, 2	1	2	2	1	1
1	1	Churu	1	1	1	1	1	1	2	1, 3	2, 3	1	1, 3, 2	2	1	1	1	0	0	0	0	0	0	0	0
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3	1	Nashik	2	3	2	1	1	1	1	0	0	0	0	0	0	0	0	2, 3, 4	1	1, 4	2	2	1	1	1
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1	2	Surat	1	1	3	1	1	1	2	2, 1	2, 1	1	3, 4, 5	1	1	1	2	0	0	0	0	0	0	0	0
1	2	Gurugram	1	1	1	1	1	2	2	2, 3	3, 1	1	1, 3, 5	2	1	1	1	0	0	0	0	0	0	0	0
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1	1	Nashik	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	2, 1, 5	2, 1	1, 3	1	2	1	1	1
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1	1	Nashik	1	1	2	1	2	1	2	1, 3	2, 1	1	2, 4, 5	2	1	1	1	0	0	0	0	0	0	0	0
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1	2	Nashik	1	2	2	1	1	1	2	2, 1	2, 1	1	3, 2, 4	2	1	1	2	0	0	0	0	0	0	0	0
1	1	Nashik	1	1	2	1	1	1	2	2, 4	2, 1	1	3, 4, 5	2	1	1	2	0	0	0	0	0	0	0	0
1	1	Pune	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	2, 1, 4	3, 1	1, 3	1	1	1	1	1
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1	1	Nashik	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	2, 1, 5	1	4, 3	1	1	1	1	1
1	2	Pune	4	1	3	1	1	1	1	0	0	0	0	0	0	0	0	2, 5, 4	1	4, 2	3	3	1	2	1
1	1	Nashik	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	2, 1, 5	1	1, 3	1	1	1	1	1
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1	2	Nashik	1	1	1	1	1	2	2	2, 1	3, 1	2	2, 4, 5	1	1	1	1	0	0	0	0	0	0	0	0
1	1	Nohar	4	1	1	1	1	1	1	0	0	0	0	0	0	0	0	3, 1, 5	1	1, 4	2	2	1	1	2
1	1	Sirsa	1	1	1	1	2	2	1	0	0	0	0	0	0	0	0	2, 1, 5	3	1, 4	1	1	1	2	1
3	2	Mumbai	2	3	2	1	1	1	1	0	0	0	0	0	0	0	0	3, 1, 4	2	1, 2	1	2	1	1	1
1	2	Sirsa	1	1	1	1	1	2	1	0	0	0	0	0	0	0	0	2, 3, 1	3	1, 3	1	1	2	1	1
1	1	Jalgaon	1	1	1	2	1	2	1	0	0	0	0	0	0	0	0	2, 3, 1	1	2, 3	1	1	2	1	1
2	1	Nashik	1	2	4	1	1	2	1	0	0	0	0	0	0	0	0	2, 3, 4	2	1, 3	1	2	1	1	1
1	1	Varanasi	1	2	2	1	1	2	2	1, 3	1, 4	2	1, 3, 5	1	1	1	1	0	0	0	0	0	0	0	0
1	1	Pune	4	1	1	1	1	2	2	2, 1	3, 1	1	1, 2, 4	2	1	2	2	0	0	0	0	0	0	0	0
1	2	Nashik	1	2	2	1	1	2	2	2, 4	2, 3	2	1, 2, 4	1	1	2	1	0	0	0	0	0	0	0	0
1	1	Pune	1	1	1	1	1	2	1	0	0	0	0	0	0	0	0	2, 1, 4	3	2, 3	1	1	1	1	1
2	1	Surat	1	3	4	1	1	1	1	0	0	0	0	0	0	0	0	3, 1, 4	1	2, 3	3	2	1	2	1
1	1	Nashik	1	3	4	1	1	2	2	1, 3	1, 4	1	2, 4, 5	1	1	1	2	0	0	0	0	0	0	0	0
1	2	Jhansi	1	1	1	1	1	2	1	0	0	0	0	0	0	0	0	2, 3, 1	1	1, 3	2	1	1	1	1
1	2	Etah	1	1	1	2	1	1	2	2, 4	1, 4	1	3, 2, 5	1	1	1	1	0	0	0	0	0	0	0	0
1	2	Nashik	1	1	2	1	1	1	1	0	0	0	0	0	0	0	0	3, 1, 5	1	1, 3	1	2	1	1	1
1	2	Nashik	1	1	1	1	1	1	2	2, 1	3, 1	2	1, 4, 5	1	1	1	2	0	0	0	0	0	0	0	0
1	1	Nashik	1	1	1	2	1	1	2	2, 1	1, 4	1	1, 4, 5	1	2	1	2	0	0	0	0	0	0	0	0
2	1	Nashik	1	3	3	1	1	1	2	2, 3	2, 4	2	1, 3, 4	1	1	1	2	0	0	0	0	0	0	0	0
1	2	Nashik	1	1	1	1	1	2	1	0	0	0	0	0	0	0	0	2, 1, 4	2	1, 3	1	2	1	1	1
1	1	Nashik	1	1	1	1	1	2	1	0	0	0	0	0	0	0	0	3, 1, 4	1	1, 4	1	2	1	1	1
1	2	Nashik	1	1	3	2	1	1	2	2, 1	1, 4	1	1, 3, 5	1	1	1	2	0	0	0	0	0	0	0	0
1	1	Nashik	1	3	4	1	1	1	1	0	0	0	0	0	0	0	0	3, 5, 4	2	1, 2	2	2	1	1	1
1	1	Nagpur	3	2	2	2	1	1	2	1, 3	2, 1	1	1, 4, 5	2	1	1	1	0	0	0	0	0	0	0	0
1	2	Pune	2	2	1	1	1	2	2	1, 3	2, 1	1	1, 2, 5	3	1	1	1	0	0	0	0	0	0	0	0
2	2	Pune	2	4	1	1	1	1	2	4, 1	2, 1	1	1, 3, 2	2	2	1	1	0	0	0	0	0	0	0	0
3	1	Nagpur	3	2	3	1	1	1	1	0	0	0	0	0	0	0	0	2, 1, 4	1	1, 3	1	2	2	1	1
1	2	Nashik	1	1	1	1	1	2	1	0	0	0	0	0	0	0	0	2, 3, 1	2, 1	1, 3	1	1	1	1	1

Statistical Tools Used For Analysis

1. Diagram:

   a) Simple bar diagram
   b) Pie diagram
   c) Multiple bar diagram
   d) Sub-divided bar diagram

2. Testing of Hypothesis:

   a) χ^2 -Test for independence of two attribute
   b) Test for population proportion equal to specified value
   c) Test for equality of two population proportions

3. Analysis

Naïve Bayes

Software used in project:

1. R-Software
2. MS-Excel and MS-Word
3. Google sheets and forms

Description of Statistical Tools

1. Diagrammatic Representation:

❖ Simple Bar Diagram:

This is the simplest way of representing the statistical data classified according to single characteristics. It can be used to represent the data like population of different cities, export of different countries, import of a country for different years. In general it can be used for representing any single series but generally it is used to show categorical series.

❖ Pie-Diagram:

It is special type of diagram used to represent the whole quantity by circle and sub-division of the whole quantity are shown by the sector of that circle. This diagram is a two-dimensional diagram. It can be used to represent sub-division of total budget or total expenditure or total income, etc.

❖ Multiple-bar Diagram:

It is used for presenting more than one characteristics using multiple bars adjacent to each other. It can be used to represent data on number of males and females, students studying in different years, imports and exports of a region for several years, etc.

❖ Sub-divided Bar Diagram:

Many times we require to represent whole quantity and its sub-division in the same diagram. In such cases simple bar diagram is used to represent whole quantities and sub-division can be represented proportionality by dividing each bar into number of parts. This type of diagram is called sub-divided bar diagram.

2. Test:

❖ Chi-Square Test:

A chi-squared test (also chi-square or χ^2 test) is a statistical hypothesis test that is valid to perform when the test statistic is chi-squared distributed under the null hypothesis, specifically Pearson's chi-squared test and variants thereof. Pearson's chi-squared test is used to determine whether there is a statistically significant difference between the expected frequencies and the observed frequencies in one or more categories of a contingency table.

Test statistics that follow a χ^2 distribution occur when the observations are independent. There are also χ^2 tests for testing the null hypothesis of independence of a pair of random variables based on observations of the pairs.

The Chi-square test of independence checks whether two variables are likely to be related or not. We have counts for two categorical or nominal variables. We also have an idea that the two variables are not related. The test gives us a way to decide if our idea is plausible or not.

Here, we want to test,

H_0: Two attributes A and B are independent

v/s H_1: Two attributes A and B are not independent

Let, e_{ij} = Expected frequency of $(i,j)^{th}$ cell and

O_{ij}= Observed frequency of $(i,j)^{th}$ cell.

Then, under H_0 the statistic $\chi^2=\frac{\sum_{i=1}^{r}\sum_{j=1}^{s}(O_{ij}-e_{ij})\text{^}2}{e_{ij}} \sim \chi^2_{(r-1)(s-1)}$

Criteria: Reject H_0 at α% l.o.s. if $\chi^2_{(r-1)(s-1)} \geq \chi^2_{(r-1)(s-1),\alpha}$

Otherwise accept H_0.

R-command for Chi-square Test:

R-software provides direct command for chi-square test for independence of attributes

>chisq.test()

❖ Test for Proportion:

A test of proportion will assess whether or not a sample from a population represents the true proportion from the entire population.

Sometimes observations are taken on qualitative characteristics. In this case number of observations of specific type are counted and its proportion is determined.

A. Testing population proportion (P) equal to a specified value (P_0):

Here we want to test,

H_0: $P=P_0$ v/s H_1: $P>P_0$, H_1: $P<P_0$ or H_1: $P\neq P_0$

Under H_0,

the test statistic used is $Z=\frac{(P)-(P_0)}{\sqrt{\frac{P_0Q_0}{n}}} \sim N(0,1)$

Criteria: Reject H_0 at α% l.o.s. if $|Z_{cal}| \geq Z\alpha / Z\alpha_{/2}$

Otherwise accept H_0.

R-command for Tests on Proportion:

- Consider the alternative hypothesis H_1:$P>P_0$

>prop.test(x,n,p=NULL,alternative=c(”greater”),conf.level=0.95,correct=T)

- Consider the alternative hypothesis H_1:$P<P_0$

>prop.test(x,n,p=NULL,alternative=c(”less”),conf.level=0.95,correct=T)

- Consider the alternative hypothesis H_1:$P\neq P_0$

>prop.test(x,n,p=NULL,alternative=c(“two-sided”),conf.level=0.95,correct=T)

B. Testing equality of two population proportions($P_1=P_2$)

Suppose we draw two samples. Suppose these samples give proportions of specific items as p_1 and p_2 respectively. We are interested in knowing that the population proportions from which these samples are chosen are same.

Let, P1=proportion of specific items in first population

P2=proportion of specific items in second population

n_1=size of sample drawn from first population

n_2=size of sample drawn from second population

x_1=number of items of specific type in first sample

x_2=number of items of specific type in second sample

$p_1= x_1/n_1$ = proportion of specific items in first sample

$p_2= x_1/n_2$ = proportion of specific types of items in second sample

The hypothesis will be:

$H_0: P_1=P_2$ v/s $H_1: P_1>P_2$, $H_1:P_1<P_2$ or $H_1:P_1\neq P_2$

Under H_0, the test statistic used is : $Z=\frac{(P_1)-(P_2)}{\sqrt{(\bar{P})(\bar{Q})\left(\frac{1}{n_1}+\frac{1}{n_2}\right)}} \sim N(0,1)$

Criteria: Reject H_0 at α% l.o.s. if $|Z_{cal}| \geq Z\alpha_{/2}$

Otherwise accept H_0 .

R-command for Tests on Proportion:

- Consider the alternative hypothesis $H_1: P>P_0$

> prop.test(x,n,p=NULL,alternative=c(”greater”),conf.level=0.95,correct=T)

- Consider the alternative hypothesis $H_1: P<P_0$

>prop.test(x,n,p=NULL,alternative=c(”less”),conf.level=0.95,correct=T)

- Consider the alternative hypothesis $H_1: P\neq P_0$

>prop.test(x,n,p=NULL,alternative=c(“two-sided”),conf.level=0.95,correct=T)

3. Naïve Bayes:

In statistics, naive Bayes classifiers are a family of simple "probabilistic classifiers" based on applying Bayes' theorem with strong (naive) independence assumptions between the features. Naive Bayes classifiers are highly scalable, requiring a number of parameters linear in the number of variables (features/predictors) in a learning problem.

Naive Bayes is a simple technique for constructing classifiers: models that assign class labels to problem instances, represented as vectors of feature values, where the class labels are drawn from some finite set. Naive Bayes model is easy to build and particularly useful for very large data sets. Along with simplicity, Naive Bayes is known to outperform even highly sophisticated classification methods. Bayes theorem provides a way of calculating posterior probability P(A|B) from P(A), P(B) and P(B|A).

Bayes' Theorem:

If A_1, A_2, ……., A_n are mutually exclusive and exhaustive events and B is any other event then,

$$P(A_i \mid B) = \frac{P(B \mid A_i) * P(A_i)}{P(B)}$$

Applications of Naïve Bayes Algorithm:

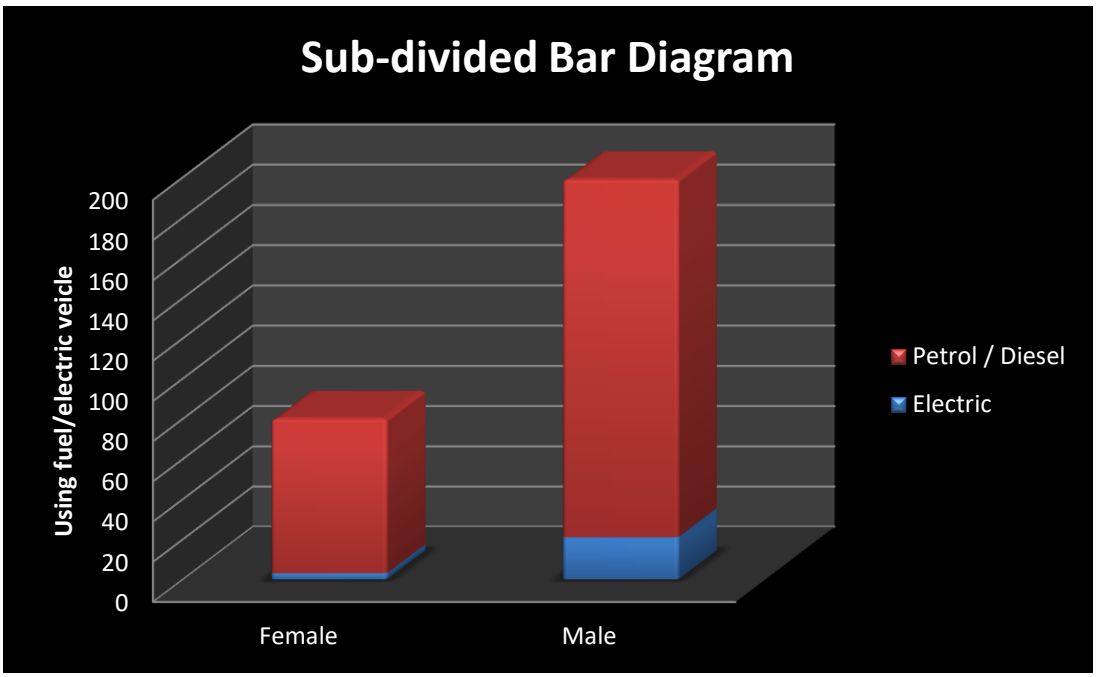
- As this algorithm is fast and efficient, you can use it to make real-time predictions.
- This algorithm is popular for multi-class predictions.
- You can find the probability of multiple target classes easily by using this algorithm.

Analysis of Data

1. Graphical representation:

- **Sub-divided Bar Diagram of gender wise classification of the people using either fuel or electric vehicle:**

Gender	Electric Vehicle	Petrol / Diesel Vehicle	Grand Total
Female	3	77	80
Male	21	179	200
Grand Total	**24**	**256**	**280**

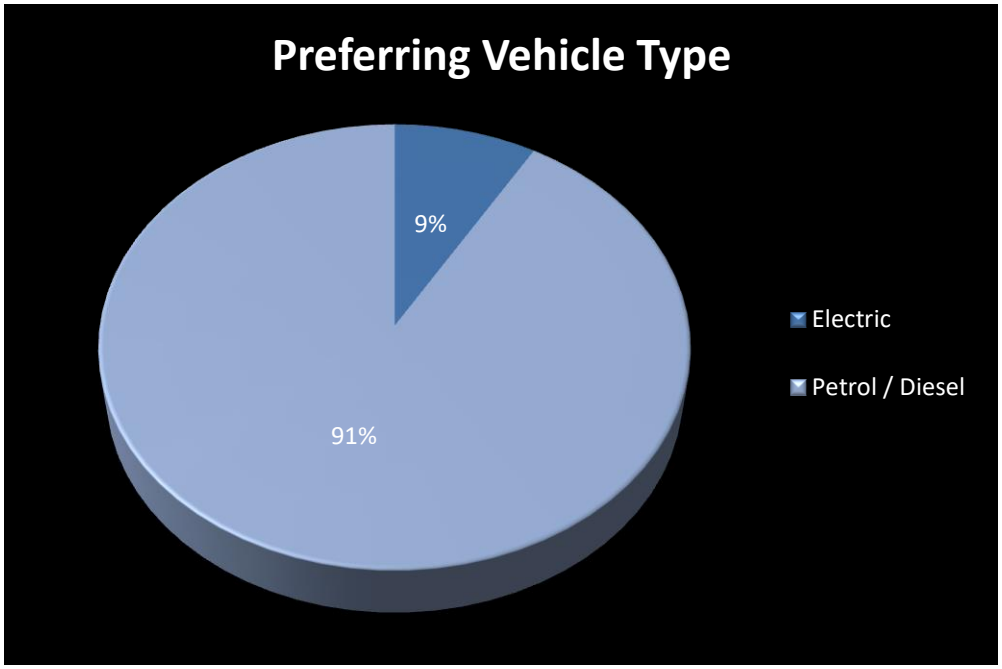


Interpretation:

Above diagram shows that more number of males and females use fuel vehicles at present as compared to electric vehicles. Whereas when we compared gender wise, more number of females prefer fuel vehicles as compared to males.

- **Pie diagram of people preferring fuel/electric vehicle:**

Prefer Vehicle Type	Frequency
Electric	24
Petrol / Diesel	256
Grand Total	**280**

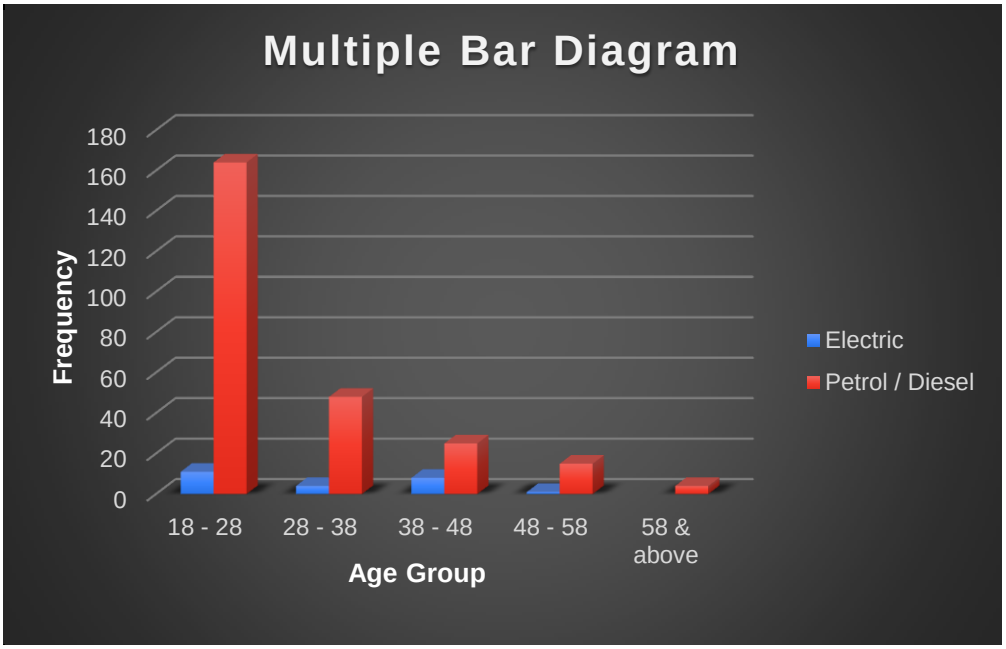


Interpretation:

From above diagram we can see that more number of people prefer petrol/diesel vehicle over electric vehicle. One of the reason for this can be the unawareness about the benefits of electric vehicle among the people.

- **Multiple bar diagram of age wise classification of the people preferring type of vehicle(electric or fuel):**

Age Group	Frequency		
	Electric	**Petrol / Diesel**	**Grand Total**
18 – 28	11	164	175
28 – 38	4	48	52
38 – 48	8	25	33
48 – 58	1	15	16
58 & above		4	4
Grand Total	**24**	**256**	**280**

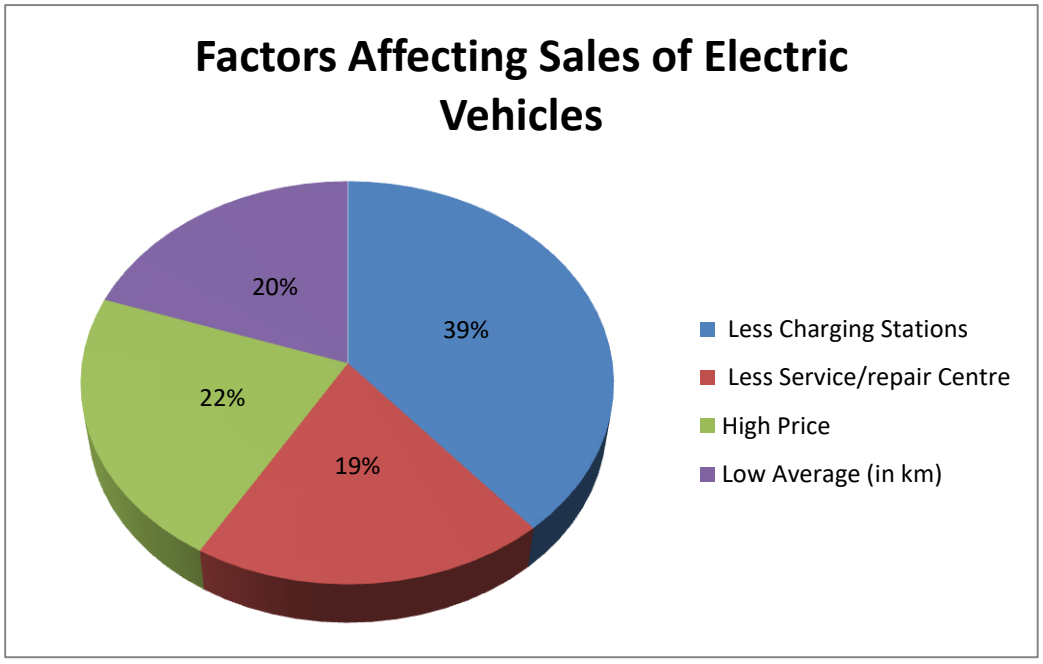


Interpretation:

From the above diagram the age group 18-28 has the highest number of people for preferring both electric vehicle as well as petrol/diesel among all other age groups. Whereas age group 58 and above has least number of people. Furthermore most of the people in that age group prefer to use petrol/diesel vehicle. It can be concluded that for all age groups the bar is highest for petrol/diesel type vehicles.

- **Pie Diagram of factors affecting the sales of electric vehicles:**

Factors Affecting Sales	Frequency
Less Charging Stations	73
Less Service/repair Centre	37
High Price	41
Low Average (in km)	37
Grand Total	**188**

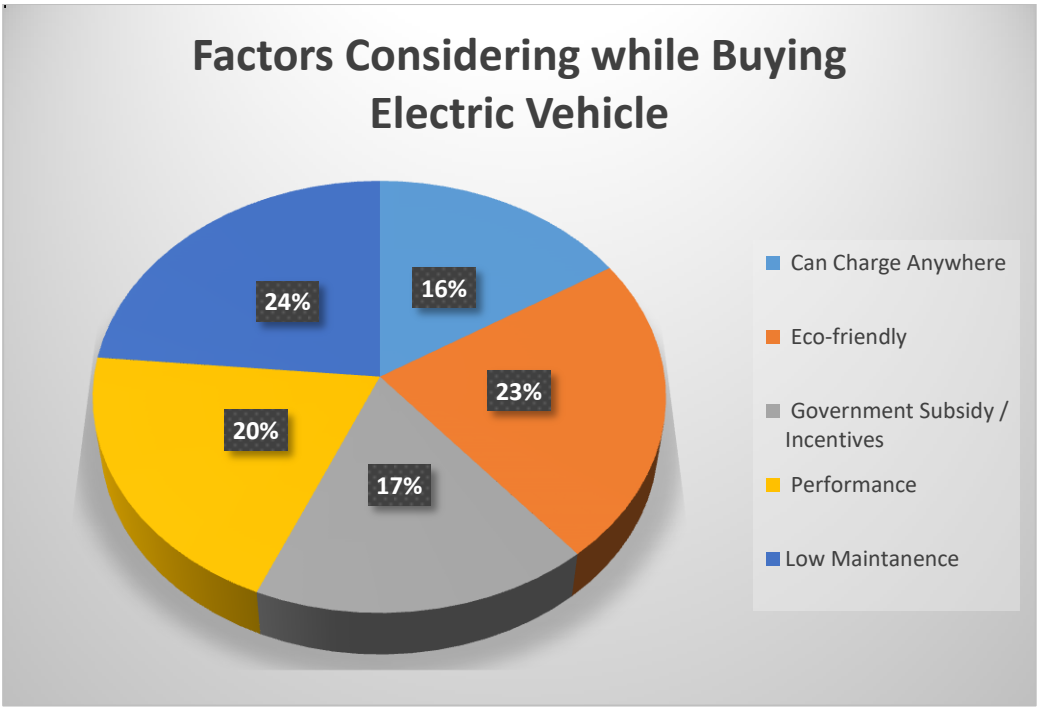


Interpretation:

From the above diagram it can be seen that the factor "less charging stations" comprises most of the share. This implies that less charging stations can be considered as the most important factor affecting the sales of electric vehicles. Followed by high price, low average and less service/repair centres.

- **Pie diagram of factors considered by people while buying electric vehicle:**

Factors consider while buying	Frequency
Can Charge Anywhere	45
Eco-friendly	64
Government Subsidy / Incentives	49
Performance	56
Low Maintenance	66
Grand Total	**280**



Interpretations:

From the above pie diagram, it can be seen that the low maintenance is the major factor which people consider while buying electric vehicles.
Whereas the factor least considered by people is they can charge anywhere.

2. Tests:

▪ Chi square Test:

a) Chi square test for independence between age and preference:

A sample of 280 people is selected about the purchase of an electric vehicle by various age groups. It revealed the following information:

Test whether purchase of an electric vehicle is independent of Age or not.

Let,

A: Age group

B: Purchase of an electric vehicle

Purchase / Age group	No	Yes	Grand Total
18 – 28	25	150	175
28 – 38	4	48	52
38 – 48	2	31	33
48 – 58	1	15	16
58 & above	1	3	4
Grand Total	**33**	**247**	**280**

Here we want to test,

H_0: Attributes A and B are independent

V/s H_1: Attributes A and B are not independent

For this purpose we use chi square test for independence of attributes

Under H_0, the test statistic is $\chi^2_{(r-1)(s-1)}$ and alpha l.o.s

Criteria: Reject H_0 at α% l.o.s if p-value < α

```
> purchase=c(25,154,4,48,2,31,1,15,1,3)
> purchase
 [1]  25 150   4  48   2  31   1  15   1   3
> m=matrix(purchase,byrow=T,ncol=2)
```

```
> m
     [,1] [,2]
[1,]   25  150
[2,]    4   48
[3,]    2   31
[4,]    1   15
[5,]    1    3
> chisq.test(m)


        Pearson's Chi-squared test


data:  m
X-squared = 3.8806, d.f. = 4, p-value = 0.4224
```

Decision:

Here, p-value=0.4224 and α=0.05

p-value > α

Therefore, we may accept H_0 at 5% l.o.s

Conclusion:

Attributes A and B are independent i.e purchase of an electric vehicle is independent of age group.
From the data collected for our project, it may be concluded that age and purchase of electric vehicle are independent which means that people of any age group may purchase electric vehicles at their own will.There is no restrictions for them.

b) Chi square test for independence between income preference:

People with different various income levels are investigated regarding the purchase of an electric vehicle, it yielded the information as below:

Let,

A: Income

B: Purchase of an electric vehicle

Income \ Purchase	No	Yes	Grand Total
3 - 5 lakhs	1	30	31
5 - 7 lakhs	6	23	29
7 lakhs & above	5	65	70
Below 3 lakhs	21	129	150
Grand Total	**33**	**247**	**280**

Here we want to test,

H_0: Attributes A and B are independent

H_1: Attributes A and B are not independent

For this purpose we use chi square test for independence of attributes

The test statistic under H0 is $\chi^2_{(r-1)(s-1)}$ and α % l.o.s

Criteria: Reject H_0 at α % l.o.s if p-value < α

```
> purchase=c(1,30,6,23,5,65,21,129)
> purchase
[1]   1  30   6  23   5  65  21 129
> m=matrix(purchase,byrow=T,ncol=2)
> m
     [,1] [,2]
[1,]    1   30
```

[2,] 6 23

[3,] 5 65

[4,] 21 129

> chisq.test(m)

Pearson's Chi-squared test

data: m

X-squared = 6.5549, df = 3, p-value = 0.08752

Decision:

Here, p-value=0.08752 and α=0.05

p-value > α

Therefore we may accept H_0 at 5% l.o.s

Conclusion:

We have accepted H_0 which means that attributes A and B are independent i.e Purchase of an electric vehicle is independent of income.
From the data collected for our project, we may conclude income and purchase of an electric vehicle are not associated .Thus it is very obvious that income does not affect the purchase of electric vehicle which is obviously means that even common people can buy electric vehicle if they wish to .But this conclusion is related to our project only.

c) Chi square test for independence between income and type of vehicle purchased (2 wheeler or 4wheeler):

The following table gives information regarding the sales of an electric vehicle:

Test the dependence of type of vehicle purchased on income

Let,

A: Income

B: Type of vehicle purchased

Type of vehicle purchase / Income	**2 - wheeler**	**4 – wheeler**	**Grand Total**
3 - 5 lakhs	16	15	31
5 - 7 lakhs	11	18	29
7 lakhs & above	19	51	70
Below 3 lakhs	80	70	150
Grand Total	**126**	**154**	**280**

Here we want to test,

H_0: Attributes A and B are independent

v/s H_1: Attributes A and B are not independent

For this purpose we use chi square test for independence of attributes

The test statistic under H0 is $\chi^2_{(r-1)(s-1)}$ and α% l.o.s

Criteria: Reject H_o at α % l.o.s if p-value< α

> Type of vehicle purchased=c(16,15,11,18,19,51,80,70)

> Type of vehicle purchased

[1] 16 15 11 18 19 51 80 70

> m=matrix(Type of vehicle purchased,byrow=T,ncol=2)

> m

[,1] [,2]

[1,] 16 15

[2,] 11 18

[3,] 19 51

[4,] 80 70

> chisq.test(m)

Pearson's Chi-squared test

data: m

X-squared = 14.361, d.f. = 3, p-value = 0.002453

Decision:

Here, p-value=0.002453 and α=0.05

p-value < α

Therefore we may reject H_0 at 5% l.o.s

Conclusion:

Here H_0 is rejected. This means that attributes A and B are not independent i.e Type of vehicle purchased and income are not independent.
This leads to the conclusion that purchasing any type of vehicle (2-wheeler or 4-wheeler) is dependent on income .In general we know that income plays a major role in deciding whether a person will buy 2-wheeler or 4-wheeler in future as an individual with considerable income can only afford to buy a 4-wheeler.

- **Test for proportionality:**

Proportionality test to check whether population prefers more than 50% electric vehicle or not:

From the data collected for our project, in certain cities, 190 people out of 280 are preferring electric vehicle over fuel vehicles. We want to check whether that in future more than 50% of them will prefer electric vehicles.

Let, X= Number of people preferring electric vehicles over fuel vehicles =190

n= Total number of people surveyed =280

p = Proportion of people preferring electric vehicles

We want to test,

H_0: P=0.5 against H_1 : P>0.5

Criteria: We reject H0 at 5% l.o.s if p-value < α

```
> x=190
> x
[1] 190
> n=280
> n
[1] 280
> prop.test(x,n,p=0.5,alternative=c("greater"),conf.level=0.95,correct=T)

        1-sample proportions test with continuity correction

data:  x out of n, null probability 0.5
X-squared = 35.004, df = 1, p-value = 1.646e-09
alternative hypothesis: true p is greater than 0.5
```

95 percent confidence interval:

0.6293084 1.0000000

sample estimates:

p

0.6785714

Decision:

Here p-value = 1.646e-09 and $\alpha = 0.05$

p-value < α

Therefore, we may reject H_0 at 5% l.o.s

Conclusion:

Here we have rejected H_0 i.e we have accepted H_1 which means that P>0.5. Hence the information in our project supports the conclusion that in future more than 50% of people will prefer electric vehicles .
This is the main aim of our project that whether in future people will prefer buying electric vehicles or not and this test is in favour of our project. It may be considered that electric vehicles have some scope in future but this conclusion is based on the data of our project only.

- **Testing equality of two population proportion:**

Proportionality test to check whether population prefers electric vehicles or not:

In a random sample of 80 females, 67 are found to be preferring electric vehicles over fuel vehicles. In a random sample of 200 males, 180 are found to be preferring electric vehicles over fuel ones. Test whether the proportion preferring electric vehicles is same for females and males.

Here, X = No of females preferring electric vehicle = 67

Y= No of males preferring electric vehicle = 180

$n_1=80$

$n_2=200$

We want to test,

$H_0: P_1=P_2$ against $H_1: P_1 \neq P_2$

Criteria: We reject H_0 at 5% l.o.s if p-value$<\alpha$

```
> prop.test(c(67,180),c(80,200))

2-sample test for equality of proportions with continuity correction

data:

c(67, 180) out of c(80, 200)

X-squared = 1.5879, df = 1, p-value = 0.2076

alternative hypothesis: two.sided

95 percent confidence interval:

 -0.16215456  0.03715456

sample estimates:

prop 1 prop 2
```

0.8375 0.9000

Decision:

Here p-value = 0.2076 and α = 0.05

p-value > α

Therefore, we may accept H_0 at 5% l.o.s.

Conclusion:

Here we have accepted H_0 i.e $P_1=P_2$. To be more specific the proportion of females and proportion of males preferring electric vehicles in future is same. This conclusion helps us understand the preference of electric vehicles is not gender biased.

3. Naïve Bayes:

- **People who preferred buying petrol/diesel vehicles:**

Factors while buying electric vehicle	No	Yes	Total
Eco-friendly	2	8	10
Low Maintenance	20	46	66
Performance	4	14	18
Total	26	68	94

Purpose to drive	No	Yes	Total
City Driving	23	58	81
Highway Driving	2	11	13
Total	25	69	94

Factors Affecting Sales of electric vehicle	No	Yes	Total
High Price	11	30	41
Less Charging Stations	6	18	24
Low Average (in km)	8	21	29
Grand Total	25	69	94

Will you prefer?	Total
Yes	178
No	8
Total	186

Considered highest two probabilities for people who preferred buying fuel vehicle:

X is the factors considered for Naïve Bayes Algorithm:

P(Yes)	0.956989
P(No)	0.043011

1. 1st highest:

X	
Factors while buying electric vehicle	Eco Friendly
Factors Affecting Sales of electric vehicle	Less Charging Station
Purpose to drive	Highway Driving
P(X|Yes)	0.004893
P(X|No)	0.001477
P(Yes)*P(X|Yes)	0.004682
P(No)*P(X|No)	6.35E-05
Add	0.004746
P(Yes|X)	0.986615
P(No|X)	0.013385

Interpretation:

From Naïve Bayes Classifier performed for knowing the factors for preferring electric vehicles, it can be concluded that the most preferred factor people consider for buying electric vehicle is eco-friendly and purpose for using vehicle is highway driving. The factor affecting the sales of electric vehicles is less charging stations.
Hence the charging stations should be increased so that people will prefer to buy electric vehicles in future.

2. 2nd highest:

X	
Factors while buying electric vehicle	Eco-friendly
Factors Affecting Sales of electric vehicle	High Price
Purpose to drive	City Driving
P(X|Yes)	0.042996
P(X|No)	0.031138
P(Yes)*P(X|Yes)	0.041147
P(No)*P(X|No)	0.001339
Add	0.042486
P(Yes|X)	0.968477
P(No|X)	0.031523

Interpretation:

From Naïve Bayes Classifier performed for knowing the factors for preferring electric vehicles, it can be concluded that the most preferred factor people consider for buying electric vehicle is eco-friendly and purpose for using vehicle is city driving. The factor affecting the sales of electric vehicles is high price.
If the vehicle prices are dropped people will prefer to buy electric vehicle in future.

- **People who preferred electric vehicles:**

Factors while buying electric vehicle	No	Yes	Total
Eco-friendly	1	10	11
Low Maintenance	6	124	130
Performance	1	44	45
Total	8	178	186

Factors Affecting Sales of electric vehicle	No	Yes	Total
High Price	1	13	14
Less Charging Stations	6	141	147
Low Average	1	24	25
Total	8	178	186

Purpose to drive	No	Yes	Total
City Driving	6	139	145
Highway Driving	2	39	41
Total	8	178	186

Will you prefer?	
Yes	178
No	8
Total	186

Considered highest two probabilities for people who preferred buying electric vehicle:

X is the factors considered for Naïve Bayes Algorithm:

P(Yes)	0.956989
P(No)	0.043011

1. 1st highest:

X	
Factors while buying electric vehicle	Performance
Factors Affecting Sales of electric vehicle	High Price
Driving	City Driving
P(X| Yes)	0.014098
P(X| No)	0.011719
P(Yes)*P(X|Yes)	0.013491
P(No)*P(X|No)	0.000504
Addition	0.013995
P(Yes|X)	0.963986
P(No|X)	0.036014

Interpretation:

From Naïve Bayes Classifier performed for knowing the factors for preferring electric vehicles, it can be concluded that the most preferred factor people consider for buying electric vehicle is performance of vehicle and purpose for using vehicle is city driving. The factor affecting the sales of electric vehicles is high price.
If the vehicle prices are dropped people will prefer to buy electric vehicle in future.

2. 2nd highest:

X	
Factors while buying electric vehicle	Performance
Factors Affecting Sales of electric vehicle	Less Charging Stations
Driving	Highway Driving
P(X| Yes)	0.042902
P(X| No)	0.023438
P(Yes)*P(X|Yes)	0.041057
P(No)*P(X|No)	0.001008
Addition	0.042065
P(Yes|X)	0.976035
P(No|X)	0.023965

Interpretation:

From Naïve Bayes Classifier performed for knowing the factors for preferring electric vehicles, it can be concluded that the most preferred factor people consider for buying electric vehicle is performance of the vehicle and purpose for using vehicle is highway driving. The factor affecting the sales of electric vehicles is less charging stations.
Hence the charging stations should be increased so that people will prefer to buy electric vehicles in future.

Conclusions

1. From Graphical Representation:

- Sub-divided Bar Diagram of gender wise classification of the people using either fuel or electric vehicle shows that more number of males and females use fuel vehicles at present as compared to electric vehicles.
- Pie diagram of people preferring fuel/electric vehicle shows that more number of people prefer fuel vehicles over electric vehicles.
- Multiple bar diagram of age wise classification of the people preferring type of vehicle shows that age group 18-20 has the highest number of people for preferring both electric as well as fuel vehicles among all other age groups.
- Pie diagram of factors affecting the sales of electric vehicles shows that the factor "less charging stations" comprises most of the share.
- Pie diagram of factors considered by people while buying electric vehicles shows that the "low maintenance" is major factor which people consider while buying electric vehicles.

2. From Testing of Hypothesis:

- Chi square Test:
  I. Purchase of an electric vehicle is independent of age group.
  II. Purchase of an electric vehicle is independent of income.
  III. Type of vehicle purchased i.e. 2-wheeler or 4-wheeler is dependent on income.
- Test for Proportionality:
  I. According to our test, in future more than 50% of people will prefer electric vehicle.
  II. The proportion of males and females preferring electric vehicles in future is same.
- From Naïve Bayes':
  I. The most preferred factors people consider while buying electric vehicles is eco-friendly and purpose for using vehicle is highway driving as well as city driving. The factor affecting sales is less charging stations and high price.
  II. The most preferred factors people consider while buying electric vehicles is performance and purpose for using vehicle is highway driving as well as city driving. The factor affecting sales is less charging stations and high price.

Major Findings

From the findings of our project it is mainly highlighted that the most important factors that people consider while buying electric vehicle are eco-friendly, low maintenance and better performance. This can be concluded as:

- Environment friendly as they do not emit pollutants. People who switched to electric vehicles have contributed in reducing CO_2 emissions at high level.
- Lower maintenance due to an efficient electric motor. Electric motors have less parts that lead to less damage than a traditional non electric vehicle which means you save an operating cost!
- Better performance. Electric vehicles are not only lighter but also have faster acceleration.

But as we all know that every coin has two sides, so is the case with electric vehicles. From major findings we come to know that electric vehicles have some drawbacks as well. We may conclude that the main factors affecting the sales of electric vehicles are less charging stations and high price.

- Infrastructure of charging stations should be increased so that more and more people will switch to electric vehicles.
- There is less service availability for electric vehicles than for fuel vehicles.
- The prices of electric vehicles are very high as compared to fuel vehicles. If the prices drop upto certain level where common people can afford buying electric vehicle then it would be very much beneficial.

As per recent study electric vehicles market is expected to be worth around at least Rs. 475 billion by 2025.

Hence, electric vehicles have wider scope in future

Limitations

- This data is limited to 280 respondents. Therefore whatever conclusions are drawn are limited to only this sample. These results cannot form a standard basis for other research purposes.
- The information of our project is not for public distribution and must not be redistributed to others, none can use the project information as a base for any claim.
- Data of the project is collected from the questionnaire prepared by us and this questionnaire was spread only to limited people.
- The conclusions may vary from sample to sample and this project may not be suitable for others.
- There might be human errors in calculations, tabulations and conclusions drawn from testing of hypothesis may get wrong due to type I error.

Suggestions

For increasing the adoption of Electric Vehicles in India the government should implement the following measures:

- Build public electric vehicles charging infrastructure and encourage other stakeholders to invest or broader adoption of electric vehicles, all stakeholders need to work together.
- Offer public parking band priority parking and consider offering free charging initially.
  Manufacturing firms, government bodies, dealers and salespersons should promote the benefits of electric vehicles to increase adoption.
- Senior Politician and members of parliament may switch to travel by electric vehicles, thus setting examples for common man.
- All stakeholders may launch a campaign on the lines of 'Pollution free Bharat'.
- Celebrity endorsement is another means that may influence the adoption of electric vehicle.
- Advertising should evoke emotional appeal that depicts the EV in a positive way.
- Further policies need to be framed to provide incentives to shift corporate fleets cabs, public transport system, and auto rickshaws into electric vehicles.
  Waiving auto rickshaw permits, parking fees, registration charges and road tax for e-autos should be encourage.

The suggested measures may have a positive influence on the people.

Survey Experience:

It was an enthusiastic experience to conduct survey on the adoption of electric vehicle in India. We collected more data than we anticipated, giving us more leverage and scope for analysis The average timespan needed to complete online survey is shorter than that of the traditional methods. The information was gathered automatically and we didn't had to wait for the paper questionnaire to come back to us. It saved us a lot of time & energy.

References

- A text book of testing of significance & Statistical methods, sampling distributions & Exact test
- A text book of statistical method & use of R-software Statistical computing using R-software.
- Software used : MS Word, MS- Excel, R-software