



Artificial Neural Network for Analyzing the Customer's Perceived Service Quality and Satisfaction of Online Cab Services

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Abstract

India has been witnessing rapid growth in travel with the occurrence of online cab service especially in urban sector. The high demand for transport service and lack of good quality of public transport has given the opportunity to many cab aggregators to gain customers. People go for cab because it offers desirable comfort, flexibility and privacy. It also helps to avoid problem like parking issues. Hence, it's important to assess the aspects that the customer/user is looking for the most while hailing an online cab service. To study the relationship of service quality attributes with overall satisfaction of the cab users, a web-based survey was conducted in Tiruchirappalli and Pune city. This paper proposes the use of Artificial Neural Network (ANN) to analyze perceived service quality of online cab users and to find out the attributes of importance a customer consider while hailing an online cab service. Model developed show that the attributes like safety, waiting time, driver behavior, comfort, cleanliness and trust on driver are some of the variables that have relatively higher influence on overall satisfaction.

Keywords: Service Quality, Online Cab Services, Artificial Neural Network.

1. Introduction

Transport is considered as very important element that tries to connect different communities with different factors that facilitates socio-economic development. It is the mode by which urban and rural communities' access to different facilities like recreational, jobs, healthcare, etc. According to World Bank (2017), passenger traffic will increase by 50% to exceed 80 trillion passenger-kilometres by 2030 compared to 2015 and additional 1.2 billion cars will be on the road (Mensah and Ankomah, 2018). The

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constant growth in the number of private vehicles travelling on urban roads causes congestion, traffic jams, pollution noise, etc. (Alonso et al., 2018). Due to rapid growth in population and changing the lifestyle of the people and their progress, people choose luxuries well-being, and their transportation needs have been sustained on the safety, speed and convenience while travelling. The middle-class population in India increased from 15 million in 1991 to 160 million in 2016 (Velmurugan et al., 2019). The rapid growth in the urban sector due to the migration of people from rural areas has increased the demand for travel. This has become opportunity to various private vehicle aggregators to gain customers. This has created strong competition between the aggregators as there are more than 10 different private companies offering this service. As taxi is regarded as public transport with one vehicle providing service to many users without owning the vehicle, and to encourage public use of it, the service needs to be assessed for the aspects that customer is looking for the most while making use of online cab services in India.

Cab has covered the gap between private and public transport in time. Unlike traditional taxis, online cab hailing services are carried out by an online platform, which kind of bridges the gap between cab driver and customer/passenger simultaneously to satisfy the demand of both. The online platform helps drivers receive orders quickly, and passengers are able to track location of driver via smartphone, which indirectly reduces vehicle ownership and greenhouse gas emissions (Lyu et al., 2021). Online cab services are playing very important role in people's daily commute (Zhang et al., 2020). Public transport like bus, metro, etc. are mostly associated with the government where all operations, fixed routes, and schedules are important aspects. When it comes to cab services, it ensures privacy and comfort more than public transport. Online cab service has more flexibility than a bus by providing door-to-door services (Shaaban and Kim, 2016). Cab or taxi may not be a sustainable mode of transport, but it has its own advantages to people. People generally go for cab because it offers desirable comfort, flexibility and privacy. It also helps to avoid problem like parking issues, parasitic traffic, etc. (Alonso et al., 2018).

Over the past few years, the radio taxi (online taxi) concept has made travel simple, secure and convenient in India (Sharma and Das, 2017). Online cab booking is just a matter of few clicks on a smartphone, and it will arrive at the desired location to help you to reach the destination with hassle-free in travel. The online cab market has grown by 30% in last one year with monthly bookings crossing 65 million (redseer.com 2018). Particular cab aggregators like Uber and Ola have shown almost exponential growth aiming to solve intra-city commuting problems of customers (Sharma and Das, 2017).

In this study, a web-based survey is conducted to identify the factors which influence the customer's perceived service quality of online cab services. ANN is used to analyze the perceived service quality of online cab users and to find out the attributes of importance a customer considers while hailing an online cab service. Later the interpretation of the model results is also carried out to understand the influence of the service quality measures on satisfaction.

2. Objectives of the Study

The study was carried out with the following objectives:

- To identify the attributes that influence the customer's perception of service quality of online cab services.

- To find out the SQ attributes that required greater need of improvement using the Importance-Satisfaction analysis.
- To ascertain the relationship between SQ and demographics of online cab users using Bi-variate analysis.
- To develop an ANN model to identify the SQ attributes and their influence on overall satisfaction of the user towards online cab service.

3. Literature Review

Sharma and Das (2017) studied the service quality and customer satisfaction with online cab services in India and found that tangibles, physical facilities have significant effect on overall satisfaction followed by responsiveness. The research on modelling taxi user service quality by Alonso et al. (2018) found that waiting time is the most important factor considered by frequent users and journey time considered as important by almost all users along with safety. The study showed that different users have different perceptions about service quality which depends on travel characteristics, way of accessing journey, waiting time and socio economic characteristics. Velmurugan et al. (2019) study about users' perception of Ola services in Salem city, showed that driver's irresponsibility and at times driver cancelling rides are the highest ranked issue by users. Shaaban and Kim (2016) paper focused on passengers' satisfaction of taxi services and found that income is the greatest factor influencing satisfaction followed by age and occupation. Mensah and Ankomah (2018) found that there is significant effect of service quality on commuter's satisfaction with taxi services. However, responsiveness did not have a significant effect on satisfaction. A user's perception study by Dachyar and Rusydina (2015) found that company's image has the strongest impact followed by companies trust. Companies need to consider these factors to increase customer's satisfaction and earn customer's loyalty. Garrido et al. (2014) proposed the use of ANN for analysis of perceived service quality of public transportation systems. Analysis showed different categories of variables have greater and lesser impact on overall satisfaction. Frequency is the most influential variable followed by speed and information and proximity. Rahman et al. (2016) assessed the service quality of paratransit in Dhaka city using Structural Equation Modelling (SEM) technique. They found that latent variables like physical appearance are less influential when compared to service features and variables like punctuality, reliability, fitness of vehicle and travel cost. Wang et al. (2020) studied the public transport equity in Shenyang using SEM. They found that there is direct link between public transport equity and public transport quality. Islam et al. (2016) proposed a bus service quality prediction model using ANN, found that public opinion and service frequency are most affecting factors for bus service quality.

In the service industry, perceived service quality is considered as very important issue. There is different definition of service quality based on different perception. Considered service quality as a customer's judgment about the overall excellence of product. Generally service quality is defined as the difference between customer's perception and their expectation with the service. There are two different theoretical method for analysing the service quality mainly. First is the performance perception and expectation approach (Parasuraman et al., 1985), which includes a parameter service quality as a difference between expectation and performance from user's perspective. Second one is the only performance perception approach (Cronin and Taylor, 1992). Researchers have used different analysis techniques for analysing service quality in the past. In some studies

researchers constructed hypothesis and verified using different statistical tests like regression analysis, t-test, chi-square test, ANOVA etc. Some used more advanced techniques like Structural Equation Modelling or path analysis and resulted in a greater accuracy (Eboli and Mazzulla, 2007). Alternative approaches like Artificial Neural Network (Behara et al., 2002), discrete choice models (Alonso et al., 2018), classification tree techniques (Hensher and Prioni., 2002) are also used. Some studies have correlated perception performance and served quality with socio economic characteristics.

4. Methodology

Various literatures were reviewed to understand the modelling techniques and to know about the factors that influence the model. The questionnaire was designed based on the literature studies and the survey was carried out in the study area to collect the data. Statistical package SPSS and Orange software were used for the analysis part. The methodology adopted for the study is shown in figure 1. The study areas considered are Pune and Tiruchirappalli city. After finalizing the study area, next step was the preparation of questionnaire in such way to capture both socio economical as well as perception data of online cab users. Various statistical tests were carried out to validate the data. Based on the literature review it was decided to develop the model using SEM and ANN. Different parameters were considered and based on the model estimation results conclusion were made.

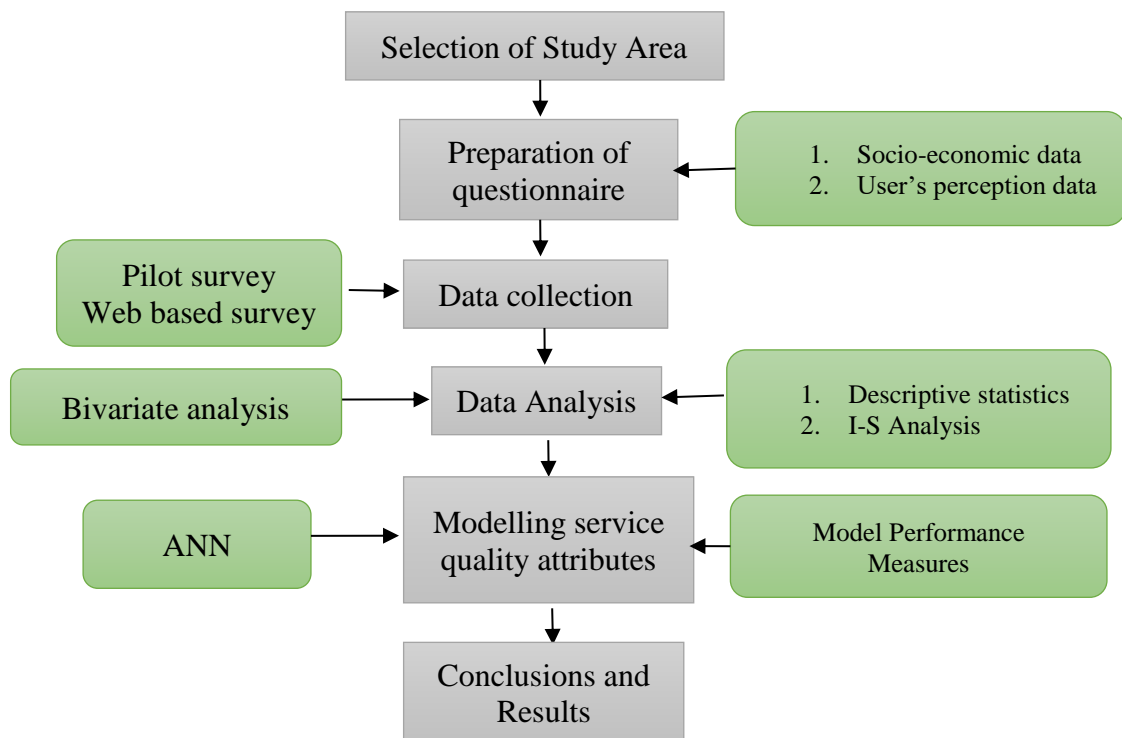


Figure 1: Detailed Methodology.

5. Study Area and Data Collection

5.1 Study Area

To understand customer's perception about service quality of cab services, service quality dimensions related data and primary data was collected in Tiruchirappalli and Pune city. The online cab service and operation is same everywhere in India. Starting from booking a cab online to payment mode to mode of transport etc. Hence, a web-based survey was conducted for data collection. In Tiruchirappalli city only Ola cab service is available whereas in Pune, Ola, Uber and Meru cabs are the three dominating cab aggregators.

5.2 Data Collection

The SERVEQUAL model is used for questionnaire design. The SERVEQUAL questionnaire was first published in 1985 by A. Parshuraman, (Parasuraman et al., 1985). The SERVEQUAL model is designed to capture the customer expectation and perception of a service along five dimensions that are believed to represent service quality. The attributes that are considered for the study are divided into two categories as part A and part B. Part A of the questionnaire includes information related to socio-economic data and travel related data. Socio-economic data like age, gender, monthly income etc. Travel related data includes frequency of cab usage etc. Variables were categorized as given in table 1.

Part B includes user's perception data includes of service quality dimensions related questions. The service quality dimensions are Tangibility, Reliability, Responsiveness, Assurance and Empathy. Tangibility includes with physical facilities, equipment personnel, and interior facilities. Reliability is the ability to perform promised service dependably and accurately. Responsiveness is the willingness to help customer and prompt service. Assurance is the ability to inspire trust and confidence. Empathy deals with the trustworthiness and honesty. Likert scale was used ranging from 1 to 5 for both importance and satisfaction rating of service quality indicators. Dimensions and their respective indicators are given in table 2.

Table 1: Categorization of primary data.

Variable	Categorization of variable
Age (in years)	18-25 , 25-40 , 41-60 , >60
Gender	Male; Female; Other
Monthly Income (in INR)	Not earning ; <10,000; 10,000-30,000; 30,000-50,000; 50,000 - 1,00,000; Above 100,000
Frequency of usage of cab service	Less than 5 times; 5-15 times; More than 15 times

Table 2: Measured variables/ attributes of service quality.

Service Quality Dimensions	Measured variables (indicators)
Tangibility	Q1-GPS system, comfort & cleanliness inside the cab Q2-Driver's appearance Q3-Cab was visually appealing (attractive)
Reliability	Q4-You reached destination in the stipulated period of time using cab service Q5-Cab service is available for you 24*7 Q6-Cab arrived for you at desired pickup location without delay Q7-Driver drove vehicle safely, followed traffic rules Q8-Cab didn't break down on the road
Responsiveness	Q9-Driver showed genuine interest in solving problem Q10-Driver was never too busy to listen to your request Q11-Driver provided timely and efficient service for you
Assurance	Q12-You felt safe inside the cab Q13-You had trust on driver when driver choose an alternate route Q14-Driver was consistently Courteous (Polite) with you Q15-Driver had the knowledge to answer your questions
Empathy	Q16-Driver gave you personal attention (Didn't talk on phone while driving) Q17-Driver informed about the delay or inability to deliver Q18-Driver was honest and righteous

6. Results of Data Analysis and Discussions

6.1 Preliminary Data Analysis

The data collected through web-based survey was analyzed. Microsoft Excel and SPSS are used to analyze the primary data obtained from the survey. In total, data from 320 respondents has been collected. Figure 2 shows the primary data analysis. The data analysis shows that majority of respondents are male (81%). Age distribution analysis shows that the majority of the respondents belong to 18-25 year age group (54%). 37% of the respondents belong to the age group 26-40 years old. Majority of respondents were 'no earning' people (40%) followed by people having monthly income Rs.30, 000 – Rs.50, 000 (16%). Customers were asked about how many times they used the cab services in last 3 years. The data showed that majority of respondents used online cab service more than 15 times (57%). The customers were asked about why they go for online cab services instead of other modes of public transport. The analysis from figure 3 showed that majority of them uses the cab service for Comfort (73%) and Accessibility (71%).

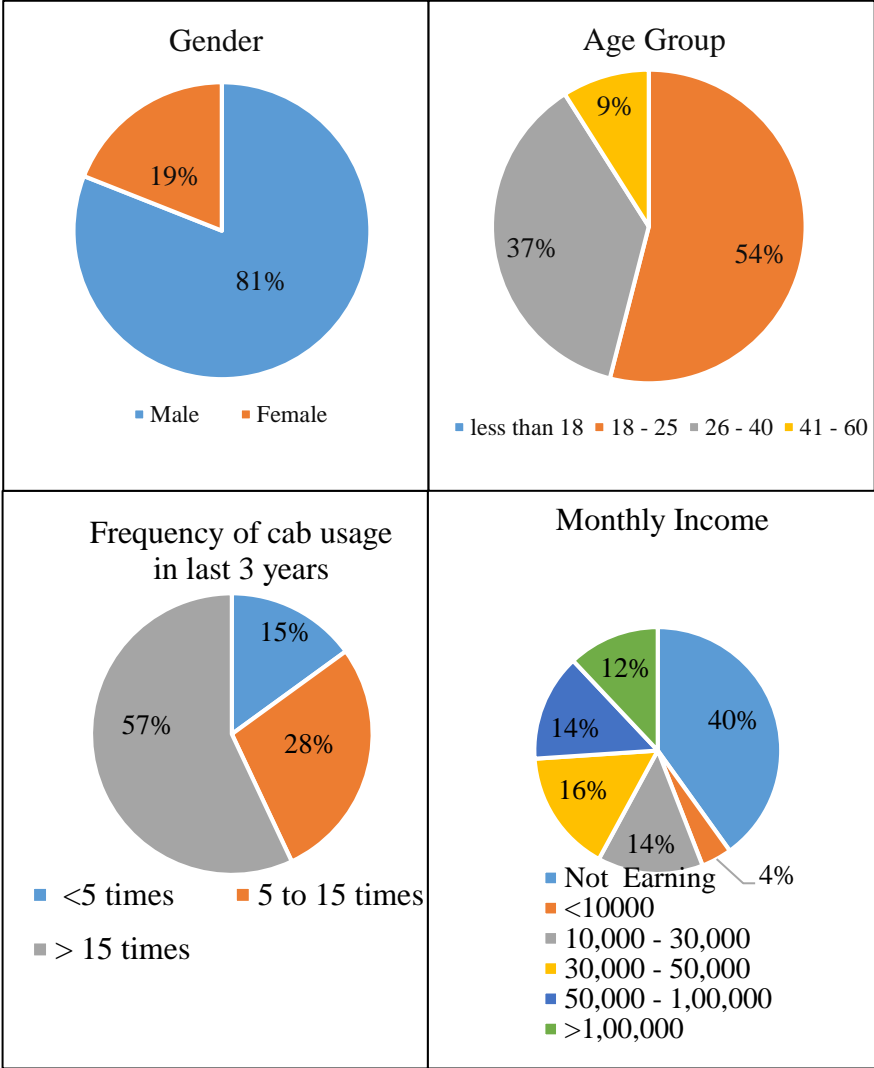


Figure 2: Primary data analysis.

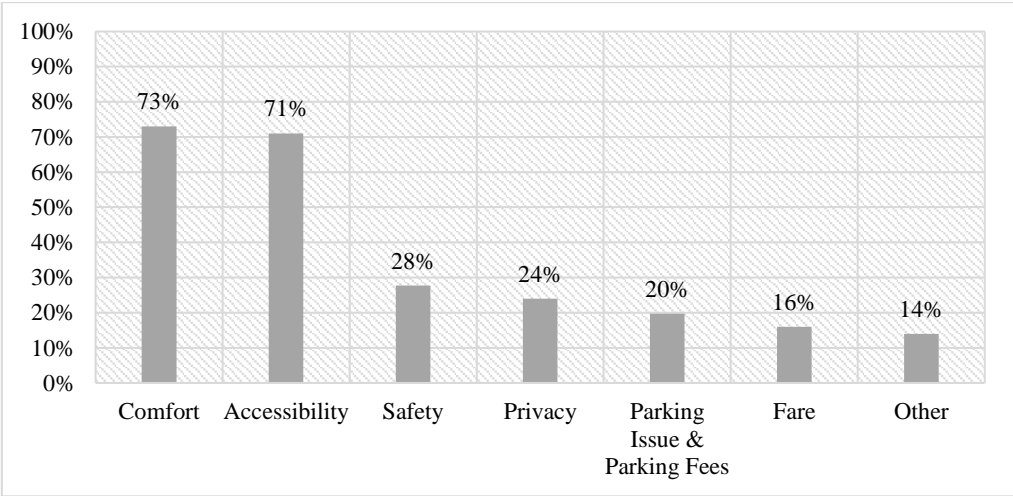


Figure 3: Reason for choosing cab service.

The next important question asked to respondents were about the difficulty and the issue they face the most while using cab services. Analysis showed that ‘at time driver cancel the ride’ (75%) is the issue majority of the people faced along with ‘extra charges on cancelling the ride’ (60%). The same has been shown in figure 4.

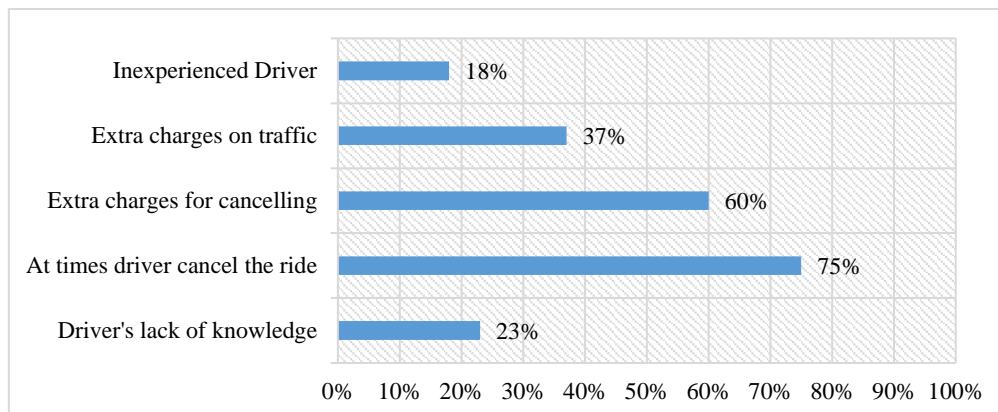


Figure 4: Difficulties faced while using cab services.

Reliability test was performed to check whether data collected is consistent for use or not. For checking consistency of the data Cronbach's Alpha value was calculated for each latent variable. Alpha value for each latent variable came to be more than 0.7 showed that data is reliable to use. KMO test value was 0.94 which is greater than 0.75. Alpha value, mean and variance of each service quality dimension (construct) is given in following table 3.

Table 3: Characteristics of service quality dimensions.

Dimensions	Cronbach's Alpha value	Mean	Variance
Tangibility	0.820	3.305	0.066
Reliability	0.833	3.473	0.091
Responsiveness	0.858	3.409	0.081
Assurance	0.840	3.355	0.087
Empathy	0.853	3.170	0.089

6.2 Importance-Satisfaction Analysis

Importance-Satisfaction (IS) analysis was carried out to know which attributes or factors are highly important and satisfactory. This analysis helps to understand which factors are highly important according to user and they are less satisfied with it. The formula to calculate IS rating given by Iseki and Smart (2012) as follows.

$$IS \text{ rating} = \text{Importance rating} (\text{Satisfaction rating}-100) \quad (1)$$

where, satisfaction rating is the percentage of the people who rated the factor as highly satisfied and importance rating is the percentage of the people who rated the factor as highly important.

Table 4 gives the ranking of the factors based on satisfaction, importance and IS rating. Importance rank '1' indicates highly important factor for the user. Similarly, satisfaction rank '1' indicates highly satisfied factor for the user. IS rank '1' indicates that for user this factor is most important, but they are less satisfied with it and requires improvement for it.

Salient findings from IS analysis table 4 are as follows:

- 'Cab service is available for you 24*7' is the most important factor according to users followed by 'You felt safe inside cab' and 'cab arrived for you at desired pickup location without delay'.
- It was found that 'travel time, 'driver should follow traffic rules' and 'cab performance (doesn't break down on the road)' are factors users are highly satisfied with it.
- From the IS rank it was understood that 'cab service is available for you 24*7' is the most important factor that requires greater need of improvement followed by 'waiting time for cab arrival' and 'Safety inside cab'.
- IS ranking indicates that 'visual appeal of cab' and 'drivers appearance' are the factors less important to user and they are satisfied with it.

6.3 Bi-variate Analysis

To ascertain the relationship between service quality attributes and demographics of online cab users, a bi-variate analysis using Chi-Square test was carried out with the help of Python script. The following table 5 gives the chi square test results for some important relations. The average satisfaction rating for each service quality attributes is analyzed based upon gender, age group and income. It was found there is different satisfaction level for different group of people. For example, from the analysis it was found that, when it comes to safety inside cab, female cab users are less satisfied with the service with average rating of 3.21 out of 5 when compared to male cab users with the average rating of 3.71 out of 5.

Table 5: Bi-variate analysis.

Variables	Service Quality Attributes	Chi-Square value	DOF	p-value
Gender	Safety inside cab	11.38	4	0.02*
Age	Safety inside cab	15.52	12	0.21
Income	Safety inside cab	19.31	20	0.50
Gender	Overall Satisfaction	2.35	4	0.67
Age	Overall Satisfaction	16.69	12	0.16
Income	Overall Satisfaction	35.38	20	0.01*
Frequency of cab usage	Overall Satisfaction	19.31	8	0.51

*Significant at 5% significance level

Table 4: Importance-satisfaction analysis.

Indicators	Importance		Satisfaction		IS rating	
	Rating (%)	Rank	Rating (%)	Rank	Rating (%)	Rank
Availability 24/7	40.10	1	9.90	11	36.13	1
Pickup delay	37.69	4	6.70	15	35.16	2
Drive drove vehicle safely	39.30	3	13.50	4	33.99	3
Safety inside cab	40.07	2	17.50	2	33.06	4
Reached destination in stipulated time	37.61	5	13.50	3	32.53	5
Driver inform about the delay/inability to deliver	33.33	8	8.30	13	30.56	6
Driver was honest and righteous	32.90	9	10.30	10	29.51	7
Comfort & cleanliness inside the cab	33.38	7	11.90	6	29.41	8
Driver provide timely and efficient service	32.14	10	11.50	7	28.44	9
Trust on driver when driver choose an alternate route	30.00	12	5.94	16	28.22	10
Driver is consistently Courteous	31.00	11	11.11	8	27.56	11
Cab doesn't break down on the road	37.31	6	29.36	1	26.36	12
Driver show genuine interest in solving problem	27.38	13	10.30	9	24.56	13
Driver give you personal attention	25.80	15	7.10	14	23.97	14
Driver is never too busy to listen to your request	25.82	14	12.30	5	22.64	15
Driver has the knowledge to answer your questions	24.60	16	9.50	12	22.26	16
Driver's appearance is neat & well dressed	17.40	17	5.10	18	16.51	17
Cab was visually appealing	13.89	18	5.90	17	13.07	18

Salient findings from bivariate analysis are as follows,

- Female cab users are less satisfied with safety while hailing a cab however the factor is equally important for both male and female.
- Different income group people have different satisfaction level about online cab services.
- Frequency of cab usage does not affect the overall satisfaction level of the cab users.

7. Multilayer Perceptron (MLP) Neural Network Model

A Neural Network, or, more appropriately an artificial neural network is a model or methodological tool that is a loose adaptation of the process by which the brain is thought to operate (McMillen and Henley, 2001). ANN capture the inherent information from the considered variables and learn from the existing data, even when noise is present, therefore no formulation or a prior model is required (Garrido et al., 2014). These model consist of network of artificial neurons or nodes that are representatives of neurons or neuron cells of human brain. Neural Networks are designed to mimic human activity such as learning and pattern recognition (Behara et al., 2002). These characteristics have made it possible to apply them in diverse fields such as engineering, psychology, statistics and economics (Cooper, 2010).

ANN structure is composed of elemental information processing units, called neurons. They are organized into several layers and interconnected with each other through synaptic weights. Synaptic weights represent the intensity of the interaction between every pair of neurons, and the activation functions calculate the potential of every neuron (Garrido et al., 2014). In this study a multilayer perceptron (MLP) with the backpropagation learning algorithm technique is used, which is most widely used ANN type.

For this study, a three layer MLP model was developed using Orange data mining software shown in figure 5. Orange is an open-source data visualization, machine learning and data mining toolkit. The input layer is made up of service quality attributes of online cab service which corresponds to predictor variables. The output layer consist of different class of overall satisfaction given by cab users for online cab service available to them. To get the best fit model with higher accuracy, multiple iterations were performed by changing the hyperparamters. Hyperparameters are the variables which determines the network structure (e.g. no. of hidden layers and neurons in hidden layers) and the variables which determine how the network is trained (e.g. activation function and epochs).

To get the best fit model which will predict the overall satisfaction of the online cab users towards online cab service, multiple iterations were performed on ANN model by changing the hyperparamters like no. of hidden layers, no. of neurons in hidden layers, test-train split and no of epochs using Orange software shown in figure 5 .

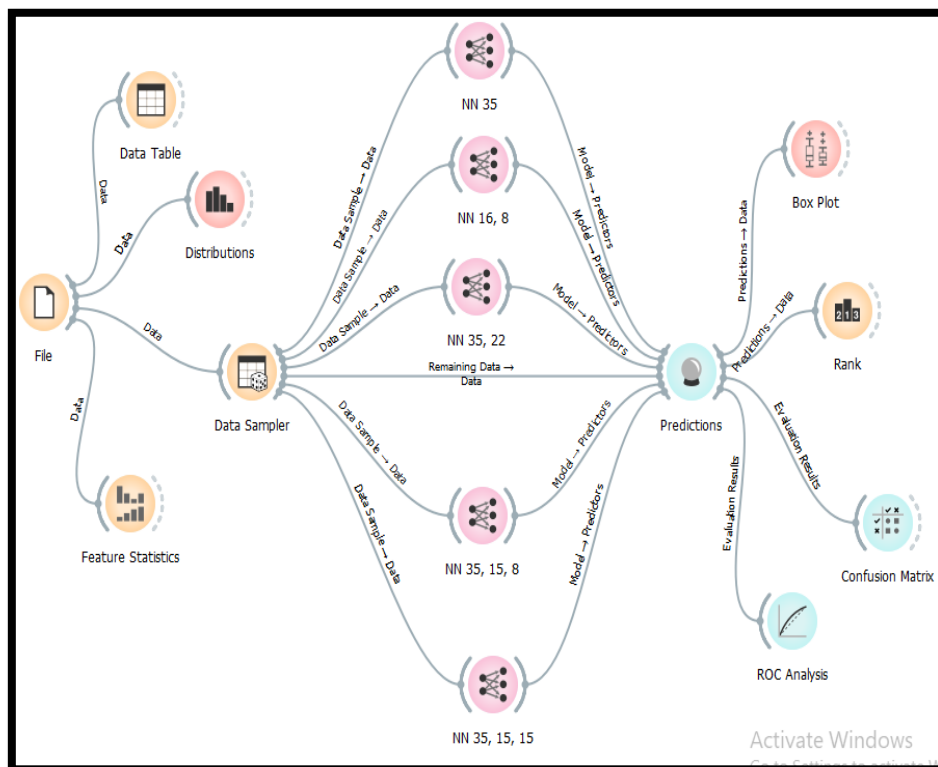


Figure 5: ANN model in Orange software.

The Relu activation function was used for both hidden layers as well as output layer. Adam is the optimizer used in the model. Optimizers generally used in neural network to change the attributes of the neural network such as weights and learning rate to reduce the losses. Optimizers are used to solve optimization problems by minimizing the loss function. The regularization parameter i.e. Lambda value kept as 0.01 for the model. To evaluate the model fit, classification accuracy and F1 score were parameters considered. Table 6 gives the results of multiple iterations carried out by changing hyperparameters of the model and best fit model results.

Table 6: Results of multiple iterations on ANN model.

Sl. No.	No. of neurons and hidden layers	Train/Test split (%)	No. of iterations (epochs)	Classification Accuracy	F1 score
1	30	70/30	100	0.58	0.50
2	30	70/30	200	0.59	0.52
3	30	80/20	200	0.57	0.49
4	35	70/30	100	0.65	0.53
5	35	70/30	200	0.66	0.55
6	35	80/20	200	0.62	0.53
7	16,8	70/30	100	0.65	0.55
8	16,8	70/30	200	0.59	0.55

9	16,8	80/20	200	0.5	0.50
10	35,22	70/30	100	0.64	0.55
11	35,22	70/30	200	0.64	0.56
12	35,22	80/20	200	0.63	0.50
13	35,15,8	70/30	100	0.64	0.38
14	35,15,8	70/30	200	0.68	0.61
15	35,15,8	80/20	200	0.62	0.50

Feature importance refers to techniques that assign a score to input features based on how useful they are at predicting a target variable. Its scores can be used directly to select features that are most useful to a predictive model. Feature importance helped to know the relative important features for direct output classifier. Following table 7 gives result of feature importance ranking. Some of the important factors influencing customer's satisfaction about online cab service are shown in figure 6.

Table 7: Feature importance analysis.

Sl. No.	Service Quality Attribute	Importance Score (%)
1	Safety inside cab	18.64
2	Driver informed about the delay or inability to deliver	17.03
3	Driver was consistently Courteous (Polite) with you	16.16
4	Cab arrived for you at desired pickup location without delay	14.24
5	Comfort & cleanliness inside the Cab	10.90
6	You reached destination in stipulated period using cab	9.26
7	Trust on driver when he/she choose an alternate route	8.57
8	Driver provided timely and efficient service for you	7.53
9	Driver drove vehicle safely, followed traffic rules	6.38
10	Visual appeal of cab (attractiveness)	5.24
11	Cab service is available for you 24*7	5.06
12	Cab didn't break down on the road	4.88
13	Driver's appearance was neat & well dressed	4.14
14	Driver was honest and righteous	3.72
15	Drier Didn't talked on phone while driving	2.51
16	Driver was never too busy to listen to your request	2.15
17	Driver showed genuine interest in solving problem	1.83
18	Driver had the knowledge to answer your questions	1.12

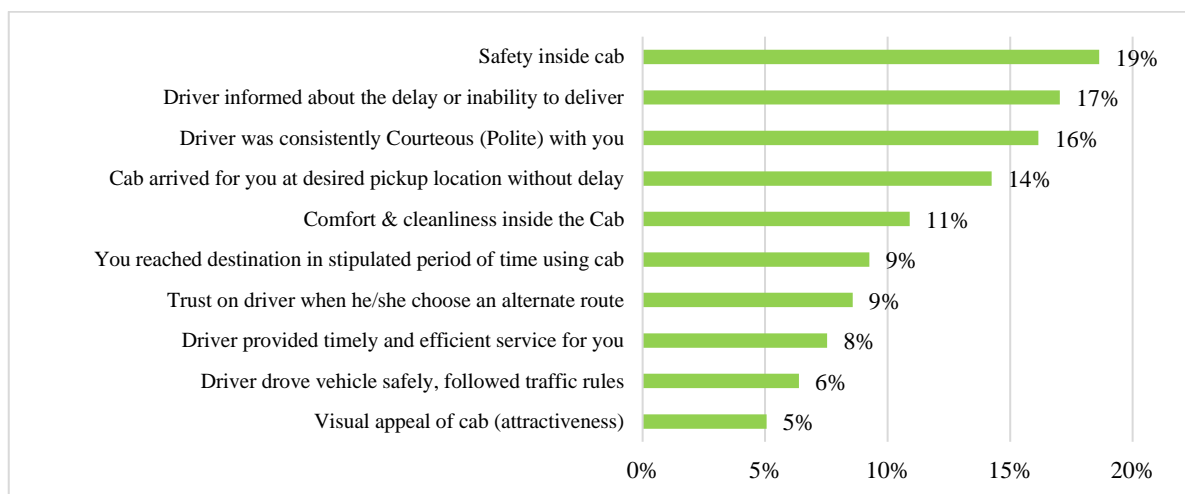


Figure 6: Important features from the prediction model.

8. Conclusions

To study the relationship of service quality attributes with overall satisfaction of the cab users, a web based survey was conducted in Tiruchirappalli and Pune city. SERVQUAL model was used to collect data related to five service quality dimensions Tangibility, Reliability, Responsiveness, Assurance and Empathy. Likert scale was used to analyze importance and satisfaction of each indicator of the service quality dimensions. Two modelling techniques, SEM and ANN were considered to analyse user's perception of the service quality of online cab service. The majority of the people go for cab service instead of other mode of transport for comfort and accessibility Majority of the people are facing issues related to ride cancellation by driver and its extra charges. From the IS rank it was understood that 'cab availability 24/7' is the most important factor that requires greater need of improvement followed by 'waiting time for cab arrival' and 'safety inside cab. 'Visual appeal of cab' and 'drivers appearance' are the factors least important to user and they are satisfied with it. From the bi-variate analysis it is understood that female cab users are less satisfied with safety while hailing a cab however the factor is equally important for both male and female. Results of ANN show that safety, waiting time, driver behavior, comfort cleanliness and trust on driver are some of the variables that have more influence on overall satisfaction of the cab user towards online cab service. Demographic data like age, gender and income have very less influence on overall satisfaction of user towards online cab service. Visual appearance of cab as well as of driver questions are some of the features which does not contribute to the overall satisfaction.

Travel characteristics of the customer e.g., O-D data, data related to various transit/para-transit facilities and their service quality, first mile/last mile connectivity facilities in the city which might contribute to the service quality of online cab service in a city etc. were not considered in the present study. Factors related to online cab booking facilities like coupon redemption, piece consciousness can be considered as a possibility for future studies.

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