Abstract

Bicycles are one of the most affordable and flexible means of transportation in the context of a developing country such as India. Despite being an important mode of transportation and trip lengths being favorable for bicycling, a sharp decline in bicycle mode share has been observed in small and medium sized Indian cities mainly due to two reasons— a) inadequate infrastructure and b) unsafe conditions for bicycling. In this context, preservation of bicycle base could only be restored by providing users with a safe and comfortable bicycling infrastructure, which may also attract new users, provided that right policies are adopted. In this regard, it is essential to revisit the requirements of bicyclists in small and medium sized Indian cities such that appropriate policies could be formulated based on user preference and priorities on bicycle infrastructure. For this purpose, two case study cities in eastern India, a small sized city Kharagpur and a medium sized city Asansol were selected and a comprehensive methodology for bicycle infrastructure planning was developed.

To start with, a methodological framework was developed to understand the relationship between user perception towards bicycle commuting and simultaneously to identify and prioritize a smaller set of factors (both motivators and deterrents) influencing bicycling in the Indian context in general, and those related to bicycle infrastructure in particular. Initially, a comprehensive set of fifteen factors influencing bicycling either as a motivator or as a deterrent are identified. A five point Likert-type ordinal scale rating survey was designed and user perceptions on these fifteen factors were collected from bicyclists in both cities. In order to capture the underlying relationship between the identified factors and cluster them into a set of latent factors or constructs, Exploratory Factor Analysis (EFA) was adopted. Further to select the most important variables from each latent factor, two Multi Attribute Decision Making (MADM) techniques, namely RIDIT and GRA were used. Subsequently, from each extracted latent factor, the top ranked variable was identified, which includes both bicycle mode specific and infrastructure specific variables. Since the main focus of this study is to develop a framework for planning of bicycle infrastructure, only the bicycle infrastructure specific factors are selected for travel behavior analysis of bicyclists.

In the second stage of the thesis, bicyclists' perceptions on these identified infrastructure specific factors are investigated in terms of user benefit through a detailed travel behavior analysis. In this study, Willingness to pay (WTP) for a factor, is used as a measure of user benefit. For the stated purpose, a stated preference (SP) experiment was designed and responses were collected from bicyclists using travel intercept surveys in both Kharagpur and Asansol. The collected data were analyzed by developing appropriate econometric models (Multinomial Logit-MNL and Random Parameter Logit-RPL). Based on the econometric model coefficients, the WTP estimates or the perceived benefit associated with each infrastructure specific factor was calculated. The effect of bicyclists' socioeconomic and trip characteristics on WTP values were also investigated by assuming heterogeneity around the means of random parameters while developing RPL models. Using the WTP values, Generalized Cost (GC), an integrated measure of perceived disutility was also estimated.

Significant values of WTP estimates for different bicyclist user groups clearly indicate that there is substantial scope for improvement in bicycle infrastructure in typical Indian context. However, due to limited available resources, it is not possible to implement all improvement measures on all roadway segments simultaneously. As a result, a methodology for prioritization of roadway segments for bicycle infrastructure improvement needs to be formulated. The estimated GC values from the travel behavior analysis can be used for prioritization of roadway segments. On the other hand, bicycle suitability criteria have widely been used for evaluation of existing bicycle suitability of roadway segments. With that in mind, bicycle suitability criteria have been formulated by associating bicyclist perceived suitability of a segment with segment specific traffic and operational characteristics. Ordered Probit (OP) modelling

technique was adopted for formulating bicycle suitability criteria. The roadway segments are then evaluated by both GC estimates and bicycle suitability criteria to check if results converge and lead to a consistent prioritization list. Results indicate that roadway segments with lower bicycle suitability are also associated with relatively higher GC. Therefore, roadway segments with higher GC estimates and lower bicycle suitability are prioritized for bicycle infrastructure improvement. Further, to recommend for specific improvement measures for the prioritized roadway segments, a method for prioritization of bicycle infrastructure improvement was developed. In this method, a set of alternative scenarios for improvement were developed and associated lifecycle costs were calculated. Benefit resulting from improvement in the bicycle infrastructure was also calculated using GC equation and a cost-benefit analysis is carried out to report the findings in terms of Economic Internal Rate of Return (EIRR).The results provide directions on specific improvement measures, from which significant benefit in terms of high EIRR could be achieved.

Overall, this thesis develops a comprehensive methodology for planning of bicycle infrastructure in the context of two Indian cities with different demographic and transportation characteristics. While the findings of this study are case specific, the methodology developed could be followed with results serving as basis for comparison across other cities with similar characteristics.
Key words: Bicycle; Motivators; Deterrents; Likert-type ordinal scale; Latent Factor; Exploratory Factor Analysis (EFA); RIDIT; GRA; Travel Behavior Analysis; Stated Preference (SP); Willingness to pay (WTP); Multinomial Logit-MNL; Random Parameter Logit-RPL; Generalized Cost; Heterogeneity; Bicycle suitability criteria; Prioritization; Ordered Probit; Cost-benefit analysis; Economic Internal Rate of Return (EIRR)