Transportation Research Part A 88 (2016) 26–39

Contents lists available at ScienceDirect

Transportation Research Part A

journal homepage: www.elsevier.com/locate/tra

A utility-based travel impedance measure for public transit network accessibility

Neema Nassir [a,*], Mark Hickman [b], Ali Malekzadeh [c], Elnaz Irannezhad [b]

[a] Massachusetts Institute of Technology, USA
[b] University of Queensland, Australia
[c] Queensland University of Technology, Australia

ARTICLE INFO

Article history:
Received 6 July 2015
Received in revised form 21 January 2016
Accepted 24 March 2016
Available online 12 April 2016

Keywords:
Transit network accessibility
Transit impedance
Logit logsum

ABSTRACT

A utility-based travel impedance measure is developed for public transit modes that is capable of capturing the passengers' behaviour and their subjective perceptions of impedance when travelling in the transit networks. The proposed measure is time-dependent and it estimates the realisation of the travel impedance by the community of passengers for travelling between an origin–destination (OD) pair.

The main advantage of the developed measure, as compared to the existing transit impedance measures, relates to its capability in capturing the diversity benefit that the transit systems may offer the society of travellers with different traveling preferences. To clarify the necessity of such capability, we demonstrate the randomness (subjectivity) of travel impedance perceived by transit passengers, through evidence from the observed path choices made in the transit network of the greater Brisbane metropolitan region in Australia.

The proposed impedance measure is basically a nested logit "logsum" composition over a generated set of reasonable path options whose systematic utilities are evaluated based on a discrete choice model previously developed and calibrated for the greater Brisbane transit passengers. As a case study, the proposed impedance measure is calculated for all the origin blocks in the Brisbane area, during the morning commutes to the Central Business District (CBD). The results are presented and discussed, and intuitive and important advantages are demonstrated for the proposed measure.

© 2016 Elsevier Ltd. All rights reserved.

1. Introduction

Improving the accessibility of public transport is essential to the sustainability, liveability, and welfare of human societies. An accessible public transport system can encourage people to use and to rely on public transport, leading to a mode shift in favour of public transport (Owen and Levinson, 2015), which in turn decreases the negative effects of automobiles on the environment, and on urban mobility in populated cities. An accessible public transit network can also enhance liveability and welfare of our cities by improving equity, easing work-related commutes, and encouraging the social inclusions of the carless, elderly and disabled (Cervero et al., 1995; Currie and Stanley, 2008).

On the other hand, there are interesting arguments in the literature noting the possible drawbacks of infrastructural development – mainly highways but public transport systems too – and of the increased accessibility of distant suburbs

* Corresponding author.
E-mail addresses: neeman@mit.edu (N. Nassir), m.hickman1@uq.edu.au (M. Hickman), ali.malekzadeh@student.qut.edu.au (A. Malekzadeh), e.irannezhad@uq.edu.au (E. Irannezhad).

http://dx.doi.org/10.1016/j.tra.2016.03.007
0965-8564/© 2016 Elsevier Ltd. All rights reserved.

to the central business districts of cities. These studies highlight the detrimental effect of such developments from an urban planning and environmental perspective, such as induced long-distance travel demand, urban segregation and separation, energy use, etc., and they emphasize these potential detriments on the sustainability and the quality of our modern cities (Metz, 2008; Banister, 2011; Crozet, 2013). As a result, the analysis of accessibility in general, and the study of transit network accessibility in particular, has become a sensitive topic and important direction of research which has recently attracted a lot of attention among researchers in transport planning, urban geography, and sustainable development. The main goal of the research reported in this paper is to improve estimates of public transit travel impedance, which is an important component in the measurement of accessibility.

During the past few decades, a significant body of literature has contributed to quantifying urban accessibility. A majority of these approaches have agreed on measuring accessibility based on two main components (Hansen, 1959; Pirie, 1979; Handy and Niemeier, 1997; Bhat et al., 2002; Church and Marston, 2003; Kwan et al., 2003; Levinson and Krizek, 2005; Cascetta et al., 2013). These two components are: (1) locations and attractiveness of urban opportunities (benefit side); and, (2) impedances of travelling to these locations from residential areas in the network (cost side). Based on these definitions, more accessible areas are the ones that have lower impedances for travelling to attractive locations.

Transit accessibility has also been defined in a similar fashion, with the only difference that the mode of travel is restricted to public transit (and perhaps walking), and the impedances are calculated based on the public transit network (Hillman and Pool, 1997; Murray et al., 1998; O'Sullivan et al., 2000; Liu and Zhu, 2004; Zhu and Liu, 2004). However, due to the inherent complexities in the transit network that are the result of spatio-temporal constraints in service, accurate calculation of transit costs and travel times in real-sized time-dependent networks has often been compromised. A large body of research in transit accessibility is focused on accessibility to the transit network, as a potential end in itself, instead of serving as a means of transport to other destinations (Murray, 2001; Polzin et al., 2002; Rastogi and Rao, 2002, 2003; Currie, 2010; El-Geneidy et al., 2010). Although an important part of a transit journey is the access from the origin to the public transit service, the spatio-temporal connectivity of the transit network also affects the accessibility of destinations significantly. It has been argued that measuring transit accessibility by only considering the access to the transit network is proper only in high frequency and dense transit networks (Lee, 2005); or, that such a measurement would overestimate the accessibility (Lei and Church, 2010). Moniruzzaman and Páez (2012) investigated accessibility to transit, accessibility by transit, and the mode share, and their case study of the city of Hamilton, Canada, concluded that accessibility by transit is a significant predictor of modal share. Therefore, for creating a positive mode shift to public transport, a closer analysis of transit accessibility and its related component, namely transit impedance, is imperative.

Some researchers have recently acknowledged the importance of accessibility through the transit network and to destinations. With a lack of detailed transit schedule information, they have applied simplified transit cost calculations and made travel time estimates based on average route speeds and route frequencies (O'Sullivan et al., 2000; Liu and Zhu, 2004; Moniruzzaman and Páez, 2012), or based on simplifying assumptions regarding transfer waiting times (O'Sullivan et al., 2000; Lee, 2005; Yigitcanlar et al., 2007; Mavoa et al., 2012; Tribby and Zandbergen, 2012) regardless of the time dependence of the service.

A recent body of research has based accessibility measurement on accurate time-dependent travel times. A majority of these approaches use schedule-based shortest path algorithms that calculate the fastest travel time between the origin–destination (OD) pair in the time-dependent transit network, with walk links for access, egress, and transfer interchanges (Church et al., 2005; Lei and Church, 2010; Lei et al., 2012; Salonen and Toivonen, 2013). This recent research has been successful in calculating the accurate time-dependent travel times in a transit network as a representation of travel cost between OD pairs. However, in this paper we argue that limiting the perceived impedance of transit passengers only to the total travel time might be a strong assumption. And perhaps more fundamentally, by investigating a dataset of actual transit passengers' path choices, we empirically demonstrate that the assumption that the transit impedance is perceived uniformly among the passengers also needs careful revisions.

One inherent feature that differentiates public transit journeys from other transport modes relates to the complexities of public transport, e.g. the spatio-temporal limitations of the service, the importance of transfers, the multimodality of service, and the importance of strategic path choices (Cats, 2011). These complexities, in turn, result in complexities in behaviour, diversity in user preferences, and random variation in perceptions of transit impedance among the users of the system. This research aims to account for these complexities and to rely on a systematic analysis of observed passengers' behaviours in estimating the impedance. To this end, the proposed measure is defined in a utility-based structure as a function of a diverse set of travel attributes calculated for a diverse set of path/mode options in the transit system. Nassir et al. (2015a) estimated a discrete choice model to describe the access behaviour of users based on various service attributes of the transit network between given OD pairs and at given times of service. Their model was estimated using household travel survey (HTS) data collected from the Southeast Queensland (SEQ) region in Australia. For estimating the impedances, we use the utility function estimated in Nassir et al. (2015a), and we apply the proposed set generation algorithm to generate the universal set of reasonable access stop choices and their utility attributes, from which the perceived travel impedance is calculated. A case study is performed on the SEQ transit network to highlight the characteristics of the developed measure.

Section 2 briefly discusses the background of utility-based logsum measures that have been used in the literature of accessibility measurement. In Section 2 we also highlight the methodological contrasts between the proposed method and the existing relevant logsum measures. Section 3 briefly reviews the access choice model in Nassir et al. (2015a). In Section 4, the variability of the observed path choices and the subjectivity of the perceived transit impedances are empirically

Download English Version:

https://daneshyari.com/en/article/6780870

Download Persian Version:

https://daneshyari.com/article/6780870

Daneshyari.com