

Development of a TOD Typology for Hefei City Subway

Wu Wei

1. Introduction

1.1 Background

The continues migration of people since 1987 from rural areas to cities and metropolitan areas has increased the population density in Chinese cities. The limited availability of developed land to accommodate them has created high density, urban expansion, and long commuting distances in cities. Consequently, cities become more dependent on motorized private transportation and public transportation such as buses, to overcome long-distance daily travels.

As a solution to that, an increasing number of Chinese cities are developing rail transit systems. More and more Chinese cities are building rail transit systems as a strategy to reduce the negative environmental and social consequences of rapid urbanization over the past decade.

Transit-oriented development (TOD) has become an accepted development strategy for integrating land use planning and public transit. And it has been identified as one solution to improve accessibility by strengthening the relationship between transportation and urban development.

Many cities pay increasing attention to the development of the public transit system. During that process, they pay less attention to land-use development during the implementation of the TOD concept. The current subway planning of Hefei city is also facing the same problem. This situation would disintegrate the land use and transportation system and create an imbalance between them. Therefore, it is necessary to formulate a systematic method to implement the TOD concept that is right for the local context and integrates the land-use and transport of TOD projects successfully.

1.2 Current conditions of TOD concept in Hefei city

Hefei city is the capital city of the Anhui Province of China. Hefei city has experienced significant urban growth since 2010 and facing severe problems due to the rapid growth of the population and urban expansion (Fig. 1). The urbanization rate is expected to increase from 80% to 82% by 2030 in Hefei City. Recently, the government is paying

more attention to the development of rail transit and TOD development, to promote the integrated transport system. In total, there are 3 subway lines with 77 subway stations in operation now (Fig.2) in Hefei City. Hefei is also planning to build 12 additional metro lines, 4 intra-metropolitan rail transit, and 3 tram lines by 2030.

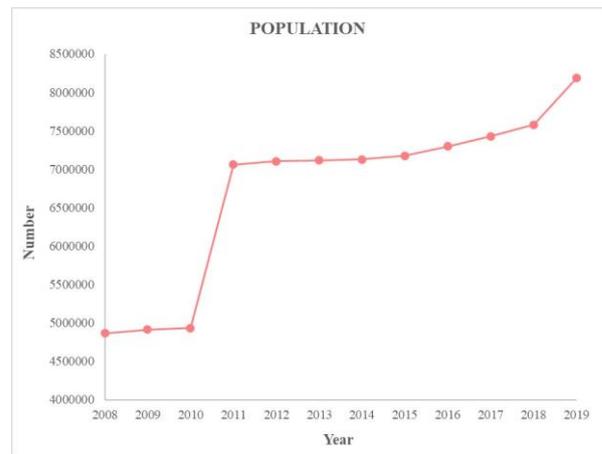


Figure 1. Population of Hefei city change over time

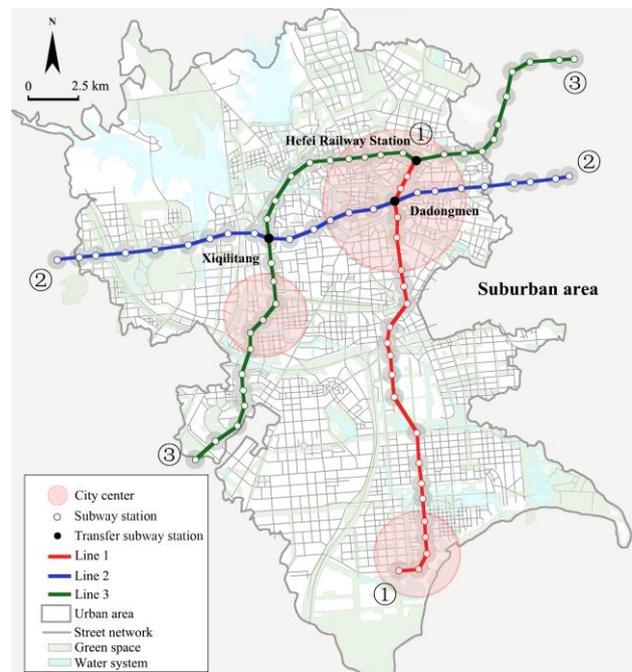


Figure 2. Subway system of Hefei city

However, the Hefei city always plans the subway system first and then drives the surrounding development through the subway system when developing the TOD network. Therefore, land-use planning often falls behind urban traffic planning. And land-use planning is often in a passive

position. This issue will lead to many problems in the future. For instance, there will be some gaps between the master plan and the current situation. A good understanding of the gaps between the current situation and the expectations will be helpful to decide the directions of future development. Therefore, research on developing methods to analyze the current development condition of stations and their development directions is necessary.

1.3 Research Objective

The objective of this research is to develop a method to identify weaknesses of accessibility and land-use of TOD projects in Hefei city and to evaluate their future growth direction. The following are the three questions answered in this research.

- 1) What are the current accessibility and land-use situation of TOD projects in Hefei city?
- 2) What is the relationship between level of development in each TOD and their composition of subway users?
- 3) How to discover the future development direction of TODs based on the relationships found in the above analysis?

2. Research Method

With the growth of urban communities, the concept of transit-oriented development (TOD) has been redefined. Now, the TOD concept is defined as “a mixed-use community that encourages people to live near transit services and to decrease their dependence on private cars.”

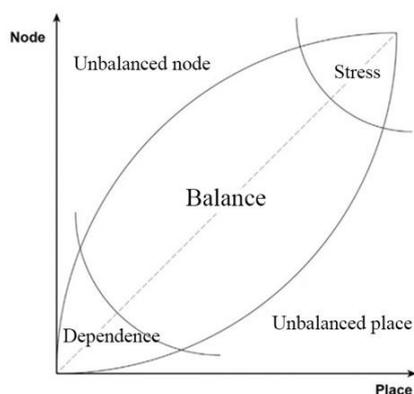


Figure 3. The original node-place model

Researchers recognize that TOD projects could take different forms depending on the urban structure. It is important to develop a practical tool that can capture the

characteristics of a wide variety of TOD projects. The node-place model (Fig.3) is a frequently cited and applied approach by researchers and practitioners to assess and describe TOD projects. The node-place model provides an analytical framework to describe transport, land use, and the interaction between transportation and land-use systems around TOD projects. This research applied the node place model to analyze the accessibility and land-use intensity of TODs in Hefei City projects.

However, some researchers argued that the original node-place model is incapable of clearly classifying TOD areas into different typologies since some neighboring TODs have similar transport and land use characteristics. The similarities within a type could allow urban and transport planners and policymakers to improve the existing situation of TODs and develop long-term strategies to promote future TOD development. This research developed a typology of TODs for Hefei City by comparing the TOD value derived from the node-place model with population composition at each TOD. Later the development direction was discovered from the position of each TOD in the new model and future land-use type in the Hefei City master plan.

3. Assessing current accessibility and land use of existing Hefei TODs by using the Node-place Model

The node-place model focuses on measuring the level of accessibility and activity intensity of stations. This study applied the node-place model to evaluate the Hefei TOD network. In this research, the station catchment areas were defined as a buffer area of 500 meters from a station which is the walkable distance from a subway station. One of the main reasons for this assumption was that the recent Master Plan of Hefei established a 500 meters walkable neighborhood for residents (Fig.2). The master plan demarcates this area as the zone where residents have the access to all the basic public services within walking distance from transit.

The indicators to evaluate the node and place values of the station catchment areas were defined from previous studies to analyze the environment and the functional conditions of the existing stations (Table 1).

Table 1. Indicators were chosen for Hefei city

Node-value (Accessibility)		Place-value (Land use)
Accessibility by train	Number of directions served by Metro (y1)	Residential land (x1)
	Daily frequency of Metro services (y2)	Retail, hotel and catering land (x2)
	Number of stations within 20 min of travel (y3)	Parks, forest (x3)
Accessibility by bus	Travel time to the CBD (seconds) (y4)	Industrial and distribution land (x4)
	Number of directions served by buses (y5)	Education, health, culture land (x5)
Accessibility by car	Daily frequency of bus services (y6)	Service and administration land (x6)
	Distance from the closest motorway access (y7)	Degree of functional mix(x7)
	Car parking capacity (y8)	

The node value of a station describes the transport accessibility to other places and the service capacity of stations within the metro network. The node value was derived from 3 indicators namely, accessibility by subway, accessibility by bus, accessibility by car. The place value describes the density and diversity of activities in the 500-meter neighborhood of each station. Previous studies conducted by researchers suggests that a high level of density and diversity of activities increases the transit ridership in an existing station area.

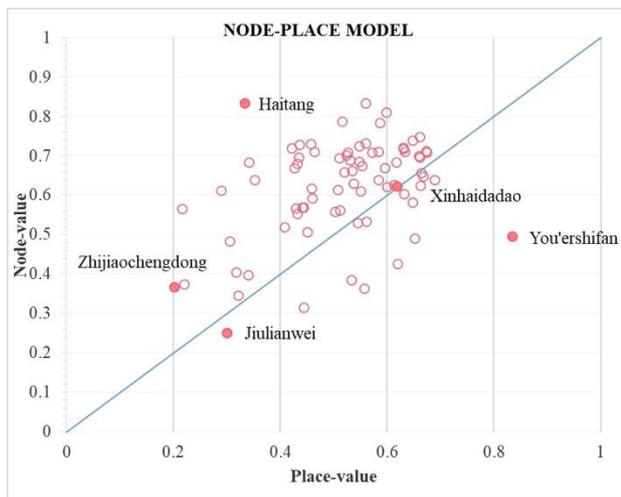


Figure 4. Results of 77 TODs in the node-place model

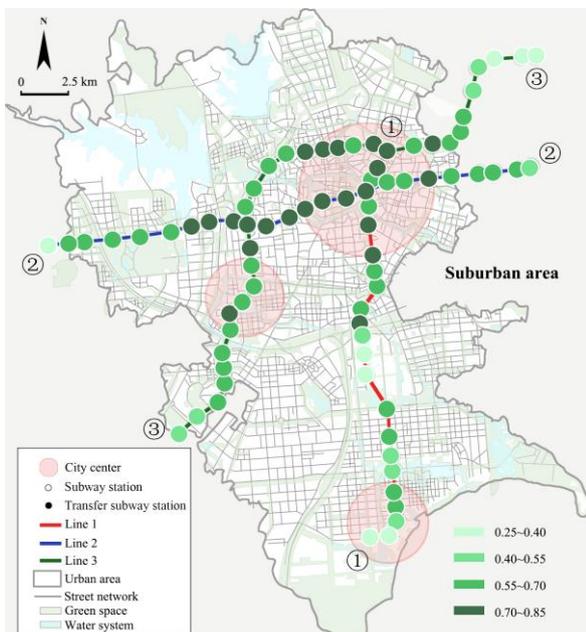


Figure 5. Node-value of the 77 TODs

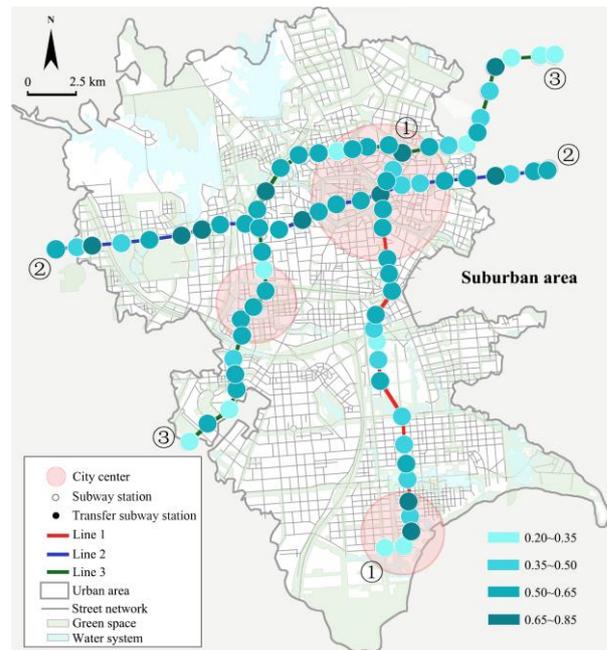


Figure 6. Place-value of the 77 TODs

The result of the node-place model for Hefei City illustrates the relative position of 77 existing TODs according to its node and place values (Fig.4). The results also show node value and the place value in most stations are not close enough to each other, indicating that the development of accessibility and land use of these stations are unbalanced. Only a few stations are in the balanced portion of the node-place model. The result also indicates that station areas with high node values and high place values are concentrated in the existed city center (Fig.5,6).

4. TOD Typology of the Existing TODs in Hefei based on the Current Conditions and Needs of Station Users

The original node-place model only considers accessibility and the land use of station areas. The analysis of accessibility and land-use alone is not enough to understand the development needs of station areas. A better understanding of the relationship between the current conditions of the TODs and the needs of the station users is important to evaluate the future success of the TOD network. The main goal of the application of needs of station users in the TOD typology is to formulate more accurate development directions of TODs. TOD typology can classify different TODs into several clusters by common characteristics. The typology of TOD stations not only can identify directions for subway development, but also provide recommendations to achieve the development goals of the TOD project. This research extended the

original node-place model by adding two additional types of data, the employment, and the residential population to develop an operational TOD typology of Hefei subway stations. This phase of the research built a TOD-value as it helps to measure the TOD degree of TODs, and employment-population ratio to reflect the ability to bring commuters to the station areas.

$$\text{TOD-value} = \text{Node-value} + \text{Place-value}$$

$$\text{Employment-population ratio} = \frac{\text{Employments at TOD}}{\text{Residence Population at TOD}}$$

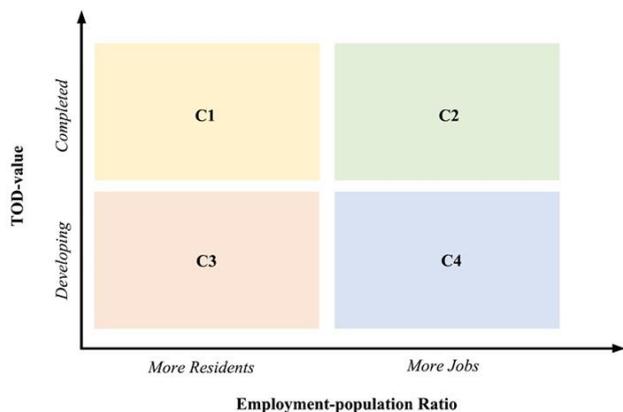


Figure 7. A theoretical model of classification

A new classification model (Fig.7) was developed for Hefei TOD typology through TOD-value and the employment-population ratio. This model can classify TODs into four clusters based on mean values of the TOD-value and E-P ratio.

The distribution characteristics of these TODs in Hefei city can be found by combining the results of TOD typology with the station-area types (Fig.8). The station areas can be divided into five types based on characteristics commonly found in surrounding areas of master plan, such as commercial place, residential place, educational place, industrial place, green place.

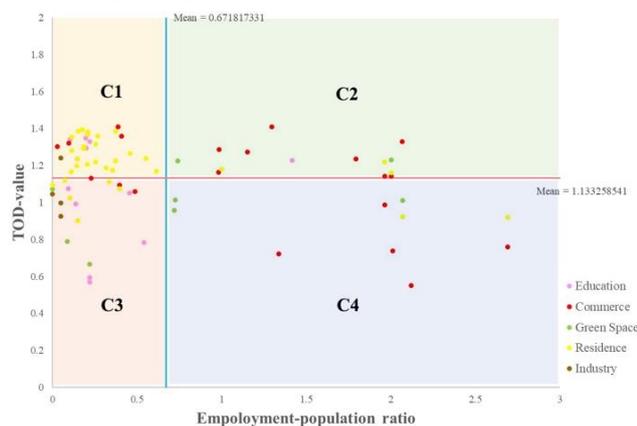


Figure 8. Combining the results of TOD typology with station-area types

At the same time, this research suggests the dynamic growth direction of each station to help planners to understand the future development of the existing TODs more clearly. For instance, stations located in Cluster 3 with lower land-use diversity and accessibility can move to Cluster 1 by increasing land-use diversity and accessibility. Or the same station can move to Cluster 2 by providing more job opportunities, then drive surrounding TOD development eventually. Stations located in Cluster 4 can move to Cluster 2 by increasing land-use diversity and accessibility. However, reducing employment opportunities is not practical. Therefore, the development of this model provides a clue for development direction and the process to planners. According to the results, planners can understand the growth directions of existing Hefei TODs, then can develop these TODs with less waste and resources.

5. Conclusions

The results of node-place model show node value and the place value in most stations are not close enough to each other, indicating that the development of accessibility and land use of these stations are unbalanced.

The current research proposed a new classification model to divide the existing TODs into four clusters. The model assessed the interaction between human activities and TODs. Through the results of the model, the research can obtain the current conditions and future growth directions of the TODs. Future research will compare the current condition of the stations and the Master plan. Comparing the current condition and the master plan will help to find the development potentials of stations.

References

- 1) National Bureau of Statistics of the People's Republic of China, 2011. Archived from the original on 2013-04-05. Retrieved 2018-01-02.
- 2) Hefei Municipal Bureau of Statistics, 2017, Hefei Statistical Yearbook.
- 3) Li, Z., Han, Z., Xin, Jing., Luo, Xin., Su, Shiliang., Weng M., 2019. Transit oriented development among metro station areas in Shanghai, China: Variations, typology, optimization, and implications for land use planning. *Land Use Policy* 82 (2019) 269–282.
- 4) Vale, D.S., Viana, C.M., Pereira, M., 2018. The extended node-place model at the local scale: evaluating the integration of land use and transport for Lisbon's subway network. *J. Transp. Geogr.* 69 (December 2017), 282–293.