An Application of the Node Place Model to Explore the Interactive Mechanism Between Rail Stations and Urban Functions--A Comprehensive Analysis and a Case Study in Guangzhou

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Abstract. In the recent two decades, transit-oriented development (TOD) has been applied to deal with multiple traffic problems. To alleviate the urban traffic pressure, the Chinese government aims to establish rail transit in numerous cities, including the traditional rail, metro rail, light rail, and high-speed rail (HSR). Based on the notion of TOD, the balance of transport service and urban development is important for the TOD railway station. To explore the interaction mechanism between railway stations and surrounding area, this paper focuses on the coordinated evaluation of the interaction using the mode-place model. In the first part, a literature review is done to explore the overall interactive effects between node and place and the mode-place model applied to rail stations in Tokyo, Korea, and Shanghai. In general, there is a robust relationship between the transport service and the urban development of surrounding areas, and this interaction is affected by the location of rail stations. Furthermore, the application of this model not only corroborates these effects but also provides insight into the future development of rail stations. In the second part, the node place model is used to assess the node and place development of Guangzhou metro stations. The result shows that location, functional characteristics, and government planning play essential roles in the station area development.

Keywords: TOD, node-place model, rail stations, urban function.

1. Introduction

In the last two decades, a large amount of the population has migrated from rural areas to principal cities. Furthermore, the increase in urban population leads to the enlargement of the urban scale, which is especially prominent in Eastern China. Under this situation, the railway system, including traditional rail, HSR, light rail, and metro rail, has experienced rapid development to meet the demand of the population and urban function. However, while some rail stations undergo tremendous stress with excessive passenger flow and functional overload, others suffer from discordance between transit and land use [1] and weak spatial connection with urban function. The stressed or unbalanced development of railway stations leads to resource waste and low traffic efficiency, which highlight the necessity to promote a sustainable rail transit mode in China. Therefore, it is important to identify, analyze, and solve the rail development problems mentioned above. TOD, proposed by Peter Calthorpe [2], is one of the most influential attempts to foster sustainable transportation and urban development. Due to the large transport volume, high efficiency, and high interconnectivity, railway transit is an optimal mode for TOD's application [3]. The node-place model, introduced by Bertolini [4], provides coordinated evaluation for the TOD station development. Incorporating the assessment of station characteristics and the local situation, the model has been employed in worldwide case studies and provides insights into the development strategy of TOD stations. In the first part, based on the concept of TOD, this paper conducts a literature review on the interactive mechanism between rail stations and surrounding space and the applications of node-place model as a coordinated evaluation system of this interaction. In the second part, the paper applies the node-place model on Guangzhou metro stations by conducting data analysis. The literature review and the case study

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provide insight into what factors are influential in the station area development, which is conducive to exploring a suitable TOD mode and promoting sustainable transportation in China.

2. Methodology

2.1. Literature Review

This paper provides a review of the concept and development of the TOD, the general interactive mechanism of rail stations and surrounding space on macroscopic and microscopic scale, and mode-place model case studies on Tokyo, Korea, and Shanghai that investigate the development of station areas.

2.2. Case Study in Guangzhou, China

This paper thoroughly describes the metro rail network in Guangzhou and its roles on the urban and regional scales. Then, this paper uses the node-place model for assessing the transport service and urban development of the metro station area in the administrative area of Guangzhou. There is no unified definition of "station area," but most studies focus on the walking range of the station, and North American scholars usually use the 400-800m range [1]. In this paper, the station area is defined as the area within the 400m range of the metro station. To select typical metro nodes, all metro stations composed of at least two metro lines are selected, and metro stations that pass through existing and planned major traditional rail stations, HSR stations, ferry ports, and airports are included as well. 49 metro stations under these criteria are selected. Then, data that represent node and place value of these selected metro stations are collected with the help of Gaode Map, Baidu Map, and the Annual Report of Guangzhou Metro of 2021 [5]. The node indicators include the number of metro transit lines, the number of entries and exits, the number of bus stations within the station area, and the average daily ridership in 2021 (in ten thousand person-time), and the place indicators include the number of shopping mall, hospital, and schools (primary schools, middle schools, and colleges) in the station area. Furthermore, these stations were classified into six categories based on their spatial context and functional characteristics. Based on the study of Liu et al. [6] that divides the administrative area of Guangzhou into "urban core area" (there are multiple core areas, and the biggest one is Guangzhou's principal urban core area) and other types of area, this paper defines the stations in Guangzhou's principal urban core area as "core stations" and other stations as "non-core stations." According to the station characteristics, the core stations are classified into three categories: A) stations in fully developed urban areas; B) stations in non-fully developed urban areas, C) core stations at principal transport hubs (traditional/HRS stations, ferry port, and airport), and the non-core stations are classified into three categories: A) stations at the urban fringe or rural area; B) stations in other urban core areas; C) non-core stations at principal transport hubs. Finally, this paper evaluates the node and place level and the node-place balance of these stations and examines the influence of station categories on their performance.

3. Results

3.1. The concept of TOD

TOD was first conceived by Peter Calthorpe [2] in The Next American Metropolis, which was primarily aimed to deal with typical problems in the United States, such as excessive use of the private automobile, low accessibility of public service, low efficiency of land use, lack of walkability, etc. According to Calthorpe, TOD creates a "mixed-use community within average 2000-foot [AN: 600m] walking distance of a transit stop and core commercial area (1993)." He also conceived two spacial layers according to the distance from the station, including the "primary area" that supports principal commercial and residential functions and ensures the "neighborhood vitality" and "secondary area" (the maximum radius is 1.6km) with a relatively low density of community land use such as residential area, park, and schools; the “secondary area” and “primary area” should be connected by sufficient traffic artery to ensure the accessibility [2, 7].

Nowadays, the concept of TOD has been fully developed and applied to multiple projects to improve the quality of public transport. In general, TOD refers to the transit system and land use that makes transportation more efficient and desirable, which highly focus on the development of surrounding urban space [8]. Characterized by “careful coordination of urban structure around the public transport network [9]”, TOD stations have intense and compact land use in their station areas, serving a mixed use of functions both vertically and horizontally that allows people to complete most of their activities within a small area without too many constraints [10]. Railway transit is a typical mode of public transport that provides an appropriate condition for the TOD in China. In fact, the Chinese government has started pushing forward the implementation TOD mode that promotes the station-city integration, and multiple TOD projects are under construction in principal cities in China.

3.2. Overview of the Interactive Mechanism

To understand the interactive mechanism of rail stations and surrounding area, this paper adopts a hierarchical spatial scale of the interaction, which discusses the interaction from macroscopic and microscopic perspectives. While the macroscopic scale is regional or city-wide, the microscopic scale focuses on a smaller zone surrounding the station.

On the macroscopic scale, the high-speed rail (HSR) is the main concern due to its relatively large influence boundary compared to intra-city rail. Generally, HSR increases the accessibility and competitiveness of cities and reorganizes the regional and urban space pattern [11]. Specifically, HSR saves time for passenger flow and commodity exchange due to its relatively high velocity, which promotes economic and social links between cities, strengthens the structure of urban agglomerations, and promotes the aggregation of production factors and life factors, facilitating residential population growth in the surrounding area [11-14]. Due to these effects, HSR station is an important strategy for decentralization [15] by locating them in suburban or peripheral zones, which attract a large number of short-time travelers and business commuters [12] to these areas; furthermore, building new HSR stations in China becomes a strategy for urban and economic growth, which specifically targets on medium-sized cities [15]. However, location plays an essential role in the social-economic effect of HSR stations: The effect of factor aggregation is more prominent in major cities than edge cities [11], and middle-sized cities on the HSR line have limited accessibility and ridership attractiveness compared to major cities [16, 17].

On the microscopic scale, the literature review mainly focuses on the interaction between metro stations and their station area. According to Wang [1], the impact of stations on station area land use is demonstrated in land price and land use structure & intensity: affected by station service quality and demographic characteristics, the value of residential and commercial land generally increases; high accessibility often leads to high-density land use that is usually composed of high yield types like commerce and business. Furthermore, the station ridership is affected by land use intensity, mix-use, and accessibility: high density of land use and employed population in the station area promote public transit ridership; the diversity of land use balance the transit demand at different time, affecting the time-varying characteristic of the station; The accessibility of stations to residents determines the passenger flow of urban rail (connection of different transport mode is one of the means to improve the accessibility) [1]. The microscopic aggregation effect of HSR stations is similar to intra-urban rail stations: HSR stations can lead to high-intensity land use, including commerce, dining, business, entertainment, and a variety of activities [18].

Overall, the mutual effects between rail stations and surrounding areas reveal the potential of the station-city integration, which is crucial for the application of TOD for rail stations. To address the stressed and unbalanced development of rail stations, a coordinated evaluation should be conducted to assess the node-place interaction and figure out what measurements should be taken to promote a balanced state.

3.3. Coordinated Evaluation

a. Overview of the Node-place Model

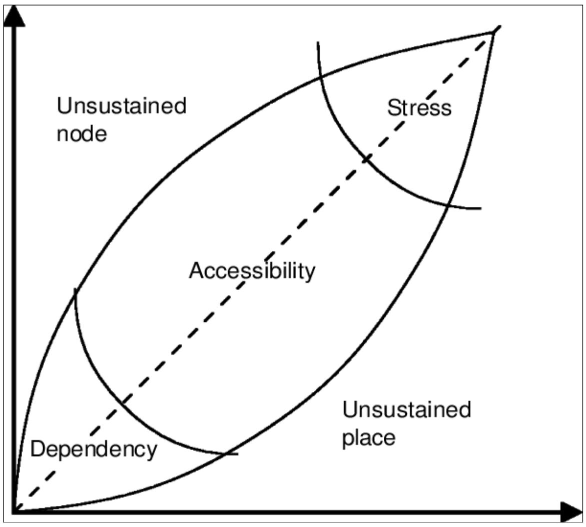

Figure 1. The node-place model [4]

Since each TOD station is affected by "a variety of factors, trends and complex interrelations between them" [7], a typology analysis based that incorporates local conditions is required. The node-place model introduced by Bertolini [4] is an important methodology of TOD typology that adopts a dichotomy between the transport function and station area development. According to Ibraeva [7], as shown in figure 1, the x-axis represents the place index that demonstrates the urban function of the station area, and the y-axis represents the node index that demonstrates the transit service level of the station; After calculating both indexes of a station using a variety of indicators, the station is placed at the diagram according to its performance; A balanced station is located at the middle of the diagram with reasonable transportation service supply and land-use in station area; A stressed station with excessive passenger flow and very intensive land use is placed near the upper right corner, while a dependent station with low ridership and underdeveloped station area is placed near the lower left corner; A station with more urban functions than transport supply is defined as an "unsustained place", while a station with more transport supply than urban functions is defined as an "unsustained node." This model corresponds to the "transport land use feedback cycle": more node value of a station leads to higher accessibility of that location, which fosters further urban function development in the station area, improving the place value; In turn, when the place value increased, transport demand grows and thus enhances the node value of the station [19]. Following this underlying n, this model can be employed to evaluate the performance of a station site based on its transport service quality and land-use characteristics [7], which helps identify the current weakness and future measurements for TOD.

b. Intra-city Rail in Tokyo

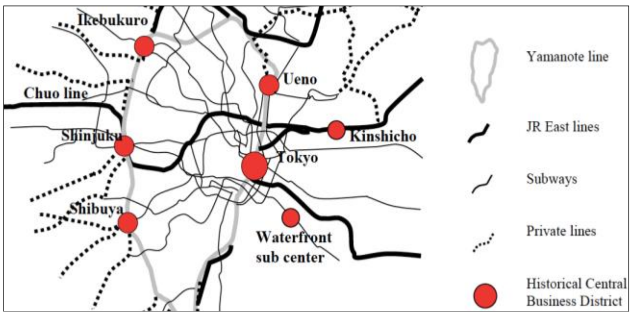

Figure 2. Tokyo's rail network [19]

In Tokyo, as shown in figure 2, the urban structure is characterized as a core center (Tokyo Station) surrounded by multiple sub-centers. The rail system contributed to the formation of this structure: the government allowed private railway operators to compete outside the Yamanote loop (a loop-shaped railway line) and set up transfer stations on the loop. The result of this competition is the formation of subcenters at junctions of the private rail line and the loop, which attract a large number of passengers traveling in and out of the core urban center. In addition, the government assigns extra permissible floor area ratio (FAR) to these subcenters to stimulate development and provide a FAR bonus for private operators who invest in infrastructure construction.

The node-place approach in the Tokyo railway system is conducted by Chorus and Bertolini [19]. In this study, 99 rail station nodes are selected. The node indicators include the number of train connections, the number of rail line connection types, the proximity to the CBD, and the number of bus connections, which represent the service quality of the stations as a node, while the place indicators include the residential population, the size of several types of workforces, and the degree of multi-functionality, which represent the diversity of urban activities in the station area. Through the correlation analysis, the study reveals a positive correlation between workforce size in the station area and all of the node indicators as well as a negative correlation between residential population and node indicators except for the bus connections number. Furthermore, the combination of proximity to CBD and the number of train connections relative to workforce size has the greatest impact on the station area redevelopment. In general, these results align with the interactive mechanism between node stations and urban functions in surrounding areas: stronger transport service capacity usually comes with a larger workforce that reflects the greater land use intensity. In addition, these result shows that the interaction pattern is strongly influenced by the location (proximity to the urban center) and the demographic characteristics (workforce or resident) in the station area.

Furthermore, in order to address the extent of the influence of these factors, the study explores three cases of station area development, finding out whether or not the node-place model predicts the development path well and why. The analysis shows that Ueno and Urawa stations seemed to correspond with the expectation of the model. For example, as the model revealed, Ueno Station is an unbalanced node with a strong transfer node function but a relatively weak urban function in terms of workforce. Despite a large number of cultural facilities, there is low spatial development for commerce or business. According to the railway's investment record, the station's node value will fall, but the place value will stay still, just as the model expected. However, in the case of Shinjuku, some factors other than transport service and urban functions appear to boost the station redevelopment. Shinjuku is the largest subcenter in Tokyo, acting as the major transfer node and economic and cultural center in the Western metropolis area. Defined as a stressed station area, the Shinjuku station should not further improve transport provision and station area development due to limited space and resources available. However, the investment record seems to contradict the expectation of the model: the government policy triggers redevelopment around Shinjuku Station because the station is thought highly by the government, which is assigned with a great amount of permissible FAR value. Besides the intervention of the government, "chronic traffic congestion, a lack of pedestrian space, and an inconvenient transfer from train to highway buses [19]" also stimulate the station area redevelopment. Although the node-place model cannot perfectly predict how the station area will develop in the future, it's crucial for the station planning process leading toward a more balanced state: the model indicates the potential location for developing employment and transport service to relieve the stress at central stations, figures out what stations should be assigned with higher FAR value to promote the intensity and diversity of land-use, and points out what stations should improve the road connection and integrate other transportation forms.

c. Inter-city HSR in Korea

The application of the node-place model in the Korean HSR, Korean Train eXpress, or KTX (figure3), was conducted by Kim et al. [20]. Composed of both dedicated HSR tracks and upgraded conventional railway tracks, the KTX network is an economic strategy to foster urban and regional development. However, it was proved that the HSR stations located far away from the urban area or small/mid-size cities have limited economic effects [15]. Adopting the idea from Chorus and Bertolini

[19], the study considered the proximity to the CBD as an important indicator for the HSR station area development and thus classified the HSR stations into different categories based on their locations and relationship with conventional rail. As shown in figure 4, these categories include: City center: A) stations in the previous location of conventional stations; B) stations as part of upgraded conventional rail; Suburban Area: A) stations that were moved to suburban areas due to insufficient space in the city; B) stations as part of upgraded conventional railways; C) stations as part of the dedicated HSR but constructed after the operation began; D) stations as expanded conventional railway in suburban areas. Selecting eighteen KTX stations on two principal HSR lines, the study analyzes the node and place value and their balance level. Similar to the case study in Tokyo, the node indicators reflect the connectivity of rail lines, accessibility of stations, and ridership volume, and the place indicators reflect population size in the station area and the variety of economic activities.

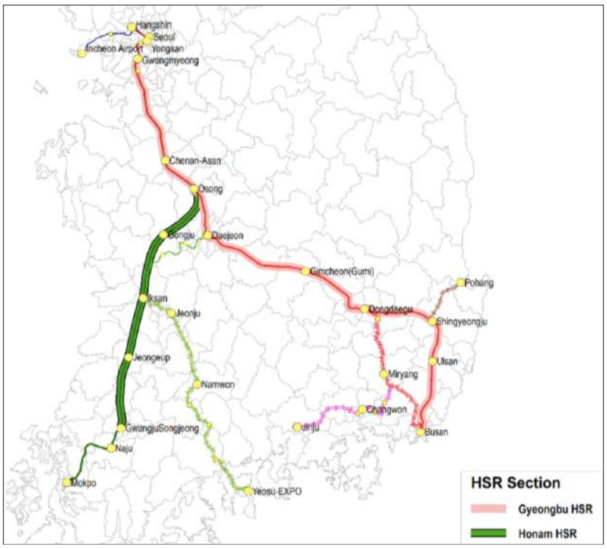

Figure 3. HSR network of Korea [20]

Through the evaluation of the station's performance, the study found that the node and place indicators have positive effects on urban development of the station area. However, it found that the intensity of the effect is subjected to the proximity to the urban center. For example, as a stressed station that is crowded with passengers and commercial facilities, the Seoul Station is a station of city-center B type, which acts as a central node for the whole country that attracts large ridership and vital economic activities. In contrast, as an unbalanced place, which belongs to type suburban D, Hangshin Station is located at a newly developed urban area but has relatively low service capacity and traffic connections. As an unbalanced node, Gumi station is a suburban C station located at the geographic mid-point of two cities, serving as a connector but fails to serve as an economic hub. These examples illustrate that stations located in urban area often have higher ridership and abundant urban functions, while stations located far away from urban center would have less balanced development due to lack of accessibility. To solve these problems, the study suggested that the government should invest in additional road connection to the unbalanced suburban stations or integrate these station with local transportation to increase their accessibility. Furthermore, to relieve the stress of urban stations, the government can renovate the station into a multi-purpose complex or redevelop the CBD area. In conclusion, the study not only used the node-place model as a coordinative evaluation for HSR station, but also incorporated a typology of stations based on their spatial context. The result of the study is in line with the interactive mechanism between HSR stations and surrounding area discussed above and demonstrates that the station location determines the social-economic effect of HSR stations on regions and cities.

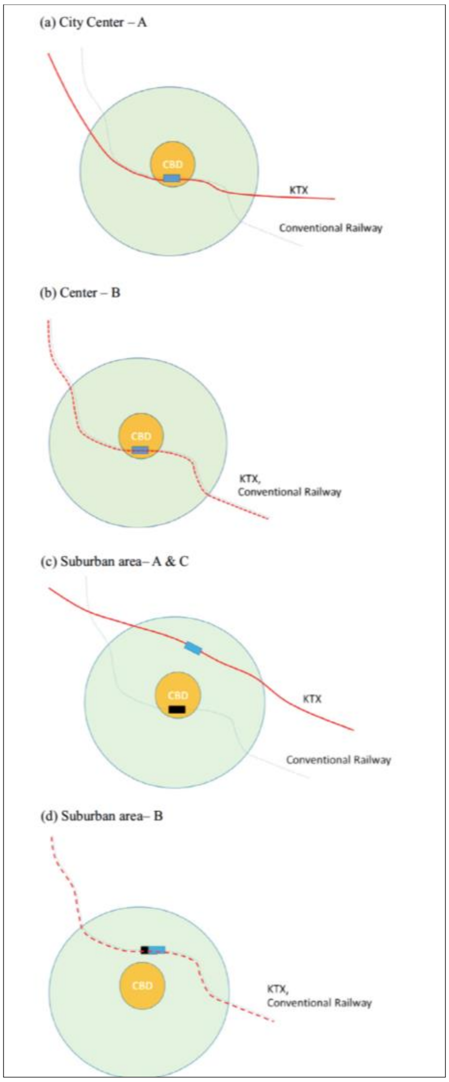

Figure 4. Types of HSR stations in Korea [20]

d. Integrated transport hub in Shanghai

After discussing the node-place model application for intra-city and inter-city rail transit, the study [21] focuses on the Shanghai Hongqiao Integrated Transportation Hub using this model. Located outside of the Outer Ring Road of Shanghai, Hongqiao CBD has become a new economic growth pole and subcenter of the city. Similar to the Korean KTX, Hongqiao Hub is also used as a strategy for decentralization and stimulating economic growth. What makes the Hongqiao Hub prominent is that it not only incorporates multi-modal transportation, combining air, railway, coach bus, and metro subway system in a single urban complex but also serves both intracity and intercity transport functions, acting as an important transport node with a large number of passengers. As shown in figure5, the study defines three hierarchical geographic layers to analyze the scope of influence of the hub: layer I, the hub complex and its core area, serving major transportation functions; layer II, the Hongqiao CBD, which provides supporting land use for the complex; layer III is the greater Hubtropolis. The paper described the transportation value of layer I, analyzed the urban function of layer II, and then conducted a node-place balance analysis.

Figure 5. Hongqiao Hub [21]

The result shows that the Hongqiao Hub has strong nodal value because it's at the center of the Z-shaped center of the Yangtze River Delta (YRD) region, the junction of three main HRS lines, and the western end of the city's east-west modern service axis. Through the examination of layer I, the study discovered that the rail serves more transport functions than air transit, train departure/end has lower time but higher frequency than bus departure/end, and metro serves more passengers for accessing the traditional rail/HSR stations than the airport. According to the land use data, layer II has more commerce and business function than residential functions. According to the government investment plan, layer II plans to build expressways, major arterial streets, and metro subway lines in both east-west and north-south directions to improve the accessibility of the hub. This development will not only allow more social-economic factors to agglomerate and attract more business travelers and tourists but also relieve the transportation stress of the hub. The node-place balance analysis reveals that Hongqiao Hub is still an unbalanced node station with a high transportation service level but relatively weak urban functions. When the CBD is fully completed, it will be more balanced. However, since most passengers transport from the hub to the central urban area with few activities in the station area, how to relieve nodal stress and improve the place value is still a challenging task.

3.4. Case Study of Metro Rail in Guangzhou

As a principal commercial and trade center in Southern China, Guangzhou has the 3rd largest urban rail transport system in the country. According to the development pattern of the city, the western part of the city was developed earlier than the east and has multiple traditional business districts. However, the eastern part has developed to be a new growth pole in the recent two decades: The Tianhe CBD is the top CBD in Guangzhou, attracting finance, business, technology, culture, and multiple urban functions. The development pattern is reflected in figure 6, which shows the urban core area in the red zone, the urban fringe area in the pink zone, and the rural area in the green zone. The classification of metro stations in this paper is based on the definition of the urban core area shown in this figure. Besides the principal urban core area, multiple growth poles outside this area are in rapid development due to the government's development strategy. For example, the Nansha CBD is dedicated to becoming the sub-center of Guangzhou due to its function as a principal port for Guangzhou and geographic advantage, and the Guangzhou South Railway Station is triggering the development of a new CBD surrounding the station. By now, 16 metro lines and 260 metro stations have been established within the network (figure7), which covers most of the principal urban area and connects the downtown with surrounding towns in the administrative area such as Nansha, Panyu, Huadu, Zengcheng, and Conghua and nearby city like Foshan. The metro system also pass-through major transportation hubs, including Baiyun International Airport near Huadu, the Nansha Ferry Port, and multiple principal rail stations such as Guangzhou Railway Station, Guangzhou East Railway

Station, and Guangzhou South Railway Station. As a result, the metro system facilitates the agglomeration of economic factors and the flow of population in the metropolitan area, improves the accessibility of major transport hubs, and promotes connectivity between the city and the surrounding region. In the future, the government plans to expand the rail transit network with 53 additional rail lines (5 high speed metro, 11 fast speed metros, and 37 regular metro), which realizes the 30min travel time to Nansha sub-center and surrounding towns like Foshan and Dongguan and the 60 min travel time to other cities in the PRD region [23].

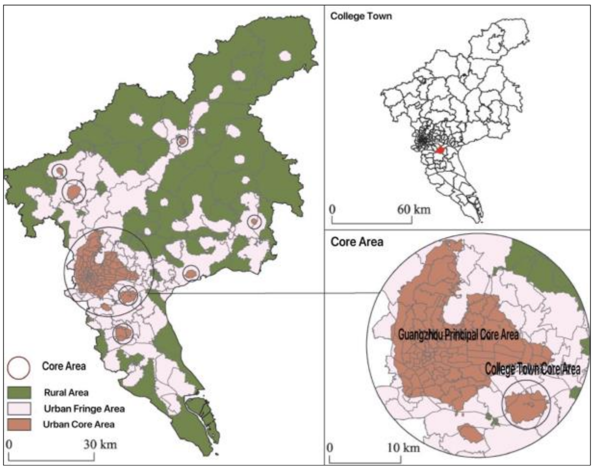

Figure 6. The spatial distribution of urban core in Guangzhou [6]

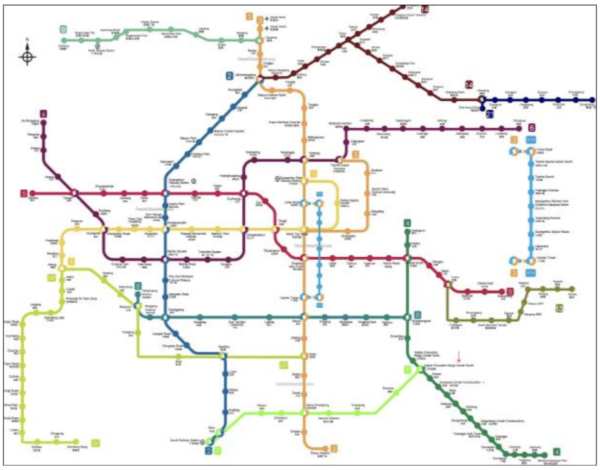

Figure 7. The metro network in Guangzhou [22]

The data for most node indicators and all place indicators is accessible, but the ridership data is only available for the top 10 stations from the Annual Report of Guangzhou Metro [5]. Through the analysis of node indicators of 49 metro stations (table1), this paper finds that metro stations at major transport hubs and core urban areas usually have a high node value. Guangzhou South Railway Station, which is a major HSR transport node, has the most metro transit lines and entries and exits; Guangzhou East Railway Station and Guangzhou Station also have a relatively high number of entries and exits. Furthermore, stations located in traditional core urban areas in western Guangzhou, such as Gongyuanqian Station and Changgang Station, and stations located in the eastern core urban area (the Tianhe CBD), such as Tiyu Xilu Station and Zhujiang New Town Station, have a high number of entries and exits, bus connection, and ridership. In contrast, stations located in the suburban area, such as Xintang Station, and Qingsheng Station has a relatively low node value. Although new transport hubs are planned to be established at these stations, they still have weak accessibility and long distance from the core urban area. Noticeably, for stations with top 10 ridership (which indicates high nodal value), while some of them, such as Jiahewanggang Station, Chebeinan Station, and Wanshengwei Station, are not located in the fully developed urban area, some stations like Kecun Station, have a relatively low number of entries and bus connections.

Furthermore, the analysis of the place data shows that metro stations in the western traditional urban area and eastern CBD have a relatively higher place value. Except for Canton Tower Station, all core stations in the fully developed urban area, which have dense and diverse land use, have at least 1 shopping mall or at least two indicators greater than 0. In addition, stations in the urban area of some surrounding towns, such as Panyu (Panyu Square Station) and Zengcheng (Zengcheng Square Station), have relatively good place development. In contrast, a large proportion of core stations at less developed urban area and non-core stations have less shopping malls, hospitals, or schools than core stations in the fully developed urban area. The exception includes Jiahewanggang Station, Tianhe Coach Terminal Station, and Nancun Wanbo Station, which are not in the fully developed core urban area but have relatively high place value. This can be explained by the fact that the former two stations have a relatively high node value, and the latter one is a newly developed CBD. Furthermore, for stations located at the existing or planned principal transport hubs, the proximity to the core urban area is crucial for their urban development. For example, the Guangzhou East Railway Station has a high place value since it's located next to the Tianhe CBD. On the contrary, all non-core stations at existing and planned principal transport hubs, such as Guangzhou South Railway Station, Qingsheng Station, and Xintang Station, have low place value as the business districts around these stations are still under construction.

Based on the analysis above and the comparison of the value of node and place indicators, the study assesses the balance state of these metro stations. Firstly, the result reveals that the core stations in the fully developed urban area are generally more balanced than stations in the less developed urban area, the urban fringe, or the rural area. In the core urban area, especially CBD, there are well-developed urban traffic networks, high population density, and well-arranged sites for public service and business activity, which explains the balanced development of metro stations. Second, stations at principal transport hubs are more likely to be in an unbalanced or dependent state if they are located outside the urban center area. For example, the Guangzhou South Railway Station and the Nansha Ferry Port have delayed urban function construction; despite the role of an aviation node, the Baiyun International Airport has insufficient metro line connection. In general, the result implies that the station function (whether the station passes through principal transport nodes) has an effect, especially on the node value of the metro station, and the proximity to the urban center has a substantial impact on the balance state of the stations.

Table 1. Examples of Metro Station in The Node-place Analysis of 49 Stations

[1] **Name**	[2] **Node Indicators**				[3] **Place Indicators**			[4] **Type**
	[5] ***a***	[6] ***b***	[7] ***c***	[8] ***d***	[9] ***e***	[10] ***f***	[11] ***g***	
[12] Guangzhou	[13] 2	[14] 7	[15] 4	[16] N/A	[17] 2	[18] 1	[19] 0	[20] core C
[21] Guangzhou Sourth Railway	[22] 4	[23] 16	[24] 4	[25] N/A	[26] 0	[27] 0	[28] 0	[29] non-core C
[30] Zhujiang New Town	[31] 2	[32] 6	[33] ≥10	[34] 33.83	[35] 3	[36] 0	[37] 1	[38] core A
[39] Tanwei	[40] 2	[41] 7	[42] 7	[43] N/A	[44] 0	[45] 0	[46] 1	[47] core B
[48] Zhenlong	[49] 2	[50] 3	[51] 1	[52] N/A	[53] 0	[54] 0	[55] 0	[56] non-core A
[57] Zengcheng	[58] 1	[59] 5	[60] 8	[61] N/A	[62] 1	[63] 0	[64] 0	[65] non-core B

Note: a, transit-line; b, Entry and exit; c, Bus stop; d, Ridership; e, shopping mall; f, Hospital; g, School.

In fact, government planning also plays an important role in the urban function development of station areas and the socio-economic development of cities and regions. The Guangzhou Metro Group Co. Ltd, an enterprise directly supervised by the Guangzhou government, is cooperating with real estate companies in multiple TOD projects. There are five joint venture investment companies of Guangzhou metro that participate in real estate development in the metro stations area [5], which aims to improve the urban function development of the rail stations. To foster the nodes' transport service and regional connectivity, the government is planning to construct multiple metro lines and inter-city rails that pass through all cities and towns as well as multiple transport hubs in the PRD region.

4. Conclusion

This study explores the interactive mechanism between railway stations and surrounding areas at the regional/city level and the station area level, and then review several case studies that apply the node-place model to evaluate the station area development of intra-city rails in Tokyo, inter-city HSR in Korea, and integrated transport hub in Shanghai. In general, there is substantial relation between the station transport service and surrounding urban functions, and the interaction is affected by the location of rail stations. In the second part, the node place model is used to assess the station area development of Guangzhou metro stations. The result shows that location, functional characteristics, and government's development strategies contributes to the node-place balance of stations. In future research, the coordinated evaluation of TOD should establish different assessing systems for rail stations with different characteristics and include more comprehensive and well-defined indicators.

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