Electric Vehicle Market Segmentation

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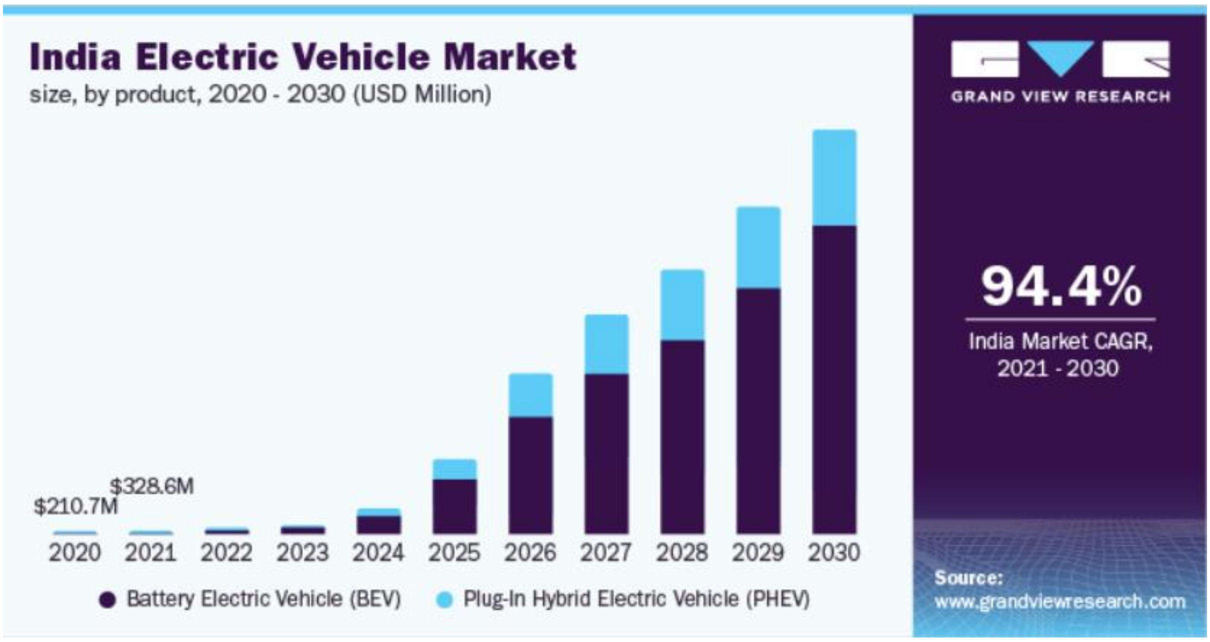
Market Overview -

The India electric vehicle market size was valued at USD 220.1 million in 2020 and is expected to expand at a compound annual growth rate (CAGR) of 94.4% from 2021 to 2030. The attractive incentives being offered by the Indian government on the production and purchase of electric vehicles to encourage the adoption of electric vehicles are anticipated to drive the growth of the market over the forecast period. The outbreak of the COVID-19 pandemic triggered a significant decline in the overall sales of passenger and commercial vehicles in 2020. However, the sales of electric vehicles in India remained unaffected. The post-lockdown sale of pure and hybrid electric vehicles is a prominent driving factor for the electric vehicle market in India.



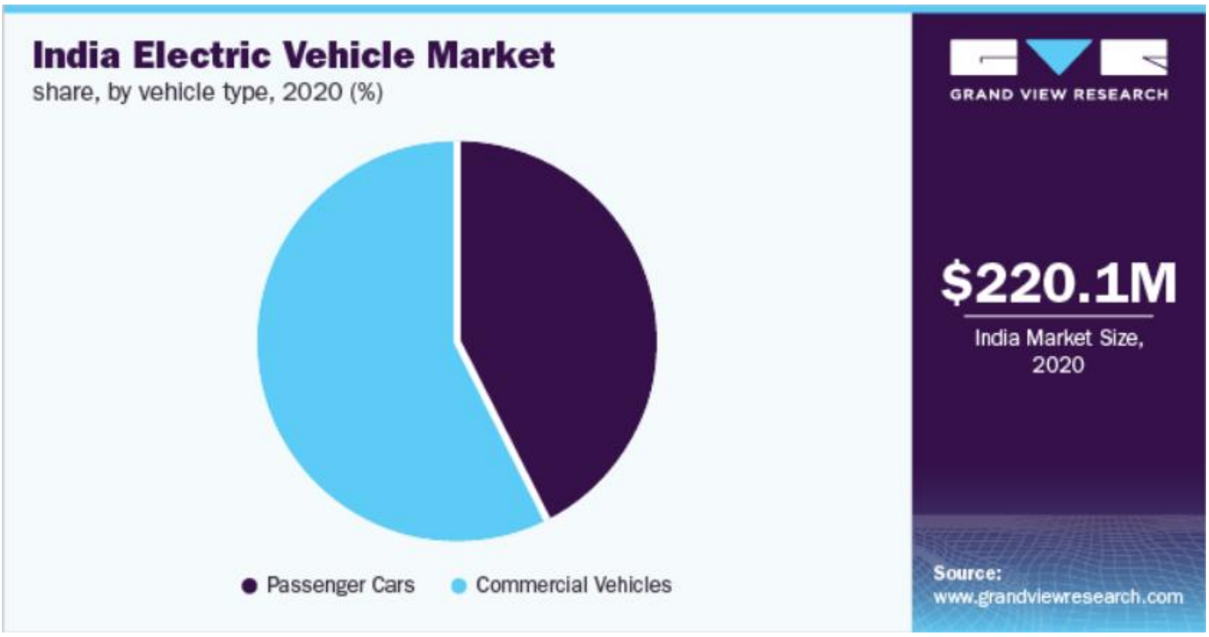
The increasing prices of conventional fuel are expected to accentuate the development of vehicle electrification. The stringent emission norms being drafted by the government and the growing environmental awareness among Indian consumers are also expected to fuel the demand for electric vehicles. Furthermore, Indian automakers, such as Tata Motors, and

Mahindra and Mahindra Ltd., have embarked upon aggressive efforts to add electrified vehicles to their product portfolio, which is expected to encourage Indian consumers to opt for electric vehicles. All these factors bode well for the growth of the electric vehicle market in India over the forecast period.

The EV market in India comprised only two electric vehicle models in 2019. As a result, only 0.15% of the new passenger cars registered between April 2019 and March 2020 were BEVs. However, at the beginning of 2021, the India electric vehicle (EV) market consisted of around eight electric vehicle models, thereby offering more options for Indian consumers looking forward to buying electric vehicles. Moreover, the prices of electric vehicles are also expected to decline over the forecast period, thereby allowing EVs to provide a lower Total Cost of Ownership (TCO) as compared to conventional vehicles. This is expected to pave the way for the mass-market penetration of electric vehicles.

Market Constituents –

The commercial vehicle segment accounted for the largest share of around 57% of the overall market in 2020. The growth of the segment can be attributed to the continued introduction of electric light-duty commercial trucks and electric buses in the country. Electric buses are already gaining traction as the government is pursuing aggressive plans to have more and more electric vehicles plying on the roads to reduce vehicular pollution in major cities across the nation. Companies, such as Tata Motors, Mahindra and Mahindra Ltd, and Olectra Greentech Limited, are already offering electric light-duty commercial vehicles and electric buses in the country.



Influencing Factors –

Rational Choice Theory –

Individual decision-making is the foundation of almost all microeconomic analysis (Levin and Milgrom, 2004), it is difficult for individuals to make a purchase decision as a result of so many available and good options. The rational choice theory (RCT) has dominated economics for more than 50 years, and it is becoming increasingly important in management and marketing research (Grüne, 2010). The early neoclassical economists studied RCT, including William Stanley Jevons (1832-1885), who argued that agents make consumption decisions so as to maximize the utility. Looking back at history, this theory was deeply discussed and developed by Becker (1976), Radnitzky and Bernholz (1987), Hogarth (1987), Svedberg (1990), and Green and Shapiro (1996). Those advocates of RCT often presume that the individual decision-making unit in question is "typical" or "representative" of some larger group such as buyers or sellers in a particular market. Once individual behaviour is established, the analysis generally moves on to examine how individual choices interact to produce outcomes. Shortly, the RCT tends to explain social phenomena by assuming rational choice at the consumers' aspect (Coleman, 1990; Hechter and Kanazawa, 1997). The core notion of RCT is the process of determining what options are better and then choosing the preferred one according to some consistent outcome (Levin and Milgrom, 2004). Rational choice theory (RCT) generally begins with a consideration of the choice behaviour of one or more individual decision-making units (Green, 2002). Anable et al. (2011) emphasized that RCT is the main theoretical paradigm used to understand individual behaviour in economics. RCT is a suitable theoretical lens to study the individual consumption of electric vehicles, as unlike fast-moving products, electric vehicles are more expensive and an essential part of the household property, particularly in China. This makes consumers usually think carefully before 8 buying electric vehicles. The adoption of electric vehicles is generally regarded to be more rational and takes more time to consider, because it is a relatively infrequent act of significant financial outlay (Anable et al., 2011). This is stressed by Simon (1997), who asserts that individual systematically considers the attributes of vehicles and conduct a rational cost-benefit analysis in which the outcome is maximized by maximizing personal advantage. To reach the maximized benefit, consumers make a consideration and rational evaluation of vehicle brands, models and their attributes (Dagsvik et al., 2002; Brownstone et al., 2000).

Utility –

Consumers prejudge the utility of the purchased goods and then rank the social outcome based on utility when making a rational purchase choice (Sato, 2013). This pre-judgment includes personal preferences and actual conditions, which means that a rational consumption choice usually represents preferences with a utility function, hence, the utility is crucial to be considered when rationally consuming (Green, 2002). The utility is particularly important in electric vehicles since most of the consumers buy electric vehicles for daily life, which is called the daily utility of electric vehicles (Rezvani et al., 2015). The use of vehicles directly affects the lives of consumers when they use them for their work commute and travel transportation. In addition, Rezvani et al. (2015) emphasizes that the technical utility includes performance, speed, noise, range, etc. Particularly, the driving range are more sensitive (Rezvani et al., 2015). As the electric vehicle is a recent high-tech product, which has more uncertainties in utility compared with conventional fuel vehicles. To consider a utility, this study mainly focuses on the driving range of electric vehicle, as it is particularly important for the consumers.

Constraints –

Consumers are limited by some constraints when they want to buy something, such as budget. The financial situation is an effective condition for limiting over-consumption, which is particularly true in purchasing costly electric vehicles. The constraints change the costs and benefits of alternatives, which emphasizes the importance between subjective constraints and objective constraints (Sato, 2013). Due to the effect of constraints, alternatives become a critical assumption for consumers. Consumers could make a rational decision to purchase what they want, but should depend on their individual condition. Some researchers describe product differentiation as an alternative to market segmentation (Evans and Berman, 1982; Mandel and Rosenberg, 1981; Neidell, 1983; Pride and Ferrell, 1985; Stanton, 1981). Furthermore, Chamberlin (1965) has recognized that it becomes less price elastic when the differentiated 9 product more exactly satisfies consumer wants. Therefore, constraints have been defined as that the limits of a set of feasible actions (Wittek et al., 2013).

Driving Range –

In the study by Hidrue et al. (2011), the driving range increments have the highest value, followed by charging time, performance, and pollution reduction, it means the driving range is the key aspect of electric vehicle attribute and utility to affect individual willingness to purchase. Several papers have identified driving range as an essential factor influencing the adoption of electric vehicles (Burgess et al., 2013; Carley et al., 2013; Lieven et al., 2011). Consumers generally have certain expectations for driving range because the higher mileage can reduce their charging time. The increased driving range can improve the utility of electric vehicles, which enables consumers to drive electric vehicles to further afield where they want to go.

But, owing to limited technology development, the driving range still has a long way to develop and upgrade. It is difficult to break through 1000 kilometers in a short time, for example, currently, the famous Tesla models only have a driving range of 335 miles (Tesla, 2019). However, due to the short driving range of electric vehicles, it is too short to meet the requirements for users wanting to travel long distances.

In contrary to the thesis proposed, it will be beneficial to Indians living in suburban areas as their range of travel is usually very less too medium. The main issue however is the rate of increasing traffic that causes a problem to the consumers.

Hypothesis 1: The driving range of electric vehicles has a positive effect on the Indian willingness to purchase electric vehicles.

Charging Infrastructure –

The constraint of consumption can be from both finance and public environments. The recent research has discovered that most consumers not only worried about the driving range but also want to drive long distances (Element Energy, 2009; Golob and Gould, 1998). The long-distance driving of electric vehicles largely relies on charging infrastructure. In other words, poor charging infrastructure is one of the critical constraints for long-distance driving. This has been stressed by several researchers who identified that developing charging infrastructure can facilitate more consumers to purchase electric vehicles because it allows them to drive further (Adepetu et al., 2016; Caperello et al., 2015; Javid and Nejat, 2017; Mersky et al., 2016). For 11 potential consumers, they will consider the following factors when purchasing electric vehicles: charge-point location, charge-point interoperability, charge cost and the number of charging stations (Hardman, et al., 2018). Normally, the charging-points will be installed at the following positions, outside of the home, outside of the office, publicly accessible locations and highway service stations (Idaho National Laboratory, 2015; Ji et al., 2015; Nicholas et al., 2017b; Nicholas and Tal, 2014).

Hypothesis 2: The good construction of charging infrastructure has a positive effect on the Indian willingness to purchase electric vehicles.

Purchase Cost –

A typical constraint in a simple one-period consumer choice problem is budget (Green, 2002). In the constraints of RCT, consumers are limited by budget, so the relationship between cost and benefit needs to be fully considered before buying, particularly in the current market for electric vehicles because electric vehicles are much more costly than conventional vehicles (Turrentine and Kurani, 2007). It may make consumers prefer to buy conventional vehicles because they have no choice if they do not have a big enough budget. The higher price of electric vehicles is mainly due to the expensive battery pack, but also to the absence of economies of scale (Thomas, 2009). Lévay et al. (2017) state that the high purchase cost is an important barrier to electric vehicle sales compared to conventional vehicles. In general, as Lebeau et al. (2012) state, financial factors are always important for consumers when they decide to buy a new vehicle.

Hypothesis 3: The purchase cost has a negative effect on the Chinese willingness to purchase electric vehicles.

Government and Financial Investments –

In the study of Wang and Liu (2015), they found that the government policies include monetary incentives and non-monetary incentives. The concept of government policy is too big to study in depth, so this study only focuses on monetary incentives (financial incentives) of the government on electric vehicles, which can actually reduce the financial constraint of purchasing electric vehicles. Wang and Liu (2015) clearly identify that government financial 12 incentives can effectively reduce the cost of purchases, thereby encouraging consumers to buy electric vehicles.

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Individual Environment Analysis –

Environmental awareness has provided some confusion in environmental psychology research about the precise meaning of environmental concern (Bamberg, 2003; Fransson and Gärling, 1999). Environmental awareness has been linked with reference to individual specific beliefs about (Stern et al., 1995) or general environmental beliefs and worldviews (Dunlap and Van Liere, 1978). Hansla (2011) further clearly states that environmental awareness is one of special belief. Clearly, individual environmental awareness is an important type of personal belief. In the notion of RCT, belief is one of the critical elements. Thus, consumers' environmental protection or belief is a potential factor to shape their purchase decision of environment-friendly products. Various studies on consumer adoption of electric vehicles have indicated that electric vehicles are eco-innovations that have the potential to reduce the environmental problems of the transportation sector (Egbue and Long, 2012; Lane and Potter, 13 2007; Schuitema et al., 2013). The role of these environmental-related variables has also been found in exploratory studies where some electric vehicle adopters expressed protecting the environment as a motivation for their choice of electric vehicles (Egbue and Long, 2012; Wang and Liu, 2015; Carley et al., 2013).

Hypothesis 4: The individual environmental awareness has a positive effect on Indian willingness to purchase electric vehicles.

Analysis and Approach –

Clustering

Clustering is one of the most common exploratory data analysis methods used to get an intuition about the structure of data. It can be defined as the task of identifying subgroups in data such that the data points in the same subgroup (cluster) are very similar while data points in different clusters are very different. In other words, we try to find homogenous subgroups within the data such that data points in each cluster are as similar as possible according to a similarity measure such as Euclidean distance or correlation-based distance.

Clustering analysis can be done on the basis of the features where we try to find subgroups of samples based on features or on the basis of samples where we try to find subgroups of features based on samples.

Algorithms used –

One of the most conventional clustering methods commonly used in clustering techniques and efficiently used for large data is the K-Means clustering algorithm. However, it's method is not good and suitable for datasets that categorical values. This problem happens when the cost function in K-Means algorithm is calculated using Euclidian distance which is only suitable for numerical data. While K-Mode is suitable only for categorical data, not mixed data types.

Facing these problems, Huang proposed an algorithm called K-Prototype which is created in order to handle clustering algorithms with the mixed data types (Numerical and Categorical variables). K-Prototype is a clustering method based on partitioning. It's algorithm is an improvement of the K-Means and the K-Mode clustering algorithm to handle clustering with the mixed data types.

Formula for K-Prototype Algorithm –

Mathematics Formula
Suppose that $X = \{X_1, X_2, \dots, X_n\}$ is a set of n object and $X_i = \{X_{i1}, X_{i2}, \dots, X_{im}\}^T$ where m denotes the variables and i denotes i-th cluster.

The Measure of Similarity
General formula for the measure of similarity is denoted as follows.

$$d(X_i, Z_l) = \sum_{j=1}^{m} \delta(x_{ij}, z_{lj}) \tag{1}$$

Where $Z_l = \{z_{l1}, z_{l2}, \dots, z_{lm}\}^T$ is a prototype for cluster l. A measure of similarity for numerical variables is well-known as euclidian distance that is denoted as follows.

$$d(X_i, Z_l) = \sqrt{\sum_{j=1}^{m_r} (x_{ij}^r - z_{lj}^r)^2} \tag{2}$$

Where x_{ij}^r is a value of numerical variables j, z_{lj}^r is the average of prototype for numerical variables j cluster m, and number of numerical variables.

While a measure of similarity for categorical variables is denoted as follows.

$$d(X_i, Z_l) = \gamma_l \sum_{j=1+1}^{m_c} \delta(x_{ij}^c, z_{lj}^c) \tag{3}$$

Where simple matching similarity measure for categorical variables is denoted as follows.

$$\delta\left(x_{ij}^c, z_{lj}^c\right) = \begin{cases} 0, & x_{ij}^c = z_{lj}^c \\ 1, & x_{ij}^c \neq z_{lj}^c \end{cases} \tag{4}$$

Where γ_l denotes the weight for categorical variables for cluster l that is standard deviation of numerical variables in each clusters. The x_{lj}^c denotes the categorical variables, z_{lj}^c is the mode for variables j cluster l, and m_c denotes the number of categorical variables.

The modification of simple matching similarity measure as follows.

$$\delta\left(x_{ij}^c, z_{lj}^c\right) = \begin{cases} 1 - \omega(x_{ij}^c, l), & x_{ij}^c = z_{lj}^c \\ 1 \qquad\qquad\quad , & x_{ij}^c \neq z_{lj}^c \end{cases} \tag{5}$$

The above formula increases the object similarity within cluster with categorical variables so that the result will be better where $\omega(x_{ij}^c, l)$ denotes the weight for x_{ij}^c where

$$\omega\left(x_{ij}^c, l\right) = \frac{f(x_{ij}^c | c_l)}{|c_l| \cdot f(x_{ij}^c | D)} \tag{6}$$

Where $f(x_{ij}^c | c_l)$ is the frequency of x_{ij}^c in cluster l and $|c_l|$ is the number of object in cluster l, and $f(x_{ij}^c | c_l)$ is the frequency of x_{ij}^c in the whole of data.

According to the equation (1) to (5), it obtains the measure of similarity prior to the data with numerical and categorical variables as follows.

$$d(X_i, Z_l) = \sqrt{\sum_{j=1}^{m_r}(x_{ij}^r - z_{lj}^r)^2 + \gamma_l \sum_{j=1+1}^{m_c} \delta(x_{ij}^c, z_{lj}^c)} \tag{7}$$

Huang Cost Function

Huang declared that cost function equation for mixed data type (numerical and categorical) is as follows.

$$Cost_l = \sum_{l=1}^{k} u_{il} \sum_{j=1}^{m_r}(x_{ij}^r - z_{lj}^r)^2 + \gamma_l \sum_{j=1}^{m_c} u_{il} \sum_{j=1}^{m_c} \delta(x_{ij}^c, z_{lj}^c)$$
$$Cost_l = Cost_l^r + Cost_l^c \tag{8}$$

Where $Cost_l^r$ denotes the total cost of all the numerical variables for the entire objects within cluster l. $Cost_l^r$ is minimized while z_{lj} being calculated with following equation.

$$z_{lj} = \frac{1}{n_l}\sum_{i=1}^{n} u_{il} \cdot x_{ij} \text{ for } j = 1, 2, \dots, m \tag{9}$$

Where $n_l = \sum_{i=1}^{n} u_{il} \cdot x_{ij}$ is the number of objects within cluster l.

Further, the categorical variables e.g. C_j is a set of unique value in each categorical variables j and $p(q_{ij}^c \in C_j|l)$ is the probability for c_j within cluster l. So, $Cost_l^c$ can be rewritten as follows.

$$Cost_l^c = \gamma_l \sum_{j=1}^{m_c} n_l \left(1 - p(q_{ij}^c \in C_j|l)\right) \tag{10}$$

where n_l denotes the objects within cluster l. The solution in order to minimize the $Cost_l^c$ is explained clearly in **lemma 1**.

Lemma 1

For special cluster l, $Cost_l^c$ is minimized if and only if $p(z_{ij}^c \in C_j|l) \geq p(c_j \in C_j|l)$ for $z_{ij}^c \neq c_j$ to all categorical variables. So that *cost function* can be rewritten as follows.

$$Cost = \sum_{l=1}^{k}(Cost_l^r + Cost_l^c)$$
$$Cost = \sum_{l=1}^{k} Cost_l^r + \sum_{l=1}^{k} Cost_l^c \tag{11}$$
$$Cost = Cost^r + Cost^c$$

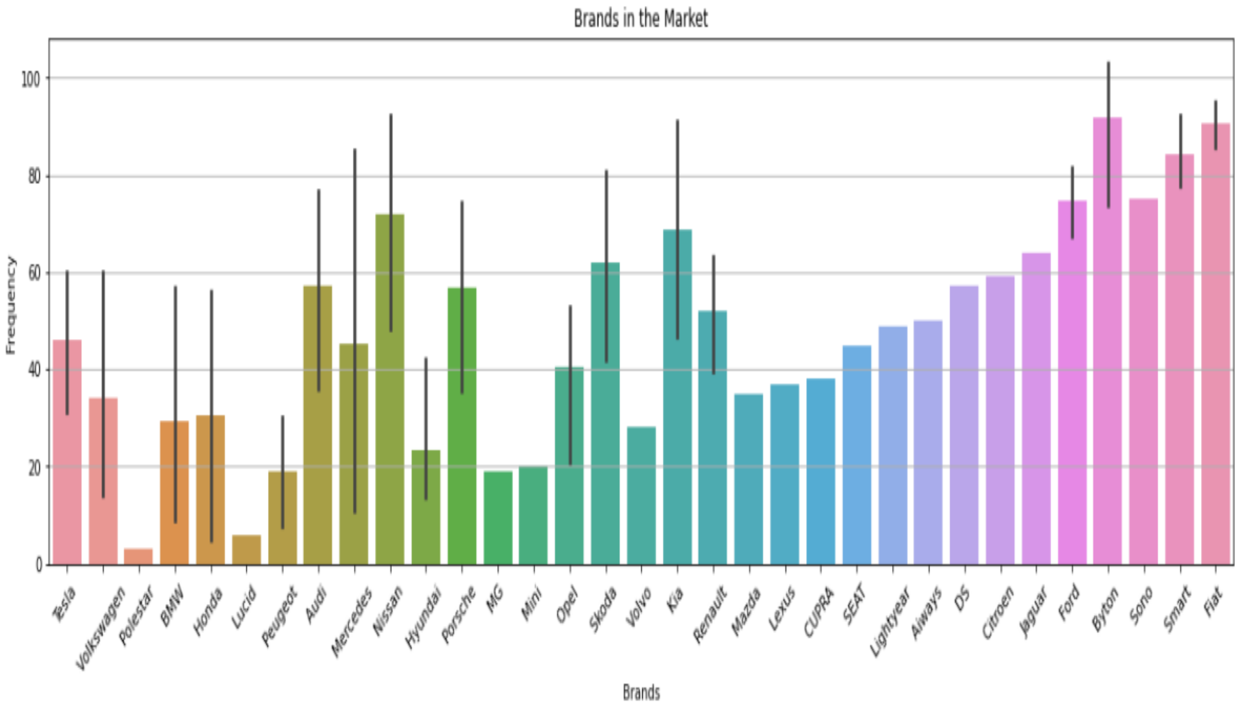
Because $Cost^r$ and $Cost^c$ are non-negative, $Cost$ minimalization can be done by minimizing the $Cost^r$ and $Cost^c$.

Data Used –

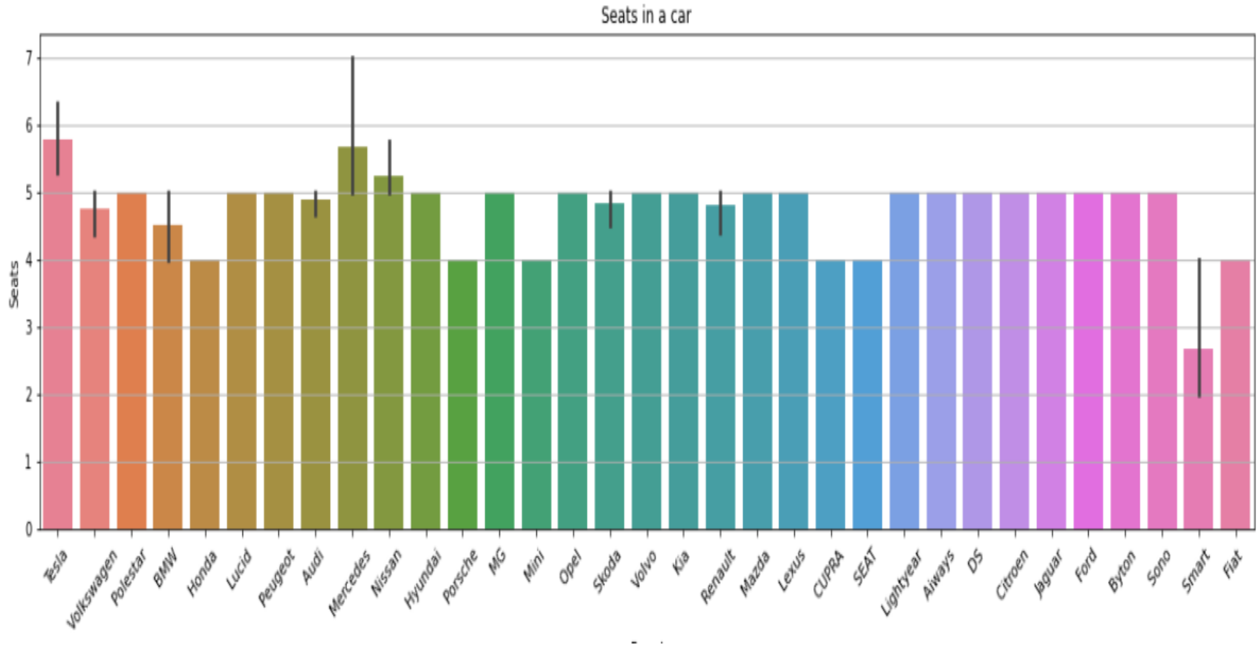
https://www.kaggle.com/datasets/geoffnel/evs-one-electric-vehicle-dataset?select=ElectricCarData_Norm.csv

Exploratory Data Analysis –

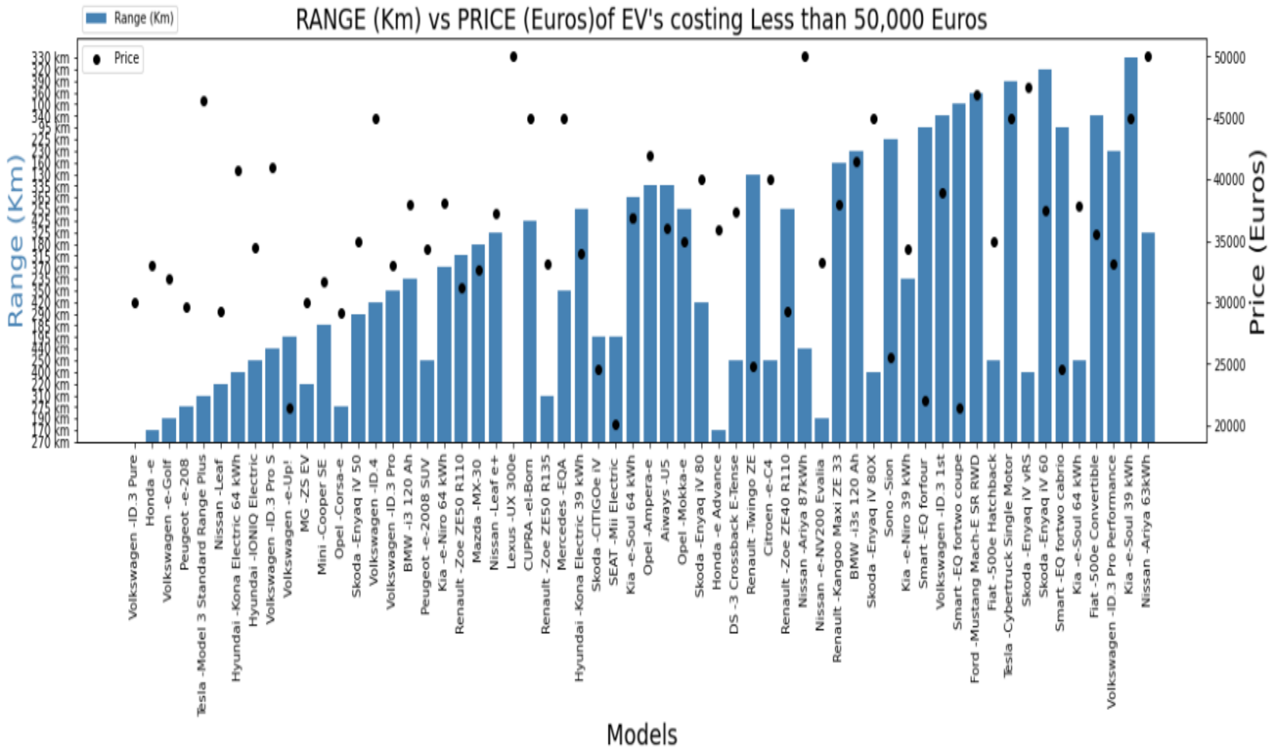
Number of Brands in the market

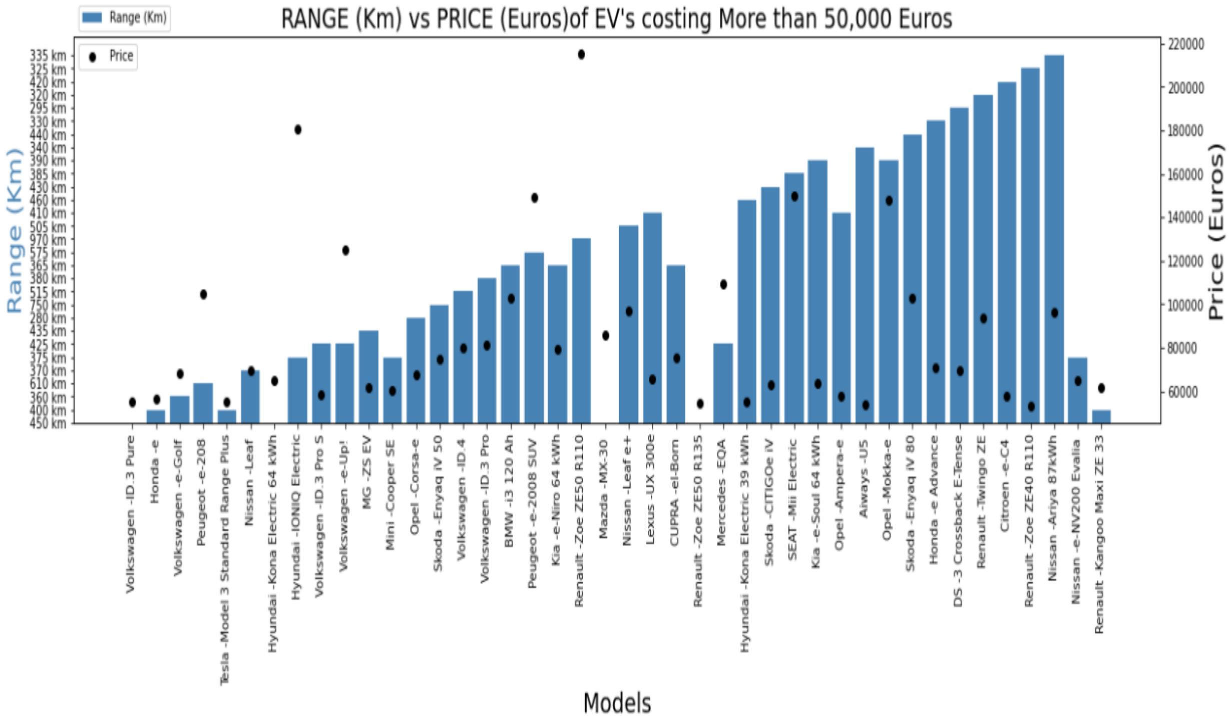


Number of Seats Per Brand in the market –

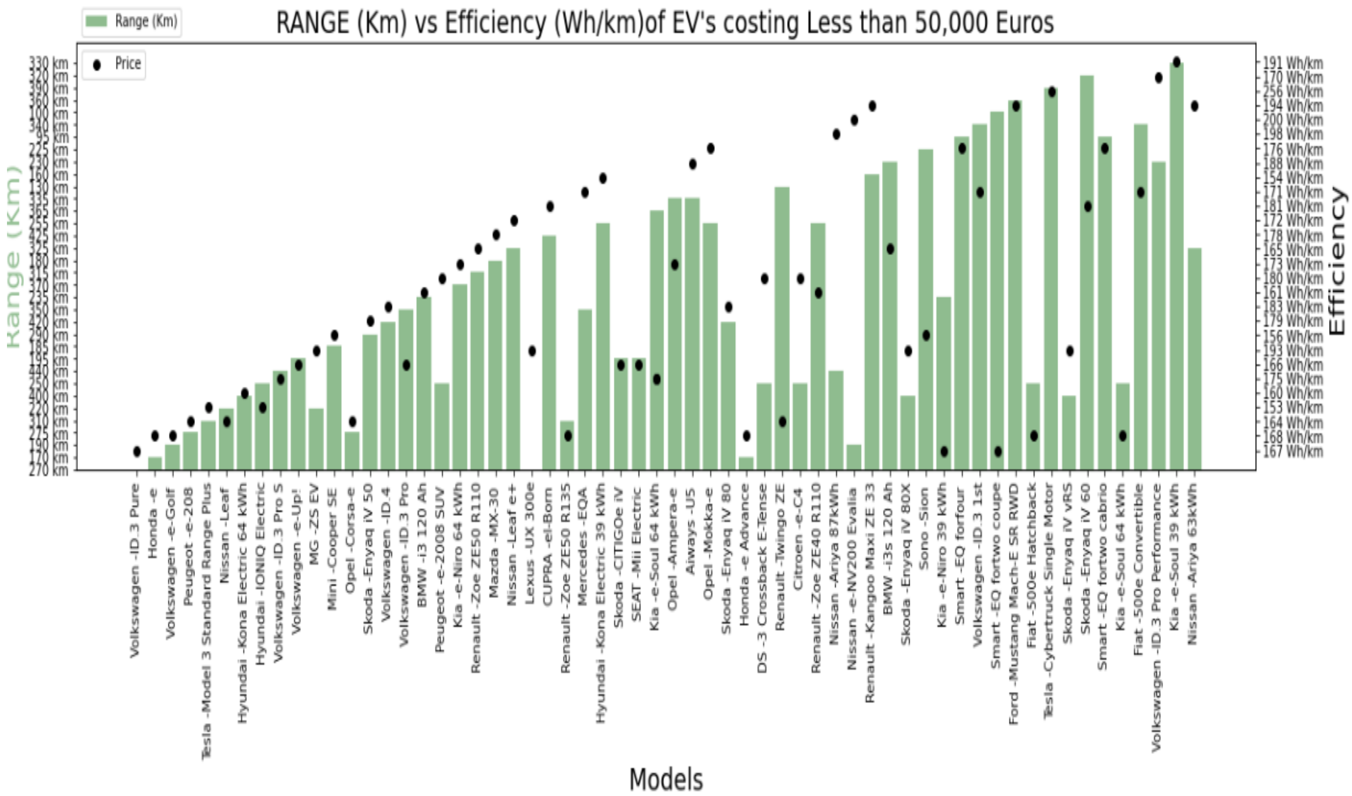


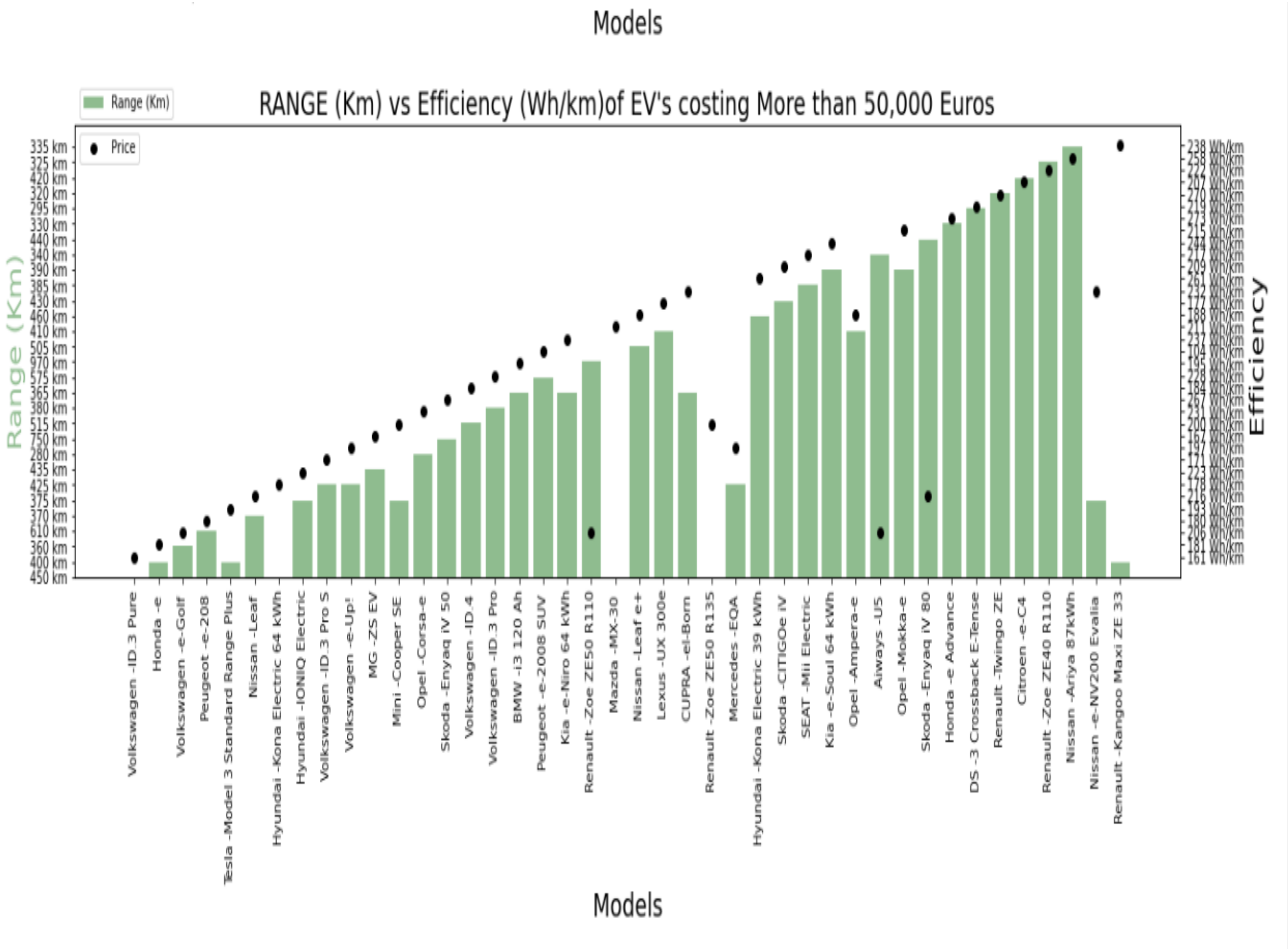
Range with respect to the Price –





Range with respect to the efficiency of the car –





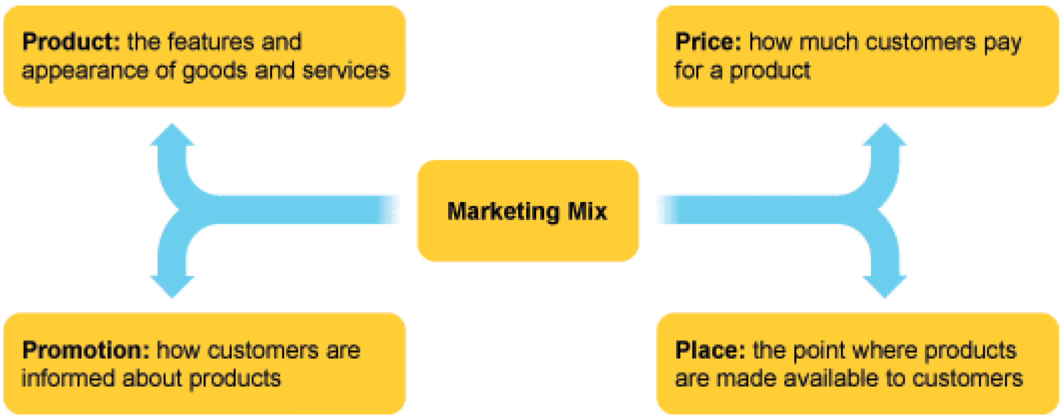
Target Segments –

According to the infrastructure of our country, most of the citizens prefer short periods of commutes rather than long period because of their affordability and the time constraints. With the quality of our roads being above average, investing in an electric vehicle is a calculated risk. However, considering the factors such as Efficiency, RapidCharge and the Range of the vehicle we can divide the target segments. Moreover, with the population of our country increasing at a rapid rate, the concept of nuclear families is relatively new hence the people opting for buying new cars may prefer a larger number of seats as compared to the small 4-seater cars that dominate the Indian vehicle market.

Marketing Mix –

The marketing mix refers to the various elements of your company's offerings in the market. It is a varied 'mix of ingredients' used by the business to achieve its objectives by marketing its products or services effectively to a particular customer group.

The marketing mix also referred to as the 4P's, is comprised of four main pieces – Product, Price, Promotion and Place. The 4P's describe what marketers can control and are the most critical elements when building your marketing strategy.



Market segmentation cannot be used as a stand-alone marketing tactic. Instead, it complements the other components of strategic marketing, most importantly, positioning and rivalry. In fact, segmentation, is frequently used as part of what is known as the segmentation targeting positioning. The segmentation targeting positioning assumes an approach where the events happen in order. Market Segmentation, which involves extracting, describing, and characterising market segments, is the first step in the process.

Last but not the least, positioning (the actions that the organisations can take to ensure that their products are viewed as significantly different from competitor's offerings and in line with segment needs) involves assessing segments and choosing a target segment. Although the segmentation-targeting-positioning process is sequential, it's crucial to not stick to it too rigidly. From the segmentation to the targeting process, it could be required to go back and forth before being in a position to make a long-term commitment to one or a small number of segments.

Github Link - https://github.com/kalyaannnn/MarketSegmentation