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Identification of factors influencing bicycling in small sized cities: A case study of Kharagpur, India

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ABSTRACT

With increasing concern about global warming, greenhouse gas emissions and rising fuel prices, non-motorized modes, such as bicycle are gaining importance as viable mode in urban transportation worldwide. In small sized Indian cities non-motorized transportation accounts for over two thirds of all trips, but with increase in purchasing power and affordability, Indian commuters are leaning towards motorized private modes leading to a rapid growth in motorized vehicle population and thus increasingly congested roadways and urban air pollution. At this juncture it is very important to investigate that what influences people's mode choice in general and bicycle mode choice in particular.

This study has identified specific attitudinal attributes related to Physical factors, Psychological factors, Travel Time sensitivity, Economic aspects, Congestion, Parking, Route or Link level facilities, Route topography, Safety related factors, Security related factor, Environmental awareness and Weather related factors. A travel behavior survey with questionnaire designed to address these attributes was conducted to understand user's attitude toward bicycling in a small Indian city. The survey outcomes were then used in exploratory factor analysis (EFA), which revealed Perceived Benefits, Physical Barriers, Safety Hazards, Social Barriers, and Road Condition to be the major factor classes influencing bicycle mode choice.

In order to compare user perception with expert perception, a pair-wise comparison using analytical hierarchy process (AHP) has also been performed on factors related to user-specific, route-related and journey-related components. The results reveal physical factors, safety related concerns and route topography to be the key and common set of parameters influencing bicycle choice both from the user's and as well as expert's point of view.

1. Background

Urban population in India is increasing rapidly and the number of cities in India is projected to increase in an exponential manner. Although over two thirds of all trips in small sized Indian cities are made by non-motorized modes, with rise in disposable income, inadequate public transport and safety concerns for cyclists (Tiwari, 2011), the average Indian commuter is increasingly leaning toward motorized private modes, a trend which has serious implications for sustainability. Padam and Singh (2001) mentioned that travel distances (trip lengths) and travel costs increase geometrically as cities grow in size. This means that to travel the distance which was previously walk-able or bicycle-able, has now become necessary to use vehicles. Although attempts are being made to address mobility and accessibility issues in urban areas with varying degrees of success, problems including delay, congestion, accidents, air and noise pollution, excessive fuel consumption, energy wastage, etc. persist. These can be largely attributed to rapid urbanization. In this regard, a study (Table 1) conducted by Wilbur Smith Associates (2008) shows that the average trip length in Indian cities varies with population size from 2.4 km to 10.4 km. The small sized cities (up to Category 3) still have comparatively smaller trip lengths, but even these are being increasingly getting replaced by private motorized modes.

At this juncture it is important to re-look and assess if modes such as bicycles can be promoted as a potential alternative private mode for short trips in urban India. For this purpose, it is important to identify the factors which directly or indirectly affect choice of bicycle as a primary mode of transport, and design appropriate policies such that bicycle mode choice is encouraged.

As far as bicycle related policies are concerned, two very important categories of stakeholders are considered, namely the

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Table 1
Estimated average trip length for the selected city categories.

City type	Population	Average trip length (km)
Category-1-a	<500 thousands with plain terrain	2.4
Category-1-b	<500 thousands with hilly terrain	2.5
Category-2	500–1000 thousands	3.5
Category-3	1000–2000 thousands	4.7
Category-4	2000–4000 thousands	5.7
Category-5	4000–8000 thousands	7.2
Category-6	>8000 thousands	10.4

Source: Wilbur Smith Associates (2008).

user irrespective of their current mode choice and experts including researchers, professors, industry professionals and government officials who has knowledge of planning, design and operation of road infrastructure. While transportation planning experts evaluate different factors from both engineering as well as planning point of view, users tend to evaluate different factors based on the quality of their commuting experience. So user's response should be separately analyzed and compared against expert's judgment to see how these two groups value all aspects influencing bicycle mode choice. In doing that it will be interesting to see if certain factors valued highly by the professionals and considered in facility planning and design are of major concerns of the users or not. Once this comparison is done it will provide overall more scientific approach toward identifying what may be in the list with top most priorities in terms of attracting more bicycle users. Hence in this study, both perceptions are compared and combined to obtain a set of factors incorporating all aspects pertinent to bicycle mode choice.

2. Objective of the study

With this background, the proposed study focuses on identifying different attributes that are directly or indirectly influence choice of bicycle as a mode of transport and critically analyze them based on the user response and expert judgment. The broad goal of the study can be divided into some of the following sub-objectives:

- To identify attributes which positively or negatively influence bicycle mode choice by conducting a thorough literature study
- To design two different survey instruments for the users and experts to capture their individual perception of such attributes
- To compare the results from the user and expert surveys to identify a common set of factors influencing bicycle mode choice

3. Literature review

In order to investigate the overall perception of commuters toward bicycle mode choice, a thorough review of earlier research work on this subject has been done first. Literature study reveals that bicycle mode choice is affected by various attitudinal attributes or variables. Different techniques have been used to identify the latent factors that explain the manifest variables.

An extensive pool of work has sought to determine the key influencing attributes (motivators or deterrents) and measure their relative importance in terms of their impact on bicycle mode choice. Attributes are categorized into subjective groups of factors such as, distance, safety, cost, attitude (FHWA, 1992) and objective groups of factors such as topography and climate (FHWA, 1992; NHTSA, 2002; Litman, 2013). Environmental factors or human attitude toward environment have also been found to significantly influence the choice to bicycle (NHTSA, 2002; Litman, 2013; Heinen et al., 2011; Dill and Voros, 2003). Socio-economic factors such as age, gender and income have been found to be among the key influencing factors by Dill and Voros (2003) and Shafizadeh and Niemeier (2003). Route and link-related attributes are also found to have significant impact on bicycling. Route-related variables such as route topography, average slope, presence of signal, continuity of facility (Stinson and Bhat, 2005), route length (Pucher and Buheler, 2008) and roadway condition (Litman, 2013) and link-related attributes such as presence of proper parking facility, dedicated bicycle facility (Stinson and Bhat, 2010), provision of traffic calming (Pucher and Buheler, 2008) are identified as the key factors influencing bicycle choice.

Besides the above mentioned measurable factors, some unobserved or latent factors such as safety, ease of cycling, weather conditions, route conditions and interactions with motor vehicles (Winters et al., 2011), need for flexibility, sensitivity to time, need for fixed schedule, desire for economy, comfort to journey, environmental awareness, and perception toward bicycling and willingness to bicycle (Li et al., 2013) have also been found to influence bicycle mode choice significantly. Based on these research findings, several attitudinal attributes are identified and included in this study.

Stinson and Bhat (2005) and Jason et al. (2010) have used binary logit model and Heinen et al. (2011) and Pucher and Buheler (2011) have used ordinary least square regression to analyze various attributes relevant to bicycle mode choice. Winters et al. (2011) and Li et al. (2013) have used exploratory factor analysis to identify the latent factors underlying bicycle mode choice. Outwater et al. (2003), have tested the validity of the theoretical construct by Confirmatory Factor Analysis, and used Structural Equation Modeling for the clustering (Li et al., 2013; Outwater et al., 2003). In EFA, the analyst has no a priori hypothesis regarding the number or nature of the variables and as the title suggests, is exploratory in nature. That is, it allows the researcher to explore the main dimensions to generate a theory, or model from a relatively large set of latent constructs often represented by a set of items or indicators (Williams et al., 2012). On the other hand CFA is a special case of structural equation modeling used for theory testing (Hair et al., 2012; Williams et al., 2012). The literature provides useful guidelines on the use of Factor Analysis (Costello and Osborne, 2005; Hogarty et al., 2005). Given the nature of the problem at hand the authors have used EFA to construct a theory concerning the latent factors influencing bicycle mode choice in general and in small size Indian city in particular.

Most of the studies in the literature studying bicycle mode choice, such as Winters et al. (2011) and Li et al. (2013) have preferred user perception over expert judgment for analysis. However, from the view point of an informed and balanced policy making, authors feel that along with user perception and preference, experts (engineers and planners) opinion is as important, since ultimately experts decides for the users – at least till date in India and in many other emerging economies around the world. Multi criteria decision making techniques such as analytical hierarchy process (Sinha and Labi, 2007; Wong and Li, 2007; Cheng and Li, 2002; Kong, 2010), TOPSIS, fuzzy AHP and a combination of these (Shelton and Medina, 2010) are extensively used for weighting of such competing opinions. Among others, AHP compares the pair-wise responses in terms of numeric values that can be processed and compared for each element of the hierarchy in a rational and consistent way (Kong, 2010).

4. Methodology

The overall methodology adopted for this study (Fig. 1) can be broadly divided into three stages: