User Satisfaction of Electric Vehicles (EVs) as an Alternative form of Public Road Transport System: A Survey-based Approach

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Abstract

Electric Vehicles (EVs) being newly introduced in Bangladesh, attains much popularity among the urban passengers and it also reduces environmental pollution. EVs now become an inseparable part of the public transportation system in Bangladesh. This study is carried out to measure user satisfaction in the perspective of EVs passengers. Heterogeneous Customer Satisfaction Index (HCSI), is used to measure the level of user satisfaction. Here, customer satisfaction represents a measure of EVs performance according to user needs and expectations. Ten transit service quality attributes are used to calculate HSCI, and the value obtained is 5.90. Finding also reveals that skill of the driver, environment-friendliness, service availability, noise and vibration level, and cleanliness are the most critical transit service quality attributes. The transit service quality attributes of EVs with which users are most satisfied are environment-friendliness, hood facility, service availability, and users are least satisfied with skill of the driver, administration of complaints and cost of travel.

Keywords: Electric Vehicle, Transit User Satisfaction, E-Rickshaw, Transport Service Quality.

1. Introduction

In the modern era, climate change and limited fossil fuel resources are highly essential concerns. In the EU, automobiles are responsible for one-fifth of CO_2 emissions. The widespread adoption of renewable energy based transportation has become critically important in order to reduce CO_2 emission. An electrically powered vehicle (EV) according to the present invention composed of a battery, an electric power converting device, an electric motor, a drive wheel, a control part, an accelerator, a brake, and a rotation sensor [1]. Commercial electric vehicles were available by the end of the 19th century. Electric vehicles (EVs), with an electric power train, that only work on a battery, represent one promising technological development that has the potential to reduce CO_2 emissions significantly emitted by automobiles [2]. Economic development and transportation are closely related. Transportation is necessary because it carries not only passengers but also enables trade among people, which is essential for the development of civilization. Bangladesh is a developing country in South Asia, where most of the people use road transportation for their daily traveling and transporting goods. Dhaka, the capital city of Bangladesh, is known as the 'Rickshaw Capital' of the world due to having the highest number of rickshaws [3]. Electric powered rickshaw (three-wheeler), also known as E-Rickshaw (locally called 'Auto') is a newly added mode of transportation in the urban transportation system of Bangladesh and only known form of Electric Vehicles (EVs). The popularity of e-rickshaw has increased because of faster speed, and low traveling cost. E-rickshaw can provide a non-polluting and very silent transport system for urban and rural areas and busy cities [4]. They are best suited to narrow, crowded streets, and are thus the primary means of covering longer distances within urban areas. The low rolling resistance and light weight make this vehicle very energy efficient and cost effective. Despite having significant progress made in developing automotive batteries that are used in EVs, major challenges remain, and they are: reducing cost, improving safety, prolonging the life span, reducing the charging time and reducing the size and weight of the battery pack [5].

Service quality involves finding out if a customer's satisfaction of a service meets, exceeds, or falls short of the customer expectations [6]. Service quality can be defined as the degree and direction of the discrepancy between the consumer's perceptions and expectations, or the extent to which a service meets or exceeds customer expectations [7]. De Oña et al. defined user satisfaction in

a public transport system as the overall level of attainment of a customer's expectation, measured as the expectations fulfilled [8]. To relate this to public transport services, a transit user is viewed as a customer whose needs to be satisfied with the quality of service [9].

2. Literature review

The People's Republic of Bangladesh is a major developing and one of the most densely populated countries in South Asia where most of the people use road transportation for their daily traveling and transporting goods. Human pulled rickshaw, two-stroke and four-stroke diesel driven auto rickshaw, compressed natural gas (CNG) driven autorickshaw and bus is the most common mode of public transportation used by urban peoples to travel short distances in Bangladesh. However, in recent years, some Electric Vehicles (EVs) is added in the public transportation system of Bangladesh. EVs are getting popular due to reduced carbon emission and the elimination of dependency on imported oil. Many leading manufacturers have already assembled their own EVs models due to the creation of a genuine interest for EVs in the car market, and the popularity of EVs is apparent from the impact studies undertaken all around the world. Problems caused by additional power demand by EVs can be easily evaded by avoiding fast-charging methods or by implementing smart charging methods [10].

Rahim et al. showed that e-rickshaw is preferable over other similar internal combustion engine vehicles due to less air pollution, less noise pollution, less vibration and can reduce unemployment problem in Bangladesh about 2% [11]. Rana et al. found that e-rickshaw has lower travel cost, greater comfort, and reasonable travel speed, which is the reasons behind its popularity among passengers. They also found that around 88% of people living in an urban area where e-rickshaws are available, use this mode to meet their travel demand. E-Rickshaw is also economically beneficial as it involves an income-cost ratio of 1.85 to 1.96 [12, 13]. Majumdar et al. found that e-rickshaw is an energy efficient mode of transportation than other forms of motorized mode and has the potential to reduce environmental pollution. Also suggests maintaining safety standard during designing and proper route management [14]. Buhler et al. showed that EVs are already evaluated positively, but in order to achieve broad market success, solutions to import barriers are needed and providing real-life experience could be a promising marketing strategy [15]. According to a report by Bangladesh Passengers' Welfare Association (BPWA) published in April 2018, over 77% of drivers in Bangladesh do not possess driving licenses. The association also found that at least 87% of public transport drivers in Dhaka drive recklessly and violate traffic laws, which are the major causes of user dissatisfaction [16]. Laura Eboli and Gabriella Mazzulla

introduced Heterogeneous Customer Satisfaction Index (HCSI) methodology for evaluating transit service quality. Mentioning its several advantages over other methods, they conclude that the Heterogeneous Customer Satisfaction Index can be considered a useful tool for measuring transit service quality and identifying causes generating customer satisfaction/dissatisfaction [17]. Purba et al. used HSCI to measure transit service quality of TransJogja, a new transit service in Indonesia, which results in an HSCI value of 7.22 out of 10 and also suggests HSCI as a useful tool for measuring transit service quality to oversee transit agency performances and fulfill user requirements [18]. Munira and Santoso also used HCSIto reveal people's view and experience related to the sustainable transport operation in Dhaka city and found a Heterogeneous Customer Satisfaction Index value of 4.06 out of 5 [19].

As can be seen from the above literature, there is no specific study on the user satisfaction of Electric Vehicles (EVs) in Bangladesh. On this backdrop, this study is performed to measure the level of satisfaction of Electric Vehicles (EVs) user. Ten transit service quality attributes namely (i) Administration of Complaints, (ii) Comfort, (iii) Cleanliness, (iv) Environment Friendly, (v) Cost of Travel, (vi) Hood Facility, (vii) Noise and Vibration Level, (viii) Service Availability, (ix) Skill of Driver and (x) Physical Appearance of Vehicle are used in this study to evaluate the EVs performance against user expectations. This study will also reveal the ranking of EVs transit service quality attributes and thus paves the way to maximizing to user satisfaction by investing on top priorities attributes only.

3. Methodology

The index, named Heterogeneous Customer Satisfaction Index (HCSI) is a modified form of traditional Customer Satisfaction Index (CSI) [17]. Heterogeneous Customer Satisfaction Index takes into account the variability monitor service quality, identifying the causes which generate customer satisfaction/dissatisfaction and define the strategies for improving the service quality.

Heterogeneous Customer satisfaction index (HCSI) is calculated as $HCSI = \sum_{k=1}^{N} S_k^c \cdot W_k^c$ (1) Where, Adjusted Satisfaction,

$$S_k^c = \bar{S}_k \times \frac{\frac{\bar{S}_k}{var(S_k)}}{\sum_{k=1}^{N} \frac{\bar{S}_k}{var(S_k)}} \times N \qquad (2)$$

And Adjusted Weight,

$$W_k^c = \frac{\frac{\bar{I}_k}{var(I_k)}}{\sum_{k=1}^{N} \frac{\bar{I}_k}{var(I_k)}} \qquad (3)$$

Also, $\bar{S}_k$ is the mean satisfaction rate of k attribute and $\bar{I}_k$ is the mean importance weight of k attribute. The adjustment of mean satisfaction and mean importance rates allows the attribute characterized by more homogeneous user judgments to be considered more significant; to the contrary, the attributes with heterogeneous judgments are considered less significant. Independent sample t-test, an inferential statistical test, has been used to determine whether there is a statistically significant difference between the means in two independent groups. The licensed SPSS software for windows version 12 has been used to perform t-test in this study, and a p-value of less than 0.05 is considered to be statistically significant. In this study, a structured questionnaire is used to collectqualitative data. To evaluate EVs service quality, passengers are asked to provide a rating of importance, and a rating of satisfaction on each transit service quality attributes on a scale of 1 to 10 in increasing order of importance and satisfaction. Several socio-economic characteristics are also recorded during the data collection process.

4. Results and discussion

This section summarizes the analyses carried out on the data obtained from the survey. For Heterogeneous Customer Satisfaction Index (HCSI) measurement of EVs, data has been collected from the passengers who use EVs as their daily transportation within the city area.

Table 1 shows the socio-economic characteristics of 300 respondents. The gender distribution of the respondents is almost equal, of which 60% are male and, 40% are female. Also, an equal number of responses are observed in three age categories. Majority of the responders are employed (48%) followed by housewife (22%), student (16%) and unemployed (14%).

Table 2 shows the mean importance of different transit service quality attribute given by the users. By applying the formula (3), an adjusted weight of each attribute is obtained. Skill of driver, environment-friendliness, service availability, and noise & vibration level are found asthe most critical transit service quality attributes to EVs user.

Table 3 shows the mean satisfaction of different transit service quality attribute expressed by the users. Adjusted satisfaction of each attribute is obtained by applying the formula (2). EVs usersarefound most satisfied with environment-friendliness, hood facility, and service availability; while they are least satisfied with skill of driver, administration of complaints, and cost of travel. The adjusted satisfaction score is also observed tobe above 5 for all transit service quality attributes except the administration of complaints, cost of travel, and skill of the driver. This result suggests that, except a few attributes, EVs meets most of the users'expectations. Heterogeneous Customer Satisfaction Index (HCSI) value of EVs is calculated using formula (1) and found a

Table 1. Socio-economic characteristics of respondents

Variables	Category	Percentage
Gender	Male	60
	Female	40
Age	20-30 years	33
	31-40 years	35
	41-50 years	32
Employment	Employed	48
	Unemployed	14
	Student	16
	Housewife	22

Table 2. Importance score of transit service quality attributes

Transit Service Quality Attribute	Mean Importance ($\bar{I}_k$)	Weight (W_k)	VAR (I_k)	Adjusted Weight (W_k^c)
Administration of Complaints	6.5	0.095	6.959	0.084
Comfort	6.8	0.100	7.157	0.085
Cleanliness	6.9	0.101	6.638	0.092
Environment Friendly	7.6	0.111	5.704	0.119
Cost of Travel	6.9	0.101	7.099	0.087
Hood Facility	6.2	0.091	7.453	0.074
Noise and Vibration Level	6.8	0.100	5.565	0.110
Service Availability	6.7	0.097	5.291	0.113
Skill of Driver	7.2	0.105	4.196	0.153
Physical Appearance of Vehicle	6.9	0.101	7.516	0.082

value of 5.90.

Independent sample t-test has been performed between importance given by male and female on each transit

service quality attributes to determine whether there exists a statistically significant difference between them.

Table 4 shows that, at 5% level of significance, there

Table 3. Satisfaction score of transit service quality attributes

Transit Service Quality Attribute	Mean Satisfaction($\bar{S}_k$)	VAR (S_k)	Adjusted Satisfaction(S_k^c)
Administration of Complaints	5.4	7.359	3.8
Comfort	6.2	5.844	6.3
Cleanliness	5.9	4.842	6.9
Environment Friendly	6.1	4.376	8.2
Cost of Travel	5.7	6.471	4.9
Hood Facility	6.4	5.405	7.3
Noise and Vibration Level	6.2	5.512	6.6
Service Availability	6.1	5.028	7.1
Skill of Driver	4.5	6.570	2.9
Physical Appearance of Vehicle	6.5	6.610	6.1

Table 4. T-test summary between male and female importance on transit service quality attributes

	Male	Female	Test Summary	
Transit Service Quality Attribute	Mean (SD)	Mean (SD)	t value	p-value
Administration of Complaints	6.48 (2.57)	6.50 (2.74)	0.0609	0.9515
Comfort	6.83 (2.74)	6.80 (2.59)	0.0980	0.9220
Cleanliness	6.78 (2.47)	6.95 (2.74)	0.5288	0.5973
Environment Friendly	7.42 (2.43)	7.80 (2.32)	1.3713	0.1713
Cost of Travel	7.35 (2.58)	6.30 (2.68)	3.3894	0.0008
Hood Facility	6.08 (2.70)	6.40 (2.82)	0.9838	0.3260
Noise and Vibration Level	6.68 (2.33)	7.03 (2.40)	1.2582	0.2093
Service Availability	6.46 (2.31)	6.98 (2.25)	1.9089	0.0572
Skill of Driver	7.18 (2.00)	7.17 (2.12)	0.0578	0.9540
Physical Appearance of Vehicle	6.95 (2.75)	6.86 (2.74)	0.2562	0.7980

Table 5. T-test summary between male and female satisfaction on transit service quality attributes

	Male	Female	Test Summary	
Transit Service Quality Attribute	Mean (SD)	Mean (SD)	t value	p-value
Administration of Complaints	5.82 (2.67)	4.84 (2.69)	3.1237	0.0020
Comfort	6.01 (2.38)	6.50 (2.46)	1.7192	0.0866
Cleanliness	5.76 (2.23)	6.13 (2.15)	1.4346	0.1524
Environment Friendly	6.20 (2.04)	6.03 (2.17)	0.6879	0.4921
Cost of Travel	5.50 (2.52)	6.10 (2.54)	2.0354	0.0427
Hood Facility	6.56 (2.23)	6.22 (2.46)	1.2473	0.2133
Noise and Vibration Level	6.49 (2.16)	5.70 (2.53)	2.8999	0.0040
Service Availability	6.21 (2.26)	5.98 (2.21)	0.8837	0.3776
Skill of Driver	4.68 (2.60)	4.23 (2.49)	1.5102	0.1320
Physical Appearance of Vehicle	6.62 (2.45)	6.30 (2.74)	1.0612	0.2894

exists astatistically significant difference in importance given by male and female for the cost of travel. These results suggest that the cost of travel is comparatively more critical to male than a female when choosing EVs for transportation, while the importance of all other attributes is found equal for male and female.

Again, independent sample t-test has been performed between male and female satisfaction on each transit service quality attributes to determine whether there exists a statistically significant difference between the means. Table 5 shows that, at 5% level of significance, there is a statistically significant difference in the male and female's satisfaction withthe administration of complaints, cost of travel, and noise and vibration level attributes. Male are more satisfied than the female withthe administration of complaints and noise & vibration level attributes while the female is more satisfied than the male withthe cost of travel attribute.

5. Conclusion

This research has explored electric vehicles (EVs) transport users' satisfaction through surveys. Users are satisfied with seven out of the ten attributes of the EVs transportation systems in Bangladesh. The lowest scoring attribute is the skill of driver (2.9/10) followed by administration of complaints (3.8/10). Although having road transport law with capital punishments for traffic rule violations, its effective implementation lacks and thus generates user dissatisfaction due to accidents caused by it. Training facilities for vehicle operators should be increased to minimize the risk of accidents and to enhance the users' satisfaction. Both EVs owner associations and law enforcing agencies should provide proper administration of complaints by their users. These improvements should be made to make the EVs more sustainable and hence, reduce the use of fossil fuel-driven automobiles in the future.

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