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Enhancing active transport demand Modelling by incorporating accessibility measures

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ABSTRACT

Accessibility measures have been recognized as valuable input for decision support tools for land-use and transport planning. However, despite the relatively large number of available measures outlined in the literature, they are not widely used in planning practice, particularly in non-motorized transport modelling. Furthermore, the concept of availability of activities within acceptable walking/cycling travel distances may potentially affect the travel behaviour of pedestrians and cyclists, as distance has always been a significant barrier for travellers using active transport. Hence, this study aims to investigate the benefits of incorporating accessibility in active transportation modelling. For this purpose, three non-motorized accessibility measures are used in cluster analyses for classifying levels of access. Subsequently, three separate negative binomial regression (NBR) models are applied to examine the impact of including the access measure versus land-use measures in the models. Key findings indicate that the performance of active transport demand models is enhanced by incorporating accessibility as an explanatory variable as well as land-use measures.

1. Introduction

The term accessibility is commonly defined as the ease with which any land-use activity is reachable from a certain location and by a certain mode of transport (Dalvi & Martin, 1976; Lee & Goulias, 1997). The definition of accessibility varies depending on the goal and perspective of the study (Eizaguirre-Iribar, Igiñiz and Hernández-Minguillón, 2016). Since distance has been always a significant barrier to travellers using active transport, accessibility potentially influences the frequency of non-motorized trips (Cao, Mokhtarian, & Handy, 2009b; Cervero & Kockelman, 1997; Greenwald & Boarnet, 2001; Rodríguez & Joo, 2004).

A growing number of studies in the past few years have investigated the link between land use and design measures, such as population density, land-use mix and connectivity and active transport (Duncan et al., 2010; Kim, Park, & Lee, 2014; Song, Merlin, & Rodriguez, 2013). According to Soria-Lara, Aguilera-Benavente, and Arranz-López (2016), six groups of land use factors are interconnected with transport, including settlement size, urban density, land-use mix, urban design, local accessibility to public transport, and the provision of parking. More recently, transportation research has become concerned with built-environmental determinants of "active transport", driven mainly by the need to reduce the negative side effects of car-related issues. Active transport is commonly defined as trips made by non-motorized modes of transport such as walking and cycling (Frank & Engelke, 2001; Sallis, Frank, Saelens, & Kraft, 2004). However, the use of public transport is considered within the definition of active transport, as it often involves some walking or cycling to be connected from origins to destinations of trips (Taniguchi, Thompson, & Yamada, 2013). As Sallis et al. (2004) state, two fundamental urban features that impact travel choice and active transport are the proximity of different land uses and the connectivity between complementary activities (e.g. work, shops, etc.).

There has been considerable research on the measurement of access levels of active modes of transport (Currie, 2010; Frank, Schmid, Sallis, Chapman, & Saelens, 2005; Iacono, Krizek, & El-Geneidy, 2010; Krizek, 2005). Although non-motorized accessibility to a range of destinations has recently emerged as an important issue in transport and urban planning (Faskunger, 2013; Iacono et al., 2010; Krizek, 2005), accessibility as an integrated measure for non-motorized modes of transport has not been particularly considered in previous research (Iacono et al., 2010). A considerable amount of research has used land use and design measures as influential factors on non-motorized trips. Nevertheless, the importance of accessibility as an explanatory variable has been neglected (Cervero, 1996; Ewing & Cervero, 2010b; Van Acker & Witlox, 2011). Therefore, the aim of this study is to define an access measure based on walking, cycling and public transport accessibility

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measurements and employ it to examine whether it improves the performance of active-transport demand models.

The next section describes the research background regarding the concepts of active transport, built environment and accessibility. Section 3 presents the methods of the study, and describes the dataset, study area, and explanatory variables. This is followed by an analysis from the perspective of planning practitioners focusing on the usefulness of accessibility measures (Section 4). Thereafter, in Section 5, the results of the analysis are discussed, while in the final section, the conclusions and future directions of this study are outlined.

2. Research background

2.1. Active transport and built environment

In recent decades, active modes of transport have attracted increased attention in urban mobility studies and policies due to their potential as complementary strategies to achieve urban sustainability (Hino, Reis, Sarmiento, Parra, & Brownson, 2014; Lamíquiz & López-Domínguez, 2015). In other words, studies of non-motorized means of transportation such as walking, cycling and public transport have increased in recent years, owing to their importance as sustainable transport modes (Vandenbulcke, Steenberghen, & Thomas, 2009).

The interaction between the built environment and physical activity has also received considerable research attention in recent decades (Freeman et al., 2013; Handy, Boarnet, Ewing, & Killingsworth, 2002; Wang, Chai, & Li, 2011). Many studies on the built environment and mobility have found that land-use factors such as density and the mix of land use have a strong influence on non-motorized mobility (e.g. Etminani-Ghasrodashti & Ardeshiri, 2016; Litman, 2017; Marquet & Miralles-Guasch, 2015; Nasri & Zhang, 2014). Frequently, these studies have also considered other influential factors including connectivity and roadway measures under the category of urban design (Cervero & Kockelman, 1997; Handy, Clifton, & Fisher, 1998; Lee, Nam, & Lee, 2014). However, several researchers have found that land-use factors may be more important than urban design features in determining people's choice of mode of transport (Krizek, 2000; Schlossberg, Greene, Phillips, Johnson, & Parker, 2006).

The arrangement and distribution of different types of land use in the surroundings of living areas is one of the main factors found to influence urban transport patterns. The provision of services and utilities for residents in their neighbourhoods is a way to minimize the need to travel long distances and increase the chance of walking and cycling (Boarnet, 2011; Lee et al., 2014). Several studies investigating active transport and land use features (Cervero, 1996; Cervero & Gorham, 1995; Cervero & Kockelman, 1997; Ewing & Cervero, 2010a; Ewing & Cervero, 2010b; Friedman, Gordon, & Peers, 1994; Kitamura, Mokhtarian, & Laidet, 1997) have found that the frequency of walking and cycling trips is different in neighbourhoods in terms of the level of being walkable. In these studies, more walkable neighbourhoods were found to have higher population densities, greater mixed land use, and higher connectivity, while less walkable neighbourhoods were found to have low density, mostly residential land use, and low connectivity. In their international review, Légaré, Krizek, Forsyth, and Baum (2009) claimed that as a special mode of mobility, walking not only relies on dedicated infrastructure (e.g. pavements and crossings), but is also highly dependent on the built environment. In another study by Lamíquiz and López-Domínguez (2015), the results indicated that street networks and built environment factors are clearly associated with the percentage of walking trips in urban areas. McCormack, Giles-Corti, and Bulsara (2008) argued that proximity and mix of destinations appear to be strongly associated with walking for transport, and increasing the diversity of destinations may contribute to adults doing more transport-related walking and achieving recommended levels of physical activity.

2.2. Accessibility measures and non-motorized transportation

Accessibility in terms of proximity is a highly effective tool to promote smart growth planning in cities and has a major influence on physical activity and health. Numerous studies have examined the impacts of different aspects of accessibility on active trips (Djurhuus, Aadahl, Hansen, & Glümer, n.d.; Cheng, Bertolini, Clercq, & Kapoen, 2013; Chin, Van Niel, Giles-Corti, & Knuiman, 2008; Coombes, Jones, & Hillsdon, 2010; Paquet et al., 2013).

While the integration of transport and land-use planning is extensively recognized as an essential requirement for sustainable development, the concept of accessibility is believed to provide a central framework for this integration (Bertolini, Le Clercq, & Kapoen, 2005; Silva, Bertolini, Te Brömmelstroet, Milakis, & Papa, 2017; Wang et al., 2011). There are a variety of concepts and tools for addressing the theoretical and methodological aspects related to the definition and measurement of accessibility (Geurs, Montis, & Reggiani, 2015; Iacono et al., 2010; Shliselberg, 2015; Silva et al., 2017). However, these concepts and tools have not been extensively used in professional planning practice. Hence, as Brömmelstroet (2010) argues, there is a significant gap between the advances in scientific knowledge on accessibility and its application in planning practice. Millward, Spinney, and Scott (2013) analysed active-transport behaviour focusing on distance, duration, purposes and destinations of trips, while other studies have focused on calculating non-motorized accessibility. For instance, Iacono et al. (2010) developed an accessibility measure for non-motorized modes, namely bicycling and walking. Mavoa, Witten, Mccreanor, and O'sullivan (2012) also introduced a combined public transit and walking accessibility index, highlighting the importance of accessibility for the potential use of non-motorized modes of transport.

Accessibility can be directly related to both the quality of the transport system and the land-use system, including the functional density and land-use mix. At the same time, it can be directly related to economic and social goals as well as environmental goals in terms of the resource efficiency of activity and mobility patterns. In other words, shifting from more accessible neighbourhoods to more car-oriented suburban areas was found to reduce the use of sustainable travel options such as walking and cycling (Bertolini et al., 2005). One of the most effective ways to incorporate physical activity into daily routines is through active travel, which not only benefits public health but can also help prevent climate change (Maibach, Steg, & Anable, 2009; Rissel, 2009). Although it is widely agreed that walking and cycling are good for individuals' health, there is a lack of evidence about what works to promote active travel (McCartney, Whyte, Livingston, & Crawford, 2012). In addition, despite a noticeable focus on the importance of promoting walking and cycling in many transport-related strategies, policies and plans, there is relatively little robust evidence regarding the relationship between accessibility and levels of walking and cycling.

Although the transportation planning literature contains many examples of the calculation of measures of accessibility for urban areas, these measures are not usefully employed in practice. Therefore, this paper aims to contribute to the implementation of accessibility in practice, by innovatively integrating accessibility in active transportation modelling. Three walking, cycling and public transport accessibility indices, which have been recently developed for the Melbourne metropolitan area, are used to define an integrated access measure. This access measure is then employed to examine the importance and applicability of including accessibility in active-transport demand modelling.

3. Methods

The methods used in this study involve two main parts. In the first part, three measures of walking, cycling and public transport accessibility are converted into an access level measure using cluster analysis.