Electric Vehicle Market Analysis in India

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Github link: https://github.com/amit-sur/indian_ev_market_segmentation.git

Background:

India, with its growing economy is a lot of potential for various new industries and businesses. Electric vehicle industries are one of them. Electric vehicles include a large range of vehicles from two-wheelers, three-wheelers, cars, buses. An EV can be classified based on various factors, like, how long does it take for a full charge, the range that one can get from a full charge, the top speed, the battery capacity, maximum load that it can carry, to name a few. Being an electric vehicle, the main features that the potential customers might see in it are the charging speed, battery capacity, top speed and range. Considering the depletion of natural resources, global warming and climate change, electric vehicles are generally seen as an alternative to the traditional vehicles that run on petrol or diesel or CNG.

The motto of this project is to analyze the potential of India as an Electric vehicle market and decipher meaningful business insights and get to know the market segments that would succeed in India.

Problem Statement and Question Formation:

The main problem is to segment the Electric vehicle market in India and analyze each segment individually to gain insights and to come up with a feasible strategy to enter the market.

Data Collection:

For this task, data has been collected from Open Government Data (OGD) Platform India, Accelerated e-Mobility Revolution for India's Transportation (e-AMRIT) . Some specifications about the electric vehicles have also been scraped from CarDekho

A total of five datasets have been used for this study and they are:

1. `state_ev_non-ev_count.csv` which contains the number of EVs and non-EVs in each state. Data dataset looks as following:

Sl.No.	State/UT	Electric	Non-electric
1	Andaman and Nicobar	190	161258
2	Andhra Pradesh	67905	16553509
3	Arunachal Pradesh	28	303673
4	Assam	120423	5312457
5	Bihar	161060	11631081

2. `state_ut_pcs.csv`, this dataset contains the number of public charging stations (PCS) in each state and union territory. The following snippet shows a glimpse of the dataset:

Sl. No.	State/UT	No. of Operational PCS
8	Delhi	1845
27	Sikkim	1
33	Uttarakhand	48
4	Assam	48
26	Rajasthan	254

3. `state_area.csv` dataset contains the land area covered by each of the states

Rank	State / Territory	Area (km2)	Region	National Share (%)
1	Rajasthan	342239	Northern	10.41
2	Madhya Pradesh	308252	Central	9.38
3	Maharashtra	307713	Western	9.36
4	Uttar Pradesh	240928	Central	7.33
5	Gujarat	196024	Western	5.96

4. `state_petrol_diesel_price.csv` dataset contains the price of petrol and diesel in each state and union territory.

Sl. No.	State/UT	Reference City	Petrol (Rs./Litre)	Diesel (Rs./Litre)
15	Uttarakhand	Dehradun	95.33	90.33
11	Madhya Pradesh	Bhopal	108.65	93.90
17	Haryana	Ambala	97.48	90.31
13	West Bengal	Kolkata	106.03	92.76
5	Chhatisgarh	Raipur	102.45	95.44

5. `yearwise_car_growth.csv` contains the number of different types of cars over the past few years.

|	Category	Segment	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-2011	2011-12	2012-13	2013-14	2014-15
0	Passenger Vehicles (PVs)	Passenger Cars	500301.0	557410.0	782562.0	960487.0	1046133.0	1238032	1426212	1516967	1932620	2453113.0	2775124.0	2668633.0	2519281.0	2590917.0
1	Passenger Vehicles (PVs)	Multi-Utility Vehicles	169418.0	165920.0	206998.0	249389.0	263167.0	307202	351371	321626	424791	534183.0	370945.0	564928.0	568692.0	629255.0
2	Passenger Vehicles (PVs)	Total Passenger Vehicles (PVs)	669719.0	723330.0	989560.0	1209876.0	1309300.0	1545234	1777583	1838593	2357411	2987296.0	3146069.0	3233561.0	3087973.0	3220172.0
3	Commercial Vehicles - M & HCVs	Passenger Carriers	20283.0	21156.0	27628.0	30419.0	28982.0	32828	46542	40995	46026	54552.0	54156.0	50024.0	41175.0	49360.0
4	Commercial Vehicles - M & HCVs	Goods Carriers	76469.0	99346.0	138495.0	184388.0	190313.0	261438	248415	151288	204145	289990.0	330645.0	228536.0	180381.0	219193.0

6. `indian_ev_details.csv` dataset contains details of various EVs in India and the dataset looks as below:

|	Vehicle full name	Manufacturing	Model	Top speed (km/hr)	Price (INR)	Fuel Type	Wheelers type	Battery capacity [kWh]	Full charging time (HR)	Range (km/hr)	Fast Charging	Number of Seats	Type of brakes	Type of Vehicle
0	Revolt RV400	Revolt Motors	RV400	85	134000.0	Electric	Two Wheeler	4.0	4.5	150.0	YES	2	Disc	Motor cycles
1	Revolt RV300	Revolt Motors	RV300	65	94999.0	Electric	Two Wheeler	2.7	4.2	180.0	YES	2	Disc	Motor cycles
2	Tork Motors(Kratos)	Tork Motors	Kratos	100	192499.0	Electric	Two Wheeler	4.0	5.0	180.0	NO	2	Disc	Motor cycles
3	Tork Motors(Kratos R)	Tork Motors	Kratos R	105	207499.0	Electric	Two Wheeler	4.0	5.0	180.0	YES	2	Disc	Motor cycles
4	Oben Rorr	Kabira Mobility	Oben Rorr	100	102999.0	Electric	Two Wheeler	4.4	2.0	200.0	YES	2	Disc	Motor cycles

Data Analysis:

Geographic Segmentation: Geographic Segmentation is done based on the location of the customers and it has the advantage that it is easier to target each of the segments through regional communication channels.

Directly analyzing the number of public charging stations (PCS) that one state or UT has will not be a very good result because if a state with smaller land area contains fewer number of PCS compared to a state with larger land mass, then comparing the states only on the basis of number of PCS will give a false impression and so rather, for this study, PCS per sq. Kilometers have been used as it will give a relative density of PCS.

Distribution of Public EV Charging Station per Sq. Kilometers Across Different States and UTs
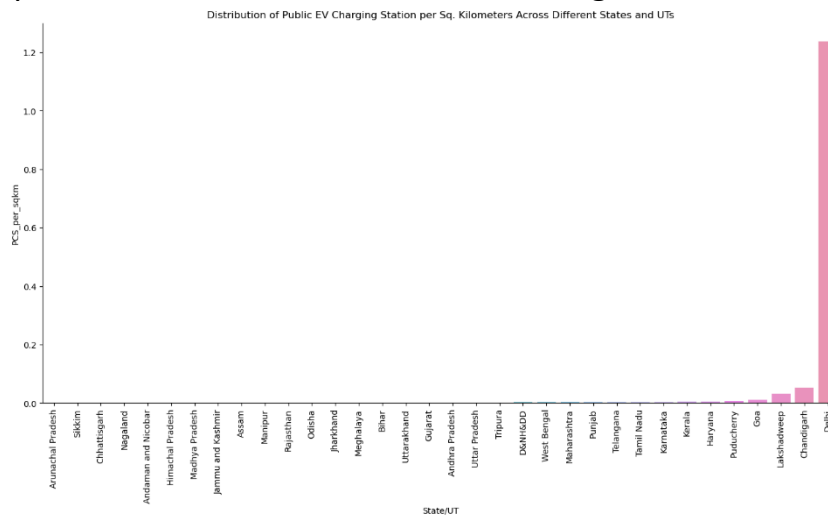
As we can see, Delhi has many PCS, so many that the other states look negligible here, so the same graph of number of PCS across states have been plotted again but this time without Delhi.

Distribution of Public EV Charging Station per Sq. Kilometers Across Different States and UTs
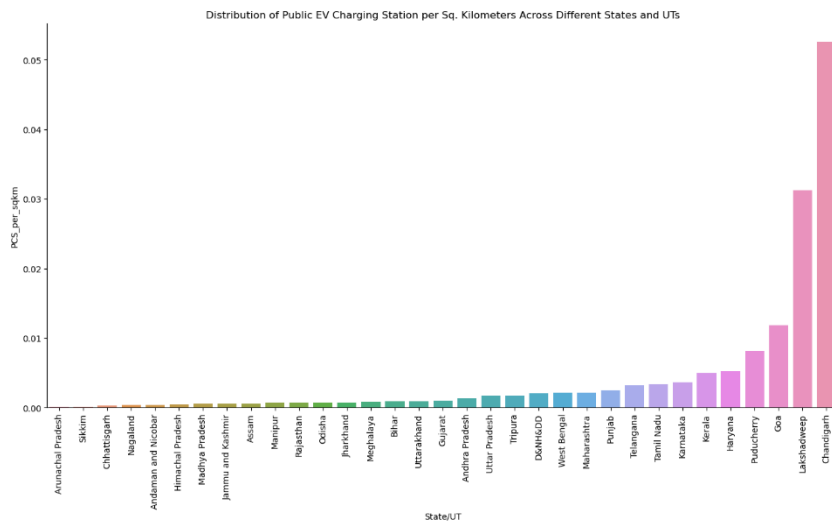
So, as we can see, Delhi has the most public charging station density followed by Chandigarh, Lakshadweep, Goa, Puducherry, Haryana, Kerala and Karnataka.

So, targeting customers of these states might turn out to be a good idea because these states have very high number of PCS and so the people might be more likely to buy EVs compared to non-EV or traditional vehicles if the EVs can be sold a reasonable price point with some attractive features.

Now, the next plot shows the average price of petrol and diesel per litre across different states.
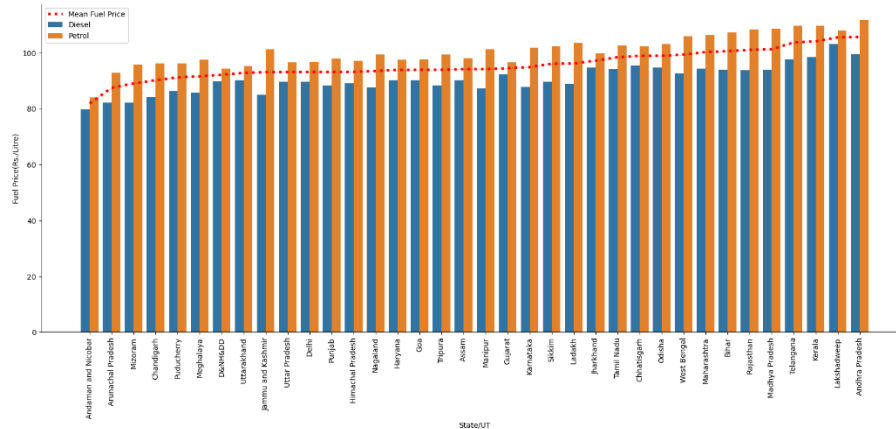
So, the fuel price is very high in Andhra Pradesh, Lakshadweep, Kerala, Telangana. So, people of these states might prefer EVs over traditional petrol or diesel run vehicles.

If we analyze the fuel price plot and the number of PCS per sq. kilometers plot carefully, we see that in Lakshadweep, the price of fuel is very high and at the same time, Lakshadweep has a good density of PCS; so, it might turn out to be a good market for EVs. Also, Andhra Pradesh, Kerala, Telangana have a good potential for EV market.

For better visualization, the number of charging stations and the fuel price across different states have been normalized and shown here in the plot below:
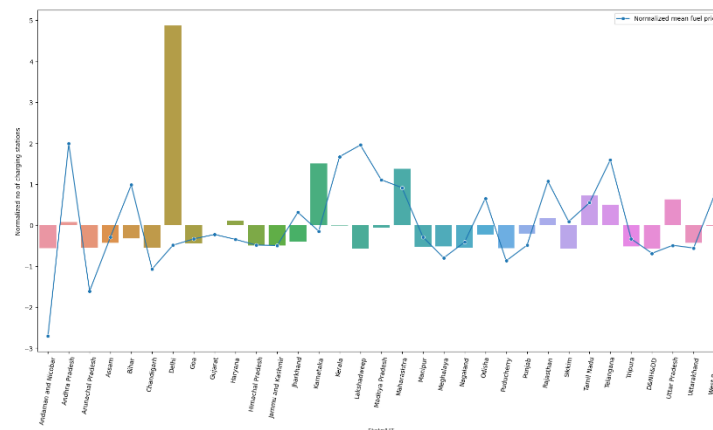
Here, from the above plot, we can notice that, in Delhi, there is highest number of publicly available EV charging stations; so, it can prove to be a good market for EV start-ups. After Delhi, Karnataka, Maharashtra, Tamil Nadu and Uttar Pradesh dominate the EV market, in order. But among all of these 5 states, Karnataka has been found out to be the state where the mean price for petrol and diesel is very high. It might mean that people will be more prone to buy EVs if they can be launched at a reasonable price.

Psychographic and Geographic Segmentation: Geographic Segmentation is done based on the location of the customers and it has the advantage that it is easier to target each of the segments through regional communication channels. On the other hand, Psychographic Segmentation is done based on the beliefs, interests, preferences, and benefits sought. It has the advantage that it is easier to analyze the behavior of the customer using this segmentation criterion, but it becomes complex to analyze.
Using the state-UT wise EV and non-EV dataset, we can get an idea of how popular EVs are in each state, it is an indication of how people of those states are adapting to EVs. For this, a new feature named fraction of EV has been constructed which is the ratio of number of EVs to the total number of EVs which will act as an indication of how preferably the people choose EVs over non-EVs.

```python
1 ev_nonev_data['Total Vehicles'] = ev_nonev_data['Electric'] +
  ev_nonev_data['Non-electric']
2 ev_nonev_data['fraction of EV'] = ev_nonev_data['Electric']/
  ev_nonev_data['Total Vehicles']
3 ev_nonev_data.head()
```

Sl.No.	State/UT	Electric	Non-electric	Total Vehicles	fraction of EV
1	Andaman and Nicobar	190	161258	161448	0.001177
2	Andhra Pradesh	67905	16553509	16621414	0.004085
3	Arunachal Pradesh	28	303673	303701	0.000092
4	Assam	120423	5312457	5432880	0.022166
5	Bihar	161060	11631081	11792141	0.013658
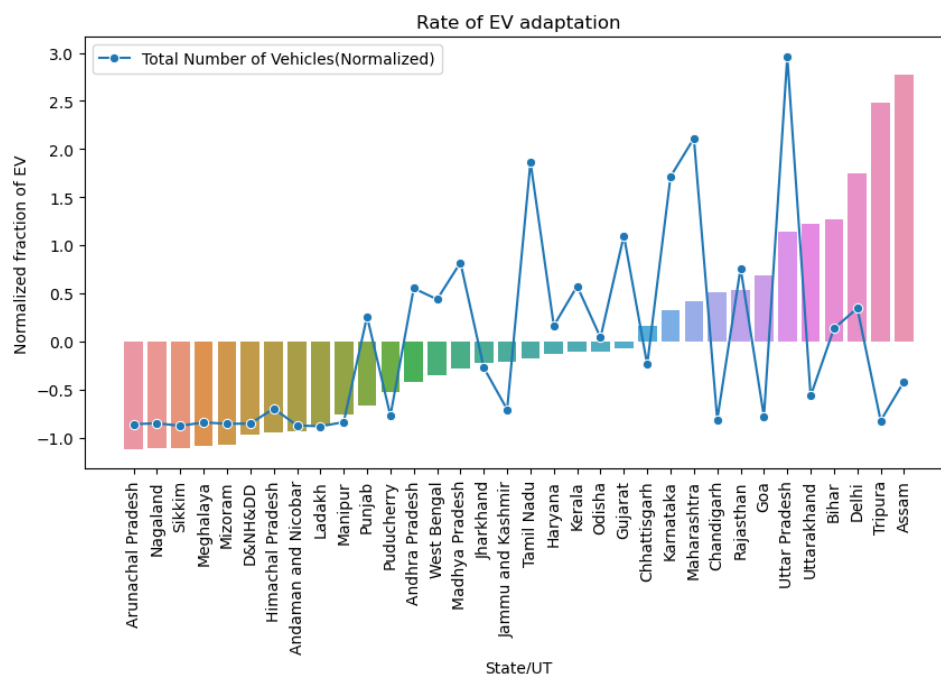
From the above observation, we can see that the ratio of EV to total vehicles is highest in Assam followed by Tripura, Delhi, Bihar, Uttarakhand. But we can also notice that the total number of vehicles in Assam and Tripura is very low compared to that in Delhi, Bihar, Uttarakhand. Following this observation, we can say that the EV adaptation rate is high in Assam and Tripura. But in the case of Uttar Pradesh, we can assume that EV adaptation rate is low.

Combining the rate of EV adaptation, fuel price and number of PCS in each state, we get the following plot:
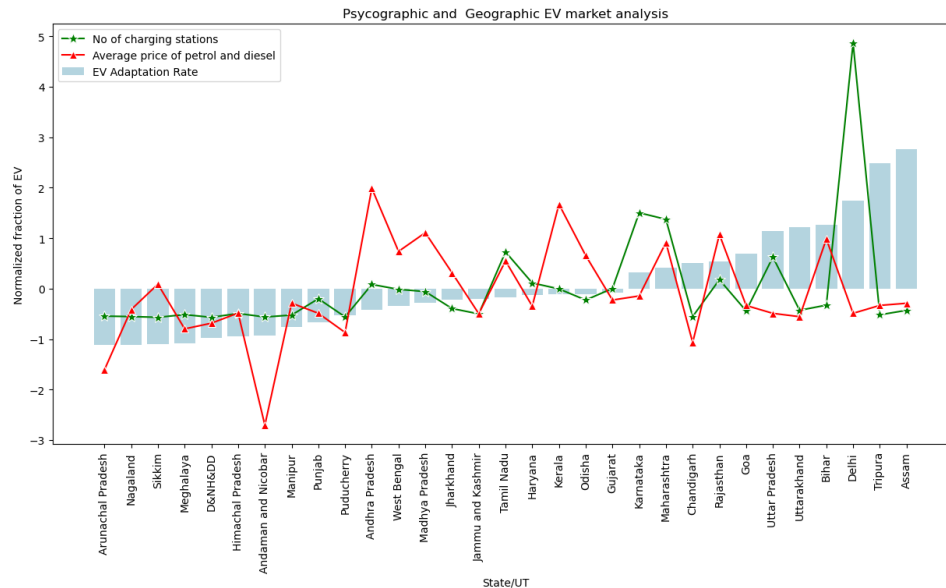
In the above graph, the bar plots show the adaptation rate of EVs in each state. Adaption rate is calculated as (number of EVs in a state / total number of vehicles in a state). In Assam, the EV adaptation rate is the highest, followed by Tripura and Delhi. Even though the adaptation rate for EV is very high in Assam, there are very few public EV charging stations in Assam, so it might not prove to be a very good market for EV start-ups. But if the number of PCS increases, then it will be a good market for EV.

EV adaptation rate is not very high in Rajasthan, but the rate of petrol and diesel is very high, because of which, people in Rajasthan might eventually prefer to buy EVs if they are sold at a reasonable price. The same is true for Kerala, Andhra Pradesh, Maharasthra.

So, Delhi should be the first choice of the EV start-up but the EVs must be launched at a very reasonable price in order to be able to compete with other companies, following Delhi, Uttar Pradesh, Goa, Rajasthan might be a good choice at initial period and then eventually the company may expand its business in Maharasthra, Kerala, Andhra Pradesh, Assam, Tripura.

Now if we analyze the growth of different types of vehicles over the past few years, we see the following trend:
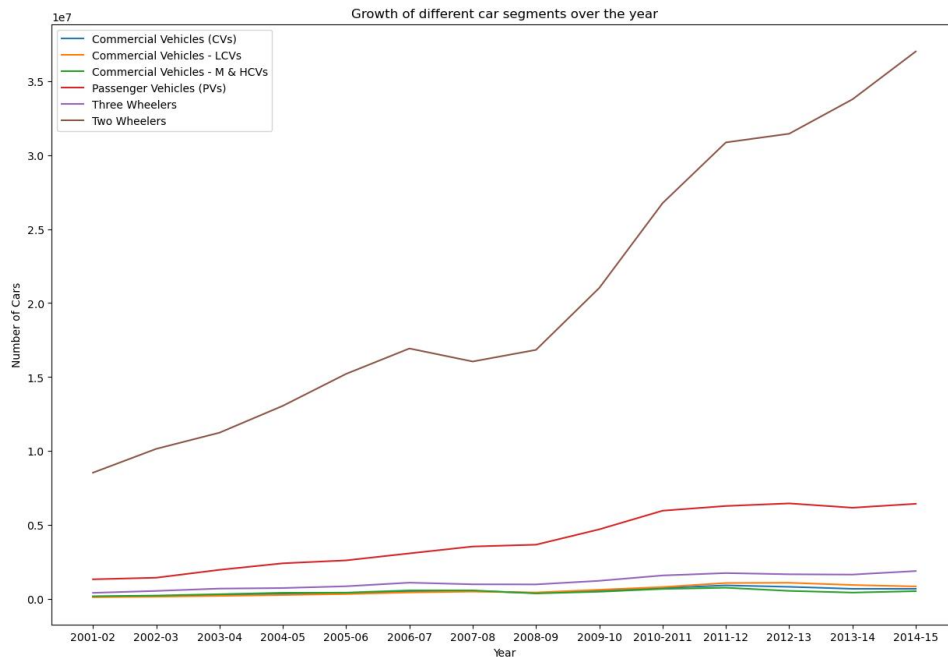

From the above plot we can infer that the company should target two-wheelers and passenger vehicles as there has been huge growth in these two segments over the years.

Strategic Decision Making:

The company should target customers from Delhi, Lakshadweep, Kerala, Karnataka, Maharashtra first. Then when the company establishes its presence in the market, it could possibly expand its business to states like Assam, where the adaptation rate of EV is very high, but the EV infrastructure is not very good. Also, the company should focus more on two-wheelers than four-wheelers.

Again, using the other dataset that contains specification of EVs, a psychographic segmentation has been performed.

The plot below shows how the price of the EVs is distributed.
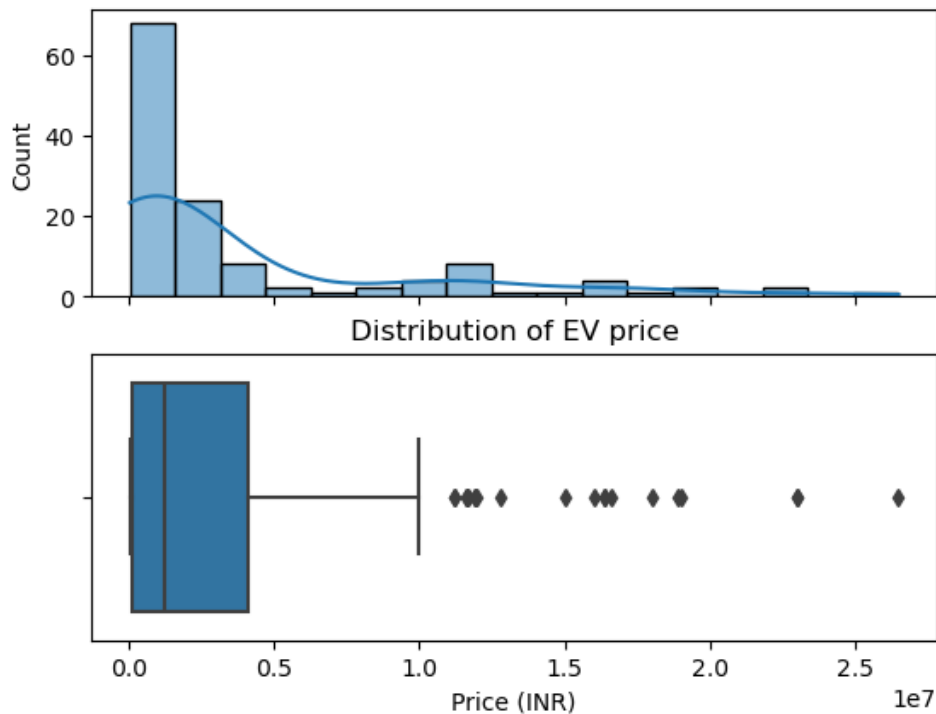
As we can see, most EVs are priced low, while there are certain EVs whose price is considerably very high. So, the EV manufacturing company should target low price segment EVs to compete with other companies that already exist in the market.

Next, K-means clustering has been performed and for choosing the optimal number of clusters, elbow plot has been used and the elbow plot is shown below:
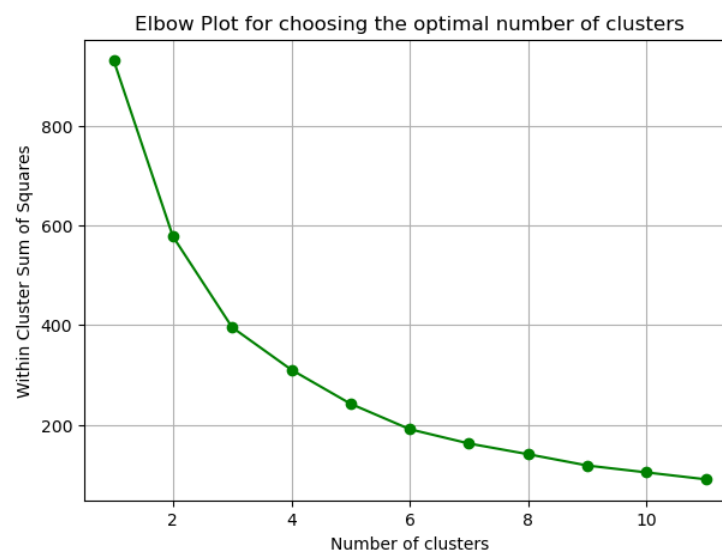
Four has been chosen as the optimal number of clusters or segments.

Next, PCA has been performed and to choose the number of principal components that we need to consider, scree plot has been used which is shown below:

Scree plot to choose the optimal number of principal component
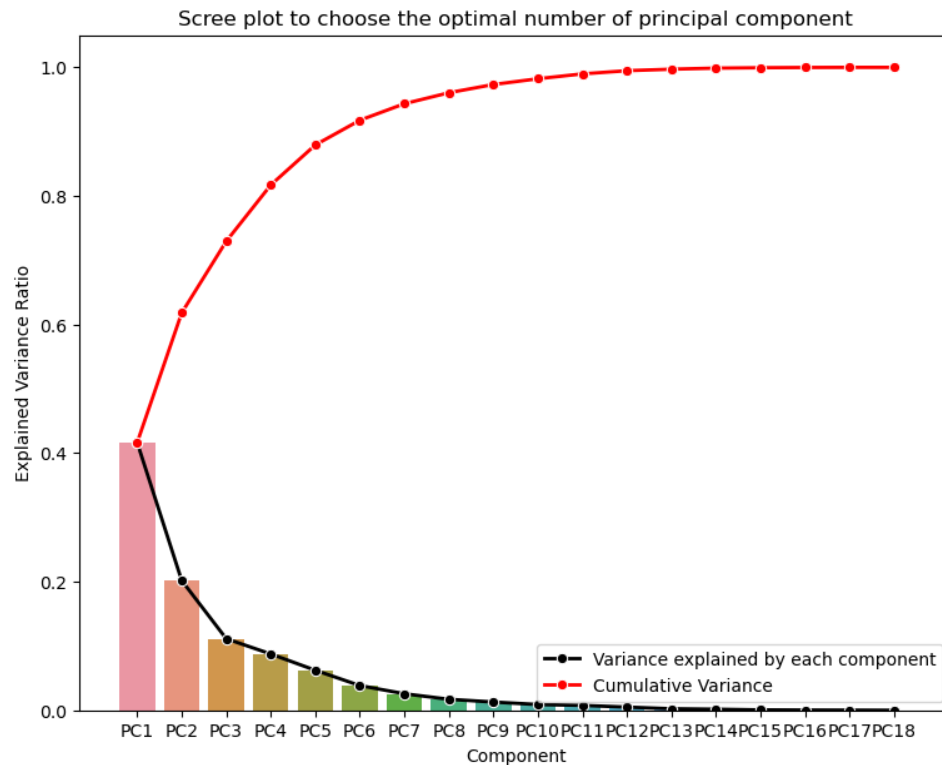
So, we can see that the first 6 principal components explain about 95% of the variability in the dataset. So, the first six principal components have been used.

Strategic Decision Making:

The figure below shows a biplot using which we can observe how each feature contributes to each of the principal components and how the features vary for each segment.
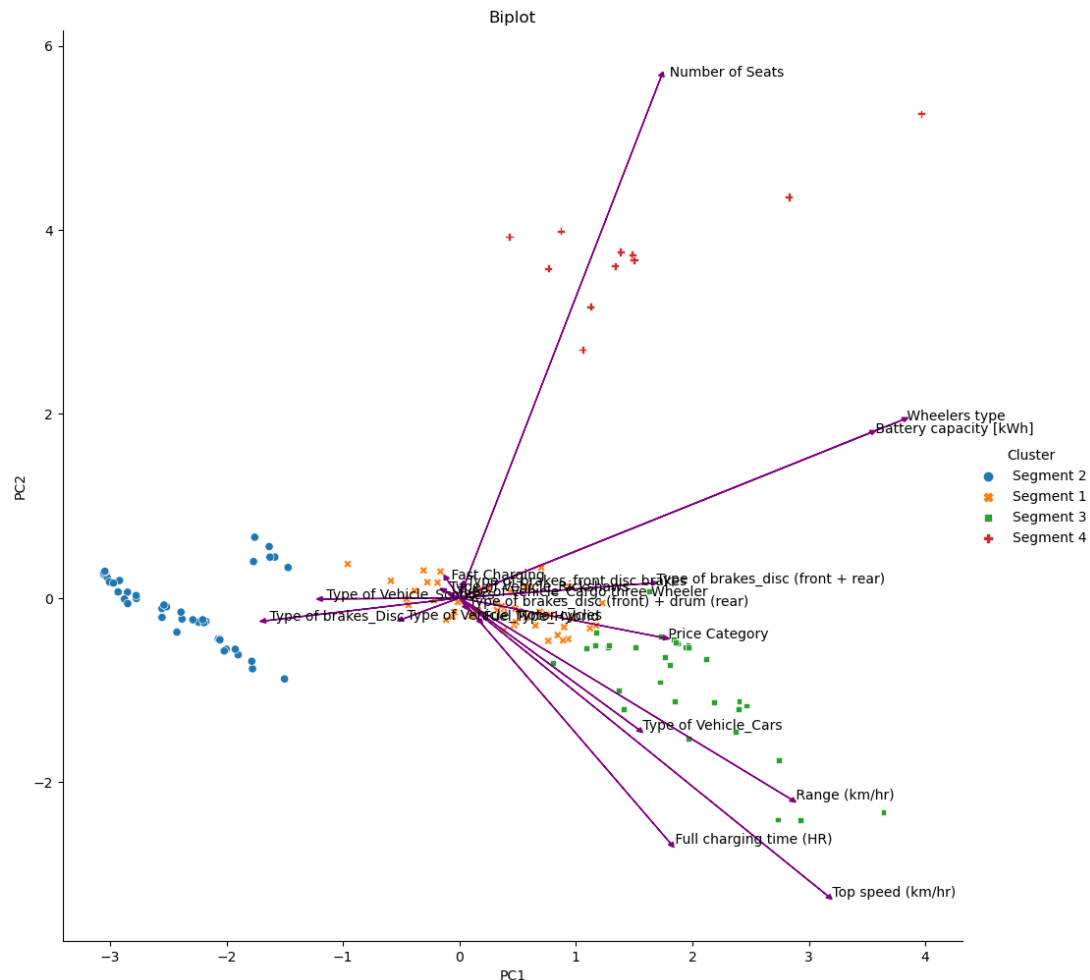
Segment 2 customers are most concerned about the type of brake that they have and mostly they prefer disc brakes, and they also prefer motorcycle over four-wheelers.

On the other hand, segment 3 customers care most about the charging speed or in other words the time it takes to full charge an EV, top speed, range of the EV. They also prefer cars over motorcycles or other types of EV. They also care about the price of the EV.

From the biplot above, the segment 4 customers care most about the number of seats in EV and then battery capacity of the EV. This segment might correspond to electric bus or such EV owner.

The needs of segment 1 customers are very ambiguous, so it's better to avoid that segment for an EV start-up.