Transportation Research Part A 92 (2016) 43–58

Contents lists available at ScienceDirect

Transportation Research Part A

journal homepage: www.elsevier.com/locate/tra

Commuters' willingness-to-pay for improvement of transfer facilities in and around metro stations – A case study in Kolkata

Shubhajit Sadhukhan [a], Uttam K. Banerjee [b], Bhargab Maitra [c,*]

[a] RCG School of Infrastructure Design and Management, Indian Institute of Technology Kharagpur, Kharagpur 721302, India
[b] Department of Architecture and Regional Planning, Indian Institute of Technology Kharagpur, Kharagpur 721302, India
[c] Department of Civil Engineering, Indian Institute of Technology Kharagpur, Kharagpur 721302, India

ARTICLE INFO

Article history:
Received 8 October 2014
Received in revised form 24 May 2016
Accepted 11 July 2016
Available online 27 July 2016

Keywords:
Metro stations
Transfer facilities
Random parameter logit model
Willingness-to-pay
Preference heterogeneity

ABSTRACT

Although several cities in India are developing the metro system, there are lacunas associated with transfer facilities in and around metro stations. The present work aims to investigate the perception of commuters of Kolkata city, India in terms of their willingness-to-pay (WTP) for improvement of transfer facilities. A stated preference survey instrument was designed to collect choice responses from metro commuters and the database was analysed by developing random parameter logit (RPL) models. The decomposition effects of various socioeconomic and trip characteristics on mean estimates were also investigated in random parameter logit models with heterogeneity. The work indicates significantly high WTP of metro commuters as compared to the average metro fare for improvement of various qualitative attributes of transfer facility such as 'facility for level change', 'visual communication', 'pedestrian crossing', and 'pedestrian environment'. The WTP values are also found to vary across different groups of commuter formed on the basis of 'trip purpose', 'monthly household income', 'station type' and 'metro fare'. 'Work trip' commuters are found to have higher WTP for improvement of access time, pedestrian environment and use of an escalator over the elevator. On the other hand, 'high-income group' commuters have shown higher WTP for improvement of access time, pedestrian crossing, and pedestrian environment. While 'high fare group' commuters have higher WTP for access time and pedestrian environment, heterogeneity is also observed in WTP for facility for level change, pedestrian crossing, and pedestrian environment across commuters using different 'station type' (underground, at-grade, and elevated). The findings from the study provide a basis for formulating policies for the improvement of transfer facilities in and around metro stations giving due attention to the preference of commuters having different socioeconomic and trip characteristics.

1. Introduction

Rapid urbanization and momentous growth of private vehicle ownership are intensifying the travel demand in urban India (MHA, 2011; MoRTH, 2013) where the road capacity augmentation in urban areas is also often restricted by space constraints. These create an imbalance between the demand and the supply of transport infrastructure. The growing imbalance

* Corresponding author.
E-mail addresses: shubhajit.iitkgp@gmail.com, shubhajit.sadhukhan@idm.iitkgp.ernet.in (S. Sadhukhan), ukb@arp.iitkgp.ernet.in (U.K. Banerjee), bhargab@civil.iitkgp.ernet.in (B. Maitra).

http://dx.doi.org/10.1016/j.tra.2016.07.004
0965-8564/© 2016 Published by Elsevier Ltd.

is aggravating traffic congestion and vehicular emissions in urban areas and becoming a daily hurdle for urban dwellers (Maitra and Sadhukhan, 2013). In this context, the need for improving public transport patronage is well recognised by the Governments, transport planners, and researchers. The Government of India and several State Governments have already been taken up several initiatives to uplift the public transport usage and thereby cater down the private vehicle shares in urban areas (MoUD, 2014). Although, bus is the predominant mode of public transport in the majority of Indian cities because of its 'low fare' and 'flexibility', megacities such as Kolkata, Delhi, Bengaluru, and Mumbai have also developed metro rail as an 'efficient' and 'eco-friendly' mass rapid transit system (MRTS) to increase public transport patronage. A few more cities such as Hyderabad, Ahmedabad, Kochi, Jaipur, Patna, and Pune are planning to develop metro rail system in the near future (MoUD, 2013) to strengthen their urban transportation systems. The successful implementation of the metro in highly populated Indian cities could be a great solution considering the limitation of road infrastructure and high travel demand.

The success of metro does not rely solely on the design of network, location of station, frequency of service, fare, etc., but also on 'transfer facilities' in and around metro stations as metro rail does not provide 'door-to-door' facility. In this context, 'transfer facilities' refer to the facilities provided inside and around metro stations such as 'level change', 'travel information', and 'pedestrian facilities' to facilitate metro commuters to get their easy access to feeder mode stops from the metro platform and vice versa. Several researchers have highlighted the need for incorporating 'transfer facilities' around multi-modal passenger stations (Cheung and Lam, 1998; Krygsman et al., 2004; Liao et al., 2013). The prominence of station area transfer facilities and their influences on commuters' travel behaviour have also been investigated by researchers (Alshalalfah and Shalaby, 2007; Dell'Olio et al., 2011; Givoni and Rietveld, 2007; Lai and Chen, 2011). The role of transfer facilities is given due importance in the 'Station Site and Access Planning Manual' developed by the Washington Metropolitan Area Transit Authority (WMATA, 2008). Recent guidelines published by the Transportation Research Board (TRB) for 'providing access to public transportation stations' also highlight the need for transfer facilities in the context of access area planning for public transportation stations (TRB, 2012). Unfortunately, the adequate emphasis has not been given on transfer facilities in and around metro stations in the Indian context. There are glaring deficiencies related to 'qualitative' attributes of transfer facilities. For example, adequate travel information inside and outside metro stations (such as directional information, feeder service, and route related information) are inadequate or missing in many metro stations. Pedestrian facilities are poor in several locations due to the absence of footpath (sidewalk) or encroachment of footpath by hawkers. At some locations, the crossing of the road is considered unsafe due to the absence of pedestrian-phase in a traffic signal or zebra-crossing. Also, no attempt has been made to understand the perception of metro commuters in terms of their willingness-to-pay (WTP) for improvement of transfer facilities in the context of emerging countries such as India. It is necessary to understand WTP values in order to quantify the likely benefits to metro commuters due to the improvement of transfer facilities and decide additional charges (or metro fare) in lieu of improvement, which is commensurate with the benefits. It may be mentioned that in Indian megacities, there is substantial heterogeneity in socioeconomic and trip characteristics of commuters which may influence commuters' WTP for improvement of transfer facilities. Therefore, it is also important to investigate the heterogeneity effects (if any) of various socioeconomic and trip characteristics on commuters' WTP for formulating improvement strategies giving due attention to the preference of commuters having different socioeconomic and trip characteristics.

In the present study, WTP of metro commuters is calculated with respect to some of the transfer facility attributes. A stated choice survey instrument was designed to collect responses from metro commuters and the data were analysed by developing a random parameter logit (RPL) model. The effects of socioeconomic and trip characteristics of metro commuters on the mean estimates of random parameter and WTP values are also investigated using RPL models with heterogeneity. The present study is demonstrated with reference to Kolkata metro city.

2. Study area

Kolkata is one of the most important metro cities in India having a population about 4.49 million as recorded in the Census of India 2011 (MHA, 2011). The percentage of the male population is close to 53 while the average monthly household income is about INR 25,000 for city dwellers. The Kolkata metro rail serves as one of the most efficient public transport modes for daily trip makers within the city. The existing North-South metro corridor has an operational length of 27.217 km and serves about 0.543 million commuters per day on weekdays (IRPCMST, 2012). The corridor includes 24 metro stations covering north, central to south regions of the city (IRPCMST, 2012). Out of these 24 stations, 15 are underground, 2 are at-grade and remaining 7 are of an elevated type.

3. Theoretical background

In travel behaviour research, econometric models such as multinomial logit (MNL), mixed logit (ML) or random parameter logit (RPL), nested logit (NL), and generalised multinomial logit (GMNL) have been used extensively by the researchers (Fiebig et al., 2010; Greene et al., 2006; Hensher and Rose, 2007; Hess, 2010; Iraguen and Ortúzar, 2004). As the present paper aims to capture the preference heterogeneity of metro commuters towards the improvement of transfer facilities based on their socioeconomic and trip characteristics, RPL model was used. The RPL model has widely been used by the researchers in the field of travel behaviour analysis (Cherchi and Ortúzar, 2006; Greene et al., 2006; Phanikumar and

Maitra, 2010). Though RPL model is well documented in the literature, a brief theoretical framework has been given below in the context of the present study.

If a respondent 'n' faces a choice among 'J' alternatives, the utility of the respondent 'n' for alternative 'j' is specified in the RPL model as;

$$U_{nj} = \beta_n X_{nj} + \varepsilon_{nj} \tag{1}$$

where X_{nj} is the observed variable which relates the alternative and respondent, and β_n is a vector of the coefficient of these variables for the respondent 'n' representing 'individuals' tastes, while ε_{nj} is a random term with an IID extreme value distribution (Train, 2003). The heterogeneity in individual' preferences may be captured in RPL model through interactions between alternative's attributes and socioeconomic or trip characteristics of individuals such as household income, and trip purpose (Train, 2003). Individual specific parameter vector β_n varies across individuals both randomly and systematically with observable variables z_n.

Thus, when random parameters are assumed to be uncorrelated, the utility function of alternative 'j' for individual 'n', becomes

$$\begin{aligned} &U_{nj} = \beta_n X_{nj} + \varepsilon_{nj} = \left(\beta + \Delta z_n + \sum^{\frac{1}{2}} v_n\right) X_{nj} + \varepsilon_{nj} = (\beta + \Delta z_n + \eta_n) X_{nj} + \varepsilon_{nj} \\ &Where, \quad \beta_n = (\beta + \Delta z_n + \eta_n) \\ &Or \quad \beta_{nk} = (\beta_k + \delta_k z_n + \eta_{nk}) \end{aligned} \tag{2}$$

where β_{nk} is the random coefficient for the kth attribute in a choice set faced by individual 'n' and '$\beta_k + \delta_k z_n$' accommodates heterogeneity in the mean of the distribution of the random parameter. The random vector η_n denotes the random parameter with its stochastic properties. v_n is a primitive vector of uncorrelated random variables with known variances. The actual scale factors which provide the unknown standard deviation of the random parameters are arrayed on the diagonal of the diagonal matrix $\sum^{1/2}$ (Train, 2003).

The RPL model assumes a general distribution (normal, lognormal, uniform, triangular, etc.) of β_{nk} and an IID extreme value type 1 distribution for ε_{nj}. For a given value of β_n, the specific probability (P_n) conditioned on z_n for choice 'j' in choice situation 't' is multinomial logit, as the remaining random term, ε_{int}, is IID extreme value.

$$P_n(\beta_{njt}) = \frac{e^{(\beta_n X_{njt})}}{\sum_{k \in A_t} e^{(\beta_n X_{knt})}} \tag{3}$$

where $A_t = \{A_1, \ldots, A_N\}$ is the choice set and the corresponding characteristics are gathered in $X_{tn} = [x_{1tn}, x_{2tn}, \ldots, x_{ktn}]$. Let the marginal joint density of the random coefficients (β_{nk}) be $f(\beta_n | \Omega, z_n)$ where the elements of Ω include the underlying parameters of the distribution of β_n, (β, δ, $\sum$) and z_n is observed data specific to the individual characteristics (such as socio-demographical, socio-economical characteristics) that influence the determination of β_n.

The specification is easily generalised to allow for repeated choices (Panel Effects) of each individual. The simplest specification treats the coefficients that enter utility as varying over people but being constant over choice situations for each individual. Utility from alternative 'j' in choice situation 't' by the individual 'n' is, $U_{njt} = \beta_n x_{njt} + \varepsilon_{njt}$ with ε_{njt} being IID extreme value over time, individuals, and alternatives. Consider a sequence of alternatives, one for each time period, $i = \{i_1, \ldots i_r\}$. The conditional probability of observing a sequence of choices by each individual is given by the product of the conditional probabilities:

$$S_n(\beta_n) = \prod P(k(n,t)t | \beta_n) \tag{4}$$

where k (n, t) denotes the sequence of choices from choice sets that an individual 'n' chooses in situation 't'. In the choice experiment (correlated), the sequence of choices is the number of hypothetical choices each respondent makes in the survey.

The unconditional probability for a sequence of choices for individual 'n' can be expressed as the integral of the conditional probability in the following equation over all values of β:

$$P_n(i | \Omega, z_n) = \int S_n(i | \beta) f(\beta_n | \Omega, z_n) d\beta_n \tag{5}$$

RPL model uses simulated maximum likelihood estimator (SML). The literature shows that the results can be sensitive to the distributional assumptions and the number of draws applied in the simulation (Hensher et al., 2005; Hess, 2010). It may be noted that the Halton draws ensure the improvement of the computations of simulated likelihoods as compare to Pseudo Monte Carlo (PMC) random draw for the same (Bhat, 2003). In RPL model, the commonly used distributions for random parameters are normal, log-normal, uniform, and triangular (Train, 2003). The assumption of normal and triangular distribution may give the 'wrong' sign to some shares due to the spread of the distribution, whereas lognormal distribution may be disadvantageous due to its long upper tail, and the application of uniform distribution is limited only to the estimation of dummy variables (Hess, 2010). However, constrained distributions appear to be more instrumental for RPL models (Hensher and Greene, 2003). The advantages of a constrained triangular distribution (say where mean equals spread) may be enumerated as it assures that the sign of the mean is constant throughout the sample, bounded in nature which results in early convergence (less computational time), estimation of WTP value is simple as the impact of spread is negligible due to constraint. The overall goodness-of-fit of RPL models are carried based on adjusted pseudo rho-square (ρ^2).

$$Adjusted\ \rho^2 = 1 - \frac{LL(1) - K}{LL(0)} \tag{6}$$

where LL (1) is the value of the log-likelihood function of the estimated parameters, LL (0) is its value when all the parameters are set equal to zero and K is the number of parameters (Ben-akiva and Lerman, 1985). In RPL (with constrained triangular distribution) models, valuing of an attribute is measured as the ratio of partial derivatives of the constant utility function with respect to that attribute and the cost attribute (i.e. marginal rate of substitution between any attribute and cost attribute at constant utility) (Hensher et al., 2005).

In the present study, random parameter logit (RPL) models with constrained triangular distribution were developed to estimate the coefficients of transfer facility attributes and capture the heterogeneity in choice preferences among different groups of metro commuters (based on their socioeconomic and trip characteristics) in Kolkata city. In RPL model estimation, Halton sequence draw was used for the simulation.

4. Survey and database

4.1. Type of data and elicitation techniques

In travel behavioural analysis, revealed preference (RP) or/and stated preference (SP) data have been used extensively by the researchers (Hensher et al., 2005; Kroes and Sheldon, 1988; Louviere et al., 2000). In general, RP data are used for demand modelling (Hensher et al., 2005). On the contrary, SP data are considered to be effective for the valuation of attributes (Hunt, 2001; Iraguen and Ortúzar, 2004; Louviere and Timmermans, 1990; Phanikumar and Maitra, 2010). As the focus of the present work is the valuation of transfer facility attributes, SP data was preferred to RP data.

Although in several SP based survey, rating or ranking have been selected as preferred elicitation techniques (Hunt, 2001; Loureiro and Dominguez, 2012), these techniques do not have strong theoretical foundation consistent with economics (Hensher et al., 2005). On the contrary, the discrete choice experiment (DCE) has a framework to estimate relative marginal disutility of variation in attributes and their potential correlations (Hess et al., 2005; Louviere et al., 2000). Therefore, DCE technique was adopted in the present study.

4.2. Selection of attributes and attributes' levels

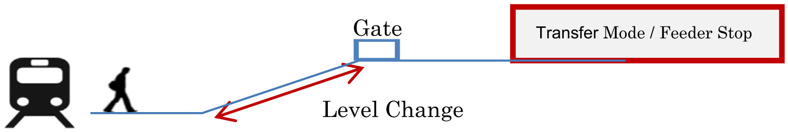
In order to select attribute, a two-stage approach was followed in the present study. In stage one, a pool of attributes describing transfer facility was created based on reconnaissance, review of the literature, discussion with expert and metro commuters. In stage two, responses of commuters in terms of rating towards transfer facility attributes were obtained and analysed by using different techniques such as TOPSIS, RIDIT, and GRA to understand the importance of transfer facilities from commuters' point of view (Sadhukhan et al., 2014). Based on that analysis, attributes were selected for the stated choice experiment in the present study. A total of six transfer facility attributes were included in the present work, namely 'Access Time' (AT), 'Facility for Level Change' (FLC), 'Visual Communication' (VC), 'Pedestrian Crossing' (PC), 'Pedestrian Environment' (PE) and 'Metro Fare' (MF) (Sadhukhan et al., 2014). A brief description of selected transfer facility attributes is given in Table 1.

Levels of attribute were selected based on the existing condition, possible practical alternatives, and review of the literature. For 'Access Time', possible options were taken into consideration based on the existing situation. It may be mentioned that the metro fare in Kolkata city is highly subsidised and 'low present fare' is not practical for improved transfer facilities in and around metro station. Therefore, levels for fare attributes were decided based on a present fare with an increment. The level of qualitative transfer facilities such as facility for level change, visual communication, pedestrian crossing, and pedestrian environment, do vary across different metro stations in Kolkata. However, based on the prevailing scenario, the best and the worst level of transfer facilities were observed and various levels of transfer facility attributes were decided. Various attribute levels are listed in Table 2.

4.3. Generation of alternatives and choice sets

The number of alternatives in choice sets should be 'finite', 'mutually exclusive', and 'exhaustive' (Hensher et al., 2005; Train, 2003). Among the available 'design of experiment (DOE)' techniques, a full factorial design produces a large number of choice scenarios (Louviere et al., 2000) which is not practical to manage in the context of the present study with six attributes and a minimum of three levels for each attribute. Whereas, a fractional factorial design considerably reduces the size of the design by considering the main effects and higher order interaction effects (Hensher et al., 2005). On the contrary, the efficient designs do not merely try to minimize the correlation in the data for estimation purposes but aim to result in data that generates parameter estimates with as small as possible standard errors (Kuhfeld et al., 1994). These designs make use

Table 1
Description of Selected Transfer Facility Attributes.

Attributes	Descriptions
Access time **(AT)**	It is the time taken by a metro commuter to reach to feeder stops from the metro platform (or vice versa). Access time (AT) does NOT include 'Ticketing Time' for metro bound commuters
Facility for Level Change **(FLC)**	It is the movement between metro platform level and entry/exit gate of the metro station (i.e. staircase, escalator, and elevator) 
Visual Communication **(VC)**	This relates to a type of guidance available to commuters for movements between the metro platform and entry/exit gates or feeder stops 
Pedestrian Crossing **(PC)**	This relates to the degree of separation of pedestrian traffic from motorized traffic for movements between feeder stops and metro entry/exit gates
Pedestrian Environment **(PE)**	This relates to the degree of interruptions to the movements of pedestrians primarily due to hawking activities around the metro stations. 
Metro Fare **(MF)**	Transfer facilities are to be used by Metro commuters only. Accordingly, the fare of the metro (direct travel cost) is expected to be influenced by the type of transfer facilities available in and around the metro stations

of the fact that the AVC (Asymptotic Variance-Covariance) matrix (the roots of the diagonal of this matrix are the asymptotic standard errors) of the parameters can be derived if the parameters are known. The most commonly used efficiency measure is called the D-error, which takes the determinant of the AVC matrix, assuming only a single respondent (Rose et al., 2008). A design with the lowest D-error is called D-optimal (Dette and Neugebauer, 1997; Huber and Zwerina, 1996; Jafari, 2010). When there is no prior information is available (not even the sign of the parameters), Dz-error is measured for D-optimal design (Kanninen, 2002). In the present study, D-Optimal design (measuring Dz-error) was used. Choice scenarios generated from D-Optimal design were blocked in several groups to give parity in similar combinations of alternatives (Hensher et al., 2005). In the present study, after selecting attributes and their levels, an unlabelled D-Optimal design was made to generate a total of 48 choice sets using the software named NGENE 1.1.1 (ChoiceMetrics, 2012). The choice scenarios were then blocked in 8 groups and 6 choice sets were included in each questionnaire to make the questionnaire non-lengthy to the respondents. A sample choice set from a survey questionnaire is shown in Fig. 1, where a respondent had to choose any one of the two given options of metro travel consists of various transfer facilities in and around metro stations.

4.4. Survey instrument

The questionnaire was comprised of three parts. The first part was to collect respondents' socioeconomic and trip characteristics related information. The second part was to inform respondents about relevant transfer facility attributes through description and pictorial illustrations. The third part was to collect choice responses from metro commuters with respect to alternative hypothetical scenarios of metro travel with various levels of transfer facilities. Several rounds of pilot surveys were conducted in November-December, 2012 in order to identify various important aspects of the questionnaire such as respondents' understanding level, proper explanation of stated choice (SC) experiment, decision on the likely number of

Table 2
Description of transfer facility attributes and their levels.

Attributes	Levels	Level descriptions
Access Time (in minutes)	I	9 min
	II	6 min
	III	3 min
Facility for Level Change (Inside metro station)	I	Staircase
	II	Elevator (Lift)
	III*	Escalator
Visual Commutation (In and around metro station)	I	Directional information within metro station for movement between metro platform and exit gates/streets
	II	Level-I + Display board in the metro platform indicating feeder modes/routes and corresponding exit gates
	III*	Level-II + Directional information for movements between 'feeder stop to entry gate' and 'exit gate to feeder stop' outside the metro station
Pedestrian Crossing (Outside metro station)	I	At-grade crossing without pedestrian phase
	II	At-grade crossing with pedestrian phase
	III*	NO At-grade crossing
Pedestrian Environment (Outside metro station)	I	Open to sky facility with obstructed pedestrian movements due to medium or high level of hawking activity
	II	Open to sky facility with unobstructed pedestrian movements (i.e. no or low hawking activity)
	III*	Largely or fully covered facility with unobstructed pedestrian movements (i.e. no or low hawking activity)
Metro Fare (in INR)	I	Present metro Fare + INR 3.00
	II	Present metro Fare + INR 2.00
	III	Present metro Fare + INR 1.00
	IV	Present metro Fare

* Considered as the base level for the attribute during analysis; INR = Indian Rupees.

Choice Set - C1 (Fill the circle of your choice)						
	Access Time	*Facility for Level Change*	*Visual Communication*	*Pedestrian Crossing*	*Pedestrian Environment*	*Metro Fare*
○	3 Minute	Escalator	Level-III	At Grade Crossing with Pedestrian Phase	Largely or Fully Covered Facility with Unobstructed Pedestrian Movements	Rs. **1.00** More than Present Fare
○	9 Minute	Staircase	Level-I	At Grade Crossing without Pedestrian Phase	Open to Sky Facility with Obstructed Pedestrian Movements	Rs. **2.00** More than Present Fare

Fig. 1. A sample choice set.

SC observations for different combinations considering respondents' fatigue, and identification of various strategic locations to obtain a likely distribution of the population in the sample. Several minor changes were incorporated in the questionnaire based on the pilot surveys.

4.5. Data collection and organization of data

A paper-pencil based, a face-to-face interview was carried out by intercepting metro commuters at 20 metro stations (includes all types; underground, at-grade, and elevated stations) in Kolkata during January-May, 2013. The survey was carried out during day and night; morning and evening; peak and off-peak hours. The Survey was carried out for weekdays, weekends, and holidays. In order to collect responses, simple random sampling (SRS) technique (Cochran, 2007) was employed, where the selection of each commuter was equally likely. During the SP survey, 794 metro commuters were intercepted. However, 573 metro commuters (say, 72.17%) actually agreed to take part in the survey. Along with the face-to-face interview, an attempt was made to collect responses through an online survey. Accordingly, a web-based online survey questionnaire was prepared and the web link was sent to commuters having internet access with the aim to reduce time and difficulties of the on-spot survey at peak hours. Unfortunately, the online survey in return did not provide a good number of responses. Only a few responses were obtained through the online survey as the commuters of Kolkata are not so familiar with online survey and were found not interested in filling the online form. In most of the surveyed questionnaires, the majority of the respondents filled all the choice sets, while a few evaluated only some of the choices. Besides, in a few questionnaires, socioeconomic and trip characteristics related information of commuters was incomplete. Therefore, during initial processing and data refinements, some of the observations were eliminated and 543 fully filled up questionnaires including a very few online filled up survey data (say less than 10% of used database) were taken into the final database which satisfied the minimum required sample size for the present study considering SRS during survey (Orme, 2010; Rose and Bliemer, 2013). Accordingly, a total of 3258 refined observations (resulting from 543 respondents) were used for the analysis of database by developing random parameter logit (RPL) models and for the calculation of willingness-to-pay (WTP). The socioeconomic characteristics and trip characteristics of respondents are summarised in Tables 3 and 4 respectively.

It may be observed from Table 3 that the percentage of male commuters is more than female commuters. The reason is that the majority of the working population is male in the context of Kolkata city. The majority of the metro commuters are in the age range between 18 and 34 years. Table 4 indicates that the metro facility is majorly used by work trip and educational trip makers. Before developing the econometric models, the data were coded in a digital database. The database was checked in terms of its completeness of information and necessary refinement was done before carrying out the analysis. Dummy coding was used for representing various levels of qualitative attributes (Louviere and Timmermans, 1990) while, quantitative attributes were entered in cardinal linear form (Hensher et al., 2005). Access Time (AT) and Metro Fare (MF) were entered in the model in cardinal linear form, while dummy coding was used for the remaining four qualitative attributes; Facility for Level Change (FLC), Visual Communication (VC), Pedestrian Crossing (PC), and Pedestrian Environment (PE). In Facility for Level Change (FLC), three levels were represented by two dummy coded variables FLC-I (Staircase) with (1, 0) and FLC-II (Elevator/Lift) with (0, 1) considering FLC-III (Escalator) as the base level. In the case of Visual Communication, VC-III (Directional information within metro station for movement between metro platform and exit gates/streets + Display board in the metro platform indicating feeder modes/routes and corresponding exit gates + Directional information for movements between 'feeder stop to entry gate' and 'exit gate to feeder stop' outside the metro station) was considered as the base level and three levels were represented by two dummy coded variables as VC-I (Directional information within metro station for movement between metro platform and exit gates/streets) with (1,0) and VC-II (Directional information

Table 3
Socioeconomic characteristics of metro commuters.

Socioeconomic characteristics	No. of observations	Percentage
Gender		
Male	1956	60.04
Female	1302	39.96
Age Group		
<18 Years	150	4.60
18–24 years	864	26.52
25–34 years	1368	41.99
35–55 years	708	21.73
>55 years	168	5.16
Occupation		
Service/job	1500	46.04
Business	168	5.16
Student	1494	45.86
Self-employment	30	0.92
Others	66	2.02
Monthly Household Income (in INR)*		
Up to INR 10, 000/–	108	3.31
INR 10, 000/– to 20, 000/–	324	9.94
INR 21, 000/– to 30,000/–	996	30.57
INR 31, 000/– to 40,000/–	744	22.84
INR 41, 000/– to 50,000/–	504	15.47
INR 50,000/– to 60,000/–	204	6.26
More than INR 60,000/–	378	11.60
Household Size		
2	306	9.39
3	1056	32.41
4	1014	31.12
5	546	16.76
6	126	3.87
7 or More	210	6.45
Car Ownership		
No Car	2640	81.03
1 Car	522	16.02
2 or More Car	96	2.95

* INR = Indian Rupees.

Table 4
Trip characteristics of metro commuters.

Trip characteristics	No. of observations	Percentage
Trip rate (trip by metro/week)		
0–1 Trip/week	654	20.07
2–3 Trips/week	456	14.00
4–5 Trips/week	1242	38.12
More than 5 trips/week	906	27.81
Trip purpose		
Work/office	1440	44.20
Business	186	5.71
Education	990	30.38
Recreation/social	630	19.34
Others	12	0.37
Feeder mode usage		
Walk	906	27.81
Rickshaw	150	4.60
Auto	1410	43.28
Bus	660	20.26
Taxi and shared car	132	4.05
Station type used		
Underground	2286	70.17
At-grade	186	5.71
Elevated	786	24.12
Metro fare paid (in INR)*		
Upto INR 6.00	1746	53.59
More than INR 6.00	1512	46.41

* INR = Indian Rupees.

within metro station for movement between metro platform and exit gates/streets + Display board in the metro platform indicating feeder modes/routes and corresponding exit gates) with (0,1). While considering Pedestrian Crossing attribute, PC-III (No at grade crossing) was taken as the base alternative and three levels were represented by two dummy coded variables as PC-I (At-grade crossing without pedestrian phase) with (1,0) and PC-II (At-grade crossing with pedestrian phase) with (0,1). Lastly, Level-III of Pedestrian Environment attribute (PE-III); i.e. largely or fully covered facility with unobstructed pedestrian movements (i.e. no or low hawking activity) was considered as the base alternative and three levels were represented by two dummy coded variables; PE-I (Open to sky facility with obstructed pedestrian movements due to medium or high level of hawking activity) with (1,0) and PE-II (Open to sky facility with unobstructed pedestrian movements with no or low hawking activity) with (0,1).

5. Model development, results, and discussion

The coded database was analysed by developing a random parameter logit (RPL) model with correlated choice (Panel Effects) using an econometric software named NLOGIT 5.0 (Greene, 2012). In the RPL model, except 'metro fare', all other transfer facility attributes and their levels were considered as random parameters and assumed to follow the constrained triangular (spared equals to mean) distribution. During RPL model estimate, 500 Halton draw was selected (Bhat, 2001, 2003).

The findings related to coefficient estimates of RPL model with correlated choice and derived willingness-to-pay (WTP) values are reported below in Table 5.

It may be observed from Table 5 that in the RPL model, all coefficient estimates are statistically significant (i.e. statistically significantly different from zero at 99% confidence level with an absolute t value > 2.576).

The signs of the parameter estimates are as anticipated and in agreement with the actual condition of the study area. The negative signs of the 'quantitative' parameters such as access time and metro fare indicate that the disutility of the metro commuters increases with an increase in the magnitude of these attributes. For qualitative attributes, negative sign indicates that the presence of those attributes or levels are considered as disutility compared to their respective base levels. The adjusted ρ^2 (rho squared) value of 0.2530 for RPL model indicate that the model is a good fit (Hensher et al., 2005; Louviere et al., 2000).

It may be seen from Table 5 that in the RPL model, access time is considered as disutility by the commuters. In the case of facility for level change, FLC-I (staircase) and FLC-II (elevator/lift) are perceived as disutility to the commuters with respect to the base level FLC-III (escalator). It is interesting to note that the FLC-II (elevator/lift) is considered as even higher disutility than FLC-I (staircase). A further investigation and interactions with metro commuters indicate the reasons as follows. First, there is also a perceived disutility due to the limited capacity of lift and long queue in busy hours. Secondly, commuters

Table 5
Coefficient estimates of RPL model (correlated choice) and derived WTP values.

Transfer facility attributes	**RPL** (*t statistics*)	WTP values[+]
Random parameters in utility function		
Access Time **(AT)**	−0.2732 *(−16.96)* [a]	0.61[**]
Facility for Level Change-I **(FLC-I)**	−1.2003 *(−11.11)* [a]	2.70
Facility for Level Change-II **(FLC-II)**	−1.3764 *(−12.18)* [a]	3.09
Visual Communication-I **(VC-I)**	−0.5548 *(−6.32)* [a]	1.25
Visual Communication-II **(VC-II)**	−0.5298 *(−7.43)* [a]	1.19
Pedestrian Crossing-I **(PC-I)**	−0.6643 *(−7.43)* [a]	1.49
Pedestrian Crossing-II **(PC-II)**	−0.3069 *(−3.14)* [a]	0.69
Pedestrian Environment-I **(PE-I)**	−0.9378 *(−10.15)* [a]	2.11
Pedestrian Environment-II **(PE-II)**	−0.3855 *(−3.79)* [a]	0.87
Non-random parameter in utility function		
Metro Fare **(MF)**	−0.4450 *(−14.73)* [a]	
Number of observations	3258	
Log Likelihood function	−1680.923	
Adjusted ρ^2	0.2530	

[a] t-statistics are significant at 99% confidence level.
[+] WTP values except for access time are for the shift from the given level to the corresponding base level and the unit is Indian Rupees (INR)/trip.
[**] Unit is Indian Rupees (INR) per minute per trip.

perceive a risk associated with the closed form of operation of elevator though a lift well. The results from RPL model indicate commuters' preferences towards escalator and staircase over an elevator.

While considering the visual communication systems, VC-I and VC-II are considered as disutility compared to their base level VC-III (Directional information within metro station for movement between metro platform and exit gates/streets + Display board in the metro platform indicating feeder modes/routes and corresponding exit gates + Directional information for movements between 'feeder stop to entry gate' and 'exit gate to feeder stop' outside the metro station). It may be observed that VC-I (Directional information within metro station for movement between metro platform and exit gates/streets) is perceived as slightly higher disutility by the commuters compared to VC-II (Directional information within metro station for movement between metro platform and exit gates/streets + Display board in the metro platform indicating feeder modes/routes and corresponding exit gates) because of the limited information.

So far the pedestrian crossing near metro station is concerned, metro commuters in the Kolkata city consider PC-I and PC-II as disutility with respect to their base level PC-III (No at-grade crossing). It may be mentioned that 'no at-grade crossing' refers to 'overpass' or 'underpass' for the pedestrians without having any conflict with mainstream vehicular traffic. Table 5 shows that metro commuters perceive PC-I (At-grade crossing without pedestrian phase) as substantially higher disutility than that of PC-II (At-grade crossing with pedestrian phase) which indicates the importance of providing a pedestrian-phase in the traffic signals. In the present scenario, such pedestrian phases are absent at several locations.

Metro commuters perceive PE-I (Open to sky facility with obstructed pedestrian movements due to medium or high level of hawking activity) and PE-II (Open to sky facility with unobstructed pedestrian movements with no or low hawking activity) as disutility as compared to the base level PE-III (Largely or fully covered facility with unobstructed pedestrian movements). It may be mentioned that in several metro stations, pedestrian pathways (sidewalk) have an inadequate width and/or encroached by roadside hawkers (persons selling goods, typically advertising them by shouting) which create hindrance to the free movements of metro commuters. It is interesting to note that metro commuters consider PE-I as substantially higher disutility than PE-II which indicates that commuters do not prefer to get an obstructed pedestrian environment caused by medium to high-level hawking activities on pathways or footpaths.

The marginal WTP values are calculated from coefficient estimates from the RPL model. The unit of WTP is considered as Indian rupees (INR) per Trip for all attributes except access time (quantitative attribute) which is measured as INR per minute per Trip. The WTP values are for a shift from the level under consideration to the respective base level except 'access time'. The existing metro fare in the Kolkata city varies from INR 4.00 to INR 14.00 with an increment of INR 2.00 based on the distance travelled by the commuters. In the present study, the average fare paid by the commuters is INR 7.00 as derived from the sample. The WTP values shown in Table 5 are considerable with respect to the average metro fare paid by commuters. The results indicate commuters' preference towards the improvement of qualitative transfer facilities around metro stations in the Kolkata city.

The WTP for access time (INR 0.61 per minute per trip) is found significant and around 9% of the average metro fare paid by commuters. The WTP values as obtained from the RPL model for the shift from FLC-I (staircase) to FLC-III (escalator) and from FLC-II (elevator) to FLC-III (escalator) indicate that facility for level change is an important consideration in the context of transfer facilities inside metro stations. It is also interesting to note that commuters' WTP for the shift from FLC-II (elevator) to FLC-III is INR 0.39 higher than that of for the shift from FLC-I (staircase) to FLC-III (escalator). In the case of visual communication, WTP for the shift from VC-I to VC-III is found higher than the WTP for the shift from VC-II to VC-III.

The WTP values as obtained from RPL model indicate substantially higher values for an improvement of the type of pedestrian crossing from PC-I to PC-III as compared to PC-II to PC-III. The values are found to be about 2.16 times higher for the improvement of PC-I to PC-III than PC-II to PC-III. This indicates commuters in Kolkata consider pedestrian crossing as an important factor in terms of the transfer facility. In the case of the pedestrian environment, the WTP value for an improvement from PE-I to PE-III is INR 2.11 per trip which is almost 2.42 times higher compared to the shift from PE-II to PE-III.

In order to capture potential heterogeneity on mean estimates of transfer facility attributes, effects of all socioeconomic and trip characteristics were investigated by developing RPL models with heterogeneity. However, heterogeneity effects on the mean estimates of random parameters were found statistically significant for four attributes namely; trip purpose, monthly household income, station type used (underground, at-grade, and elevated), and metro fare (paid by the commuters to make their trips by metro). These RPL models (with heterogeneity) and related findings are discussed in following subsections.

5.1. Trip purpose heterogeneity

In order to capture the heterogeneity effect of trip purpose on mean estimates of transfer facility attributes, commuters making work trip by metro were considered under 'work trip' and other trips were considered under 'non-work trip' to develop the database. These two trip purposes were represented by a dummy coded variable with (1, 0) in the RPL_{TPH} model specification. Coefficient estimates of the RPL_{TPH} model and derived WTP values of 'work trip commuters' and 'non-work trip commuters are summarised below in Table 6.

It may be observed from Table 6 that in the RPL_{TPH} model, all coefficient estimates are statistically significant. The adjusted ρ^2 (0.2559) indicates that the model is a good fit. In RPL_{TPH} model, preference heterogeneity is found on mean estimates of some parameters with respect to the trip purpose of metro commuters. Trip purpose is found to have decomposition effect on mean estimates of access time, facility for level change (FLC-II) and pedestrian environment (both PE-I and PE-II). The coefficient estimates indicate that the perceived disutility of 'work trip' commuters towards access time, FLC-II, PE-I, and PE-II are higher than that of 'non-work trip' commuters.

It may be seen from Table 6 that the WTP of 'work trip' commuters (INR 0.66 per minute per trip) for access time is higher than 'non-work trip' commuters (INR 0.55 per minute per trip). This reflects the greater concern of the 'work trip' commuters towards the value of time. WTP values reported in Table 6 indicate that there is no statistically significant difference between WTP values of 'work trip' and 'non-work trip' commuters for availing escalator (FLC-III) in lieu of using staircase (FLC-I). However, 'work trip' commuters are found to have nearly 1.37 times higher WTP (INR 3.40 instead of INR 2.47 per trip) than 'non-work trip' commuters for the shift from FLC-II (elevator) to FLC-III (escalator). This may be justified by the fact that

Table 6
Coefficient estimates from RPL_{TPH} (correlated choice) and derived WTP values.

Transfer facility attributes	RPL_{TPH} (*t statistics*)[*]	WTP values[+]	
		Work Trip	Non-work Trip
Random parameters in utility function			
Access Time **(AT)**	−0.3043 *(−13.47)*[a]	0.66[**]	0.55[**]
Facility for Level Change-I **(FLC-I)**	−1.2882 *(−9.19)*[a]	2.81	2.81
Facility for Level Change-II **(FLC-II)**	−1.5583 *(−10.78)*[a]	3.40	2.47
Visual Communication-I **(VC-I)**	−0.5693 *(−6.29)*[a]	1.24	1.24
Visual Communication-II **(VC-II)**	−0.5269 *(−6.71)*[a]	1.15	1.15
Pedestrian Crossing-I **(PC-I)**	−0.6294 *(−5.12)*[a]	1.37	1.37
Pedestrian Crossing-II **(PC-II)**	−0.3129 *(−1.69)*[c]	0.68	0.68
Pedestrian Environment-I **(PE-I)**	−1.1611 *(−9.15)*[a]	2.53	1.46
Pedestrian Environment-II **(PE-II)**	−0.6543 *(−4.34)*[a]	1.43	0.31
Non-random parameter in utility function			
Metro Fare **(MF)**	−0.4582 *(−14.67)* [a]		
Trip purpose heterogeneity			
Access Time **(AT)**	0.0508 *(1.80)*[c]		
Facility for Level Change-II **(FLC-II)**	0.4279 *(1.95)*[c]		
Pedestrian Environment-I **(PE-I)**	0.4943 *(2.84)*[a]		
Pedestrian Environment-II **(PE-II)**	0.5111 *(2.55)*[b]		
Number of observations	3258		
Log Likelihood function	−1670.907		
Adjusted ρ^2	0.2559		

[*] RPL_{TPH} = Random parameter logit (constrained triangular distribution for random parameters) model with 'trip purpose' heterogeneity.
[a] t-statistics are significant at 99% confidence level.
[b] t-statistics are significant at 95% confidence level.
[c] t-statistics are significant at 90% confidence level.
[+] WTP values except for access time are for the shift from the given level to the corresponding base level and unit is Indian Rupees (INR)/trip.
[**] Unit is Indian Rupees (INR) per minute per trip.

long-queuing and resulting delay is likely to be more during the peak hour (predominantly due to work trip). So far the visual communication and pedestrian crossing are concerned, no heterogeneity is observed in mean estimates as well as on WTP values of 'work trip' and 'non-work trip' commuters. In the case of pedestrian environment, WTP of 'work trip' commuters is considerably higher (INR 2.53 per trip) than 'non-work trip' commuters (INR 1.46 per trip) for a shift from PE-I to PE-III, while for the shift from PE-II to PE-III, WTP of 'work trip' commuters is about 4.61 times higher than that of 'non-work trip' commuters. It may be mentioned that the commuters making 'work trips' are frequent trip makers and they face the problem of encroached sidewalk (footpath) on a day to day basis than 'non-work trip' commuters and therefore, they have higher WTP for having obstruction free pedestrian pathway (free from hawking activities).

5.2. Income heterogeneity

In order to investigate income heterogeneity, respondents having monthly household income more than INR 30,000.00 were considered under 'high-income group' and respondents having less than INR 30,000.00 monthly household income were considered under 'low-income group'. These two income groups were represented by a dummy coded variable with (1, 0) in the RPL_{INH} model specification. The coefficient estimates of the RPL_{INH} model and derived WTP values of 'low-income group' commuters and 'high-income group' commuters are summarised below in Table 7.

It may be observed from Table 7 that all the coefficient estimates of the RPL_{INH} model are statistically significant. Adjusted ρ^2 (0.2550) indicates that the model is a good fit. In the RPL_{INH} model, monthly household income is found to have decomposition effect on mean estimates of access time, pedestrian crossing (both PC-I and PC-II), and pedestrian environment (both PE-I and PE-II). The coefficient estimates indicate that perceived disutility of 'high-income group' commuters associated with access time, PC-I, PC-II, PE-I, and PE-II are higher than that of 'low-income group' commuters.

The WTP of 'high-income group' for access time is higher (INR 0.70 per minute per trip) compared to the concerned value of 'low-income group' commuters (INR 0.52 per minute per trip). In the RPL_{INH} model, no heterogeneity is observed on mean estimates of the facility for level change and visual communication as well as no difference in WTP values is observed in this context across commuters from different income groups. It may be observed from Table 7 that WTP values due to an improvement from PC-I to PC-III are found to vary from INR 1.74 per trip to INR 1.17 per trip for 'high-income group' and 'low-income group' commuters respectively. It may also be observed that the WTP of 'low-income group' commuters for the shift from PC-II to PC-III is only INR 0.22 per trip which is very low as compared to a WTP value of INR 1.09 per trip for the same by 'high-income group' commuters. The findings indicate that 'high-income group' commuters in Kolkata give relatively higher importance towards pedestrian safety than that of 'low-income group' commuters. The findings reported in

Table 7
Coefficient estimates from RPL_{INH} (correlated choice) and derived WTP values.

Transfer facility attributes	*RPL_{INH} (*t statistics*)	WTP values+	
		Low income	High income
Random parameters in utility function			
Access Time **(AT)**	−0.3150 (−14.27)[a]	0.52**	0.70**
Facility for Level Change-I **(FLC-I)**	−1.1417 (−7.70)[a]	2.52	2.52
Facility for Level Change-II **(FLC-II)**	−1.4636 (−9.72)[a]	3.23	3.23
Visual Communication-I **(VC-I)**	−0.5675 (−6.32)[a]	1.25	1.25
Visual Communication-II **(VC-II)**	−0.5385 (−6.89)[a]	1.19	1.19
Pedestrian Crossing-I **(PC-I)**	−0.7856 (−6.51)[a]	1.17	1.74
Pedestrian Crossing-II **(PC-II)**	−0.4922 (−3.65)[a]	0.22	1.09
Pedestrian Environment-I **(PE-I)**	−1.0859 (−8.67)[a]	1.79	2.40
Pedestrian Environment-II **(PE-II)**	−0.5541 (−3.75)[a]	0.53	1.22
Non-random parameter in utility function			
Metro Fare **(MF)**	−0.4502 (−14.68) [a]		
Income heterogeneity			
Access Time **(AT)**	0.0816 (2.90)[a]		
Pedestrian Crossing-I **(PC-I)**	0.2559 (1.69)[c]		
Pedestrian Crossing-II **(PC-II)**	0.3936 (1.97)[b]		
Pedestrian Environment-I **(PE-I)**	0.2748 (1.66)[c]		
Pedestrian Environment-II **(PE-II)**	0.3165 (1.68)[c]		
Number of observations	3258		
Log Likelihood function	−1672.793		
Adjusted ρ^2	0.2550		

* RPL_{INH} = Random parameter logit (constrained triangular distribution for random parameters) model with 'income' heterogeneity.
[a] t-statistics are significant at 99% confidence level.
[b] t-statistics are significant at 95% confidence level.
[c] t-statistics are significant at 90% confidence level.
+ WTP values except for access time are for the shift from the given level to the corresponding base level and unit is Indian Rupees (INR)/trip.
** Unit is Indian Rupees (INR) per minute per trip.

Table 7 highlight that WTP of 'high-income group' commuters is considerably higher (INR 2.40 per trip) than that of 'low-income group' commuters (INR 1.79 per trip) for a shift from PE-I to PE-III. On the other hand, for the shift from PE-II to PE-III, WTP of 'high-income group' commuters is about 2.31 times higher than that of 'low-income group' commuters. This indicates higher concern of 'high-income group' commuters for pedestrian environment outside metro stations to get easy and comfortable access to station premises.

It may also be interesting to compare derived WTP values with income levels of metro commuters to understand commuters' 'ability to pay' for improvements of transfer facilities in and around metro stations. It may be mentioned that in the present study, the sample respondents are categorized under seven income groups as mentioned in Table 3 and broadly classified into two groups namely 'low income group' (having a monthly household income up to INR 30,000.00) and 'high income group' (having a monthly household income more than INR 30,000.00) based on the average monthly household income of commuters in the city. It may be mentioned that at present, the transfer facilities are not similar in all metro stations. Therefore, the WTP for improvement of qualitative transfer facilities (i.e. facility for level change, visual communication, pedestrian crossing, and pedestrian environment) from the worst to the best, as per the present work, was calculated in order to compare the WTP with the monthly household income. The WTP per trip for improvement of transfer facilities is found to vary from 4.04% to 0.81% of average daily income of 'low income' group commuters (consists of commuters having monthly household income up to INR 10,000.00, INR 10,000.00–20,000.00 and INR 21,000.00–30,000.00), while for the 'high income' group of commuters (includes commuters having monthly household income of INR 31,000.00–40,000.00, INR 41,000.00–50,000.00, INR 50,000.00–60,000.00, and More than INR 60,000.00), the WTP per trip of a commuter is found to vary from 0.68% to 0.37% of their average daily income.

5.3. Station type heterogeneity

The present study also intended to capture the variation in commuters' WTP for transfer facilities due to their most commonly used station types (underground, at-grade, and elevated type stations) for commuting. Accordingly, a random parameter logit (RPL) model (with constrained triangular distribution of random parameters) namely RPL_{STH} was developed. The database consisting 'Station Type-I (ST-I)' (includes all responses collected from commuters used at-grade and elevated stations) and 'Station Type-II (ST-II)' (includes all responses collected from commuters used underground stations) were represented with a dummy variable (1, 0) in the model specification. As two 'at-grade' stations out of 24 metro stations on the existing metro corridor are 'partially' elevated (commuters need to climb a number of the stair), data collected from these two stations are clubbed with the responses collected from commuters using 'elevated' type metro stations. Coefficient estimates of RPL_{STH} and derived WTP values for two 'station types' are summarised below in Table 8.

Table 8
Coefficient estimates from RPL_{STH} (correlated choice) and derived WTP values.

Transfer facility attributes	RPL_{STH}* (*t statistics*)	WTP values+	
		ST-I	ST-II
Random parameters in utility function			
Access Time **(AT)**	−0.2770 *(−15.44)*[a]	0.63**	0.63**
Facility for Level Change-I **(FLC-I)**	−0.9010 *(−7.01)*[a]	2.04	2.76
Facility for Level Change-II **(FLC-II)**	−1.0786 *(−8.13)*[a]	2.45	3.18
Visual Communication-I **(VC-I)**	−0.5881 *(−5.55)*[a]	1.33	1.33
Visual Communication-II **(VC-II)**	−0.5415 *(−6.97)*[a]	1.23	1.23
Pedestrian Crossing-I **(PC-I)**	−0.5211 *(−5.10)*[a]	1.18	1.58
Pedestrian Crossing-II **(PC-II)**	−0.2794 *(−2.41)*[b]	0.63	0.82
Pedestrian Environment-I **(PE-I)**	−0.9530 *(−9.16)*[a]	2.16	2.16
Pedestrian Environment-II **(PE-II)**	−0.2649 *(−2.18)*[b]	0.60	1.64
Non-random parameter in utility function			
Metro Fare **(MF)**	−0.4406 *(−14.07)* [a]		
Station type heterogeneity			
Facility for Level Change-I **(FLC-I)**	−0.3156 *(−2.21)*[b]		
Facility for Level Change-II **(FLC-II)**	−0.3209 *(−2.05)*[b]		
Pedestrian Crossing-I **(PC-I)**	−0.1770 *(−3.13)*[a]		
Pedestrian Crossing-II **(PC-II)**	−0.0815 *(−1.82)*[c]		
Pedestrian Environment-II **(PE-II)**	−0.4564 *(−2.23)*[b]		
Number of observations	3258		
Log Likelihood function	−1640.506		
Adjusted ρ^2	0.2687		

* RPL_{STH} = Random parameter logit (constrained triangular distribution for random parameters) model with 'Station type' heterogeneity.
[a] t-statistics are significant at 99% confidence level.
[b] t-statistics are significant at 95% confidence level.
[c] t-statistics are significant at 90% confidence level.
\+ WTP values except for access time, are for the shift from the given level to the corresponding base level and unit is Indian Rupees (INR)/trip.
** Unit is Indian Rupees (INR) per minute per trip.

It may be seen from Table 8 that all coefficient estimates from RPL_{STH} are statistically significant. Adjusted ρ^2 (0.2687) indicates the model is good fit. The 'station type' heterogeneity on mean estimates of random parameters are found in several cases such as 'facility for level change' (both FLC-I and FLC-II), 'pedestrian crossing' (both PC-I and PC-II), and 'pedestrian environment' (PE-II). It may be observed from Table 8 that commuters using 'station type-II (ST-II)' consider these transfer facility attributes as more disutility than that of commuters using 'station type-I (ST-I)'.

WTP values reported in Table 8 indicate that commuters using ST-II (underground metro stations) have higher WTP for facility for level change (both FLC-I and FLC-II) than that of commuters using ST-I (at-grade and elevated metro stations). It may be mentioned that most of the elevated stations on the metro corridor are relatively new and equipped with advanced escalators and lifts (along with barrier free design) which essentially create the station environment more accessible, while underground stations (ST-II) are relatively old, no. of escalators, elevators and provision for barrier free environment are missing. This could be the factor influenced commuters using ST-II to show relatively higher WTP for improvement of the facility for level change in particular than that of commuters using ST-I. For 'pedestrian crossing', the commuters using ST-II are found to show higher WTP than that of commuters using ST-I. Eventually, the locations of ST-II are majorly in congested vehicular roads having no pedestrian phase and/or lack of pedestrian crossing facilities whereas, in the case of ST-I, stations are located little away from major vehicular roads and commuters use concourses level of metro stations for crossing purpose. This may be the reason for the variation in WTP values for 'pedestrian crossing' among commuters using ST-I and ST-II. Commuters using ST-II also show 2.73 times higher WTP for the shift from PE-II to PE-III as compared to WTP of commuters using ST-I. As the underground stations (ST-II) are placed just beside the congested urban roads with the poor sidewalk (uncovered) condition (Fig. 2), commuters using ST-II have shown their higher WTP for improvement of the pedestrian environment as compared to the WTP of commuters using ST-I in this context.

5.4. Metro fare heterogeneity

In order to investigate the heterogeneity effect of 'metro fare' (paid by commuters for their trips using metro), the database was split into two groups namely 'high fare group' and 'low fare group' of commuters. Based on the surveyed data, commuters paying metro fare more than INR 6.00 were considered under 'high fare group' on the basis of the average metro fare as INR 7.00 (derived from the sample surveyed in the present study) whereas, commuters paying metro fare up to INR 6.00 were considered under 'low fare group'. These two groups (on the basis of the fare paid) were represented by a dummy coded variable with (1, 0) in the RPL_{FH} model. Coefficient estimates and derived WTP values obtained from the RPL_{FH} model are reported below in Table 9.

It may be observed from Table 9 that in the RPL_{FH} model, all the coefficient estimates are statistically significant. The value of adjusted ρ^2 (0.2540) indicates that the model is a good fit. Metro fare (paid) heterogeneity effects on mean estimate of transfer facility attributes are found only in contexts of 'access time' and 'pedestrian environment' (both PE-I and PE-II). It may be observed from Table 9 that 'high fare group' commuters have higher disutility associated with 'access time' and 'pedestrian environment' than that of 'low fare group' commuters. The WTP of 'high fare group' commuters for 'access times' is INR 0.10 higher than that of 'low fare group'. In the context of pedestrian environment, WTP of 'high fare group' commuters for the shift from PE-I to PE-III and PE-II to PE-III are 1.42 and 2.57 times higher respectively than that of 'low fare group' commuters which indicate higher concern of 'high fare group' commuters towards improvement of pedestrian environment around metro station areas for easy access to the station premises.

Fig. 2. Existing pedestrian environment outside ST-II (underground type station).

Table 9
Coefficient estimates from RPL_{FH} (correlated choice) and derived WTP values.

Transfer facility attributes	[*]RPL_{FH} (*t statistics*)	WTP values[+]	
		Low fare	High fare
Random parameters in utility function			
Access Time **(AT)**	−0.3008 *(−12.83)*[a]	0.57[**]	0.67[**]
Facility for Level Change-I **(FLC-I)**	−1.2330 *(−11.19)*[a]	2.74	2.74
Facility for Level Change-II **(FLC-II)**	−1.4032 *(−12.23)*[a]	3.12	3.12
Visual Communication-I **(VC-I)**	−0.5598 *(−6.28)*[a]	1.24	1.24
Visual Communication-II **(VC-II)**	−0.5320 *(−6.85)*[a]	1.18	1.18
Pedestrian Crossing-I **(PC-I)**	−0.6673 *(−7.36)*[a]	1.48	1.48
Pedestrian Crossing-II **(PC-II)**	−0.3149 *(−3.16)*[b]	0.70	0.70
Pedestrian Environment-I **(PE-I)**	−1.1234 *(−8.63)*[a]	1.76	2.50
Pedestrian Environment-II **(PE-II)**	−0.5881 *(−3.84)*[a]	0.51	1.31
Non-random parameter in utility function			
Metro Fare **(MF)**	−0.4502 *(−14.68)* [a]		
Fare heterogeneity			
Access Time **(AT)**	0.0461 *(1.68)*[c]		
Pedestrian Environment-I **(PE-I)**	0.3312 *(2.03)*[b]		
Pedestrian Environment-II **(PE-II)**	0.3576 *(1.91)*[c]		
Number of observations	3258		
Log Likelihood function	−1677.159		
Adjusted ρ^2	0.2540		

[*] RPL_{FH} = Random parameter logit (constrained triangular distribution for random parameters) model with 'metro fare' heterogeneity.
[a] t-statistics are significant at 99% confidence level.
[b] t-statistics are significant at 95% confidence level.
[c] t-statistics are significant at 90% confidence level.
[+] WTP values except for access time are for the shift from the given level to the corresponding base level and unit is Indian Rupees (INR)/trip.
[**] Unit is Indian Rupees (INR) per minute per trip.

6. Conclusion

Qualitative aspects of travel are generally not given adequate attention in emerging countries such as India. Therefore, although several cities in India are developing metro rail as a solution for growing demand-supply imbalance of transport in urban areas, there are several lacunas associated with qualitative attributes of transfer facility such as facility for level change, visual communication, pedestrian crossing, and pedestrian environment. The present work indicates substantial WTP of metro commuters in Kolkata city for improvement of qualitative attributes of transfer facility in and around metro stations and therefore, instigate the need for improving these facilities. If all the qualitative attributes of transfer facility and the corresponding WTP values for an improvement from worst to the best (as considered in the present work) are considered then the highest WTP is found for improvement of the facility for level change followed by pedestrian environment, pedestrian crossing, and visual communications. The corresponding WTP values are 44.14%, 30.14%, 21.29% and 17.86% of the average metro fare paid by the commuters. On the other hand, the cumulative WTP per trip for the improvement of all qualitative transfer facilities from the worst to the best level is found to vary from 4.04% to 0.37% of the average daily income of the commuters belong to different income categories as considered in the present study. The derived WTP values also provide a basis for increasing the present metro fare in lieu of improving transfer facilities at metro stations. However, further investigation is necessary to investigate the feasibility of improving transfer facilities with an increase in metro fare which is commensurate with the benefit.

The WTP values are also found to vary across different groups of commuters based on 'trip purpose', 'monthly household income', 'station type' (underground, at-grade, and elevated), and 'metro fare (paid)'. 'Work trip' commuters are found to show higher WTP for improvement of pedestrian environment and use of escalator over elevator (lift). As metro stations are generally overcrowded during the peak hours predominantly due to work trips, the findings from the present work provide a basis for improving the pedestrian environment and installation of escalators at all metro stations. On the other hand, 'high-income group' commuters are found to have higher WTP for improvement of pedestrian crossing facility and pedestrian environment. 'High income' and 'work trip' commuters are also found to have marginally higher WTP for savings in access time. With an increase in income, the vehicle ownership is growing steadily in urban India. Also, with higher vehicle ownerships commuters are slowly going away from the public transportation system. The present study rationalises the need for improving the pedestrian crossing facility, pedestrian environment, facility for level change (i.e. escalator over elevators) and access time to make the metro system more attractive even to car owners. Additionally, heterogeneity is also found in mean estimate as well as on WTP for (i) level change, pedestrian crossing and pedestrian environment in the context of 'station type' (underground, at-grade, elevated) used by the commuters and (ii) access time and pedestrian environment with respect to 'metro fare' paid by commuters to avail metro. The heterogeneity study performed in the present study will help to formulate policies for the improvement of transfer facilities in and around metro stations giving due consideration to the preference of commuters having different socioeconomic and trip characteristics.

The findings from the present study are case specific, but the approach demonstrated in the paper may be adopted for other cases with necessary changes.

Acknowledgement

The authors are thankful to the anonymous reviewers for their valuable comments and suggestions which helped substantially to improve the manuscript.

References

Alshalalfah, B.W., Shalaby, A.S., 2007. Case study: relationship of walk access distance to transit with service, travel, and personal characteristics. J. Urban Plan. Dev. 133, 114–118.
Ben-akiva, M., Lerman, S.R., 1985. Discrete Choice Analysis: Theory and Application to Predict Travel Demand, vol. 9. The MIT Press, Cambridge.
Bhat, C.R., 2001. Quasi-random maximum simulated likelihood estimation of the mixed multinomial logit model. Transport. Res. Part B Methodol. 35, 677–693.
Bhat, C.R., 2003. Simulation estimation of mixed discrete choice models using randomized and scrambled Halton sequences. Transport. Res. Part B Methodol. 37, 837–855. http://dx.doi.org/10.1016/S0191-2615(02)00090-5.
Cherchi, E., Ortúzar, J.de D., 2006. On fitting mode specific constants in the presence of new options in RP/SP models. Transport. Res. Part A Policy Pract. 40, 1–18. http://dx.doi.org/10.1016/j.tra.2005.04.002.
Cheung, C.Y., Lam, W.H.K., 1998. Pedestrian route choices between escalator and stairway in MTR stations. J. Transport. Eng. 124, 277–285.
ChoiceMetrics, 2012. Ngene 1.1.1 User Manual & Reference Guide. Australia.
Cochran, W.G., 2007. Sampling Techniques, third ed. John Wiley & Sons.
Dell'Olio, L., Ibeas, A., Cecín, P., Dell'Olio, F., 2011. Willingness to pay for improving service quality in a multimodal area. Transport. Res. Part C Emerg. Technol. 19, 1060–1070. http://dx.doi.org/10.1016/j.trc.2011.06.004.
Dette, H., Neugebauer, H.M., 1997. Bayesian D-optimal designs for exponential regression models. J. Stat. Plan. Inference 60, 331–349. http://dx.doi.org/10.1016/S0378-3758(96)00131-0.
Fiebig, D.G., Keane, M.P., Louviere, J., Wasi, N., 2010. The generalized multinomial logit model: accounting for scale and coefficient heterogeneity. Mark. Sci. 29, 393–421. http://dx.doi.org/10.1287/mksc.1090.0508.
Givoni, M., Rietveld, P., 2007. The access journey to the railway station and its role in passengers' satisfaction with rail travel. Transp. Policy 14, 357–365. http://dx.doi.org/10.1016/j.tranpol.2007.04.004.
Greene, W.H., 2012. NLOGIT Version 5.0 Reference Guide. Econometric Software Inc, Australia.
Greene, W.H., Hensher, D.A., Rose, J., 2006. Accounting for heterogeneity in the variance of unobserved effects in mixed logit models. Transport. Res. Part B Methodol. 40, 75–92. http://dx.doi.org/10.1016/j.trb.2005.01.005.
Hensher, D.A., Greene, W.H., 2003. The mixed logit model: the state of practice. Transportation (Amst) 30, 133–176.
Hensher, D.A., Rose, J.M., 2007. Development of commuter and non-commuter mode choice models for the assessment of new public transport infrastructure projects: a case study. Transport. Res. Part A Policy Pract. 41, 428–443. http://dx.doi.org/10.1016/j.tra.2006.09.006.
Hensher, D.A., Rose, J.M., Greene, W.H., 2005. Applied Choice Analysis: A Primer. Cambridge University Press, Cambridge, United Kingdom.
Hess, S., 2010. Conditional parameter estimates from mixed logit models: distributional assumptions and a free software tool. J. Choice Model. 3, 134–152. http://dx.doi.org/10.1016/S1755-5345(13)70039-3.
Hess, S., Bierlaire, M., Polak, W.J., 2005. Estimation of value of travel-time savings using mixed logit models. Transport. Res. Part A Policy Pract. 39, 221–236.
Huber, J., Zwerina, K., 1996. The importance of utility balance in efficient choice design. J. Mark. Res. 33, 307–317.
Hunt, J.D., 2001. Stated preference analysis of sensitivities to elements of transportation and urban form. Transp. Res. Rec. 1780, 76–86.
Iraguen, P., Ortúzar, J.de D., 2004. Willingness-to-pay for reducing fatal accident risk in urban areas: an Internet-based Web page stated preference survey. Accid. Anal. Prev. 36, 513–524. http://dx.doi.org/10.1016/S0001-4575(03)00057-5.
IRPCMST, 2012. Metro Railway Kolkata [WWW Document]. Indian Railw. Portal C. Team. URL <http://www.mtp.indianrailways.gov.in/view_section.jsp?lang=0&id=0,1>.
Jafari, H., 2010. Optimal design for a three level nested multinomial logit model in discrete choice experiment. Int. J. Res. Rev. Appl. Sci. 2, 181–194.
Kanninen, B.J., 2002. Optimal design for experiments multinomial choice. J. Mark. Res. 39, 214–227.
Kroes, E.P., Sheldon, R.J., 1988. Stated preference methods. J. Public Transport. Econ. Policy 22, 11–25.
Krygsman, S., Dijst, M., Arentze, T., 2004. Multimodal public transport: an analysis of travel time elements and the interconnectivity ratio. Transp. Policy 11, 265–275. http://dx.doi.org/10.1016/j.tranpol.2003.12.001.
Kuhfeld, W.F., Tobias, R.D., Garratt, M., Tobias, D., 1994. Efficient experimental design applications with marketing research applications. J. Mark. Res. 31, 545–557.
Lai, W.T., Chen, C.F., 2011. Behavioral intentions of public transit passengers—the roles of service quality, perceived value, satisfaction and involvement. Transp. Policy 18, 318–325. http://dx.doi.org/10.1016/j.tranpol.2010.09.003.
Liao, M., Liu, G., Qiu, T.Z., 2013. Passenger traffic characteristics of service facilities in rail transit stations of Shanghai. J. Transp. Eng. 139, 223–229. http://dx.doi.org/10.1061/(ASCE)TE.1943-5436.0000481.
Loureiro, M.L., Dominguez, A.F., 2012. Applying best–worst scaling in a stated preference analysis of forest management programs. J. For. Econ. 18, 381–394. http://dx.doi.org/10.1016/j.jfe.2012.06.006.
Louviere, J., Hensher, D.A., Swait, J.D., 2000. Stated Choice Methods: Analysis and Application. Cambridge University Press.
Louviere, J., Timmermans, H., 1990. Stated preference and choice models applied to recreation research: a review. Leis. Sci. 12, 9–32.
Maitra, B., Sadhukhan, S., 2013. Urban public transportation system in the context of climate change mitigation: emerging issues and research needs in India. In: Khare, A., Beckman, T. (Eds.), Mitigating Climate Change: The Emerging Face of Modern Cities, Springer Environmental Science and Engineering. Springer, Berlin Heidelberg, pp. 75–91. http://dx.doi.org/10.1007/978-3-642-37030-4.
MHA, 2011. Census of India 2011. Ministry of Home Affairs, Government of India.
MoRTH, 2013. Road Transport Year Book (2011–12). Ministry of Road Transport and Highways, Government of India, New Delhi.
MoUD, 2013. Annual Report Book 2012–13. Ministry of Urban Development, Government of India, New Delhi.
MoUD, 2014. India National Urban Transport Policy, 2014. Ministry of Urban Development, Government of India, New Delhi.
Orme, B.K., 2010. Getting Started With Conjoint Analysis: Strategies for Product Design and Pricing Research. Research Publishers LLC.
Phanikumar, C.V., Maitra, B., 2010. Modeling generalized cost of travel and its application for improvement of taxies in Kolkata. J. Urban Plan. Dev. 136, 42–49.
Rose, J.M., Bliemer, M.C.J., 2013. Sample size requirements for stated choice experiments. Transportation (Amst) 40, 1021–1041. http://dx.doi.org/10.1007/s11116-013-9451-z.
Rose, J.M., Bliemer, M.C.J., Hensher, D.A., Collins, A.T., 2008. Designing efficient stated choice experiments in the presence of reference alternatives. Transport. Res. Part B Methodol. 42, 395–406. http://dx.doi.org/10.1016/j.trb.2007.09.002.

Sadhukhan, S., Banerjee, U.K., Maitra, B., 2014. Commuters' perception towards transfer facility attributes in and around metro stations: experience in Kolkata. J. Urban Plan. Dev. 141. http://dx.doi.org/10.1061/(ASCE)UP.1943-5444.0000243.
Train, K.E., 2003. Discrete Choice Methods with Simulation. Cambridge University Press.
TRB, 2012. TCRP Report 153: Guidelines for Providing Access to Public Transportation Stations. Transportation Research Board, Washington, DC.
WMATA, 2008. Station Area Access Planning Manual. Washington Metropolitan Area Transit Authority, Washington, DC.