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Preference heterogeneity towards the importance of transfer facility attributes at metro stations in Kolkata

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ABSTRACT

The present study reports an investigation on the effects of socioeconomic and trip characteristics of metro commuters on their perceived importance towards transfer facility attributes with reference to Kolkata city in India. A five-point Likert-type ordinal scale rating survey was designed to collect responses along with socioeconomic and trip characteristics by intercepting metro commuters. The database was analysed using Mann-Whitney *U* test and Wilcoxon W test to investigate the effects of socioeconomic and trip characteristic of commuters on their perceived importance towards transfer facility attributes. Relative to an Identified Distribution Integral Transformation (RIDIT) analysis was performed to derive the rankings of transfer facility attributes as perceived by different commuter groups based on 'trip rate', 'gender', and 'car ownership'. Heterogeneity found in perceived importance and derived rankings of transfer facility attributes with respect to the 'trip rate' of the metro commuters, and between 'captive riders' and 'choice riders' while no such variation is observed between 'male' and 'female' commuters. The findings of the present study will primarily help the policy makers and facilities planners to formulate improvement strategies for transfer facilities at metro stations giving due consideration to the requirements of different commuter groups based on their socioeconomic and trip characteristics.

1. Introduction

The rising urban population of developing countries such as India is employing in various economic activities particularly in rapidly growing cities, which in turn, are escalating the urban travel demand day by day (MHA, 2011; MoRTH, 2013). Considering the growing travel demand and limited scope of road capacity augmentation in urban areas, the emphasis has been given on the improvement of public transportation systems through policies and actions (MoUD, 2014). In this context, metro rail has emerged as an efficient mean of public transport to serve commuters' need of mobility. The metro rail also contributes to the reduction of untoward environmental effects and boost up the economic growth (Maitra and Sadhukhan, 2013; MGI, 2010). At present in India, the metro rail system is operational in Kolkata, Delhi, Bengaluru, and Mumbai and several other cities such as Hyderabad, Jaipur, Kochi, Patna, etc. are also opting for the same shortly. So as to account the increasing urban trips, the metro rail system is improving with a larger network, higher frequency of service, and greater onboard comfort.

In order to make the metro rail system successful, it is required to develop appropriate transfer facilities at metro stations as the metro rail does not provide 'door-to-door' service to commuters. The usefulness of 'transfer facilities' has been mentioned in the *Station Area Access Planning Manual* prepared by Washington Metropolitan Area Transit Authority (WMATA, 2008). The relevance of incorporating improved transfer facilities within station access areas for the users has also been stated in a publication of Transportation Research Board (TRB, 2012). The importance of 'transfer facilities' inside and outside public stations has also been emphasized by several researchers (Alshalalfah and Shalaby, 2007; Brons et al., 2009; Dell'Olio et al., 2011; Krygsman et al., 2004; Liao et al., 2013; Zhao and Deng, 2014). While the importance of transfer facilities are duly acknowledged in the developed countries, adequate attention has not been given on the same in the developing countries. The fare of public transport, in general, is considered as the most important parameter in developing countries, and due attention is not given to the development of allied facilities such as transfer

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facilities at metro stations (Maitra and Sadhukhan, 2013; Sadhukhan et al., 2017).

A recent study by Sadhukhan et al. (2014) highlighted the importance of various transfer facility attributes from commuters' point of views. However, in Indian megacities, there is substantial variation or heterogeneity in socioeconomic and trip characteristics of metro commuters. The effects of socioeconomic and trip characteristics of users are found significant in the contexts of selecting goods or services (Barabino and Deiana, 2013; Jim and Shan, 2013; Sadhukhan et al., 2016), valuation of travel time (Bai et al., 2012), perception towards corporate conduct (Calabrese et al., 2016), transit service quality (Cirillo et al., 2011; Morton et al., 2016), and transport mode choice (Beirão and Cabral, 2007). As the preference heterogeneity is observed in selection or perceived importance of any facilities or services, and influenced by socio-demographic characteristics of the users, it is thereby, important to understand the user specific requirements to design these facilities or services. Therefore, in the present work, an attempt was made to investigate the effects of socioeconomic and trip characteristics of commuters on their perceived importance towards transfer facility attributes to understand the requirements of different groups of commuter towards these facilities. The approach of the present study is demonstrated with reference to Kolkata city in India.

With a view to carry out the study, a paper-pencil based five-point Likert-type ordinal scale (Likert, 1932) rating survey was designed, and responses were collected by intercepting metro commuters related to their perceived importance of transfer facility attributes at metro stations. During the survey, the socioeconomic and trip-related information of the respondents were also recorded. The data were coded suitably and analysed using several non-parametric tests such as Mann-Whitney *U* test and Wilcoxon W test to check the effects of socioeconomic and trip characteristics upon the ratings of transfer facility attributes across different commuters groups. Finally, Relative to an Identified Distribution Integral Transformation (RIDIT) analysis was performed to derive the rankings of transfer facility attributes as perceived by different groups of commuter.

The remaining contents of the manuscript are organised into four sections. Theoretical backgrounds, statistical techniques relevant to the present work are described in Section 2. Section 3 includes the description of the survey procedure and the database. The findings from the data analysis are reported in Section 4 whereas the major conclusions drawn from the present study are briefed in Section 5.

2. Theoretical background

The present work was intended to capture metro commuters' preference heterogeneity in terms the perceived importance of transfer facility attributes at metro stations across different commuter groups based on socioeconomic and trip characteristics. Accordingly, a suitable rating survey instrument was designed; rating data along with socioeconomic and trip characteristics related information were collected from metro commuters, and the database was analysed using appropriate statistical methods. The type of data and the statistical methods employed in the present study are briefly discussed in following sub-sections.

2.1. Type of data

Likert-type ordinal scale (Likert, 1932) is a type of ordinal level of measurement where, the response categories persist a rank order, but that does not support the assumption of equal values between intervals like for the interval scale or continuous scale (Jamieson, 2004; Shah and Madden, 2004). Therefore, reporting means or standard deviations of ordinal data (i.e. Likert-type scale rating data) are inappropriate (Sheskin 2003). As mean and standard deviation of ordinal data are not inferential or interpretable, parametric tests like One-way analysis of variance (ANOVA), Independent *t*-test, F-test etc. may not be performed to measure the difference in means (if any) among the groups of categorical independent variable (Jamieson, 2004; Kothari, 2004). In order to analyse Likert-type ordinal scale data, median or mode as the measure of central tendency is found to be appropriate (Gibbons and Chakraborti, 2003). In order to compare categorical distributions or median values between independent groups of Liker-type ordinal scale data, several non-parametric tests such as Kruskal-Wallis H test, Chi-Squared test, Wilcoxon W test, Mann-Whitney *U* test, etc. have widely been used in the literature (Sheskin, 2003). However, the criteria of these non-parametric tests differ as per their uses in ordinal rating data analysis (Siegel, 1957). The Kruskal-Wallis H test is a popular non-parametric rank-based statistical test equivalent of the one-way ANOVA (Kothari, 2004; Kruskal and Wallis, 1952; Sheskin, 2003). The Kruskal-Wallis H test is used to measure if there are differences on some variable of interest or not among three or more independent groups of a categorical independent variable (Chan and Walmsley, 1997; Sheskin, 2003). When two independent groups are taken into consideration for a categorical independent variable, the Wilcoxon W test and the Mann-Whitney *U* test are found to be appropriate. In the present study, Mann-Whitney *U* test and Wilcoxon W test were performed that worked with the ranks of the observations among the groups of the categorical independent variable rather than the actual observations themselves. Although, the theoretical formulation of Mann-Whitney *U* test and Wilcoxon W test have been well documented in the literature, brief outlines of the same are stated the following sub-sections in the context of the present work (Gibbons and Chakraborti, 2003; Kothari, 2004; Mann and Whitney, 1947).

2.2. Mann-Whitney U test

Step 1: Compute the rank of all the scores irrespective of their groups. (i) The lowest score should be given lowest rank. (ii) In the case of 'tie' between two or more scores, the average of the ranks that they would have obtained should be assigned.

Step 2a: Add up all the ranks of Group 1 (T_1)

Step 2b: Add up all the ranks of Group 2 (T_2)

Step 3: Take the larger value among T_1 and T_2 and consider as T_X

$$T_x = \max\{T_1,\ T_2\} \tag{1}$$

Step 4: Calculate N_1 (Number of respondents provide rank total T_1), N_2 (Number of respondents provide rank total T_2) and N_x (Number of respondents provide rank total T_x)

Step 5: Compute the Mann-Whitney *U* test Statistics as follows

$$U = (N_1 * N_2) + \frac{1}{2}[N_x * (N_x + 1)] - T_x \tag{2}$$

Step 6: Assess the significance of Mann-Whitney *U* test based on the critical value of U. The U is statistically significant if it is equal to or less than the critical U value for a two-tailed test at given significance level (say 0.05).

The hypotheses for the test statistics may be formulated as follows

H_0 = There is no difference in the perception between groups towards importance of transfer facility attributes, and H_1 = There is significant difference in the perception between groups towards importance of transfer facility attributes.