Journal of Transport Geography xxx (2015) xxx–xxx

Contents lists available at ScienceDirect

Journal of Transport Geography

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

Accessibility and Transit-Oriented Development in European metropolitan areas

Enrica Papa *, Luca Bertolini

Department of Human Geography, Planning and International Development AISSR, University of Amsterdam, Nieuwe Achtergracht 166, 1018 WV Amsterdam, The Netherlands

ARTICLE INFO

Article history:
Received 2 October 2014
Revised 10 July 2015
Accepted 11 July 2015
Available online xxxx

Keywords:
Transit-Oriented Development (TOD)
Accessibility

ABSTRACT

This study investigates how urban form is related to accessibility. In particular, it explores the relationship between Transit-Oriented Development (TOD) and rail-based accessibility in a metropolitan area. The following overarching questions are addressed: Does a TOD-informed urban spatial structure correlate with high rail based accessibility? Which features of TOD are correlated to rail-based accessibility? These questions are answered through a comparative analysis of six metropolitan areas in Europe. The "TOD degree", operationalized as the extent to which urban development is concentrated along rail corridors and stations, is correlated with a cumulative opportunity measure of rail-based accessibility to jobs and inhabitants.

The comparison demonstrates that rail-based accessibility is higher in urban areas where inhabitants and jobs are more concentrated around the railway network and in lesser measure in urban areas with higher values of network connectivity. No correlation is found between rail-based accessibility and average densities of inhabitants and jobs.

1. Introduction

The urban and transport planning strategy of Transit-Oriented Development (TOD) has been generating considerable interest in academic and professional circles recently (Bertolini et al., 2012; Cervero, 2004; Curtis et al., 2009). TOD's approach of concentrating urban developments around railway networks builds upon strategies applied since the late 19th and early 20th centuries in the United States and Europe, when the construction of streetcar and metro lines was integrated with urban developments. After the Second World War planners in parts of Europe, most notably in Stockholm (Cervero, 1995) and Copenhagen (Knowles, 2012), were able to channel suburban development into satellite suburbs along transit corridors. In recent years a third generation of TOD approaches has emerged. In the United States, since the 1990s, following experiences pioneered in the 1970s in cities such as Portland, TOD has become the dominant urban growth planning paradigm. It is focused on combating unbridled urban sprawl and closely connected with Smart Growth (SG) and New Urbanism (NU) approaches (Dittmar and Ohland, 2004). Also in Europe many metropolitan areas (Bertolini et al., 2012; Givoni and Banister, 2010) are promoting urban development along rail corridors as a tool and, at the same time, a target for achieving more cohesive territories and sustainable urban development.

Under favourable conditions, TOD is seen as delivering multiple benefits, such as helping shape polycentric cities and regions, mitigate urban sprawl, boost public transport ridership, increase biking and walking, while accommodating economic growth and creating attractive places. Indeed, there is a substantial body of literature on the comprehensive assessment of TOD strategies (Arrington and Cervero, 2008; Renne, 2007); and on specific TOD impacts, such as on property values (Bowes and Ihlanfeldt, 2001; Duncan, 2011; Mathur and Ferrell, 2013) or on relocation of jobs and dwellings (Cervero and Landis, 1997; Pagliara and Papa, 2011) but much of the interest is related to analysing TOD impacts on travel behaviour (Cervero et al., 2002). However, none of these studies give direct insight into the relationship between TOD and accessibility, that is, the degree to which the urban and transit network structures enable individuals to participate in activities and obtain spatially distributed resources (Geurs and van Wee, 2004; Handy, 1992; Handy and Niemeier, 1997). This can be seen as a worthwhile objective in itself and as an influencing factor of travel behaviour change.

In this paper, we aim to address this gap by studying how the degree of TOD of a metropolitan area is related to the rail-based accessibility to jobs and inhabitants. The following research

* Corresponding author.
E-mail addresses: enrica.papa@ugent.be (E. Papa), l.bertolini@uva.nl (L. Bertolini).

http://dx.doi.org/10.1016/j.jtrangeo.2015.07.003
0966-6923/

questions are addressed: Does a TOD-informed urban spatial structure correlate with high rail-based accessibility? Which features of TOD are correlated to rail-based accessibility? The latter include such characteristics as density distribution of inhabitants and jobs, and network connectivity. By exploring these issues, we aim to provide empirical insights into the understudied relationship between TOD (a transport and urban development strategy embraced by increasing numbers of cities and regions across the world) and accessibility (a key policy aim and feature of the urban system). In so doing, we also provide a comparison of TOD degree and accessibility values in six different metropolitan contexts.

Our interpretation of TOD is different from other, more localized approaches (Bernick and Cervero, 1997; Cervero et al., 2002); for us, TOD is the measure in which the whole urban area, not just a single neighbourhood, is oriented towards transit. Accordingly, we define the "TOD degree" as the degree of correlation between the railway network connectivity and the distribution of densities in the whole urban area, and "accessibility" as the number of jobs and inhabitants that can be reached by rail as a percentage of the total jobs and inhabitants in the study area. While recognising that accessibility is affected by a much wider range of factors, including subjective ones, in this study rail-based accessibility is measured as an aggregate objective indicator, and it is defined as a condition for rail use and as an enabler (or disabler) of travel choices and behaviours.

This research employs several innovative approaches. The first is the use of accessibility in analysing the TOD degree of an urban area. As previously stated, while there are multiple empirical studies on the linkages between TOD and travel behaviour, its relationships with accessibility have attracted much less attention. By definition, accessibility by rail is dependent on the spatial distribution of jobs and residents with regards to the vicinity to rail stations. However, the two measures are still conceptually distinct (the former is a condition, or quality from a system user's point of view, the second a characteristic of urban form). Accordingly, this paper innovatively contributes (1) a transparent link between the two and (2) a systematic way of assessing to what extent and because of which transport and land use features, the spatial distribution of jobs and population matches the rail network. In this sense, we offer novel, or at least more structured, insights into how certain distribution of inhabitants and job densities and rail transport characteristics, and their interrelationships, are related to rail-based accessibility. While general TOD characteristics and benefits of TOD are extensively addressed in the literature, this research focuses on the yet understudied relationship between TOD and accessibility. Furthermore, the existing literature rarely employs accessibility metrics to compare metropolitan areas, and most empirical research measuring accessibility focuses on case studies of single regions (Benenson et al., 2011; Cheng et al., 2007, 2013; for a recent exception comparing two cities see Silva et al., 2014). In this study, we instead make a systematic comparison of accessibility measures in six different urban areas, which is seen as a valuable procedure for understanding the determinants of accessibility (Levine et al., 2012). A final innovation is the focus on Europe. TOD empirical studies focus overwhelmingly on the North American context, and few studies (Keller et al., 2011; Knowles, 2012; Singh et al., 2014) propose quantitative analysis of TOD urban structures in the European context, where the urbanisation patterns and histories differ radically from those in the US.

The paper is organised in five sections. Following this introduction, in Section 2 we position our research within the relevant literature on the relationships between TOD degree of the urban structure, accessibility and travel behaviour. In Section 3, we present the research design, subsequently turning to the presentation and discussion of the results in Section 4. On the basis of the analysis provided, we formulate several conclusions in Section 5.

2. Literature review: TOD degree of the urban structure, travel behaviour and accessibility

The interaction between the TOD degree of the urban structure, accessibility and travel behaviour has attracted considerable attention in the scientific literature worldwide. Four main groups of studies can be identified (see Fig. 1) and categorized according to the main relationships studied:

1. interrelation between rail transport network and land use, and the resulting TOD degree of the urban structure,
2. TOD degree of the urban structure as a factor affecting travel behaviour,
3. impacts of accessibility on travel behaviour, and
4. impacts of TOD degree of the urban structure on accessibility.

With regard to the first relation (arrow 1), the problem of the co-development of rail infrastructures and land use has been much discussed (Levinson, 2008; Xie and Levinson, 2011) and has been treated quantitatively in a number of examples (Anas et al., 1998; King, 2011; Mogridge and Parr, 1997). The key aim of these studies is to explore the two-way dynamics whereby transport infrastructure development drives land use change and vice versa. Within the TOD literature, an increasing number of studies focus specifically on how transit development impacts land use changes (Cervero and Landis, 1997; Ratner and Goetz, 2013). The much sparser studies that examine the two-way interaction between land use and transit network are often been based on the node-place model approach introduced by Bertolini (1999) and further elaborated in more recent applications (Chorus and Bertolini, 2011; Kamruzzaman et al., 2014; Reusser et al., 2008; Zemp et al., 2011a, 2011b; Vale, 2015). In our knowledge, no TOD studies specifically focus on how land use changes impact transit development.

With regard to the group of studies that are represented with arrow 2, and as already discussed in the introduction, they chiefly aim to examine the potential of the TOD degree of the urban structure to curb car travel demand and shift it towards transit and non-motorized modes. A significant body of research has been produced on the impact of the urban form on travel behaviour, in terms of travel distance, journey frequency, modal split, travel time and transport energy consumption (Boarnet, 2011; Cervero and Kockelman, 1997; Echenique et al., 2012; Ewing and Cervero, 2010; Naess, 2012; Schwanen et al., 2001; Shatu and Kamruzzaman, 2014; Stead and Marshall, 2001). Within this cluster a specific group of studies analyses the impact of TOD urban structure on travel behaviour, including studies considering TOD a systemic (urban area wide) rather than local characteristic (neighbourhood-focused). Some authors assert that a TOD structure is able to increase rates of transit use, particularly rail ridership (Cervero et al., 2002); to reduce car use and travel distances, and to reduce commuting distances and times (Arrington and Cervero, 2008; Cervero et al., 2002; Houston et al., 2015; Lund et al., 2004, 2006) and to stimulate non-motorized travel (Curtis and Olaru, 2010). On the other hand, studies also highlight that other factors (e.g. housing type and tenure, local and sub-regional density, bus service level, and especially parking availability) can play a much more important role than proximity to transit (Chatman, 2013). Yet others argue that TOD impacts on travel behaviour are also – or even principally – dependent on personal characteristics such as travel-related attitudes and residential self-selection, influenced by certain factors as income, or household composition. For instance, De Vos et al. (2014) and Kitamura et al. (1997) found that attitudes are more strongly associated with travel behaviour than are land use characteristics. They suggested that land use policies that promote higher densities and

Please cite this article in press as: Papa, E., Bertolini, L. Accessibility and Transit-Oriented Development in European metropolitan areas. J. Transp. Geogr. (2015), http://dx.doi.org/10.1016/j.jtrangeo.2015.07.003