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RANKING OF A PUBLIC SECTOR PASSENGER BUS TRANSPORT COMPANY USING PRINCIPAL COMPONENT ANALYSIS: A CASE STUDY

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Abstract
The public sector passenger transport has been crucial sector for transportation of people in developing countries like India. But there is less emphasis on customer expectations in this sector. This study aims at evaluating the customer expectations of this service sector in India. A questionnaire containing eighteen quality characteristics was administered to various customers of three bus depots of one division of a state road transport undertaking (SRTU) in south India. Two quality dimensions, viz. customer expectations and company responsibilities, are identified based on principal component analysis. The findings not only would help prioritise different parameters but also provide guidelines to managers to focus on or to improve. Finally three depots have been ranked.

Keywords: Performance measurement, madm, fuzzy topsis; fuzzy ahp, anova.

1.INTRODUCTION

In several Asian countries, the public sector occupies an important position in the economy. The public sector should strive to create customer value just as the private sector does (Rahman and Rahman, 2009). Over the last few years, companies have gradually focused on service quality and customer satisfaction. This strategy is very profitable for both companies and customers, particularly for transit agencies and passengers. An improvement in the service quality delivered will attract further users. This would resolve many problems such as helping to reduce traffic congestion, air and noise pollution, and energy consumption because individual transport would be used lesser (Eboli and Mazulla, 2007).

The development of techniques for customer satisfaction analysis is necessary as they allow the critical aspects of the supplied services to be identified and customer satisfaction to be increased (Cuomo, 2000). Bus is very popular sector of transportation in India because of its low cost and has made a great and significant contribution to the national economy. In India, the Association of State Road Transport Undertakings has 58 members, who form the backbone of mobility for urban and rural population across the

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country operating over 1,15,000 buses, serving more than 65 million passengers a day and also providing employment to 0.8 million people (ASTRU).

However as it is serving a large amount of passengers, the quality of service is the main concern issue. So understanding the customer expectations is of immense importance.

The measure of how products and services supplied by a company meet or surpass the customer's expectation is seen as a vital performance indicator. In a competitive marketplace where businesses compete for customers, it is seen as a key indicator that provides an indication of how successful the organization is at providing services. The level of expectation can also vary depending on other factors, such as other products against which they can compare the organization's products. The usual measures of getting this involve a survey with a set of statements using a Likert's scale (1 to 5). The customer is asked to evaluate each statement in terms of their perception and expectation of performance of the service being measured (Wikipedia). Initially when a customer survey is to be conducted a questionnaire has to be developed. The identification of parameters to be considered are to be listed. The various inputs could be obtained for the same through brainstorming, experience and thorough knowledge are vital for evolving an exhaustive and sufficient list of questions or parameters (Chidambaranathan et al., 2009). The experience and expertise of both the experts from the concerned sector or field and / or academicians would form a part such an exercise. The list of questions evolved may initially be administered to a group of customers to ascertain if all of the parameters are important or necessary. This could be done using a multivariate technique, factor analysis in particular principal component analysis which could help in this regard by way of data reduction. As a result of such data reduction one can concentrate on only the remaining and relevant criteria.

1.1. Introduction to Principal Component Analysis

Principal component analysis (PCA) is a standard tool used in modern data analysis - in diverse fields from neuroscience to computer graphics - because it is a simple, non-parametric method for extracting relevant information from confusing data sets. With minimal effort PCA provides a method to reduce a complex data set to a lower dimension to reveal the sometimes hidden, simplified structures that often underlie it (Jonathan, 2009). It is one of the most widely used multi-variate technique and popular ranking method which involves a mathematical procedure that transforms a number of correlated variables into a lesser number of uncorrelated variables called principal components (Alberto, 2000). Even though the objective of PCA may be to reduce the number of variables of a dataset it retains most of the original variability in the data. The first principal component accounts for as much of the data variability as possible and succeeding components account for as much of the remaining variability as possible (Hair et al., 2006).

The main objectives of the paper are to:

- Identify the customer characteristics for the public bus transport.
- Validate the factors responsible for service quality in the transport.
- Ranking of the depots of the bus company based on customer characteristic.

This paper is organised as follows: The literature review of factor analysis namely principal component analysis has been presented, followed by the case study where a discussion about the customer characteristics, its validation through PCA, and ranking of the depots are given. Then the results and discussion are presented and finally the conclusions drawn.

2. LITERATURE REVIEW

The following is a review of the literature on factor Analysis which has been carried out in the transport sector over the last few years. Rahaman and Rahaman (2009) focussed on the railway transportation sector to develop a model defining the relationship between overall satisfaction and twenty service-quality attributes. Using PCA they have found that overall satisfaction depended on eight service quality attributes. Kolanovic et al. (2008) have presented the methods of choosing the possible attributes affecting the perception of the port service quality. They have used PCA to reduce number of the port service quality attributes and were grouped in two dimensions of the port service quality: reliability and competence. Zoe, (2006) has conducted a study that attempts to contribute to the knowledge of how customer satisfaction, loyalty and commitment related to each other in the Greek context, based on responses collected from twenty service providers in four service sectors including transportation. Both factor and reliability analyses provided the relationship between customer loyalty and satisfaction as well as between commitment and customer loyalty. Ching-Chiao et al. (2009) have used PCA to identify crucial resources and logistics service capabilities in container shipping services. Furthermore, factor analysis was employed to identify the crucial logistics service capability in container shipping service firms. Lai (2010) explores the relationships between passenger behavioural intentions and the various factors that affect them in a new public transit company in Taiwan. The data analysis was conducted exploratory factor analyses using principal component with varimax rotation technique to examine construct dimensionalities of both public transport involvement and service quality. Chin-Shan (2007) has investigated the key factors that affect the adoption of internet services in the context of liner shipping services. PCA was used to reduce the twelve items to a three-factor solution. This is helpful for detecting the presence of meaningful patterns among the original variables and for extracting the main service factors. Pantouvakis (2010) conducted a study in Greece to assess the relative importance of various service-quality dimensions in explaining customer satisfaction and to examine whether this assessment is affected by the measurement instrument that is used. PCA has been used to find out the key or important service dimensions and factors that need more attention.

Apart from PCA the literature also reports that the confirmatory factor analysis (CFA) has been used in transport sector. Yu and Lee (2011) measured the relative influence of perceived service quality of low cost carrier airlines in South Korea on customer satisfaction; Laura and Jose (2007) have reported the customers' perceived service quality in urgent transport service; Chenga et al (2008) developed a model to investigate the important issues of airline relationship quality from the customer's perspective in Taiwan; and Changa and Chen (2007) studied customer loyalty (moving between carriers) for Taiwanese air travellers.

In all the above discussion on the factor analysis literature the focus has been on data reduction, grouping and identifying the key factors that need immediate attention for improvement in service quality, etc. In the present study, it is proposed to employ principal component analysis (PCA) to not only extract the principal components and group the (remaining) factors but also to rank the three depots.

3. RESEARCH METHODOLOGY: A CASE STUDY

In the case study a state road transport undertaking (SRTU) located in south India, operating passenger buses has been chosen. It is one of the leading public sector bus transport corporations generating consistent returns as well rendering excellent service over the years has a fleet strength of about 1350 buses. The present case study has been conducted in three bus depots of one division of the SRTU. There are various divisions such as Chennai, Villupuram, Kumbakonam, Salem, Coimbatore, Madurai, Villupuram. The present case study has been conducted in three bus depots of the Villupuram division. The fleet strength of these three depots is 98, 95 and 94 respectively. These depots each employ around 180 bus crew members, 30 maintenance staff, 10 managerial staff, and 15 -18 administrative staff. As far as the average number of passengers that travel every day is approximately one and a half lakh passengers for depot-I, around a lakh and twenty two thousand passengers for depot-II and less than one lakh passengers for depot-III.

The data was collected through a survey using a questionnaire developed by a group of three depot managers, transport officials of the SRTU and academicians through the brainstorming methodology. The questionnaire consists of a set of eighteen questions on the customer characteristics as shown in Table 1. The questionnaire was first used to enumerate the responses by 150 passengers through the interview method on these eighteen criteria through the interview method. They were asked to rate the same on a 1-5 Likert's scale (Very Good (5), Good (4), Fair (3), Poor (2), And Very Poor (1)).

Ahead of assessing the data collected, a reliability analysis is conducted, to find out the Cronbach's α value (min value of α is 0.7, Nunnally, (1978)), this will prove the reliability of the survey instrument. Subsequently based on the passenger responses received, principal component analysis (PCA) is to be employed to extract principal components (Eigen values >1). The Bartlett test of sphericity and the Kaiser-Meyer-Olkin measure of sampling were used to validate the use of PCA. The components with factor loadings greater

than 0.5 (Kannan, 2002) are extracted and the ones with values lesser than 0.5 are omitted. The resulting components would help in grouping the remaining criteria or service quality attributes.

TABLE 1 - CUSTOMER CHARACTERISTICS

Q.No	Criteria	Description
Q1	Bus punctuality	arrival of the buses as per timings
Q2	Stopping bus at correct place	bus stopping at the assigned bus stops
Q3	Backup service during breakdown	in case of breakdown is a spare or backup bus is provided
Q4	Seat comfort	the seats provide comfort for travel
Q5	Cleanliness	upkeep of the buses such as dusting, cleaning, etc.
Q6	Lighting & entertainment	provision of a lights, TV, radio/FM, DVD, etc.
Q7	Provision for luggage	whether the loft is provided or arrangement to put the luggage carried
Q8	New fleet addition	whether new buses are added periodically
Q9	Obey traffic rules	bus driver /crew following traffic signal, stop-lines, etc.
Q10	Seating for handicapped	are handicapped or physically challenged people provide separate seating
Q11	Seating for elderly	are aged & elderly people provide separate seating
Q12	First aid facility	whether first aid facility available in the bus
Q13	Driver behaviour	whether driver behaviour is kind or courteous
Q14	Conductor behaviour	whether conductor behaviour is kind or courteous
Q15	Information to passengers	adequate information about change of route, stops, schedule given to the passengers
Q16	Issue of proper ticket	whether conductor issues proper ticket
Q17	In time issue of ticket	whether conductor issues ticket immediately on boarding the bus
Q18	Issue of proper change	whether conductor issues proper change (correct amount) for the ticket taken

The components are then suitably named pertaining to the concerned grouped entities. A weighted measure is then calculated for each factor by multiplying the loadings of each component by the percentage of variance explained by that component. Then the mean value of each criteria is multiplied by the corresponding weight and a summation of all these would give the score for the corresponding depot. After the scores of all the depots have been calculated a ranking of them can be arrived. Thus the best performing depot could be identified. The flow chart for the research methodology is presented in Figure 1.

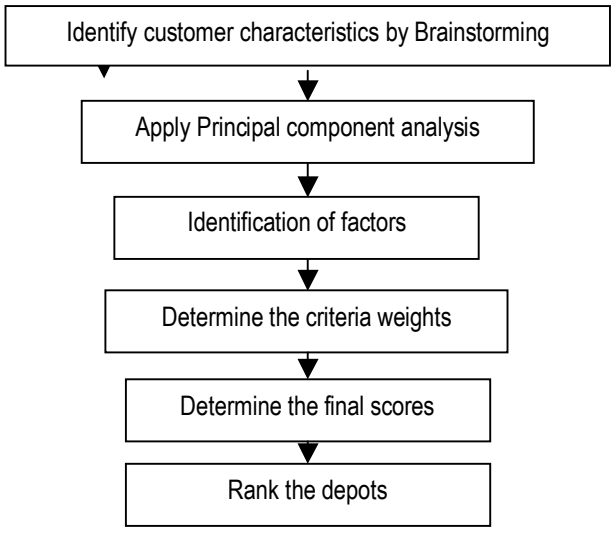

FIGURE 1 FLOW CHART FOR THE PRINCIPAL COMPONENT ANALYSIS (PCA)

4. RESULTS AND DISCUSSION

Generally, it only makes sense to use principal component analysis when the data are not independent. A method of determining appropriateness of factor analysis is Bartlett test of sphericity. The Bartlett test of sphericity had returned a value of χ^2 (153) = 4823 and the Kaiser-Meyer-Olkin test of sphericity has a KMO index value of 0.953 (greater than 0.5, Hair et al., 2006). The significance value for the same (.000) was less than 0.001, hence significant and validates the use of PCA.

Then based on the received responses, PCA has been employed to extracted two components with Eigen values > 1. These two components accounted for a total variance of 58.73%. This can be observed in Table 2 and the same be seen in the scree plot. Scree plot is a plot of Eigen values against the number of factors in the order of extraction is shown in Figure 2. In the scree plot we look for an "elbow" in the curve – that is, a point after which the remaining Eigen values decline in approximately linear fashion – and retain only those two components that are above the elbow.

From the analysis all the factor loadings were greater than 0.5 (Kannan, 2002) and all the eighteen sub-criteria are therefore significant. The two components extracted with Eigen values > 1, have been designated as customer expectations and company responsibilities as seen in Table 2. Customer expectations are the factors which gives details of the facilities that the passengers expect inside the bus to make the journey comfortable. Company responsibilities are the factors which gives details of what responsibilities the passengers expect of the bus company.

It is desirable to reorient the factor solution so that the factor loadings matrix exhibits something close to simple structure so that the factors are easier to interpret. The factor solution is oriented through a process called rotation. In this case study varimax rotation – most popular orthogonal factor rotation method is used, which tries to achieve simple structure by focusing on the columns of the factor loading matrix and is given in Table 3 (Hair et al., 2006; Lattin et al., 2003). Communality which is the total amount of variance a variable shares with all other variables being considered. The communalities may be viewed as whether the variables meet acceptable levels of explanation. A small communality figure shows that the factors taken together do not account for the variable to an appreciable extent. On the contrary, large communality figure is an indication that much of the variable is accounted for by the factors. The communality value should be greater than 0.5 (Hair et al., 2006). All the eighteen communality values were greater than 0.5 and so significant for further study.

The customer expectations factors includes bus punctuality (C_{11}), seat comfort (C_{12}), cleanliness (C_{13}), lighting & entertainment (C_{14}), new fleet addition (C_{15}), seating for handicapped (C_{16}), seating for elderly (C_{17}), issue of proper ticket (C_{18}), in-time issue of ticket (C_{19}), and issue of proper change (C_{110}) as shown in

Table 4. Earlier in the analysis these factors were known by Q1, Q4, Q5, Q6, Q8, Q10, Q11, Q16, Q17 and Q18 respectively as in Table 1.

The company responsibilities factors includes stopping the bus at correct place (C_{21}), backup service during breakdown (C_{22}), provision for luggage (C_{23}), obey traffic rules (C_{24}), first aid facilities (C_{25}), driver behaviour (C_{26}), conductor behaviour (C_{27}) and information to passengers (C_{28}) as shown in Table 4. Earlier in the analysis these factors were known by Q2, Q3, Q7, Q9, Q12, Q13, Q14 and Q15 respectively as in Table 1.

As all the eighteen variables are considered, a coefficient or weight, w_i (i = 1 to 18) is obtained by multiplying the loadings in Table 3 on each component by the percentage of variance as seen in Table 2, explained by the component. Each weight is then multiplied by the mean value (Table 4) of the respective criteria for each depot. These are then summed up to get the corresponding depot scores. Score = $\sum W_i * M_i$, Where, i = 1 to 18 and M_i – the mean value of each criteria. Based on the scores, the final ranking is obtained and presented in Table 5.

TABLE 2 - TOTAL VARIANCE EXPLAINED BY THE COMPONENTS

Component	Total	% Variance	Cumulative %
1	5.882	32.677	32.677
2	4.690	26.057	58.734

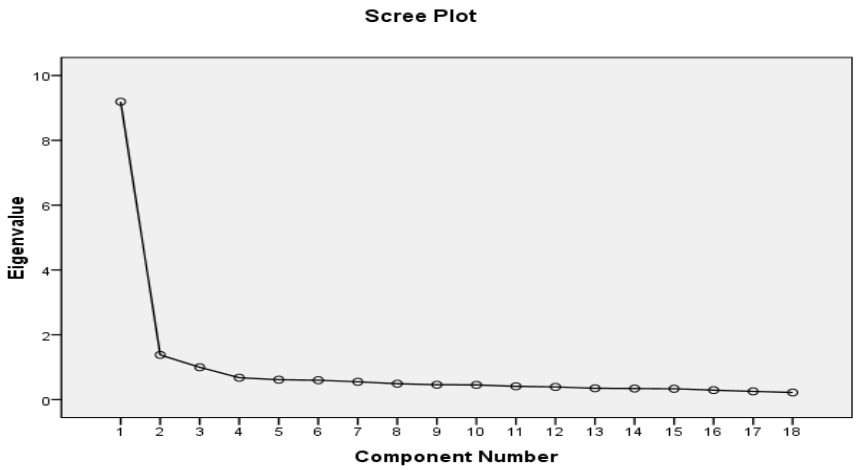

FIGURE 2 - EIGEN VALUE SCREE PLOT

TABLE 3 - PRINCIPAL COMPONENT ANALYSIS WITH VARIMAX ROTATION

Q.No.	Communalities	Rotated component matrix	
		Component-1	Component-2
Q1	0.640	0.737	
Q2	0.520		0.682
Q3	0.587		0.667
Q4	0.661	0.724	
Q5	0.692	0.820	
Q6	0.603	0.737	

Q.No.	Communalities	Rotated component matrix	
		Component-1	Component-2
Q7	0.539		0.585
Q8	0.692	0.779	
Q9	0.508		0.564
Q10	0.645	0.731	
Q11	0.623	0.746	
Q12	0.501		0.683
Q13	0.510		0.702
Q14	0.512		0.635
Q15	0.502		0.648
Q16	0.546	0.558	
Q17	0.633	0.571	0.554
Q18	0.672	0.668	

TABLE 4 - GROUPING OF FACTORS (SUB-CRITERIA) UNDER THE TWO COMPONENTS (CRITERIA) WITH THEIR WEIGHTS AND THE MEAN VALUES FOR THE THREE DEPOTS.

Criteria	Sub-Criteria	Mean values			Weights
		Depot-1	Depot-2	Depot-3	
Customer expectations	Bus punctuality (C_{11})	4.00	3.11	2.57	0.241
	Seat comfort (C_{12})	4.15	3.36	2.51	0.237
	Cleanliness (C_{13})	4.41	3.37	2.48	0.268
	Lighting & entertainment (C_{14})	4.35	3.41	2.50	0.241
	New fleet addition (C_{15})	4.13	2.95	2.50	0.255
	Seating for handicapped (C_{16})	4.09	3.11	2.41	0.239
	Seating for elderly (C_{17})	3.94	2.83	2.45	0.245
	Issue of proper ticket (C_{18})	3.85	3.49	2.45	0.182
	In time issue of ticket (C_{19})	3.73	3.29	2.39	0.331
	Issue of proper change (C_{110})	3.77	3.18	2.41	0.218
Company responsibilities	Stopping bus at correct place (C_{21})	3.30	3.43	2.50	0.178
	Backup service during breakdown (C_{22})	3.53	3.62	2.50	0.174
	Provision for luggage (C_{23})	3.44	3.46	2.51	0.153
	Obey traffic rules (C_{24})	3.45	3.33	2.50	0.147
	First aid facility (C_{25})	2.77	2.77	2.43	0.178
	Driver behaviour (C_{26})	3.21	3.31	2.56	0.183
	Conductor behaviour (C_{27})	3.50	3.23	2.42	0.166
	Information to passengers (C_{28})	3.56	3.70	2.41	0.169

TABLE 5 - RANKING OF THE DEPOTS

Depot	Scores	Ranking
Depot-I	14.43	1
Depot-II	12.40	2
Depot-III	9.40	3

5. CONCLUSIONS

This paper has presented a multi-criteria approach based on principal component analysis for a public sector bus transport company in south India, aimed at helping the company management to formulate their strategies. In today's world the thrust being privatisation of government owned sectors; particularly the public sector bus companies in India face stiff competition from the private sector. Hence it becomes increasingly relevant that they formulate policies and strategy to suit the needs of the situation. Thus this present study becomes relevant in getting to know the customers' or passengers' perspective of the quality of service rendered.

Here eighteen service criteria that were taken up for study as customer characteristics have all been found significant for further analysis by the PCA. Then the weights have been calculated and the depot scores calculated as 14.43, 12.40 and 9.40 for the depots-I, II and III respectively. This shows that depot-I, is the best performing depot (according to the passengers), depot-II is medium performing and depot-III is the worst. It shows that that depot-III needs immediate attention on all the criteria for improvement.

The managerial implication of this methodology is that it has given a clear insight into the customer preferences and perspective. The eighteen criteria enlisted in this work have found importance from the passengers i.e., to the facilities and comfort as well as the responsibilities which the company ought to take up. This gives a clear indicator to the management that it needs to come up with action plans both short term (within 3 months) and long term (geater than 3months and less than 2years) to meet the expectations of customers. If the customers' feedback is appropriately acted upon, in turn it may be a customer retention strategy (short-term benefit) and will bring in more customers to patronise the transport in future, i.e., customer development strategy (long-term benefit).

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