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# How transit oriented land-use is related to accessibility? A study in Beijing

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## 1. Problem statement

A shift from mobility-centred to accessibility-centred transport and land use planning has been advocated over a decade (Bertolini and le Clercq, 2003; Cervero, 1997; Curtis and Scheurer, 2010; Levine et al., 2017; Levine and Garb, 2002; Martens, 2016; Papa et al., 2015). This shift starts from the idea that the demand for transportation is largely derived from people's demand to reach their destinations, rather than for the sake of movement per se. It suggests that enhancing accessibility to desired destinations is what really counts for the users of that transport system (Martens, 2016). One of the most popular accessibility-centred planning approaches is Transit Oriented Development (TOD) (Curtis and Scheurer, 2010; Handy, 2002; Papa and Bertolini, 2015). Under a favourable condition, TOD can enhance accessibility through strengthening the integration between transport and land-use systems by means of relatively high-density, mixed-use, cycling- and pedestrian-friendly development around transit stations and networks (Bertolini and Spit, 1998; Cervero, 1998; Cervero et al., 2004; Curtis et al., 2009). However, studies have shown large differences in

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the application of TOD strategies, even within the same city (Atkinson-Palombo and Kuby, 2011; Lyu et al., 2016; Vale, 2015). It raises the question: what is the actual effect of TOD on accessibility? Empirically, Papa and Bertolini (2015) have done a pioneer study by investigating ‘how the degree of TOD of a metropolitan area, i.e. the degree to which the spatial distribution of jobs and population densities matches the hierarchies (i.e. the degree of connectivity of nodes) in the public transportation network, is related to the rail-based accessibility to jobs and inhabitants’. They found that cumulative rail-based accessibility is higher in cities with a higher TOD degree. Their analysis also showed high correlations between overall network connectivity levels and accessibility. However, they did not find correlations between average urban density and accessibility. Their results suggests that TOD indeed enhances accessibility at a city-wide level. But this impact seems not to relate to the average land-use density. Their findings seem to align with those of others (e.g. Mees, 2009). The finding, seem however, to contradict yet other studies, including the study of Levine et al., (2012), where authors argue that the denser metropolitan areas are more accessible. It becomes an interesting topic to research how the land-use pattern relates to accessibility, and what is, conversely, the relative contribution of the transport network. This topic relates to important policy implications: in order to improve accessibility, which type of policy should be paid more attention: transport-enhancing policy or land-use intensifying policy? Furthermore, both analyses of Papa and Bertolini (2015) and Levine et al., (2012) were highly aggregated and did not provide information how TOD relates accessibility within a city.

## **2. Research objectives**

This paper aims to address these knowledge gaps by studying how TOD characteristics, in particular, transit oriented land-use (e.g. urban density, diversity, proximity of land-uses to the transport node, and pedestrian-friendly land-use), are related to accessibility within a city. For illustration, we investigate these relationships for the Beijing metropolis, China. Beijing is home to 21.5 million residents, with 86.4 percentages of urban population, and 1,385.6km<sup>2</sup> urban built-up environment in 2014 (Beijing Municipal Statistics Bureau, 2015; Ministry of housing and urban-rural development of China, 2014). In 2014, the metro served ten million passengers each workday, with 18 lines, 268 stations and 527 km of track in operation (Beijing Infrastructure Investment Corporation Limited, 2015; Beijing Mass Transit Railway Operation Corporation Limited, 2015). TOD strategies, centred on the metro system, have been proposed and applied for many years in Beijing (Beijing municipal government, 2003).

## **3. Methodological approach**

The methodology of the study follows an empirical approach. The hypothesis is that accessibility for each (metro-centred) TOD area depends to a large extent on the transport system and the land-use pattern at the regional level. First, the study assessed the housing and job accessibilities for all metro station areas in Beijing. Second, it innovatively measured the TOD characteristics of areas at the catchment level (a catchment is defined here as the area covered by traveling one hour by means of public transport from a metro station area). Third, in order to extract the main factors that can explain the variation of TOD characteristics of catchment areas and reduce the potential collinearity of the regression model, principal component analysis was applied. Fourth, the normal standardised regression analysis (ordinary least squares model) and the standardised spatial regression analysis (spatial error regression) were conducted to explore the relationships between TOD characteristics and accessibility.

## **4. Results**

The study found that TOD characteristics are positively related to accessibility at the catchment level. Furthermore, it found that, at the catchment level, the transport feature of the TOD system is highly related to accessibility, while for transit oriented land-use patterns the associations are much smaller. This suggests that in order to improve accessibility of an area, transport-enhancing policy should be considered as the first option. If the transport system is kept unchanged, land-use policy relating improving urban density, diversity and pedestrian-friendly development is recognised as an effective tool to enhance accessibility of the area.

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