Journal of Transport Geography 48 (2015) 176–187

Contents lists available at ScienceDirect

Journal of Transport Geography

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

Identifying public transport gaps using time-dependent accessibility levels

Koos Fransen [a,b,*], Tijs Neutens [b], Steven Farber [c], Philippe De Maeyer [b], Greet Deruyter [a,b], Frank Witlox [b]

[a] Department of Industrial Engineering, Ghent University, Valentin Vaerwyckweg 1, 9000 Ghent, Belgium
[b] Department of Geography, Ghent University, Krijgslaan 281 S8, 9000 Ghent, Belgium
[c] Department of Human Geography, University of Toronto Scarborough, 1265 Military Trail, Toronto, ON, Canada

ARTICLE INFO

Article history:
Received 29 January 2015
Received in revised form 16 September 2015
Accepted 17 September 2015
Available online 29 September 2015

Keywords:
Transport gap
Transport disadvantage
Social exclusion
Public transport
GIS
Flanders

ABSTRACT

One of the concerns that has aroused much scholarly attention in transport geography lately is the extent to which public transport provision enables the less privileged population segments, especially those without privately owned motorized vehicles, to participate in activities that are deemed normal within the society they live in. This study contributes to this line of inquiry by proposing a methodology for identifying public transit gaps, a mismatch between the socially driven demand for transit and the supply provided by transit agencies. The methodology draws on the latest accomplishments in the field of modeling time-continuous, schedule-based public transport accessibility. Accessibility levels to key destinations are calculated at regular time intervals, and synoptic metrics of these levels over various peak and off-peak time windows are computed for weekdays and weekends. As a result, a temporally reliable picture of accessibility by public transport is constructed. The obtained index of public transport provision is compared to a public transport needs index based on the spatial distribution of various socio-demographics, in order to highlight spatial mismatches between these two indices. The study area consists of Flanders, which is the northern, Dutch-speaking region of Belgium. The results indicate that mainly suburban areas are characterized by high public transport gaps. Due to the time-variability of public transport frequencies, these gaps differ over time.

1. Introduction

The past two decades have witnessed a large and growing academic and policy interest in the social implications of transport planning alongside the traditionally well-studied economic and environmental outcomes (Lucas, 2012). Understanding the ways in which inadequate or lack of mobility can contribute to social disadvantage and isolation has been brought to the forefront of the transport policy agenda. Currently, there is a wide recognition that transport policies may generate spatially and temporally uneven accessibility effects that unduly favor certain population groups above others (Grengs, 2015).

One of the concerns that has recently aroused much scholarly attention is the extent to which public transport provision enables the less privileged population segments, especially those without privately owned motorized vehicles, to participate in activities that are deemed normal within the society they live. Various studies conducted under the umbrella domain of transport-related social exclusion have used geographical information systems (GIS) to unravel the connections between social disadvantage, public transport needs and public transport provision. However, much of the empirical work to date has explored these connections by examining social disparities in access to the public transit system rather than by the transit system. For example, in their assessment of the impact of bus network changes on different social groups in Northern Ireland, Wu and Hine (2003) suggested the use of public transport accessibility levels (PTAL) which essentially express accessibility as the sum of walking time to the closest bus stop plus average waiting time at that stop. Likewise, Currie (2010) applied a combined indicator of access to public transit stops (e.g., spatial coverage of walk catchments around public transport stops/stations) and their relative service (e.g., the number of bus/tram/train vehicle arrivals per week). While such indicators are insightful in identifying socio-spatial differences in access to the public transport system, they do not provide insights into whether the system brings people to desired activity locations within an acceptable travel time at the desired time of day. Furthermore, these indicators ignore that inadequate proximity to public transport provision can be compensated by local availability of amenities. Other recent studies that link transit access to social disadvantage like Delmelle and Casas (2012) assumed that public transport vehicles ride at a constant travel velocity in order to be able to construct a routable walk-transit network layer. Their multimodal approach accounted for ingress and egress time, but ignored wait and transfer times leading to an underestimation of the overall journey travel time. Other cognate studies have calculated end-to-end travel times by public

* Corresponding author at: Krijgslaan 281 S8, 9000 Ghent, Belgium.
E-mail address: Koos.Fransen@UGent.be (K. Fransen).

http://dx.doi.org/10.1016/j.jtrangeo.2015.09.008
0966-6923/

transit using bespoke database software tools such as Amelia (Mackett et al., 2008) and Accession (Preston and Raje, 2007). While these tools have proven useful in aiding transport planners in the UK to compare the impact of policy actions, they are unavailable to the wider academic public. Furthermore, they offer rather limited flexibility to analysts in order for them to develop their own procedures on top of the functionalities embedded in the software. The accessibility metrics produced by these tools are therefore static in the sense that they describe what is accessible by public transit from a particular origin at a single point in time but do not consider the temporal variability in accessibility levels. Such temporal variability occurs as a consequence of fluctuations in operating frequencies across the diurnal cycle and between weekdays and weekends.

This study contributes to the strand of literature outlined above. It puts forward a methodology for identifying public transit gaps by drawing on the latest accomplishments in the field of modeling time-continuous, schedule-based public transport (Farber et al., 2014; Lei and Church, 2010; Owen and Levinson, 2014). It measures accessibility levels to key destinations for socio-spatial population groups at regular time intervals and computes synoptic metrics of these levels over various peak and off-peak time windows on weekdays and weekends. The obtained metrics of transport provision are then compared across social cross-sections of the population and compared to a public transport needs index to highlight spatial mismatches between provision and need. The study area consists of Flanders, which is the northern, Dutch-speaking region of Belgium. This region constitutes an interesting and challenging setting for studying public transport gaps since it is characterized by a highly dense public transport infrastructure with a variety of public transport alternatives run by different operators. Furthermore, since 2001 the region has adopted a clear-cut stance towards combatting transport poverty. Flanders is one of the only regions in the world[1] where the right to basic provision to public transport, formulated as having spatial access to a minimum level of public transport service irrespective of the location of residence, is granted by law (decree '*Personenvervoer*'). Within this context, budgetary pressure has prompted the public transport company *De Lijn* to search for new cost-effective alternatives (e.g., mobility budgets and neighborhood buses) to continue guaranteeing sufficient service in all parts of the region. The results reported in this study have served to set the stage and inform *De Lijn* about the deficits in coverage of their system in Flanders.

The paper proceeds with a brief review on the measurement of transport gaps and discusses how accessibility by public transport was modeled in prior work. Subsequently, it contextualizes the research within the study area and describes the data and methodology. The results are presented in Section 4. The paper concludes with the major findings and outlines avenues for further research.

2. Literature review

2.1. Measuring public transport gaps

Policy concerns related to social disparities in mobility and access to essential goods and services have emerged and grown in tandem with a wider policy interest in the causes and effects of social exclusion. Policy interest in social exclusion originated in the United Kingdom in the late 1990s as part of a broader social welfare reform under the New Labour government. A Social Exclusion Unit (SEU) set up in 1997 has sparked off a series of policy documents including a widely applauded report that focuses on the interactions between social disadvantages and transport disadvantages and how these interactions can culminate into situations of transport poverty and exclusion. Since the publication of the report, researchers from around the world have built up empirical evidence of social exclusion as a result of transport problems. Evidence has mounted in Europe (Priya and Uteng, 2009; Schönfelder and Axhausen, 2003), North America (Farber et al., 2011; McCray and Brais, 2007; Paez et al., 2010), Latin America (Delmelle and Casas, 2012; Jaramillo et al., 2012), Australia (Delbosc and Currie, 2011; Stanley and Vella-Brodrick, 2009), and Africa (Lucas, 2011; Porter et al., 2012).

Within this emerging body of international literature much attention has been devoted to the quality of public transport and more specifically to designating individuals and areas that suffer from public transport deficiencies. However, quantifying to what extent a person suffers from public transport deficiencies is difficult because transport poverty manifests itself at the individual and household level, whilst appropriate data sets are generally available at a zonal level (Hine and Grieco, 2003; Karner and Niemeier, 2013). Furthermore, it is difficult to determine when a person is to be considered transport poor. By definition (Lucas, 2012, p. 106), this has to do with the inability to access a 'normal' range of activity locations, but the exact meaning of such a 'normal range' remains absent, apart from it being the range of activities that is available to the majority of people in society (Levitas et al., 2007). The necessity of being able to reach certain destinations evidently differs for each individual and in different societies. Having access to education, for example, is more important to students than to the elderly, whereas the opposite may be true for health care. Hence, it is up to the analyst to judiciously decide which destinations matter in the case study at hand. Another issue is the definition of the concepts 'access' and 'inability to access' and whether these have to be conceptualized in normative or relative terms. 'Normative' refers to an absolute threshold that represents policy makers' expectations about the minimum required level of accessibility, while 'relative' pertains to a particular benchmark (e.g., a population average) that expresses the accessibility levels of other individuals in the same society (Paez et al., 2012).

A common strategy to quantify socio-spatial deficits in public transport provision is to construct and compare two indices: one that expresses public transport needs and another that represents public transport provision. The former is composed of indicators that describe area-based populations who are most in need of public transport on the basis of such variables as car ownership, income, employment and age. The latter is an index representing how well an area is serviced by the public transport system. The difference between both indices is then termed the 'transport gap' which acts as a proxy for an area's vulnerability to developing transport poverty. Of particular interest are those areas with low provision and high need as well as those with low need and high provision as these cases represent situations of under-service and over-service, respectively. Exemplary to this approach is the work by Currie (2010) who found significant spatial patterns of 'high need–low provision' in Metropolitan Melbourne (Australia). Those patterns were also detected in Santiago de Cali (Columbia) by Jaramillo et al. (2012) using a similar methodology. The constructed disadvantage-impedance index by Duvarci et al. (2015) aims to counteract transport disadvantages by simulating the effects of potentially efficient policy alternatives in Arao, Japan. Aggregation errors notwithstanding, these studies help to understand the relative spatial scale of public transport shortfalls which can help inform policy makers regarding the spatial prioritization of transport policy actions. For this reason, a similar research strategy is adopted in this study.

2.2. Modeling public transport accessibility

Modeling public transport accessibility has a long history with a trend towards increasingly sophisticated measurements. At least four types of indicators of public transport accessibility can be identified. The first type measures the physical accessibility to the public transport system in terms of the proximity to transit stops in time or distance (Lei and Church, 2010). A commonly applied indicator is the walking

[1] In the UK, local transport authorities are required to publish accessibility assessment reports as part of their Local Transport Plans Atkins, 2012. Accessibility Planning Policy: Evaluation and Future Direction — Final Report (2012).