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From walkability to bikeability: A GIS based analysis of integrating bike sharing service in Tokyo TOD system

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Abstract:

Transit Oriented Development is the approach of urban development which maximizes the land use of residential, business and leisure around the public transit stops. A good TOD system can not only alleviate the contradiction between traffic congestion and insufficient land use for urban development but also significantly improve the convenience of urban residents' work and life. Moreover, while limiting the disorderly spread of the city, a good TOD system can solve the environmental and traffic problems caused by automobiles and promote synergy and integration between the industries. Traditionally, TOD is designed for facilitating the pedestrians to a convenient access to the public transportation systems so as to increase the usage rate of public transports. Despite pedestrians as the target, there are a lot of passengers move to the station via other means such as bus and bicycle. In the previous research, these two kinds of mobility are not included in the evaluation of TOD system as they have a lot of limitation on interacting with the facilities around railway station. In recent years, sharing bicycle becomes popular for solving the problem of the last one kilometer. Comparing to other means of mobility, sharing bicycle is more flexible than bus and has a higher usage rate than private bicycles. In addition, the sharing bike users have a wider access area than the pedestrians. Thus, sharing bicycle is able to play an important role in TOD system. In Tokyo metropolis, there are over 1000 railway stations and more than 50% of residents commute by railway. Nevertheless, the bike sharing system is available only in some specific area, which indicates a lot of room for the development of bike sharing service. In this research, we follow the previous studies of walkability measurement and apply two indicators include road network connectivity and facility accessibility for illustrating how could bike sharing outperforms walking in a TOD system with the case study of Tokyo 23 wards. The result of this research can instruct the government on improving the current TOD system as well as help build a sustainable society.

To conduct our research, we collect several types of spatial data include railway station and network, road network, land use information and facility data. Railway network data is provided by National Land Numerical Information (NLNI). In Tokyo 23 wards, there are totally 751 stations in different lines; the road network data is provided by Japan Digital Road Map (DRM) Association. For preprocessing we remove the urban high express and other roads which bicycle cannot be passed the total length of roads is around 15176 kilometers in Tokyo 23 wards; land use mix data is collected from Tokyo Open Data Catalog site which include three main land use types: residential, commercial and industrial; the facilities around stations are extracted from the Digital Yellow Page Data (Telepoint Data) provided by Zenrin. The facilities are categorized into 35 classes based on their functions. The visualization of the data source is shown from Figure 1 to Figure 3. For analyzing walkability and bikeability, we choose different network buffer range based on the previous studies, in

Figure 1. Railway network and stations

Figure 2. Road network

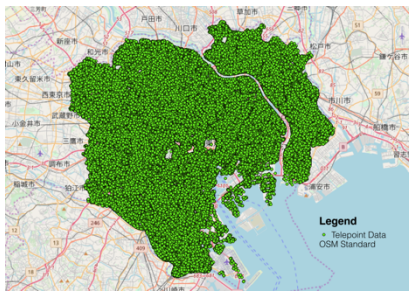

Figure 3. Facility distribution

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the current stage for walkability we set the distance range as 500 meters while for bikeability we set the range as 2 kilometers.

In the aspect of road network connectivity. In Tokyo area, the total length of roads is over 15176 kilometers. The 500-meter network buffer from the railway station covers 5326 kilometers, taking up 35% of the whole roads. Even though the coverage ratio is high when comparing to other cities all over the world, the coverage rate is very unbalanced in each ward that in central area the coverage ratio is much higher than the peripheral area as shown in Figure 2. However, with a bike sharing system of 2km activity range, the road network coverage is increased to 96%. this increasement is very obvious in peripheral area, which means that the residents there can get better access to the railway stations with the sharing bike system. In addition to the indicator of length, the number of road intersections is also a very important factor for evaluating connectivity. Generally, a large number of intersections provide much more choice for passengers to get to the objective stations. The descriptive statistic for walkable intersections and bikeable intersections is shown in Table 1. As is illustrated from the table, comparing with walkable intersections, the intersections for bike mobility around railway station is abundant enough to ensure the effectiveness of sharing bike system. Though the number of both two kinds of intersections varies from stations to stations, the bikeable intersections have less coefficient of variation. This variation will be analyzed in the future research.

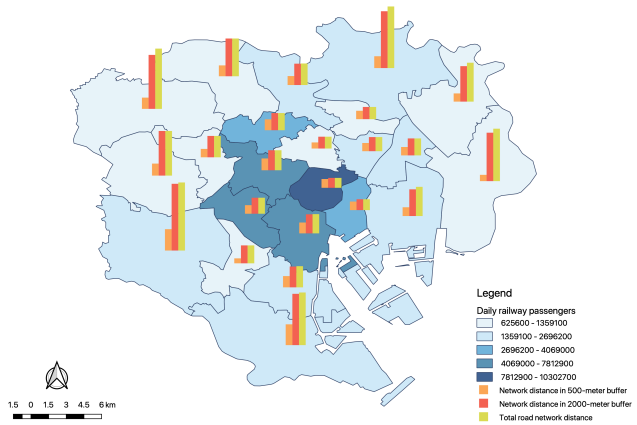

Figure 4. Walkable and bikeable Road connectivity in different wards

Table 1. Descriptive statistic on road network intersections

	Walkable intersections	Bikeable intersections
mean	129	2224
std	61	788
min	1	30
25%	84	1752
50%	130	2265
75%	172	2789
max	291	3912
cov	0.47	0.35

In the aspect of facilities, the analysis can be conducted from two perspectives: the stations and the facilities. For each station, it can be definitely accessed from more facilities when the activity range expands from 500 to 2000 meters. In the whole Tokyo 23 wards, the bike sharing system in TOD can activate more than 5 million station-facility pairs. Among the facilities, Figure shows the top five categories to which facilities the accessibility is mostly increased. As is shown from the figure, the living related services and recreational facilities takes up most of the facilities, which indicates that residents in Tokyo can benefit a lot from the sharing bike system. From the perspective of facilities, some facilities become accessible with bike sharing system. In Tokyo 23 wards, the distribution of the newly accessible POI is shown in Figure 6. From the distribution map we can find that in all regions there are a number of facilities that can be accessed by the sharing bike, and facilities in the peripheral regions can benefit more due to the less density of railway stations. In the future research, we will combine the land use mix data with POI data to analyze walkability and bikeability in details.

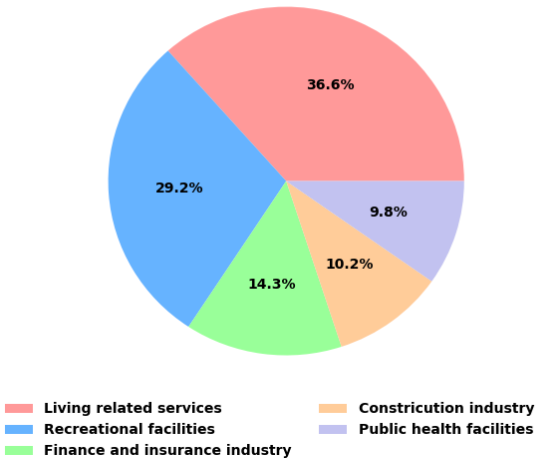

Figure 5 Category of facilities with mostly increasing accessibilities

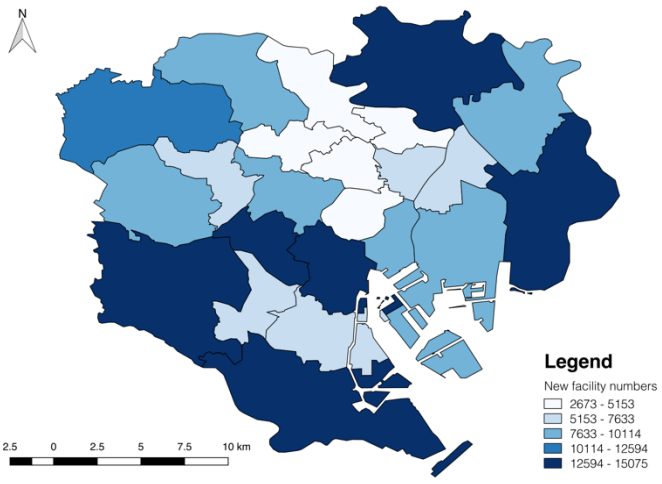

Figure 6 Distribution of new accessed POI