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Understanding Individual's Behaviour towards Two-Wheeler Electric Vehicles

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Abstract: ***The research paper is an attempt to provide ease to the potential customers of the Two-wheeler electric vehicle in the selection process depending upon their respective prerequisites. The selection of the vehicle among alternatives is a Multi-Criteria Decision Making (MCDM) problem. This paper develops an evaluation model based on the Analytical Hierarchy Process (AHP) to determine the magnitude of each criterion numerically and the fuzzy Technique for Order of Preferencebased on Similarity to Ideal Solution (TOPSIS) is used to obtain the final ranking. For our study- Brand trust, Price of the vehicle, Range, Charging Time, Cost per km, Battery Life, Aesthetics, Service, Durability, we considered the critical parameters and the elements of the discussion. The study delved into the domestic market of India for the process of evaluation. The methodology included a survey questionnaire conducted among the postgraduates and undergraduates of the institute, Professionals from industries, some entrepreneurs and others. The insights derived from the study are likely to provide a better understanding of the Two-wheeler electric vehicles market for consumers. Alternatively, the managers and organizations can help their consumers in selecting optimum alternatives from the existing convoy. The study emphasizes the degree of ease and related parameters. The study follows by further subdividing the preferred Two-wheeler EVs ranking for Entrepreneurs and Businessmen, Students, Working Professionals, and others. The collected data authenticates the premise mentioned above.***

Keywords: Two-wheeler electric vehicles, AHP, TOPSIS

1. Introduction

"EVs are a rarity in India, where more than 300 million vehicles, mostly two-wheelers, jam the highways."[1]The country is under severe environmental grab because of air pollution where vehicular emissions are emerging as one of the major contributors and are increasing continuously, so there is a dire need to drastically reduce the same."The country is now making an ambitious push for what it calls 'electric mobility', to reduce smog. But the effort is plagued with technological and logistical hurdles, even for those relatively simple vehicles."[1]Availability and affordability of capitals for OEMs, battery manufacturers, charge point operators, consistent policy support and end consumers would be key to determining the pace, efficiency and cost of India's transition to electric vehicles. India's two-wheeler EVs market is largely untapped with gigantic opportunities. A precise selection of two-wheeler EVs is, therefore, a crucial issue in the present scenario.

The purpose of this research is to understand why certain categories of individuals prefer certain EVs options over others and the important criteria they consider while purchasing. Our study, therefore, is an attempt to explore the dimensions which lead to the selection of various EVs by individuals manoeuvring for various purposes. Therefore, in this regard, their relative preferences are understood based on criteria that are most significant to and support the growth of the EV industry. This analysis provides useful information for two-wheeler EV companies about their objectives, policies, and approaches to manage their products. Further, they also provide guidelines for managers and organisations to consider suitable aspects while designing their vehicles for different categories of customers. Therefore, our study aims to evaluate the role of several parameters in selecting a two-wheeler EV.

In contrast to the various customers we examinedEntrepreneurs and Businessmen, Students, Working Professionals, and other individuals, our study abbreviates them holistically under one umbrella. It therefore integrates and understands the role of various parameters such as Brand trust, Price of the vehicle, Range, Charging Time, Cost per km, Battery Life, Aesthetics, Service and Durability and hence provides a better understanding of the two-wheeler EVs and also strategically encapsulates them in the current scenario.

Our study was based on surveys.The data affirmed the following interpretations: Those customers who are working professionals prefer price as the most important criteria and aesthetics as the least important criteria while selecting a two-wheeler EV, whereas students prefer Brand Trust as the most important criteria and durability as the least important criteria for the same. This indicates that certain customers emphasize different criteria to select their vehicle. The study strongly recommends managers and organisations cater to different customers and design vehicles accordingly. The study also contributes to the existing literature to

Criteria for selecting the Two-wheeler EV-

1) Brand Trust – "Brand trust is defined as the willingness of the average consumer to rely on the ability of the brand to perform its stated function".[2]Customers lay a special affinity for brands they trust. Therefore, individuals consider amicable brands while purchasing. These individuals, for example, are more likely to resonate and maintain harmonious relations with trusted brands. Therefore in our study, we consider the assertion of these individuals that they are likely to select the more trusted EV brand.

2) Price- "Price is a compared exchangeable value. In exchange, one must make a comparison between the value of the goods to be given and the value of those to be received."[3] However, based on our study, we tried including customers based on their professional utility. As a result, some individuals may be less subtle about the cost of the two-wheeler EV. Also, in certain cases, the dynamic pricing influences to a greater extent while selecting the

same. Therefore, it becomes crucial to analyse and understand the notion of the "price of a vehicle". EV customers potentially face various financing challenges such as limited financing options, high interest, high insurance cost, and limited loan availability. Hence it was palpable for us to include this in our study.

3) Range- "The driving range is defined as the distance a fully-charged BEV can run until the battery is out of usable electricity."[4] Range anxiety is often considered as one of the biggest barriers in electric vehicle commercialisation but it has not been well defined and discussed. One probable factor for the range anxiety can be the consternation that the vehicle could be fully discharged before the charging point is reached. Therefore this dimension cannot be left untouched for our study.

4) Charging Time-"This parameter indicates how long it takes for a fully discharged cell to be fully charged."[5] With the ever-busy lifestyle, the timely commute has become a necessity. Therefore individuals tend to prefer those EVs having lower charging time to cope up with the time-bound lifestyle of the jet age. The time required for recharging is one of the most scrutinized challenges in this field. Hence it becomes an important aspect to be considered in our study.

5) Battery Life-"The cycle life of a battery is definedas the number of discharge cycles a battery is capableof delivering before its nominal capacity falls below 80%of its initial rated capacity."[6]Battery longevity may also be defined aswhen the battery reaches 80% of its rated capacity. After this, it can still be used at a reducedcapacity. Under different loading conditions, battery life may differ and thus the bottom line here is, the battery ought to be chosen wisely to have a cut above experience.The electric vehicle battery is one of the important areas of research and development as the customers are not satisfied with average battery performance and therefore needs to be analysed in our study.

6) Cost per KM- Even as fillingup a full tank of petrol is fast becoming a pipe dream for many, the alternative, as well as futuristic electric-powered vehicles, seem to offer better running price apprehension. Consequently in this era of economic slump and increasing competition in the market the vehicle should provide an economical alternative. Conclusively, the CPKM should be as minimum as possible. Therefore, it becomes pivotal to comprehend the impact of CPKM during the selection of the vehicle by the individuals. Hence it was evident for us to include this criterion in our study.

7) Top Speed-In the 21st century, the lifestyle is precisely time-bound and therefore people want good acceleration and a higher top speed in the vehicles. Also, there's a large segment of naysayers who brush aside electric vehicles saying they are not fun to drive and they take away the mechanical fun of driving a vehicle. Electric vehicles are silent and they don't have gearboxes and are labelled as slow. Individuals also witnesses how people on bicycles would overtake them on the roads. Therefore the psychological impact of this criterion on the customer cannot be neglected.

8) Aesthetics-"It is also important to identify the design characteristicsthat distinguish between a more and a less attractive system."[7]In visual terms, aesthetics include factors such as balance, colour, pattern, shape and scale. Manufacturers use it to complement their vehicle to enhance functionality with attractive designs. So we anticipate that this factor is likely to have a strong influence in choosing one vehicle over the other.

9) Service- "Introducing the electric vehicle concept in the market isn't enough but to hold it and accelerate the growth is the vital aspect. Service stations just like for any other vehicle should be setup for facilitating repairs and service of electric vehicles. Authorized service centres can also be opened especially for electric vehicles. The main repairs in an electric vehicle include that of the battery, electric motor etc."[8]Hence it was evident for us to consider this criterion in our study and provide better insights into the said dimension.

10) Durability- "Durability may be defined as the ability of a vehicle, to maintain its intended function for its intended service life with intended level of maintenance in the intended condition of use**.**"[9] The Indian market is flooded with the toughest vehicles engineered for off-roading. Since the roads in rural India are not completely asphalted and full of potholes, so the customers from these particular areas tend to prefer durable vehicles. Hence durability becomes one of the crucial criteria to be examined.

Categories of Customers

'Followingare the categories of customers which was included in our study:

1) **Students –** Students are busy folk with heaps of academic assignments, personal problems, and limited budgets.Significant proportions of students in India prefer a personal vehicle to save their time for daily endeavours and they form a major share of customers of EVs. Therefore the opinion of these group of people can't be left unseen.
2) **Entrepreneurs and Businessmen-** The modern generation runs on innovation, sustainability, and environmental conservation – and electric vehicles fit the bill perfectly. These bunch of individuals are leading the transformation from conventional to EVs and in India, most of the two-wheeler EVs manufacturers are emerging start-ups. This indicates that they are more adaptive to change and their outlook needs to be studied.
3) **Working Professionals–** This category includes self-employed professionals or employees**.** A lot of times professionals find themselves working at the area where transportation and daily commute might be messy so EVs provides an overall pretty relaxing experience and a convenient alternative. Therefore they constitute a considerable share in the two-wheeler EVs market.
4) **Others**- This category includes all the other customers like home dwellers, farmers, part-time workers etc. They use vehicles for their day to day chores and several other purposes. The EVs manufacturers fairly target this segment of people too and hence this category finds a place in our study.

2. Methodology

The paper employs TOPSIS [10][11][12] as a tool to estimate the performance indices P_i of the criteria determined as important factors in a two-wheeler EV selection process. TOPSIS follows a certain predefined step to find the performance index P_i.

Step 1. The initial step is the configuration of the Normalization Matrix using all the values for the characteristic, which are illustrated in Table4.

Step2. We followed calculating the Weighted Normalization Matrix, as shown in Table5.

Step3. Followed this, we calculated the weighted Normalization Matrix. Additionally, we calculated the topmost and the lowermost values, which indicate the minimum and the maximum of the two values which are chosen as the most positive and most negative values. It is calculated using, as shown by equation 1:

$A = [a_{ij}]_{m \times n}$, where, a_{ij} is $A_{ij} = X'_{ij} / \sqrt{(\sum_{i=0}^{n} X'_{ij})}$

i = 1, 2…n; j = 1, 2,…….n

Step 4. The next step is the separation measures calculations, which are the deviations of the values from the weighted Normalization Matrix. The values are calculated for each dimension that is seven diverse values are obtained for eight diverse criteria. It is calculated using, as shown by equation 2:

$$S_i^+ = \sqrt{\sum_{j=1}^{m} W_j (a_{ij}^+ - a_{ij})^2}$$

$$S_i^- = \sqrt{\sum_{j=1}^{m} W_j (a_{ij}^- - a_{ij})^2}$$

Step 5. The final step is to calculate the performance index of all the criteria; it is achieved by the implementation of equation 3:

$$P_i = \frac{S_i^+ + S_i^-}{S_i^-}$$

The paper utilizes the Analytic Hierarchy Process like previous studies (AHP) [10] to determine the near-perfect weight of the criteria mention in the table. AHP "is a structured process to determine the relative importance of a set of activities in a multi-criteria decision-making problems." The data used in this process is collected using surveys. The quantitative procedure makes it an obvious choice to choose it over qualitative ones. The AHP method is based on three predicates:

- Configuration and analysis of the data collected.
- The relative judgment of the alternatives and the criteria.
- Separation of the priorities.

The performance index portrays the overall performance of the various criteria following one another based on the individual's priorities. The following tables are mentioned to provide bit by bit interaction of the cumulated data with TOPSIS and AHP. The preference of the two-wheeler EVs by the individuals revolve around these ten criteria in our study: - Brand trust, Price of the vehicle, Range, Charging Time, Cost per km, Battery Life, Aesthetics, Service and Durability. These criteria are briefly elucidated in Table1, and the data source for the Two-wheeler EVs is outlined in Table 2. The significance of each criterion is then accomplished by conducting the survey and with the use of AHP. Also, the importance is numerically obtained in Table 3. The performance index is calculated for the two-wheeler EVs which is a superior indicator for performance judgment. The steps are precisely followed as mentioned before and are demonstrated in the following tables. The study aims at getting a near-perfect ranking for the two-wheeler EVs to provide customerswith the best available option depending upon their use and requirements. Due to decision making based on analysis of mathematical and arithmetic calculations, raw facts and figures, it provides conclusions that are less prone to errors and hence are satisfactory.

Table 1: Criteria of customers for Two-wheeler EVs

Criteria	*Definition*
Brand Trust	"Brand trust is defined as the willingness of the average consumer to rely on the ability of the brand to perform its stated function."
Price	"Price is a compared exchangeable value."
Range	"The driving range is defined as the distance a fully-charged BEV can run until the battery is out of usable electricity."
Charging Time	"This parameter indicates how long it takes for a fully discharged cell to be fully charged."
Battery Life	"The cycle life of a battery is defined as the number of discharge cycles a battery is capable of delivering before its nominal capacity falls below 80% of its initial rated capacity."
Cost Per KM.	Cost per KM. refers to the running cost of the vehicle for covering the distance of unit KM.
Top Speed	"It refers to the maximum speed that can be attained by the vehicle."
Aesthetics	"Aesthetics is the branch of philosophy devoted to conceptual and theoretical inquiry into art and aesthetic experience."
Service	Service is a series of inspection and maintenance procedure carried out from time to time for efficient functioning.
Durability	"Durability may be defined as the ability of a vehicle, to maintain its intended function for its intended service life with intended level of maintenance in the intended condition of use."

Table 2: Showing values for criteria for different companies of two-wheeler EVs in India.

COMPANY	BT	PRICE	RANGE	CT	BL	CPKM	TS	AESTHETICS	SERVICE	DURABILITY
A	7	115695	95	5	3	0.35	70	2	3	3
B	1	79037	110	4.5	2.688	0.27	42	6	1	4
C	2	108847	80	5.25	2.71	0.49	80	1	4	2
D	4	53799	60	5.5	1.152	0.21	25	3	6	8
E	8	122250	75	5	2.25	0.3	78	8	2	1
F	3	74880	200	2.5	2	0.1	75	7	5	7
G	6	79999	105	4	2.5	0.28	60	5	7	5
H	9	45390	70	7	1.152	0.16	25	9	10	10
I	5	50000	100	3.5	1.296	0.1	25	4	9	9
J	10	105967	120	5.5	2.8	0.24	60	10	8	6

Table 3: Weights for different criteria calculated using AHP

CRITERIA	WEIGHT	WEIGHT%
BT	0.084734	8.473427
Price	0.154582	15.45822
Range	0.136618	13.66185
CT	0.109132	10.91318
BL	0.115218	11.52183
CPKM	0.118123	11.81228
TS	0.063469	6.346877
Aesthetics	0.04839	4.839042
Service	0.081937	8.193692
Durability	0.087796	8.779602

Table 4: Conversion into Normalization matrix for data from table 2

COMPANY	BT	PRICE	RANGE	CT	BL	CPKM	TS	AESTHETICS	SERVICE	DURABILITY
A	0.356753	0.416623877	0.27764606	0.32153676	0.419855	0.403822	0.38048	0.10192944	0.1528942	0.152894
B	0.050965	0.28461646	0.32148492	0.289383084	0.37619	0.31152	0.228288	0.30578831	0.0509647	0.203859
C	0.101929	0.391963863	0.23380721	0.337613598	0.379269	0.565351	0.434834	0.05096472	0.2038589	0.101929
D	0.203859	0.193733074	0.17535541	0.353690436	0.161224	0.242293	0.135886	0.15289416	0.3057883	0.407718
E	0.407718	0.440228782	0.21919426	0.32153676	0.314891	0.346133	0.423963	0.40771775	0.1019294	0.050965
F	0.152894	0.269646881	0.58451803	0.16076838	0.279903	0.115378	0.407657	0.35675303	0.2548236	0.356753
G	0.305788	0.288080673	0.30687197	0.257229408	0.349879	0.323058	0.326125	0.2548236	0.356753	0.254824
H	0.458682	0.163451815	0.20458131	0.450151464	0.161224	0.184604	0.135886	0.45868247	0.5096472	0.509647
I	0.254824	0.180052672	0.29225902	0.225075732	0.181377	0.115378	0.135886	0.20385888	0.4586825	0.458682
J	0.509647	0.381592829	0.35071082	0.353690436	0.391864	0.276907	0.326125	0.50964719	0.4077178	0.305788

Table 5: Conversion into the Weighted Normalization matrix

COMPANY	BT	PRICE	RANGE	CT	BL	CPKM	TS	AESTHETICS	SERVICE	DURABILITY
A	0.030229206	0.06440265	0.0379316	0.03509	0.0483749	0.047701	0.024149	0.00493241	0.0125277	0.0134235
B	0.004318458	0.043996649	0.0439208	0.031581	0.0433439	0.036798	0.014489	0.01479723	0.0041759	0.017898
C	0.008636916	0.06059065	0.0319424	0.036844	0.0436987	0.066781	0.027598	0.0024662	0.0167036	0.008949
D	0.017273832	0.029947692	0.0239568	0.038599	0.018576	0.02862	0.008624	0.00739861	0.0250554	0.035796
E	0.034547664	0.068051549	0.029946	0.03509	0.0362812	0.040886	0.026908	0.01972963	0.0083518	0.0044745
F	0.012955374	0.041682618	0.079856	0.017545	0.03225	0.013629	0.025873	0.01726343	0.0208795	0.0313215
G	0.025910748	0.044532154	0.0419244	0.028072	0.0403124	0.03816	0.020699	0.01233102	0.0292312	0.0223725
H	0.038866122	0.025266747	0.0279496	0.049126	0.018576	0.021806	0.008624	0.02219584	0.0417589	0.04474499
I	0.02159229	0.027832944	0.039928	0.024563	0.020898	0.013629	0.008624	0.00986482	0.037583	0.04027049
J	0.04318458	0.058987472	0.0479136	0.038599	0.0451499	0.032709	0.020699	0.02466204	0.0334071	0.026847

Table 6: Ideal best and ideal worst values from the weighted normalization matrix.

COMPANY	BT	PRICE	RANGE	CT	BL	CPKM	TS	AESTHETICS	SERVICE	DURABILITY
IDEAL BEST	0.004318458	0.025266747	0.079856	0.017545	0.0483749	0.013629	0.027598	0.0024662	0.0041759	0.0044745
IDEAL WORST	0.04318458	0.068051549	0.0239568	0.049126	0.018576	0.066781	0.008624	0.02466204	0.0417589	0.04474499

Table 7: Calculated Euclidian distance from the ideal best and ideal worst

Company	Si+	Si-
A	0.07481428	0.065507636
B	0.053901374	0.081074044
C	0.083418128	0.069690376
D	0.081681027	0.065935047
E	0.082148307	0.066240932
F	0.04272933	0.098548107
G	0.064395986	0.062165608
H	0.09809931	0.062401532
I	0.074267003	0.077647501
J	0.079880892	0.056301411

Table 8.1: Resultant performance index of the attributes (Students)

Ranking	Company
1	F
2	B
3	I
4	C
5	G
6	D
7	A
8	E
9	J
10	H

Table 8.2: Resultant performance index of the attributes (Businessmen and entrepreneurs)

Ranking	Company
1	F
2	B
3	I
4	G
5	D
6	A
7	C
8	J
9	H
10	E

Table 8.3: Resultant performance index of the attributes (Working Professionals)

Ranking	Company
1	F
2	B
3	I
4	G
5	A
6	C
7	D
8	E
9	J
10	H

Table 8.4: Resultant performance index of the attributes (Others)

Ranking	Company
1	F
2	B
3	C
4	A
5	I
6	G
7	D
8	E
9	J
10	H

Conclusions

In this study, data is collected using cross-sectional surveys AHP and TOPSIS is used as the analysis tool. Thus, we conclude that different categories of individuals favour different criteria for choosing the two-wheeler EV depending upon their purpose of use. Their selection criteria are well exemplified with the results so obtained. Thus, this analysis provides useful information for two-wheeler EV companies about their objectives, policies, and approaches to manage their products. Further, they also provide guidelines for managers and organisations to consider suitable aspects while designing their vehicles for different categories of customers. This research is likely to assist the two-wheeler electric vehicle industries by ranking the different companies and thus strategically understand their competitive procedures. We strongly recommend future studies to identify and explore more dimensions that may influence the selection of the two-wheeler EVs by a diverse group of individuals.

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