

Abstract

Transit Oriented Development (TOD) is widely recognized as an integrated approach to land use and transport planning that can be promoted to influence travel behavior. Specifically, this approach develops certain features of the built environment (the so-called 5Ds: density, diversity, design, destination accessibility, and distance to transit) in areas around metro and train stations to increase the patronage of public transport. A wide range of indicators has been proposed to measure these Ds, generally computed by considering the spatial distribution of certain elements (such as land use, inhabitants, intersections, POIs, etc.) within a specific two-dimensional spatial buffer around the station. The third spatial dimension, that is, the distribution of these elements along the vertical z-axis, is not taken into account. This approximation can be problematic if the area around the station is multilayered not only above ground, but also underground, as it is beginning to occur in many Chinese cities.

This article explores how to adapt methods of measuring metro station TODness by shifting from a traditional 2-dimensional spatial to a 3-dimensional spatial approach in the cases of metro stations in Chengdu. This research addresses four main questions: 1.) how to adapt methods of measuring TODness of these stations by shifting from a traditional 2-dimensional spatial approach to a 3-dimensional spatial approach, 2.) What are the indicators for the 3-dimensional TODness assessment, 3.) how is the TODness affected by underground development, and 4.) which indicators would play a more essential role in contributing to TODness?

This dissertation starts with the literature review of TOD theory, TODness, and TOD index calculation, which helps identify the major evaluation systems. These frameworks include the 5D principles, the node-place model, and multi- criteria assessment systems. Although there were many studies about TODness measurement, there is a critical gap that underground space is largely neglected. This can be particularly problematic in high-density Asian cities, where subsurface development plays an increasingly important role in shaping accessibility, land-use intensity, and pedestrian movement around transit stations.

To address this gap, the dissertation develops a three-dimensional TOD index with different indicators. These indicators combine three-dimensional spatial features. For instance, the volume of different functions is used for land-use entropy calculation. The above-ground and below-ground networks are also taken into consideration in three-

dimensional TODness measurements. Impedance pedestrian catchment areas (IPCA) are also generated based on the three-dimensional spatial structures. Then, a comparative analysis is conducted using a case study of Chunxi metro station in Chengdu to evaluate the differences between traditional TODness measurement and the three-dimensional approach. It shows that the values of the indicators traditionally used for measuring the 5Ds of TOD can change significantly when adopting a three-dimensional approach. At the same time, this approach is more expensive in terms of data requirements and computation time.

For further investigation of how underground space influences TODness, comparative analyses as well as correlation and regression methods are conducted. Metro stations in Chengdu are grouped according to their spatial characteristics and degrees of underground development. The findings reveal a generally positive association between underground volume and overall TODness, particularly in relation to density, land-use diversity, and destination accessibility.

The dissertation concludes that a three-dimensional TODness framework provides a more accurate and context-sensitive tool for evaluating TODness in high-density cities. By explicitly incorporating underground space into TOD assessment, this research contributes to a more comprehensive understanding of station-area development and offers methodological support for more integrated and effective TOD planning practice.