MODELING PASSENGERS' PERCEPTIONS OF PUBLIC TRANSPORTATION QUALITY

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Abstract - Public transportation is an urban service that provides important aspects in developing socially, environmentally and economically sustainable communities. Achieving positive levels of passenger satisfaction has been areal challenge for the Taipei Mass Rapid Transit (MRT) Authority after the Taoyuan Airport MRT line entered service after March, 2017. This study forms a model for the measurement of passengers' satisfaction, and it has identified two of the most important attributes as being tangibles. These attributes are convenient access and information availability related to safety, cleanliness, outstanding facilities, and convenient reference information related to food and shopping around the station. This model can be used to measure satisfaction levels with other similar public transport service satisfaction and serve as a planning reference for future improvement. Likewise, it is hoped that this model will provide a cost-effective solution useful in achieving levels of higher passenger satisfaction and better planning of funding allocation.

Keywords - Passengers' perceptions, Public transportation quality, Fuzzy theory.

I. INTRODUCTION

Taipei's public transport system is comprised of an extensive bus network and inter-connected metro-subway system. Taipei Mass Rapid Transit (MRT) is widely used, and it is Taiwan's largestmetro-subway system serving 2 million riders daily. Recently, the Taoyuan Airport MRT has joined service as a large scale component of the overall system (H.-T. Chen, Tsutsumi, Yamasaki, & Iwakami, 2013). The Taoyuan MRT line isexpected to offer fast and convenient service for international travelers to commute between the airport and downtown Taipeisince March 2017. Such urban public transportation serviceis regarded as anintegral aspect in the development of socially, environmentally and economically sustainable communities(van Lierop, Badami, & El-Geneidy, 2018).The mechanisms needed to prioritize investments for improvement of Public transportation (PT) authoritiesare required not only to retain existing customers, but also to attract new ridership. Consequently, effective satisfaction surveys allow PT systems to determine global satisfaction levels according to their different attributes. More importantly, an appropriate framework is necessary to measure passenger satisfaction because differences in the importance of the various attributes of PT systemsoften depends on the transportation mode at once associated with it and with the urban area in which the system operates (Allen, Muñoz, & de Dios Ortúzar, 2019).

The purpose of this study is to identify which attributes are of importance to passenger satisfaction. Elevenattributeswere identified for use in measuring the satisfaction levels of Taipei MRT users. These attributes are as follows:Staff performance, staff ability, tangibles, ambience, decor & design, entertainment, souvenirs, pleasant ride, waiting time, convenient access, and information. These attributes were described inWu, Cheng, and Ai (2018).Pastliterature was adopted and referred toin the development of the survey instrument.The next section of this study includes a brief literature review and amethodological description.Then, results of the framework are shown with the final section being a conclusion.

II. LITERATURE REVIEW

Certain factors affecting users in their choice of whether or not to take PT systems, satisfaction and retention rates,were investigated by the researchers. In order to meet the exacting requirements of potential and existing customers, improvement of the perceived service quality becomes an important issue(Friman & Fellesson, 2009).Public transportation system quality is influenced by numerous factors includingcomfort, safety, the time taken, convenience and support infrastructure(Cirillo, Eboli, & Mazzulla, 2011).

The literature reported that the importance of PT system attributes depends on the mode of transport associated with it and the city in which the system operated (Allen et al., 2019).Dell'Olio, Ibeas, and Cecin (2011) concluded that waiting time, cleanliness and comfort proved to be the most value attributes by the PT users inSantander, Spain.Mouwen (2015)foundDutch PT usersbelieved the most important qualitative service attributes were being ontime, travel speed and service frequency were best to measure users' satisfaction. According toCirillo's et al. (2011) analysis, overall reliability and on-time service were the key factors affecting PT users satisfaction in Southern Italy.Fellesson and Friman (2012) compared perceived service satisfaction with public transport in 8 European countries and identified 4 satisfaction dimensions, i.e., system, comfort, employee, and safety, but not for all cities. Aydin, Celik, and Gumus (2015) confirmed 6 important

criteria useful to evaluate PT users' satisfaction in Istanbul, Turkey: Waiting time for the Metro before departure, personal safety at Metro stations, access to Metro stations, level of crowdedness and density on the trains, and service provided by the IUAS (Istanbul Transportation Corporation)-journey time phone hotline.

In addition, according to the results, the 6 least important sub-criteria were considered to be smooth function of the tollgates, the use of modern equipment within the train service area, ticket vending machine/service, station comfort, announcements made during and after breakdown of escalators, elevators and belt conveyors. Wu et al. (2018) provided 11 dimensionsfor measuring PT quality in Hong Kong:Staff performance, staff ability, tangibles, ambience, decor & design, entertainment, souvenir, pleasant ride, waiting time, convenient access, and general information.

The findings showed pleasant ride and waiting times were the most important dimensions related to the perceived quality of PT.According to reviews, different cities have different emphasis factors pertaining topublic perception of quality public transportation.

III. METHOD

To explore the significant factors which affect PT users' satisfaction, this study collected data from Taipei MRT users in Taiwan via an online survey, with 148 valid questionnaires in total. Thissurvey was conducted as auser self-administered questionnaire to measure the importance of the 59factorsaccording to a 7-point Likert-type scale ranging from "1" (extremely important) to "7" (not important at all). Datawere then analyzed by means of appliedfuzzy set theory. The fuzzy linguistic terms used for rating purposes are defined in Table 1.Further, Figure 1 shows the membership functions of the linguistic terms in use.

Zadeh (1965) first proposed the fuzzy set theory which is deemed appropriate to deal with information related to uncertainty and inaccuracy within given parameters (Yalcin, Bayrakdaroglu, & Kahraman, 2012). Fuzzy set theory regards vague data as a possible distribution of membership within a set. Once identified and defined, the set of members in the likelihood distribution can be effectively used for logical reasoning purposes.
According to the definition given byLaarhoven and Pedrycz (1983), a triangular fuzzy number (TFN) is one of the major components, and it should have the following basic features(Wang & Chen, 2008) (see below).

Definition 1

If the membership function $\mu_{\tilde{A}}(x):\Re \to [0,1]$ of a fuzzy number A on $\Re$ isequal to

$$\mu_{\tilde{A}}(x)=\begin{cases}(x-l)/(m-l), & l\le x\le m\\ (u-x)/(u-m), & m\le x\le u\\ o, otherwise\end{cases} \quad (1)$$

Wherein l and u indicate the lower and upper limits of the fuzzy number $\tilde{A}$ denoted as $\tilde{A}=(l,m,u)$, m represent the median value. The operational law of two TFNs $\tilde{A}_1=(l_1,m_1,u_1)$, $\tilde{A}_2=(l_2,m_2,u_2)$ shown as follows.

Fuzzy number addition $\oplus$:

$$\begin{aligned}\tilde{A}_1\oplus\tilde{A}_2&=(l_1,m_1,u_1)\oplus(l_2,m_2,u_2)\\&=(l_1,m_1,u_1+l_2,m_2,u_2)\end{aligned} \quad (2)$$

Fuzzy number subtraction $\ominus$:

$$\begin{aligned}\tilde{A}_1\ominus\tilde{A}_2&=(l_1,m_1,u_1)\ominus(l_2,m_2,u_2)\\&=(l_1-u_2,m_1-m_2,u_1-l_2)\end{aligned} \quad (3)$$

Fuzzy number multiplication $\otimes$:

$$\begin{aligned}\tilde{A}_1\otimes\tilde{A}_2&=(l_1,m_1,u_1)\otimes(l_2,m_2,u_2)\\&\cong(l_1\times l_2,m_1\times m_2,u_1\times u_2)\end{aligned} \quad (4)$$
$$l_i>0,\ \ m_i>0,\ \ u_i>0,\ i=1,2$$

Fuzzy number division Æ:

$$\begin{aligned}\tilde{A}_1Æ\tilde{A}_2&=(l_1,m_1,u_1)Æ(l_2,m_2,u_2)\\&\cong(l_1/u_2,m_1/m_2,u_1/l_2)\end{aligned} \quad (5)$$
$$l_i>0,\ \ m_i>0,\ \ u_i>0,\ i=1,2$$

The results of equation (4)-(5) are not TFNs; however, the results can be approximated TFNs (Wang & Chen, 2008).

Linguistic terms	Code	Triangular fuzzy number
Extreme non-importance	ENI	(0,1.5,1.5)
Not important	NI	(0.5,1.5,2.5)
Slightly not important	SNI	(1.5,2.5,3.5)
Neutral	NE	(2.5,3.5,4.5)
Slightly important	SI	(3.5,4.5,5.5)
Important	IM	(4.5,5.5,6.5)
Extremely important	EI	(5.5,7,7)

Table 1.Fuzzy linguistic measurement terms

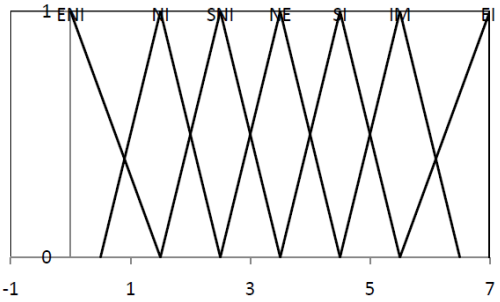


Figure 1. Membership functions of linguistic terms

The defuzzification method applied in this study was applied by maximizing set and minimizing set methods(S.-H. Chen, 1985), then ranking all of the alternatives' evaluation values so as to best select evaluation results.

Maximizing Set $R = \{(x, f_R(x)) | x \in R\}$ and

$$f_R(x) = \begin{cases} (x - x_1)/(x_2 - x_1), x_1 \le x \le x_2 \\ 0 \ , \ otherwise \end{cases} \quad (8)$$

Minimizing Set $L = \{(x, f_L(x)) | x \in R\}$ and

$$f_L(x) = \begin{cases} (x - x_2)/(x_1 - x_2), x_1 \le x \le x_2 \\ 0 \ , \ otherwise \end{cases}$$

Right Utility

$$U_R(\bar{f}^+(i)) = \sup_x (f_{\bar{f}^{(i)}}(x) \cap f_R(x)) \quad (10)$$

Left Utility

$$U_L(\bar{f}^+(i)) = \sup_x (f_{\bar{f}^{(i)}}(x) \cap f_L(x)) \quad (11)$$

IV. EXPERIMENTAL RESULTS

The dimensions related to each item and the value after defuzzification are providedin Table 2. Results showed that the top 3 attributes (consisting of10 items) affecting MRT users' satisfaction are tangibles, convenient access, and information.

Attribute	Item	Value	Rank
Tangibles	Taipei Mass Rapid Transit is very safe and reliable.	0.8299	1
Tangibles	The carriage is clean and neat.	0.8054	2
Tangibles	The station is clean and neat	0.7992	3
Tangibles	Taipei MRT has an outstanding facility.	0.7825	4
Convenient access	There are convenient for food and shopping around the station.	0.7613	5
Convenient access	Finding ways to get to the MRT station is not a difficult process.	0.7556	6
Tangibles	The signpostsarequite clear.	0.7537	7
Convenient access	I experienced no problems in getting to the MRT station.	0.7453	8
Information	I can count on the information that Taipei the MRT provides.	0.7446	9
Tangibles	There are noticeable facilities for safety in the station.	0.7426	10

Table 2. Ranking of influence attributes on Taipei MRT user satisfaction

V. CONCLUSION

Owing to the completion of the Taoyuan Airport MRT, a large-scale transportation project commenced to offer international travelers with fast and convenient service while commuting between the Taoyuan Airport and downtown Taipei in March, 2017, this study developed an appropriate framework to measure the overall service satisfaction of Taipei MRT users. Results suggested the 3 most important attributes are considered to be tangibles, convenient access, and information.Passengers cared most about safety, cleanliness, outstanding facilities, information and the convenient access to food and shopping around the MRT station. The framework obtained by analyzing passenger response can be used to measure other similar public transport service satisfaction along with being used to reference improvement plans.It will provide a cost-effective solution leading to achievable higher passenger satisfaction and better planning necessary for funding allocation.

REFERENCE

[1] https://guidetotaipei.com/article/taipei-mrt-rapid-transit-subway- %E5%8F%B0%E5%8C%97%E6%8D%B7%E9%81%8B

[2] Allen, J., Muñoz, J. C., & de Dios Ortúzar, J. (2019). Understanding Public Transport Satisfaction: Using Maslow's Hierarchy of (Transit) Needs. Transport policy. doi:https://doi.org/10.1016/j.tranpol.2019.06.005

[3] Aydin, N., Celik, E., & Gumus, A. T. (2015). A hierarchical customer satisfaction framework for evaluating rail transit systems of Istanbul. Transportation Research Part A: Policy and Practice, 77, 61-81.

[4] Chen, H.-T., Tsutsumi, M., Yamasaki, K., & Iwakami, K.

(2013). An Impact Analysis of the Taiwan Taoyuan International Airport Access MRT System—Considering the interaction between land use and transportation behavior. Journal of the Eastern Asia Society for Transportation Studies, 10, 315-334.

[5] Chen, S.-H. (1985). Ranking fuzzy numbers with maximizing set and minimizing set. Fuzzy sets and Systems, 17(2), 113-129.

[6] Cirillo, C., Eboli, L., & Mazzulla, G. (2011). On the asymmetric user perception of transit service quality. International Journal of Sustainable Transportation, 5(4), 216-232.

[7] Dell'Olio, L., Ibeas, A., & Cecin, P. (2011). The quality of service desired by public transport users. Transport policy, 18(1), 217-227.

[8] Fellesson, M., & Friman, M. (2012). Perceived satisfaction with public transport service in nine European cities. Paper presented at the Journal of the Transportation Research Forum.

[9] Friman, M., & Fellesson, M. (2009). Service supply and customer satisfaction in public transportation: The quality paradox. Journal of Public transportation, 12(4), 4.

[10] Laarhoven, P., & Pedrycz, W. (1983). A fuzzy extension of Saaty's priority theory, Fuzzy Sets and Systems. Fuzzy sets and Systems, 11, 1-3.

[11] Mouwen, A. (2015). Drivers of customer satisfaction with public transport services. Transportation Research Part A: Policy and Practice, 78, 1-20.

[12] van Lierop, D., Badami, M. G., & El-Geneidy, A. M. (2018). What influences satisfaction and loyalty in public transport? A review of the literature. Transport Reviews, 38(1), 52-72.

[13] Wang, T.-C., & Chen, Y.-H. (2008). Applying fuzzy linguistic preference relations to the improvement of consistency of fuzzy AHP. Information Sciences, 178(19), 3755-3765.

[14] Wu, H.-C., Cheng, C.-C., & Ai, C.-H. (2018). A study of experiential quality, experiential value, trust, corporate reputation, experiential satisfaction and behavioral intentions for cruise tourists: The case of Hong Kong. Tourism Management, 66, 200-220.

[15] Yalcin, N., Bayrakdaroglu, A., & Kahraman, C. (2012). Application of fuzzy multi-criteria decision making methods for financial performance evaluation of Turkish manufacturing industries. Expert Systems with Applications, 39(1), 350-364.

[16] Zadeh, L. A. (1965). Fuzzy sets. Information and control, 8(3), 338-353.

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