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Synopsis of bicycle demand in the City of Toronto: Investigating the effects of perception, consciousness and comfortability on the purpose of biking and bike ownership

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ABSTRACT

This paper provides an empirical basis for the evaluation of policies and programs that can increase the usage of bikes for different purposes as well as bike ownership. It uses an integrated econometric model of latent variable connecting multiple discrete choices. Empirical models are estimated by using a bicycle demand survey conducted in the City of Toronto in 2009. Empirical investigations reveal that latent perceptions of 'bikeability' and 'safety consciousness' directly influence the choice of biking. It is also found that the choice of the level of bike ownership (number of bikes) is directly influenced by latent 'comfortability of biking'. The number of bikes owned moreover has a strong influence on the choices of biking for different purposes. It is clear that bike users in the City of Toronto are highly safety conscious. Increasing on-street and separate bike lanes proved to have the maximum effects on attracting more people to biking by increasing the perception of bikeability in the city, comfortability of biking in the city and increasing bike users' sense of safety. In terms of individuals' characteristics, older males are found to be the most conformable and younger females are the least comfortable group of cyclists in Toronto.

1. Introduction

Biking is considered as one of the most sustainable modes of urban transportation urban transportation system (Marten, 2004). The physical and environmental benefits of bicycling have prompted transportation planner to advocate for its increased use and sparked interests in understanding bicycle travel behaviour. While feasibility of biking as an alternative mode to driving and other modes can be defined, considerable behavioural ingredients exist that influence someone's consideration of bike as a mode of transportation. However, the concept of addressing behavioural and psychological factors is not very common in bicycle research, although researchers clearly acknowledge that behavioural/psychological factors are dominant in influencing the number of bikes owned and their usage (Handy et al., 2010). In most studies these factors are considered in ad hoc ways or considered directly as exogenous variables in empirical investigations. These approaches fail to fully account for the behavioural factors and therefore more comprehensive analytical approaches are necessary to accurately investigate biking behaviour (Heinen et al., 2010). There are evident research gaps in investigating biking behaviour and more empirical research will benefit transport planners and public health officials in improving their understanding of

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urban biking behaviour. Two clear gaps exist in biking behaviour research. One is the consideration of the choice of biking for different purposes and the choice of owning different number of bikes under a comprehensive analytical framework, which would examine behavioural linkages between them. The other is accommodating behavioural or psychological variables within the analytical framework in meaningful ways. With the intension of filling these gaps, this paper presents a joint econometric model of bike usage and bike ownership level (number of bikes owned). It considers behavioural/psychological variables as latent variables that can be explained endogenously through different socioeconomic, land use and bike infrastructure-related attributes.

The empirical model is estimated using a dataset on the number of bikes owned and usage collected in Toronto in 2009. The model clearly proves that the choice of biking is influenced by two latent variables: perception of bikeability and 'safety consciousness', along with other variables. In addition, the latent variable that explains comfortability of biking influences the number of bikes owned, which eventually influences the choices of biking for utilitarian (work, school or shopping trips) and recreational (social, recreational or physical exercise trips) purposes. The empirical model establishes clear behavioural linkages among various factors influencing choice of biking, the number of bikes owned and purposes of biking. It provides clear guidelines for developing effective policies to encourage biking and possible bike intervention programs.

The paper is organized as follows: the next section presents a brief literature review to set the context of the current investigation. The following sections present descriptions of the dataset, econometric modelling framework and empirical model. The paper concludes by identifying key findings and possible implications in developing effective bike policies and/or intervention programs.

2. Context of current research

People's reasons for and extent of biking have been under investigation by travel demand researchers at least since Wigan (1984) published work on the number of bikes owned, usage and exposure. A considerable amount of research has been conducted on biking behaviour. In this section, we discuss only relevant papers that help explain the current investigation's context. We do not intent to present a full literature review on biking behaviour; as such reviews are available in other recent publications. For example, Heinen et al. (2010) present a review of literature on the determinants of bike commuting, concluding that bicycle usage and related factors should be investigated comprehensively. Their review clarifies that one must consider psychological factors (e.g., perception, attitudes) to achieve an accurate depictions of biking behaviour. These findings are also alluded in Fernandez-Heredia et al. (2014), where the authors found that many factors (including convenience, efficiencies, danger, fear of vandalism, etc.) affecting bicycle choice are psychological in nature and understanding these latent factors are key to improve our understanding on attitude towards biking.

Majority of research on biking behaviour tends to investigate the relationship between bike infrastructures and built environment attributes with bike usage and/or the number of bikes owned. Tilahun et al. (2007) used a stated preference survey technique to understand cyclists' perception to different bicycle infrastructure facilities. They found that bicyclists' travel time sensitivity to different on-street and off-street bicycle facilities are different. They also found that the respondents of their survey were willing to spend longer travel time if separated bicycle facilities were made available. Pucher et al. (2010) present a review of available evidences (literature of studies) on the effects of bike infrastructure and bike programs (bicycle interventions) on the level of bike use. They found that impact estimation processes and measurements vary widely among the researchers and it is difficult to generalize effectiveness of any individual measure. However, they concluded that the maximum benefit of bike infrastructures and programs can be achieved through coordinated/integrated strategies. In recent investigations, Titze et al. (2008) and Cervero et al. (2009) found a statistically significant relationship between bicycle use and bike infrastructure attributes (e.g., bike lane connectivity). They also found that while bike infrastructure-related attributes might be influential to bike usage decisions, built environment-related attributes (e.g., density, land use mixes) might not always be influential. However, Moudon et al. (2005) showed that bike infrastructure and neighbourhood land use characteristics (e.g., presence of parks, bike lane density, etc.) do not become statistically significant in bike usage investigations if they are objectively considered factors. These studies used fairly standard statistical techniques for the investigations.

Some researchers used advanced statistical techniques to investigate the relationship between biking behaviour and land use. Pinjari et al. (2008) investigated the correlation between factors affecting residential neighbourhood choice and the choice of owning different number of bikes. They found that ignoring these correlations may not always result in overestimations of the effects of neighbourhood attributes on the number of bikes owned. Their conclusions suggest there may be correlations between the observed factors influencing two types of choices, but the correlations between unobserved factors are not statistically justified. The main weakness of their investigation is the identification of two neighbourhood types (bike friendly and non-bike friendly) based on bike-related neighbourhood attributes, the choice of which is then modelled jointly with household bike ownership (number of bikes owned). The neighbourhood classification is based on the researchers' perception, not the bike users' perspective. As a result, their bike ownership (number of bikes owned) model is entirely a function of household socioeconomic variables without any psychological variables (e.g., perception of neighbourhood's bikeability). However, Bagley and Mokhtarian, 2002 proved that psychological variables (e.g., attitude, perception) that are apparently latent have the greatest impact on travel demand. Li et al. (2012, 2013) also found that the physical elements of road network significantly shape perceptions of comfort in biking. They also found that significant heterogeneity exists