Electric Street Car as a Clean Public Transport Alternative: A Choice Experiment Approach

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Electric Street Car as a Clean Public Transport Alternative: A Choice Experiment Approach[♣]

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Abstract

Electric Street Car (ESC) has established itself as an ideal public transport system for urban agglomeration by offering better safety, minimum pollution and conservation of fossil fuel. Yet, India envisions going all-electric by 2030 by procuring electric buses (e-buses) rather than ESCs. The crucial question is, why not upgrade the existing ESC considering that the e-buses need a profound infrastructural development in India. This paper studies the potential uptake rate of ESC over e-buses using stratified sampling data from 1226 daily public transport commuters of Kolkata, the only Indian city having an operational ESCs. We identify the demographic, psychometric and socio-economic factors influencing the probabilistic uptake of ESC over e-buses using a random utility choice model. It estimates that 38% of the commuters demand ESC over e-buses given the alternatives' comparative details. ESC can be a model electric public transport if there is an improvement in factors, like frequent availability of ESCs and technological upgradation. By promoting the ESC services over e-buses, the government can potentially save on public investment and reach a low carbon pathway cost-effectively. The findings have crucial implications in exploration of the operational feasibility of ESC in the small and medium-sized cities of developing economies like India.

Keywords: Public Transport, Electric Bus, Electric Street Car, Sustainability, Urban Area

JEL Classification: R58, R49, Q56, Q40

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1. Introduction

Urban areas are significant contributors to climate change and their response towards climate change mitigation is crucially linked to how the city operates (UNFCC, 2018; UNDP, 2011; McCarney *et al*., 2011). Fourteen out of fifteen cities in the world with the highest air pollution are in India (WHO, 2018). To achieve emission cut targets as stringently as possible, India has embarked on an ambitious plan for going all-electric by 2030. The International Energy Agency (IEA, 2017) has estimated that the ambitious target would mean selling 10 million Electric Vehicles (EVs), a figure equivalent to more than five times the number of existing EVs globally. To accelerate the growth of the electric vehicles the Government of India has also unveiled the National Electric Mobility Mission Plan (NEMMP) 2020. The push was evident from the move made by the Department of Heavy Industries (DHI) when FAME (Faster Adaptation and Manufacturing of (Hybrid) & Electric Vehicles) was launched in 2015 with a corpus of about INR 8 billion (US$115 million) to invest within 2018 for promoting production of electric and hybrid vehicles in India. Additionally, in the second phase of FAME, the INR 100 billion (US$ 1437 million) budget has been approved for three years till 2022, which is expected to create demand incentives for commercial fleet vehicles rather than for private vehicles only. As immediate target plan electric buses (e-buses) are the only action point identified by the NITI Aayog[1] (2015) in terms of fleet vehicles. The idea is to create public awareness and to ensure that shared and connected mobility is achieved along with mass EV penetration in urban areas (Lin & Zhilli, 2017). However, a globally popular clean and safe electric transport system, the Electric Street Cars (ESCs), finds no mention in any of the policy parameters. ESC, which includes traditional tramways and the modern Light Rail Transit (LRT) or fast trams, is a kind of urban rail transit using rolling stock and often operating with an exclusive right-of-way. For the four factors, viz. safety, environment, energy and land conservation, identified as important for structuring urban transport system (Nijkamp and Perrels, 2018; Rashid *et al*.,2013), ESC is the only transport system which satisfies all the four features and offers the best safety, minimum pollution, conservation of fossil fuel and minimum land requirement (Litman, 2018; Xie and Levinson, 2009). Therefore, when the master plan for most cities in India target 60-80 percent clean public transport ridership by 2025-2030, it

[1]NITI Aayog (National Institute for Transforming India) is a premier policy think-tank to Government of India, formed on January 1, 2015.

stands out as a pertaining question as to why cannot the authority upgrade the existing ESC as a part of low carbon emission initiative when the operation of e-buses need a profound infrastructure development in the city? In this paper, we analyze daily commuters' preference for ESC over e-buses and underline the important factors which may lead to a probable increase in ridership of ESC.

ESC generally provides a high-quality ride in the presence of designated tracks and regularity in service in comparison to the e-bus. Additionally, the buses lose out in terms of capacity, life-cycle cost and level of pollution. But the time required for initial infrastructural development for ESC is relatively long and initial financial investment is also voluminous. In contrast, bus services require much less initial investment and can be introduced as public transport immediately after procurement. These are the primary reasons explaining why buses play a major role in city transport even in the presence of ESC in popular urban spaces. E-buses are also a clean mode of public transport and there exists a section of commuters who would express their potential uptake intention for e-bus services according to their travel preference (Langbroek *et al*., 2016; Leibowicz, 2018), but the operational cost of e-buses are substantially high as it is pushed up by the need for initial investment. Even with government subsidies, the procurement cost of e-buses is estimated at 57% higher than conventional buses in India. However, in support of the government's mission to reduce carbon emission, NITI Aayog has proposed to allocate more funds after utilization of the INR 10000 Crores (under FAME II) for electrification of all state buses together with delivery vehicles. Additionally, the Ministry of Urban Development has launched the Green Urban Transport Scheme (GUTS) under which INR 25000 Crores fund would be made available to 5 million-plus cities for infrastructural development for environment-friendly public transport system (GOI, 2016). In line with the objective of recent policy measures to reduce carbon footprint and with the proposed allocated budget for the popularity of electric transport systems we identify, ESC can be a model example of electric public transport and hence, it generates the motivation for exploration for its operational feasibility in the cities of India.

The modern ESC has been adopted in 436 cities across the world till April 2018. Even with more than 100 years of development behind ESC, it is identified as the most successful medium capacity mode, yet it has adapted with the latest technology for the future urban spaces (LRTA, 2018). An early study on ESC show through a modal choice survey that on an average 11% commuter have revealed their choice for ESC over private cars in 93% of the European cities (UITP, 1997). Also, unanimously the commuters from all the EU cities studied in the survey rated ESC being more accessible than buses and 73% believed that Light Railway Transit (LRT or modern tramways) are even more reliable than the buses. There are evidence showing that LRT not only attracts passengers to itself but also exhibits a spill-over effect by providing a good integration between modes of transport system and as a result, increasing ridership of the public transport as a whole (Brown *et al.*, 2012; Barter *et al.*, 2000; Clercq, 2003; Ercan *et al.*, 2016). Even though the modern LRT system is not yet operational in India (old tramways operate in Kolkata), but it certainly deserves serious consideration as a mode of medium capacity mass rapid transport and hence contributing to better urban transport planning by increasing multi-modal alternatives[2]. To understand the intentions of the daily commuters to avail ESC service over electric buses, we have selected the study area in a way such that the subjects are aware of the viability and existence of ESC service. Though in India, we had ESC services in many cities[3] , it has been discontinued in all the cities due to varied reasons. Kolkata (formerly Calcutta) is the only city in the Indian subcontinent that still has an operational ESC (old tramways) amidst a lot of hurdles, barriers and setbacks. Thus, Kolkata provides a suitable premise to study the commuters' demand for ESC service even in the presence of modern, faster transport systems like e-buses. To analyze the complexities associated with transportation demand modelling we use Random Utility Model (RUM) to identify that explanatory variables like EV knowledge, monthly family expenditure, frequency of availing ESC service and average travel time are significant factors explaining the intention of the commuters to avail ESC over e-buses. We have also highlighted that improvement in frequency and technology are the two important factors in determining the service type availed by the commuters (Leibowicz, 2018). With the data on stated preference, we can estimate about 38% of stated probability, which indicates the actual potential of ESC in urban areas. Therefore, we can infer that by promoting the ESC services over e-buses, a substantial amount of public investment amount can be saved and a low carbon pathway can also be reached in a cost-effective way. The findings are the first of its kind to identify the potential of ESC as an alternative public transport system in India. It also provides a baseline to explore the feasibility

[2]In early 2018 , the center raised concern over the viability of expensive MRTS (Mass rapid transport system, popularized as metro, in India) and acknowledged the need to promote Light Rail transit as alternative transport system in smaller cities, however no further actions has been envisaged (see "Centre to promote light rail transit system in smaller cities", 2018).

[3] Trams had been operational in Indian cities like Bhavnagar, Patna, Chalakaudy, Kanpur, Chennai, Delhi, Nashik and Mumbai but it is discontinued either for urban congestion (like in Delhi), or emergence of other forms of efficient transport like train systems (in the case of Mumbai), or low ridership (case of Patna), or bankruptcy (as in Chennai), so on so forth (Bhattacharya, 1995).

and appropriateness of the expansion of ESC in smaller cities as it has been acknowledged by the public authority[4].

The rest of the paper is organized as follows. Section 2 studies the supply side feasibility of ESC. The study area and the data are explained in section 3. The methodology and the findings from our model are described in section 4 and section 5, respectively. The final section provides some concluding remarks and throws some light on the intended future works.

2. Identifying 'Supply Side' Feasibility:

When we are trying to analyze the viability of ESC as an alternate electric transport system, it is essential to justify whether the development of ESC is appropriate in urban city space, given the financial constraint faced by most of the public authorities. The table 1 below provides a comparison between e-buses and ESCs in urban India.

Table 1: Comparative details of Electric Bus and Electric Street Car

Features/types	Electric Bus	Electric Street Car (Tram)
Costs	77 Lakh (with current Govt. subsidy)	INR 1 crore
Capacity	50	100
Service life	8 Years	60-70 years
Min Fare	INR 20	INR 6 (for non AC) INR 20 (for AC)
Fuel Use	1.5 kWh/km	1.8 kWh/km
Emission	Zero Tail Pipe	Zero Tail Pipe
Fuel Cost	INR8.5/km	INR2/ km
Speed (Max)	80km/h	60 km/h (43 mph)
Frequency	Less Frequent	Less Frequent
Comfort level	Same	Same
Average Trip	6	10

Source: Secondary source

It is evident from table 1 that ESC is costlier to procure but their service life is higher. Also, fuel cost, as well as emission per passenger, is low. E-buses are comparable with ESC in the aspect of emission but they are costlier and the service life is also low. E-bus and ESC can be

[4] Excerpts from this study has appeared on popular print media and has been cited multiple times in ESC related public discussions. (see "Kolkata: Survey approves eco-friendly trams", 2019)

comparable if both the alternatives exhibits similar profitability, which is provided in the following table 2.

Table 2: Daily Profit Computation for Electric Street Cars and Electric Buses (units in INR)

	Electric Bus	**ESC (Tram-Non AC)**
Average Revenue per day	$6000 (= 50\, passenger \times 6\, trips \times INR\, 20)$	$6000\ (= 100\, passenge \times 10 trips \times INR\, 6)$
Average fuel cost per day	$1504.5\ (= 8.5 \times 177 Km)$	$160\ (= 2 \times 80 km)$
Average profit per day	5840	4495.5

Source: Author's Compilation

Note: At present, the ESC seats are not cushioned and coaches are non-air conditioned

The minimum fare of an electric bus is INR 20 and the maximum passenger carrying capacity is 50. Each bus in the city road can take a maximum of 6 trips in a single charge within the city space. In the present scenario, the city is not infrastructural ready to facilitate charging of the fleet multiple numbers of times in a day. Therefore, a conservative estimate of the average revenue per day is around INR 6000. Similarly, we can approximate the average revenue per day earned by ESC in the city of Kolkata at INR 6000 as well. Deducting the average fuel cost per day from the average revenue per day, we can derive a value for the average profit per day for both electric buses and ESC. We find the approximated average profit per day for e-bus is much higher than ESC. Still, this does not complete the feasibility analysis. Since the cost of procurement of ESC and e-bus are different, therefore if we calculate the payback period for each of the transport system, then it truly justifies the comparability. The table 3 shows that the payback periods for both the transport alternatives are comparable in their present state of operation within the city. The payback period for ESC is even lower at 1.39 years as compared to e-bus (at 2.37years) when the daily distance covered (130 Kms) and the minimum fare (INR 20) for both the alternatives are equalized. Specifically, the payback period for ESC will be lower than e-buses if the number distance travelled and fare are the same. Therefore the consideration of investment on ESC as an alternative to e-buses appears justified.

Table 3: Estimated Return on Investment for Electric Street Cars and Electric Buses

	Electric Bus	ESC (Tram-Non AC)
Annual Profit earned (in INR)	1640857.5	2131600
Market Price of Vehicle (in INR)	77,00000	1,00,00,000
Payback period	4.69 years	4.69 years

Source: Author's Compilation

Relevant in this context is to compare ESC with the most popular urban transport service, which is Mass Rapid Transit (MRT) system, known as the metro rail in India. Every Indian city (including million-plus cities of India) is either expanding the existing MRT service or trying to implement one of its kind in the city. The reason for its popularity is because of its speed, comfort and zero tailpipe emission. The ESC, on the other hand, is not comparable in terms of speed, however, it certainly ticks the other boxes of rapid transit. Therefore it is meaningful to have a comparative analysis between the cost of implementation of MRT and ESC, which can help us to understand the reasons behind the popularity of MRT and the reverse for ESC. From the pre-field survey data collected via semi-structured interviews from technicians and officials at the West Bengal Transport Department, we learnt that the expansion cost of new ESC service is 1/9 of the cost of MRT implementation. MRT requires high-end technology and it's a mass transit system with a huge scale of operation, whereas the expansion of ESC can rely on inexpensive indigenous skill and technology. Relying on the secondary information, we can compute the cost of ESC expansion as INR 56.5 Crores/ Km. But, MRT expansion is either underground or elevated. The required 'on-ground' land is not a crucial factor in MRT construction, which is not the case for LRT expansion. ESC requires acquisition of land and it runs on the street. This factor inflates the cost of ESC expansion. We can internalize the cost of land requirement and re-estimate the cost at around INR 84.7 Crores/Km, which stands at 1/6 of the cost of MRT expansion in Kolkata. Therefore, we can say that MRT and ESC are not comparable and it is meaningful to compared ESC with e-buses only as both the transport alternatives are meant for a short-distance commute.

3. Study Area and Survey Details

3.1. Study Area

A primary survey was conducted in 2018 for assessing a probabilistic intention of the commuters towards ridership of ESC in an Indian metropolitan city, Kolkata. It is the only Indian city where the ESC service (the traditional tramways) is still operational as a public transport system. On the outset, it is important to mention that the ESC of Kolkata did not undergo any technological upgradation since its inception (which goes way back around 1900 when electrification of ESC happened from horse-drawn one) and also with the development of modern faster modes of transport (like Metro rail, Radio cabs, Auto-rickshaws) it has lost its popularity. However, it is important to understand that ESC is an age-old green transport system, having a passenger capacity of about four times of a bus. In spite of these facts, the central, as well as the state government, identifies e-buses to be the only immediate action point to achieve low emission targets. Kolkata being a metropolitan city as well as the capital city of the state of West Bengal, the state transport department is keen on acquiring e-buses at the subsidized rates as suggested by the NITI Aayog. Under the FAME II policy, the Government of West Bengal has already acquired e-buses and they have hit the roads of the city in May 2019. Given, this new development in the public transport sphere of Kolkata, we enquire why modernization of ESC not been considered when the introduction of e-buses require development of new and intense infrastructure (Langbroek *et al.*, 2017). To understand this situation, we analyze the choice preference for ESC in Kolkata by enquiring about the probabilistic intentions of purchasing the service from 1226 commuters who choose public buses for their daily commute even in the presence on ESC service as an alternative mode of transportation. After data sorting, cleaning and cross-checking the rationality behind their choice preference, we have developed the analysis out of 996 number of observations.

3.2. Survey Instrument

The data was collected through stratified sampling method from individuals who regularly (>3 days a week) travel through public transport in the city. At the first six operational public bus -cum-ESC depots of the city (which accounts for 50 percent of all bus-cum-ESC depots) were randomly selected. Then, every fifth commuter from the each public bus depot was selected for the survey. If the fifth individual refused to participate in the survey voluntarily, the next individual was asked and accordingly, the next fifth individual was selected. They were given an option to opt-out any time point of the survey, so that biased and erroneous response can be minimized.

The survey was carried out with a structured questionnaire[5] designed and formulated on the basis of our findings from pre-field survey data collected via semi-structured interviews from different stakeholders of ESC service. Six separate sections of the questionnaire dealt with the identification of the sample individuals' demographic details (including their educational qualification, income level, gender, age, current occupation), their attitude towards availing public transport, attitudes towards availing e-bus compared to conventional bus, perception about the ESC services, followed by a section to understand attitudes towards availing ESC compared to e-buses and the last section helps to identify factors influencing switching intentions in availing ESC. To layout the explicit design of the questionnaire, the first part of the questionnaire deals with the personal details of the respondent for evaluating the *socio-economic status* of the individual. In the second section, *revealed preference data* like the travelling details viz. monthly expenditure for travel, time of travel, mode of travel, etc. were collected to control for the individuals' behaviour. The comparative information of e-buses and conventional buses was provided to the commuters as it was essential to generate awareness about the benefits and cost of e-buses over conventional buses. –After laying out the comparative information between e-bus and conventional bus, questions on their intention to avail the e-bus services where asked. The comparison between a standard conventional and electric bus was proposed in terms of minimum fare, maximum speed, frequency of availability, emission potential, fuel cost and passenger-carrying capacity. The respondents had to state their intention to avail the e-bus in terms of probability (i.e., through a continuous variable ranging from 0 to 1) based on the provided information. These responses are considered as the *set I of stated preference data*. The next part of the survey was designed to measure the propensity of considering ESC as a realistic electric public transport alternative over e-buses. First, a comparison between a generic ESC and a generic e-bus was proposed in terms of the categories, same as for the previous case: minimum fare, maximum speed, frequency of availability, emission potential, fuel cost and passenger caring capacity (Table 1). Based on this, respondents were again asked to state their intention to avail the ESC in terms of probability (i.e., through a continuous variable ranging from 0 to 1). Also, the purpose of this section was to check the rationality of the individual behaviour towards ESC service over e-bus services. These responses constitute the *set II of the stated preference data*. The respondents were to identify the reasons behind their choice from a list of possible reasons.

[5] Questionnaire can be shared upon request.

The following section had the *psychometric data*. A list of statements about ESC services and the individuals were asked to indicate their level of agreement with each of the statements (1="Strongly disagree"; 5="Strongly agree"). Our pre-field survey data collected through focus group discussions among ESC employees and semi-structured interviews with commuters and officials provided the framework for formulating the list of 15 important and relevant statements (Table A1). The final part of the survey was devised to understand how the purchase probability varied after the improvement of some identified_factors in ESC services. The improvement factors were identified by the respondents and were ranked according to their understanding of need-based requirements. Likewise, we have selected improvement features such as comfort, frequency, technology, traffic management and other facilities including convenient payment mode. The preferences of respondents for these factors were evaluated to understand the scope of improvement of ESC services. With this stated objective, respondents were told to assume that given there will be no change in the fare, how would they indicate their intention to avail the service (a) if the most preferred factor was improved, (b) if there is improvement in the first three most preferred factors and (c) if there is an improvement in all the listed factors. This exercise was repeated three times in total (cases (a),(b),(c)), to ensure that their stated preference is consistent and transitive, and each time the respondent was asked to indicate their intention to avail the service (as performed earlier).

To understand the basic structure of the sample households, the socio-economic structure, age-wise distribution, household types depending on the principle activity of the households, transport expenditure, income, etc. of the households were appended. In the survey, the respondents are mostly male educated, the working-class population of the city aged from 18-50 years belongs to low to middle-income groups. The reported occupations by the majority of the sample are service in private-sector, business and students. All these factors are controlled in the regression analysis. These sample characteristics are well consistent within our sample frame as in the urban space; the majority of the public transport commuters are from a working-class population. Sample respondents are the major consumers of public transport and therefore their choices affect the optimum decision alternative and thus, the sample features are well appropriate for the study also.

4. Identifying the Preference for ESC: The Methodology

The choice experiment approach is a widely used model in transport demand analysis, especially when the choice alternative is not available in the current market set-up. Also, in this study e-bus as transport choice alternative was not available during the survey. Therefore, the appropriateness of this analytical framework is justified. However, the possibility of a wedge between consumers' ex-ante stated intention and ex-post realized activity poses a drawback of this approach (Bagozzi and Dholakia, 1999; Gollwitzer, 1999; Hassan *et al.*, 204; Sheeran, 2016; Zhang *et al.*, 2019). Literature shows that there could be negative correlation between the stated intention and real activity (Balasubramanian and Kamakura, 1989; Kahneman and Snell, 1992) as the consumers tend to over-report the desired behaviour (Cecere *et al.*, 2018; Bagozzi, 1994; Bagozzi *et al.*, 1999) and this leads to overestimation of their demand (Klein *et al.*, 1997, Ben-Akiva *et al.*, 2019). But assessing intentions with purchase probabilities solves the problem of overstatement of service availing intentions partially (Cecere *et al.*, 2018), allowing us to describe situations better where people may not have planned to avail the service, but realize that they may do so in the near future (Armstrong *et al.*, 2000; Carson and Groves, 2007; DeShazo, 2016, Cai *et al.*, 2017). Also, the variables influencing the intentions to a transport alternative may not be time-invariant; for instance, new alternative modal transport may emerge within the time gap of actual purchase and stated intention of service. In our analysis, respondents are asked to state their probable intentions to avail ESC over the hypothetical alternative, e-bus.

In the traditional empirical model, the utility maximization exercise had been the basis of the majority of discrete choice modeling. However, that neglects the behavioural aspects which influence the intention to purchase services. These behavioural traits can be closely approximated by the RUM framework (Hess *et al.* 2018) under the complex transport demand analysis developed by McFaden (1976).

Our empirical analysis relies on the theoretical framework of RUM and Lancester's (1966) consumer theory of demand. By Lancesterian demand theory, the utility from a choice alternative can be derived from characteristics or attributes instead of the real consumption of the good (Lancester, 1966). In this paper, the choice preference of ESC over e-bus is assessed in terms of the utility derived from the characteristics of the service. By the random utility approach, a consumer avails a service when the utility deriving from the service is higher than a given threshold corresponding to the utility of not availing the service (i.e., of availing an outside option). In this study, we do not observe the actual purchase, i.e., the revealed choice of the consumer between ESC and e-buses. Therefore, in line with this standard literature the simple estimation of the structural equation like the following-

$$U_{in} = X_{in}\beta + \varepsilon_{in} \text{ with } E(\varepsilon_{in}) = 0 \quad (1)$$

where, the utility is a function of X, which describes a set of characteristics of the decision-maker n and product characteristics of the alternative i, and a random term (ε), poses some risk of finding spurious relationships as it is highly likely that consumers' unobserved characteristics, such as the existence of a latent bias for clean services such as ESC, correlate with both their characteristics and their stated intention to avail service. Therefore, as an additional point of departure from the standard literature, we exploit the full information of the dataset concerning the socio-economic background and product choice preference. This helps to explain the reasons behind the preference pattern and thus reduces the endogeneity issue (Petrin and Train, 2003). In this study, the statistical model is driven by the probability that choice j is made over alternative k (Greene, 2003). So to construct the measurement equation for the stated preference ordinal choice model we assign,

$$y_n^{SP} = \begin{cases} 1 & if\ \widetilde{U}_n \geq \tau\ (say) \\ 0 & otherwise \end{cases} \quad (2)$$

where, $\tau\, \epsilon (0, \rho], \rho \in \mathbb{R}^{+}$is the utility from outside option and $\widetilde{U}_n$ is defined as the difference in the utility obtained from the two transport alternatives.

And, $\widetilde{U_n} = U_{1n} - U_{2n} = \widetilde{X_n}\beta + \widetilde{\varepsilon_n}$ (3)

where $\widetilde{U_n}$ is a scalar, $U_{1n} - U_{2n}$ is the difference between the utility out of two alternatives (labelled 1 and 2), $\widetilde{X_n}$ is a row vector equal to $(X_{1n} - X_{2n})$, β is a column vector and $\widetilde{\varepsilon_n}$ is a scalar capturing the unobservable part. In the RUM, the utility from outside option, which is e-buses in our case, is often assumed to be zero (by Cameron and Trivedi, 2005). In the survey as well, respondents were asked to state the probability of their intention to avail ESC over e-bus when the market for e-bus was non-existent; therefore, it justifies to set the threshold utility out of e-bus at zero. Therefore, the likelihood function can be written as,

$$Pr(\, y_n^{SP} = 1) = Pr(U_{1n} - U_{2n} > 0) \quad (4)$$

Or equivalently $Pr(\, y_n^{SP} = 1) = Pr(\beta X_{1n} - \beta X_{2n} > \varepsilon_{1n} - \varepsilon_{2n}) = Pr(\beta\Delta X > \Delta\varepsilon) = \Phi\ (\beta\Delta X)$ (5)

where, $\Phi\ (\beta\Delta X)$ is the cumulative distribution function of the standard normal distribution. To estimate the coefficients of the deterministic part of the utility function, we assume that the error term is normally distributed; therefore, the difference in error, i.e., $\Delta\varepsilon$ is also normally distributed. The choice set has two alternatives and this yields probit form of probability for y_n^{SP} for choosing ESC over e-bus. This technique of estimation are regularly used in the problem of recreational site choice (Adamowicz *et al.*,1994), intercity mode choice (Ben-

Akiva and Morikawa,1990), or even in gasoline and alternative fuel vehicle choice model (Brownstone *et al.*,2000). In the paper, we have cross-section data to evaluate the preference for ESC over e-buses. Since for the cross-section data, the problem of endogeneity is difficult to undermine we have analyzed and estimated through probit model with endogenous covariates to get robust results.

The factors of improvement in ESC for which the uptake intentions of the service may increase has been identified using RUM with latent variable. After qualifying the specifications for selecting a latent variable (Walker and Ben-Akiva, 2002), we have used the factor of improvement for ESC as the latent variable in our model. Both exploratory, as well as confirmatory analysis, was performed to arrive at the final structure of latent variable model, which consists of five latent variables labelled as 'frequent availability of ESC service,' 'technological improvement,' 'comfortable ride' (in terms of better seats, Air-condition, etc.), 'better traffic management, and '*other facilities including convenient payment mode*'. In the survey, the respondents first declared their intention to buy (y_{nt}^{SP}), following which the respondents were asked to state their revised intentions (y_{nt+1}^{SP}), if the factors of improvement were internalised in the ESC service. We can interpret the variation in the intention to buy after the chosen improvements as an increase in the utility only due to a change in the service characteristics. In this way, we have a controlled experiment, in which the endogeneity problem is much milder. We still cannot rule out that some unobserved heterogeneity which correlates with both the intensity of change in the utility and choice of the improvement. The latent variable structural equations are:

$$\widetilde{\mathrm{X}}_{\mathrm{in}}^{*} = \widetilde{X_{in}}\gamma + \omega_{\mathrm{n}}, \text{ i=1(1)5 and } \omega_{\mathrm{n}} \sim \text{i. i. d standard normal} \quad (7)$$

The corresponding measurement equations for the latent variable as follows.

$$\tilde{\mathrm{I}}_{\mathrm{in}}^{*} = \alpha_n \widetilde{\mathrm{X}}_{\mathrm{in}}^{*} + \vartheta_{in} \quad (8)$$

where ϑ_{in}~independent normal with mean 0 and standard deviation σ_{ϑ_i}.

We estimate the model by substituting the structural equations of choice component with the likelihood function, which are integral over independent standard normal distributions. Therefore, corresponding to this RUM with latent variables, the predicted probabilities of uptake intentions corresponding to factors of improvement have been identified using multinomial probit models.

5. Data Analysis

Our empirical analysis investigates the determinants of the probable up-take intentions of ESC over e-buses, which can explain the possible requirement of resource allocation for its infrastructural development. Though ESC has been a popular clean mode of transport by the principle of sustainable development, in developing countries, like India the need for the infrastructure development for its operation depends on the critical mass of commuters opting for ESCs (Leibowicz, 2018; Langbroek *et al.*, 2016). So this study provides a baseline understanding of the situation when ESC would be preferred over e-buses by commuters. Also, the paper provides a micro-understanding of improvement factors that influence the intention of the purchase of the ESC services positively. The characteristic of our sample defined by the survey data generated out of responses by daily commuters, i.e. who travelled more than 5 days a week (47%) and 30% of the respondents travel 4-5 days a week. Their weekly expenditure on public transport is around 60-90 INR (37%) and 91-120 INR (27%). Around 50 % of commuters travel for 21-45 minutes per trip (mid-value is 33 minutes). Almost every respondent commutes by conventional bus as it is an inexpensive and faster mode of transport to reach their destination. 60% of the surveyed commuters were completely unaware of the government's new policy of substituting conventional buses with electric buses, which provide a piece of crucial information. Only 18% are completely aware of the fact and 22% had partial (or very little) knowledge of the policy. Given an option between e-bus and ESC, on average, there is a stated probability of 52% that an individual will avail ESC. A critical understanding of the preference pattern is explained in the following sections which are analyzed with sophisticated econometric tools using the 'R' software.

5.1. Revealed Preference for ESC

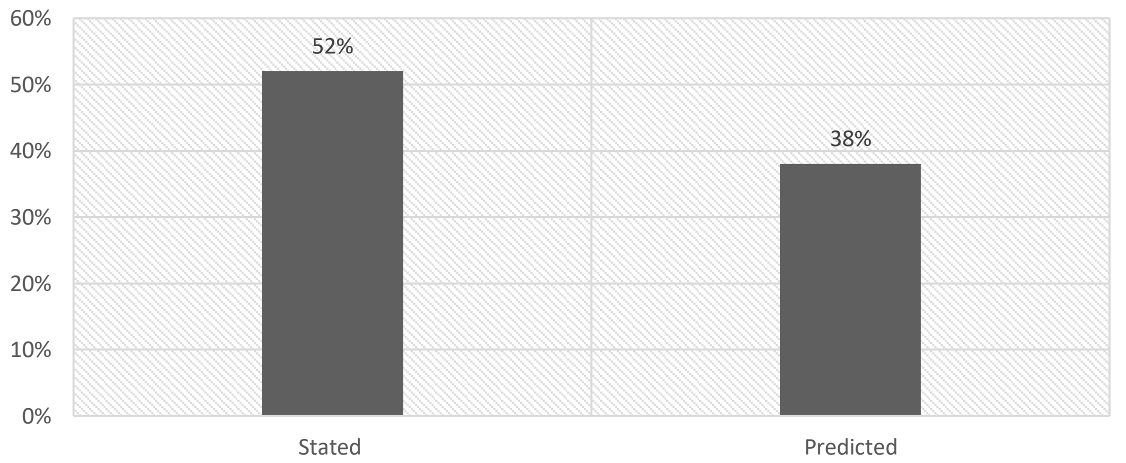
From the survey response, it can be easily deciphered that even though citizens of Kolkata expressed their views on ESC as a noisy public transport leading to havoc traffic congestions, yet they want expansion of the ESC network within the city as it is identified as eco-friendly, safe & comfortable, cheap and good for short distance travels. They believe that the existing ESC service may not be a good alternative to e-buses, but the service could be improved and expanded by technological upgradation, infrastructure development and government initiatives.

A part of the survey was designed to capture the perception of the passengers about ESC. As mentioned earlier, the individuals who were interviewed were the daily commuters via public transport. However, out of the 1226 individuals surveyed, we found that only 56% were regular commuters of ESC; others have never taken ESC for their daily commute. We found that there exists a difference in perceptions between ESC commuters and non-commuters. The perception of the respondents was captured using the Likert scale, where they were given a series of fifteen assertive statements over which they had to express their agreement or disagreement or neutral views. The perception analysis shows that the majority of the sample group shared neutral views for the statement '*ESC is as good as e-bus,'* which means they neither agreed nor disagreed with the statement. But, if we segregate the data into frequent and infrequent commuters of ESC, we find that majority of the frequent travellers (who takes ESC service> 3 times in a week) agree with the statement whereas most of the non-users of ESC (who never takes ESC service) have expressed disagreement with the statement. Another interesting insight into the perception of the individuals about ESC in accounting from the statement '*Infrastructural Development will improve the quality of ESC services'.* Among the commuters who never travelled by ESC majorly disagree with the statement. A critical study of the survey responses (appendix A1) helps us to compare and propose that, in general, there exists a similarity in the pattern of responses for all the twelve out of fifteen statements within the frequent travellers as well as for the infrequent (never travelled) travellers. We have segregated and analysed the data for factors like age, sex, occupation, educational level, family income and EV knowledge as well. An interesting insight is regarding the perception of the commuters concerning government initiatives that differ across age. We find that overall, 33.62% agree that there is a need for a government initiative. But 35.75% of the commuters above 50 years feel there is no need for a government initiative. Since the personal experience of the older generation about its association with the government and its role is more, their aspiration translating to expectation from public institutions is low. This explanation goes in line with the theory on aspiration suggesting that aspirations evolve from past personal experiences or previous generations' experiences (Bendor *et al*., 2001). Similarly, among the 60% of the sample, who were not aware of the procurement of e-buses as a policy, feel that there is an immediate need for government intervention for a revival of existing ESC service (37.03%). To our surprise, the 18% of the sample, who were aware of the EV policy felt that ESC is operational merely due to its heritage value (84.41% strongly agrees with the statement on heritage value) and they are less optimistic about its revival (36.02%). Though there is no significant deviation across gender regarding perception about ESC as quite expected, the awareness about EV is higher with a higher degree of education as well as with higher family income.

5.2. Stated Preference to Avail ESC-Regression Analysis

In the first part of the regression analysis (appendix A2), we estimate the RUM to find the factors determining the probable intentions of the commuters' to avail ESC services. For the various kinds of econometric models tested on the data set, we get monthly family expenditure, frequency of availing the ESC service and average travel time are the significant variables among all other explanatory variables (like age, gender, education, knowledge about EV, monthly family expenditure, frequency of the availing the ESC service and average travel time) explaining the stated probability of availing ESC over e-buses. Apart from these variables, age is also statistically significant in the regression model without endogenous covariate. The information about EV policy is significant in the most robust regression model of the analysis which is the probit model with endogenous covariates. The model also provides the estimated stated probabilities as 38%, making it useful to conclude that the uptake rate of ESC as a public transport system is expected to be significantly high. The predicted probability to avail ESC over e-bus (38%) is lower than the stated probability (52%) as it is estimated by controlling the exogenous variables in the choice experiment framework. It can be apprehended as the restrictive estimate of stated probability to avail of the service under the controlled model.

Fig I. Mean Probabilities of availing ESC over E-bus

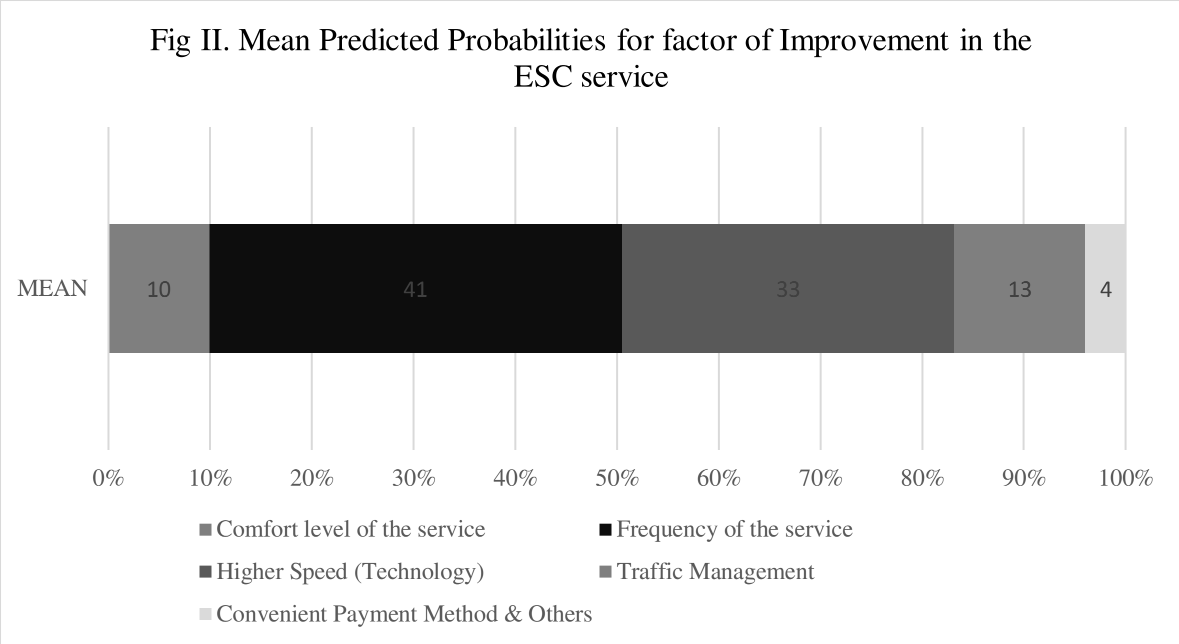


Source: Data analysis

The stated intentions to avail the ESC services in the presence of improved factors in the service, like frequent availability of ESC, technological improvement, comfortable ride (in terms of better seats, air-condition, etc.), traffic management and other facilities including convenient payment mode has been studied in a RUM with latent variable. The econometric approach of this study allows us to assess how the perceived behaviour can control or alter the individual perception as well as preference towards ESC. Out of the factors which has been identified as the relevant ones for influencing the intentions of the commuters to purchase ESC services have been *comfortable rides* (labelled as factor 1), *frequency of the availability of ESC* (labelled as factor 2), *technological improvement for higher speed* (labelled as factor 3), *traffic management* (labelled as factor 4) and *other facilities including convenient payment mode* (labelled as factor 5; considered as base outcome in the regression analysis). These factors have been identified as five latent variables of the model. The regression table (appendix A3) shows the impact of these five identified factors of improvement on the probability of switching intention to avail ESC, given that there is no change in fare.

The regression table (appendix A3) reflects that the '*frequency of the availability of ESC*' is the pivotal factor affecting the probability of switching intention to avail the service. The second and the third important factors affecting the probability of switching intention to avail the ESC service are '*increased speed through technological improvement*' and improved '*traffic management*' respectively.

Increased frequency in the availability of ESC being the most important factor contributing to the decision of switching intentions; it exhibits a predicted probability of 41%. Specifically, if an individual has decided to switch and intends to purchase ESC services, there is a 41% chance of the reason being '*increased frequency of service availability.'* However, an increase of maximum speed through technological improvement is the second important factor with a predicted probability of 33% to switch from the non-intention to the intention to avail the ESC service. When the decision-makers are usually try to improve the amenities and comfort level of the ESC service by introducing air-conditioner in the coach, cushioned seats, free Wi-Fi, etc. we find that commuters emphasize more on 'increase in service availability' and 'technological upgradation of the service.' Facilities for comfortable journeys and other facilities including convenient ESC fare payment systems like smart card systems are significant but are the least two important factors to influence commuters' preference. This finding stands out as the most intriguing result of our empirical analysis.



Source: Data analysis

Measures have been taken to ensure that the individuals in the study are well aware of the service of ESC and the utility generated out of it. The awareness about the government initiative of electric buses and the frequent travel by ESC are two case-specific regressors of the study re-enforcing the fact that the commuters' of ESC has a clear perspective on the service of ESC. Hence, their opinion on the improvement in the service as per the identified factors and related increased intentions in purchasing ESC service provides an interesting dimension from the policy perspective. On the other hand, the probability of technological upgradation, especially to increase the speed, is captured specifically by the change in all the regressors specified in the model.

6. Conclusion and Discussion:

The paper studies the uptake feasibility of ESC as a clean public transport system in the cities of India. When the issues of climate change are alarming and the burden of reducing carbon emission is disproportionately more on developing economies, it is important to consider alternative electric public transport system which can be implemented/expanded cost-effectively. In the developing countries, introduction of e-bus as a mode of clean public transport face the major challenges like high initial capital cost, increased fare, inadequate infrastructure for charging (Langbroek *et al.*, 2017), lower operational range (e-bus is effective and efficient when it operates for more than 150 KMs in a single charge). Moreover, e-buses run on lithium-ion chargeable batteries, where lithium itself is a non-renewable resource. Also, the electric fleets are so technologically new, the battery lifetime, lifecycle costs are still under research. At present, public subsidies are filling in the wedge between the market price and the costs for e-buses with lithium-ion batteries. But it is difficult to decouple the market demand and costs in the long run. ESC can be considered as a model example of electric public transport alternative and therefore creates motivation for analyzing the operational feasibility of ESC in the cities of developing countries including India. The exploratory data analysis shows that the payback period for e-buses is comparable with the existing ESC in India at 4.69 years, given the full capacity utilization of the e-buses in its present condition. Therefore, in this paper, we explore the probabilistic uptake intentions of the daily public transport commuters for ESC over e-buses.

The study estimates that the probability of commuters' demand for ESC over e-buses given the comparative details of the two transport services is 38% under the controlled choice experiment. The choice experiment approach of this study also identified that the factors influencing the decision of probable up-take intentions of ESC over e-bus as an alternative electric public transport. Specifically, using RUM, we find that EV knowledge, monthly family expenditure, frequency of ESC travel, and average travel time are significant factors in explaining the stated probabilistic intention of the commuters to avail ESC over e-bus. The paper also identifies the factors of improvements of ESC service for which the commuters' chance of availing ESC would be higher. Interestingly we find that frequency in the availability of ESC services, technological improvement followed by increased ride comfort are the important factors reflecting higher up-take intentions. This result predicts that even though the urban planners think about the improvement of services through improved amenities but essentially commuters are more concerned about higher frequency in availability and technological upgradation. The beneficiary of the public transport services believes that ESC is noisy and creates traffic congestion but it is a good alternative of e-bus, at least for short-distance travel. They also believe that the technological upgradation of the ESC system with government intervention can improve the service. The findings have crucial implications in exploration for its operational feasibility of ESC compared to e-bus in the other small and medium urban agglomeration of developing countries. In the zest of implementing electric transport in India cities, MRT (known as metro railways in India) is coming up in all major million-plus cities of the country. However, small cities like Nagpur (area of 217.56 sq km), which is not geographically stretched, MRT is an expensive and unnecessary addition to the city space. The wide roads of the city are now partly occupied with the overhead MRT lines and the beneficiaries of the new transport alternative are not large enough to create the required demand. The study explored a possibility for cities like Nagpur, ESC (in the form of LRT) can be considered as a cost-effective clean public transport system for short-distance travel where the e-bus is not an efficient one. This paper, therefore, is envisioning the potential increased uptake of ESC in India and the intriguing results generated out to the empirical model have implications for small and medium-sized cities of developing economies, in the managerial and policy perspective in their transportation sector, energy sector, urban development, climate change and even in public policy.

Appendix

Table A1: Modal perception about the ESC service among the daily commuters in the city

<table>
<tr><th>Statements</th><th>All respondents</th><th>Respondents who frequently travelled by ESC</th><th>Respondents who never travelled by ESC</th></tr>
<tr><td>ESC has heritage value.</td><td colspan="3">Strongly Agree (64%)</td></tr>
<tr><td>ESC is noisy.</td><td colspan="3">Agree (56%)</td></tr>
<tr><td>ESC creates traffic congestion.</td><td colspan="3">Agree (40%)</td></tr>
<tr><td>ESC is eco-friendly Public transport.</td><td colspan="3">Agree (60%)</td></tr>
<tr><td>ESC will be revived In the city.</td><td colspan="3">Agree (46%)</td></tr>
<tr><td>Technological upgradation will improve the quality of ESC</td><td colspan="3">Agree (55%)</td></tr>
<tr><td>Infrastructural Development will Improve the quality of ESC</td><td colspan="3">Agree (53%)</td></tr>
<tr><td>Government initiative will improve the ESC</td><td>Agree (34%)</td><td>Disagree (30%)</td><td>Agree (40%)</td></tr>
<tr><td>ESC rides are safe and comfortable.</td><td colspan="3">Agree (54%)</td></tr>
<tr><td>ESC’s ticket fare should be revised.</td><td>Agree (33%)</td><td>Disagree (30%)</td><td>Agree (38%)</td></tr>
<tr><td>ESC is as good as electric buses.</td><td colspan="3">Disagree (44%)</td></tr>
<tr><td>Citizens prefer ESC over other Public transportation.</td><td>Neither Agree nor Disagree (36%)</td><td>Disagree (38%)</td><td>Neither Agree nor Disagree (44%)</td></tr>
<tr><td>ESC is good for short-distance travel.</td><td colspan="3">Agree (68%)</td></tr>
<tr><td>Better ESC can substitute auto-rickshaw services.</td><td colspan="3">Disagree (49%)</td></tr>
<tr><td>ESC network should be expanded within the city.</td><td colspan="3">Agree (43%)</td></tr>
</table>

Source: Primary data collected from the survey

Table A2: Regression models for estimating stated probabilities of availing ESC over electric-bus.

	Probit Model (No endogenous covariates)			Probit Model (Endogenous covariates)		
No of obs=996	Coefficient	ME	z	Coefficient	ME	Z
Variables						
Age	-0.07808*	-0.02746	-2.14	-0.01781	-0.01781	-0.38
	(0.036436)			(0.0472894)		
Gender	0.080786	0.028411	0.65	0.123114	0.123114	1.11
	(0.1234683)			(0.1113742)		
Education level	402428	0.141525	1.57			
	(0.2563939)					
Knowledge about EV	-0.00198	-0.0007	-0.030	0.882677*	0.882677	2.37
	(0.0581225)			(0.3724323)		
Family expenditure	-0.22718*	-0.07989	-2	-0.31564**	-0.31564	-3.08
	(0.1135105)			(0.1025105)		
Travel Frequency	-0.3785**	-0.13311	-6.38	-0.34648**	-0.34648	-4.14
	(0.0598348)			(0.0837814)		
Travel Time	0.111361**	0.039163	3.08	0.201466**	0.201466	5.1
	(0.0362295)			(0.0394664)		
Constant	1.57005**		3.33	-0.98783		-0.64
	(0.4708053)			(1.540521)		

Table A3: Regression models for the preferred factor of improvement

Variables	Factor-Comfort		Factor-Frequency of the service		Factor-Technological Upgradation		Factor-Traffic Management		Factor- Other facilities including convenient payment mode	
	ME	***z***	**ME**	***z***	**ME**	***z***	**ME**	***z***	**ME**	***z***
Age	-0.0023832 (0.00885)	-0.27	0.015761 (0.01396)	1.13	-0.0114033 (0.01348)	-0.85	0.004753 (0.0092)	0.52	-0.0067275 (0.0047)	-1.43
Gender	-.0087881 (0.029)	-0.3	-.0399012 (0.0469)	-0.85	0.004036 (0.04625)	0.09	0.033462 (0.03452)	0.97	0.011192 (0.01555)	0.72
Education	0.029 (0.054)	0.54	0.217802* (0.09022)	2.41	-0.1812734 (0.09668)	-1.88	-0.1005494 (0.07383)	-1.36	0.034965 (0.02233)	1.57
EV knowledge	0.003 (0.013)	0.25	0.032707 (0.02171)	1.51	-0.0540313** (0.02034)	-2.66	0.023989 (0.01503)	1.6	-0.0058909 (0.00606)	-0.97
Family expenditure	-.0455001 (0.028)	-1.6	-0.222602** (0.0472)	-4.72	0.203142** (0.04114)	4.94	0.125277** (0.02654)	4.72	-.0603172** (0.01948)	-3.1
Travel frequency	0.042** (0.014)	2.91	0.010011 (0.02127)	0.47	-.0643491** (0.01961)	-3.28	0.015741 (0.01413)	1.11	-0.0031458 (0.00629)	-0.5
Travel time	0.017* (0.008)	2.11	-.0753668** (0.01372)	-5.5	0.0414** (0.01326)	3.12	0.007574 (0.0093)	0.8	0.009252* (0.00411)	2.25

No. of Observation=996
Note: 1. Numbers in parenthesis indicate the corresponding SE values

2. Codes of statistical significance- 0.001 "**", 0.05'*'

Source: Primary data collected from the survey

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