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TOD and Node-place Synergic Effect around Stations: A Case Study on Hong Kong

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Abstract

Mass transit not only provides convenient transportation but also underpin the attractiveness of areas around the stations. The story behind this phenomenon is the synergic effect between the accessibility and land use development. This study has tried to unveil the transit landuse synergistic effect around the MTR station in Hong Kong. Spatial Design Network Analysis (sDNA) was used to calculate the value of the Angular Betweenness Centrality for measuring accessibility. Land use development on the otherhand measured through Simpson's index using Geographical Information Systems (GIS) 10.5. These are the two preselected variablesto evaluate the synergy in800m radius around 84 MTR stations, selected for the study. The result has identified the quality of TOD precinct from both node and place perspective using the node-place model of Bartolini. According to this study, although most areas around the metro stations in Kowloon and Hong Kong Island are performing well, there are still some imbalancethat need proper planning actions. With these results in hand, TOD planning proposals can become more accurate by targeting investments on the most relevant or critical factors.

Key Words: Transport, Land use, Node-place, Transit Oriented Development.

Introduction

Transit Oriented Development (TOD) has been described as aplanning approach that aims to integrate land use and transport planning(Suzuki, Cervero, & Iuchi, 2013, Cervero, 1993).TOD can stimulate sustainable development by improving the interaction between transit and the surrounding development(Kamruzzaman, Baker, Washington, & Turrell, 2014; Renne, 2007; Renne & Wells, 2005; Cervero, 2013). Planning for TOD around existing transit nodes can only be effective if the assessment of the base situation is done properly.The benefits of TOD include increased access to public transportation and hence to more opportunities, utilization of already serviced land rather than servicing sprawl, increased transit ridership and reduced vehicular traffic pollution, reduced consumption of oil and gas, and healthier lifestyles(Babsin, 1997; Niles & Nelson, 1999; Porter, 1998; Transportation, 2002).To achieve these goals and to accrue thebenefits arising from them, it is necessary to ensure that the urban development interacts with the transit system. This critical link between transport and land use could beobserved over histories, like in the ancient capitals such as Rome, Madrid, London(Neuman & Smith, 2010);medieval cities such as Amsterdam and in the contemporary cities like Dubai, Singapore (Moghaddam, 2017) and Hong Kong(Loo,

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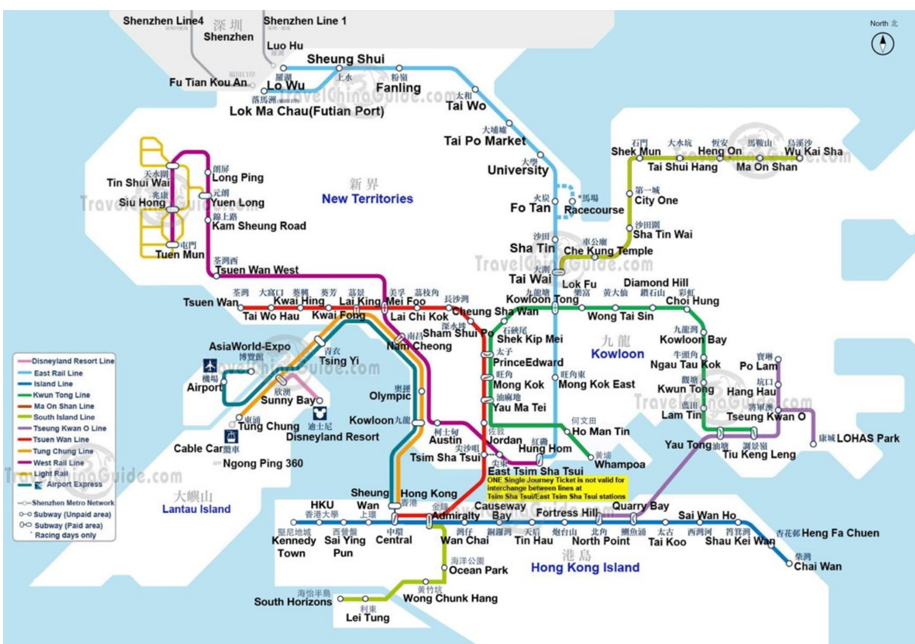
Chen, & Chan, 2010).Considering this link, Bertolini and Spit (2005) have argued that any significant transport node should ideally also be a significant place in the city.According to Bertolini (1999), each of the transit stations should has two basics. It is a node: a point of access to trains and increasingly to other transport networks and at the same time it is a place: a specific section of city with a concentration of infrastructure but also with a diversified collection of buildings and open spaces (Bertolini, 1999).When these two features perform in a balanced manner, benefit of transit and land use synergy could be properly utilized. Many studies have used node-place model of Bertolinifor station classification or measuring TOD'ness(Huang, Grigolon, Madureira, & Brussel, 2018; Paksukcharern Thammaruangsri, 2003; Reusser, Loukopoulos, Stauffacher, & Scholz, 2008; Singh, Lukman, Flacke, Zuidgeest, & Van Maarseveen, 2017). However, there are few studies on using node-place function of station areas for evaluation of synergistic effect.

Hong Kong is a city famous for its well-developed metro system which is one of the profit-makingmass transit system in the world(Tang, Chiang, Baldwin, & Yeung, 2004). Since thirty years of Mass Transit Railway (MTR) development, the first Kwun Tong Line which commenced operation in 1979 to the latest South Island Line that commenced operation in 2017, there are a total 10 MTR lines serving Hong Kong Island, Kowloon and the New Territories via 84 stations, carrying total 876 million passengers in 2006. Currently there are 11 MTR lines connected through 95 stations, serving 4.96 million passenger per day(MRT Corporation, 2019), that has been shown in figure 1.



Source: HK MTR Corporation, 2019

Figure 1: Hong Kong metro map

As the backbone of the city, the MTR not only is responsible for the efficient passenger movement but also introduces more economic activities and shapes the urban development in HK(Lo, Tang, & Wang, 2008; Tang, 2017; Transport and Housing Bureau. 2014; Tam, 2007). The introductions of metro stations are firmly connected with the development of surrounding land uses (Tang et al., 2004).Under the Rail + Property model (land development model around MTR stations), the metro company has paid much attention to the integration of the railway and the surrounding properties (Cervero, 2009), which in the end, enhanced the synergic effect between the accessibility and the land use development for better performance of the areas around metro stations. Under such condition, Hong Kong is a right place for the case study to evaluate the performance of areas around different metro stations from the dimension of the synergic effect. Against this backdrop, the research question for this study focuses on – 'what is the performance of MTR stations in Hong Kong consideringthe synergic effect between accessibility and land use development?'Thisstudy has evaluated the areas around metro stations within TOD precinct in terms of accessibility and land development as well as the synergistic effect between them.

Literature review

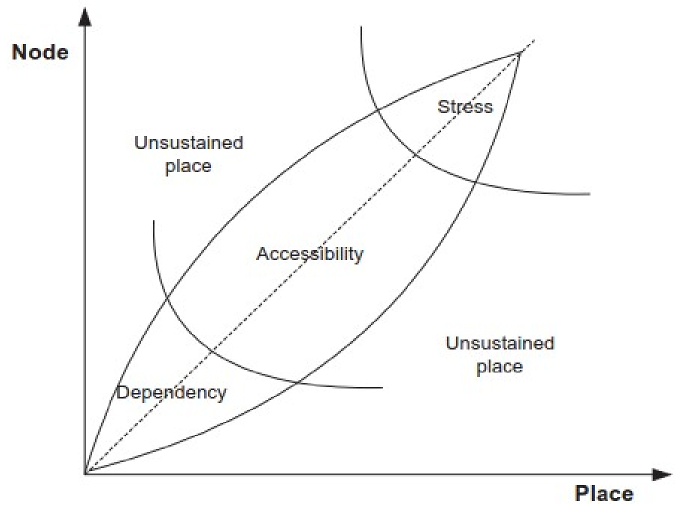
Synergic effect between accessibility and land use development

It is widely known that the accessibility of transport and the land use development have a reciprocal influence on each other(Chorus & Bertolini, 2011). It is easily understood that the spatial separation ofhuman activities creates a need for personal travel and goods transport, and thus influences themobilitybehavior ofactors such as households and firms. Less widely appreciated is the converse impact oftransport on land use (Banister & Thurstain-Goodwin, 2011; Giuliano, 2004; Wegener & Fürst, 1999). It is obvious that the availability of infrastructure makes certain locations accessible, but exactly how developments in the transport system influence the locational behaviour of landlords, investors, firms, and households is less clearly understood. The idea of the "land use transport feedback cycle"(Giuliano, 2004; Wegener and Fuerst, 1999)is often used to illustrate the complex relationship between land use and transport.In this cycle, land use and transport patterns both influence each other. Land use patterns partly determine the location ofhuman activities such as living, working, shopping, education, and leisure. The distribution ofhuman activities requires use ofthe transport system to overcome the distance between the locations where these activities take place. These activities create new travel demand and consequently, a need for transportation services, whether in the form ofnew infrastructure or more efficient operation ofexisting facilities. The resulting increase in accessibility co-determines the location decisions oflandlords, investors, households and firms and so results in changes ofthe land use, starting the cycle again. This process continues until a (provisional) equilibrium is reached or until some external factor intervenes (Meyer & Miller, 1984; Newman & Kenworthy, 1996).

Node-Place model

Research array of transport and land useusually apply different indicators and models for measuring or evaluating the connectivity betweenaccessibility and land use development. Node-place model is one of them. Bertolini(1999) in his Node-Place model considered station areas from both node and place perspective. It is generally recognized that land use patterns and transportation patterns are closely related to each other. It is easily understood that the spatial separation of human activities creates a need for personal travel and goods transport, and thus influences the mobility behavior of users. Less widely appreciated is the converse impact of transport on land use (David, 1995; Giuliano, 2004; Wegener & Fürst, 1999). It is obvious that the availability of infrastructure makes certain locations accessible, but exactly how developments in the transport system influence the locational behavior of property owners, investors and households is less clearly understood. The idea of the "land use transport feedback cycle" is often used to illustrate the complex relationship between land use and transport (Meyer & Miller, 1984). In this cycle, land use and transport patterns both influence each other. Land use patterns partly determine the location of human activities such as living, working, shopping, education, and leisure. The distribution of human activities requires use of the transport system to overcome the distance between the locations where these activities take place. These activities create new travel demand and, consequently, a need for transportation services, whether in the form of new infrastructure or more efficient operation of existing facilities. The resulting increase in accessibility co-determines the location decisions of landlords, investors, households and so results in changes of the land use, starting the cycle again. This process continues until a (provisional) equilibrium is reached or until some external factor intervenes (Meyer and Miller, 2001).The node-place model of Bertolini (1999) follows the reasoning of the transport land use feedback cycle and aims at further exploring the underlying relationships, with a focus on station areas.

The basic idea of the model is that improving the transport provision (or the node value) of a location will, by improving accessibility, create conditions favorable to the further development of the location. In turn, the development of a location (or an increase in its place value) will, because of a growing demand for transport, create conditions favorable to the further development of the transport system. The node-place model's emphasis on "conditions" is important, as it indicates a development potential that may or may not be realized, as other factors may also affect the outcome. Bertolini argues for five different scenarios to explore the relationship among transit and land use of a station area (shown in Figure 2) as both node and place (Bertolini, 1999).



Source: adopted from Bertolini, 1999

Figure 2: Node-place typology of train stations

Accessibility or Balance is a situation where a node and a place are strongly related with importance. Technical infrastructure systems and local land use profile support each other without any pressures to extend structures. The focus is on the maintenance of the systems and the environment. Stress stands for where intensity and diversity of infrastructure systems and activity of land use comes close to maximum. There is a lot of potential to make the land use more efficient (a strong node), and this potential has been realized (a strong place). Dependence means no competition for free space, and the demand of infrastructure flows is so low. There is no need for further development of infrastructure systems due to the lack of local potential. Unbalanced node is a situation when the supply of infrastructure flows is relatively stronger than the activity of land use. The imbalance might be manifested as splintered land use by massive infra lines, or environmental degradation caused by jammed traffic. Unbalanced place is where the activity of land use is more intense in relation to the supply of infrastructure systems. This kind of imbalance might come true in areas, where the atmosphere for entrepreneurship is traditionally supportive, but which is too remote for economic flows and consequent infrastructures.

Node-Place model to evaluate TOD

Bertolini (1999) developed a conceptual framework of a node-place typology of TOD, based on train stations in Amsterdam and Utrecht in the Netherlands. This study developed a node index for each station using the connectivity (e.g. number of directions served and number of stations within 45 min of travel), frequency, and diversity of transport services (e.g. train, bus, tram). The work also fashioned a place index based on walkable distance from the stations (700 m). The place index combines the number of residents in the area, the number of workers per each of four economic clusters (retail/hotel and catering, education/health/culture, administration and services, industry and distribution), and the degree of land use diversity.

More recently, Reusser et al. (2008) operationalized the node-place framework in classifying 1684 train stations in Switzerland. Eleven indicators were used in this study. Seven of these indicators were used to derive the node index including directions (e.g. number of end stations reachable), daily frequency, number of stations reachable within 20 min by train, number of end stations reachable by bus and tram, frequency of bus and tram, distance from the closest motorway access, and bike path length within 2 km. The remaining four indicators were used to derive the place index: population (number of residents); full time jobs in secondary and tertiary sectors; and land use diversity (or the degree of functional mix) within the places (700 m from the station). The node and place indicators were standardized (from 0 to 1) and summarized to form node and place indices respectively. The node and place indices were then plotted to identify whether the stations follow the node-place typology. In addition, unlike the indicators used in the node-place typology, this work identified relevant indicators based on expert questionnaires and repertory grid interviews which yielded six additional indicators (for node: number of passengers per day, ratio of the number of long distance and regional services, presence of staff; and for place: full time jobs in education, distance from town center, and the presence of grocery, restaurants, pharmacy and florist). A two-step cluster analysis was then conducted using the 17 indicators in order to classify the stations which resulted in a five-cluster solution: smallest station, small stations, mid-size stations in populated areas, mid-size unstaffed stations, and large to very large stations. These classified stations were also plotted in the node-place typology. However, the author reported that the enhanced model achieved a better fit than the node-place model in a Swiss context.

Schlossberg and Brown (2004) classified 11 TODs in Portland in terms of their pedestrian friendliness using 6 built environmental indicators at two different scales (e.g. 5 min and 10 min walk from the stations). The indicators are – quantity of accessible paths (e.g. miles of minor roads); quantity of impedance paths (e.g. miles of arterial roads), pedestrian catchments areas (PCA) or ped-shed (e.g. ratio of service area generated based on network distance and Euclidian distance from the transit stops); impedance PCA (e.g. similar to that PCA but the service area was generated by excluding the high volume, high speed corridor); intersection density, and density of dead ends. Each TOD was classified as good or poor on each indicator. Unlike the consideration of only built environmental indicators in the previously described studies, the Center for Transit-Oriented Development (2010) has taken into account both a place indicator (e.g. use-mix) and a performance indicator in order to develop TOD typologies in the USA.

Zhang (2007) identifies a specifically Chinese edition of TOD from the experience of development pattern around transit station in Hong Kong, as TOD performance standards developed in United States were not directly applicable to Chinese context. Zhuang and Zang (2016) consider that the Shanghai metro, since it's opening in 1993, (having 14 metro lines and 337 stations with a total route length of 548 km is the longest in the world that is covering 51% core area and 25% of the center of Shanghai; estimated to extend the line spanning 800 km with 18 stations) has radically changed the accessibility of the metropolitan area. Cervero (2011) also in his research argue about Shanghai metro as the best choice for TOD implementation in China and identify that in Shanghai minimum 24% of vehicle miles travelled (VMT) could be reduced by introducing metro rail system (Zhuang & Zhang, 2016).

Data and method

Since the new-built stations and surrounding land development are still under the development process which will inevitably show weak performance in the synergic effect, the study has selected metro stations in Hong Kong that are completely developed. During the past five years, there are several new-built stations, such as the Ho Man Tin Station, South Island line, etc. Therefore, the case study considered only stations before 2014 (< 2014) for analysis.

Delineating TOD buffer

As for the metro station area, most of the studies will regard areas of the radius at 400m from metro stations as the study area (Centro. 2006). Recent study shows that the radius at 800m will be better for the synergic effect analysis (Kim et al., 2016). In the European context most of the previous study (Bertolini, 1999; Reusser et al., 2008; Vale, 2015; Zemp, Stauffacher, Lang, & Scholz, 2011) prefer a 700m Euclidian distance from the transit stop as TOD sphere. In the context of American cities,ranges between 400 m to 800 m (Atkinson-Palombo & Kuby, 2011; Austin et al., 2010; Schlossberg & Brown, 2004)were considered as standard TOD perimeter. Yet, Canadian studies suggest 400 m to 600 m (Calgary, 2004 ; Farber & Marino, 2017) whereas Australian studies use 800 m (Kamruzzaman et al., 2014) which is considered as the comfortable walking distance in each context. In this paper, areas within 800m's walking distance around the metro stations were considered as TOD precinct or area under evaluation.

Indicator selection and analytical method

Accessibility

Different purposes of studies have different understandings of accessibility, therefore usedifferent selections of indicators. There are various definitions and indicators for accessibility. Among studies exploring the synergic effect, the accessibility serves as a measurement of the performance of the transport network. There are mainly three kinds of accessibility: the infrastructure-based one only considers about the transport system: the activity-based one focus on the locations of activities: the utility one is from the aspect of people's perception(Farber & Marino, 2017; Hansen, 1959; Lo et al., 2008; Sun, et.al., 2016). Since this paper is to evaluate the synergic effect between accessibility and land use development around different metro stations, which shares more commons on the locations of activities, the definition of the accessibility in this paper is activity-based accessibility. It is about the characteristics of routes, such as length, between origins and destinations and it deals with the spatial distribution of activities. It includes a transport factor for routes, such as street network and railway lines, and a land-use component representing attractive destinations (Bouacchiello et al., 2010).

As activity-based accessibility, when evaluating the synergic effect, it would be better to consider the characteristics of routes between origins and destinations only, without the effect of activities' opportunity(Shimbel, 1953). This kind of accessibility unweighted by the activities or land use, was first raised by Shimbel and the measurement of the unweighted accessibility is the number of shortest paths passing through a link (Shimbel, 1953). Those shortest paths might be the routes with least time, shortest lengths, or fewest turns, between all origin-destination pairs. This indicator can also be referred as the 'Betweenness Centrality'. Many studies are applying the Betweenness Centrality as the indicator for measuring the accessibility, and proving that it is an appropriate indicator to represent the accessibility (Chiaradia et al., 2014: Zhuang and Zhang, 2016).

Based on the previous studies, indicators were selected carefully that can express the accessibility and land use development relevant to the purpose of this paper. The 'Betweenness Centrality'is the indicator of accessibility. Since the accessibility is about the trips between origins and destinations, it is not only about the accessibility of the metro network, but also about the walking environment between the metro stations and the destinations. Accessibility of the street network and the metro network were calculated separately.

Due to the availability of the data, the data in 2015 was collected for the study. Data includes the street network, the metro network, and the number of different activities. For the street network and the metro network, the Spatial Design Network Analysis (sDNA) was used for computing the Betweenness Centrality. As for the accessibility of pedestrian, it can be obtained by setting the radius at 800m during the analysis process of sDNA, which is the micro-scale in the analysis of sDNA. For accessibility of the metro network, the transfer detail was taken into consideration under the topologic network, which is to use two steps instead of one when transfer from one line to another following the previous study of Chiaradia et al. (2005).

Land use development

As for the land use development, there are several dimensions to assess it. Accessibility, density and clustering, land use mix, and roadway design are four main dimensions for assessment(Ho & He, 2011; Wegener & Fürst, 2004). The density is the population density, and it can be measured by the number of residents and employees(Singh, Lukman, Flacke, Zuidgeest, & Van Maarseveen, 2017). As for cluster, different layouts of clusters will generate different outcomes. Assessing from the land use mix is the most direct one among all these assessing dimensions, and it is widely used(Cervero & Kockelman, 1997; Kamruzzaman, Baker, Washington, & Turrell, 2014). Studies look at the number of commercial, residential and office building, which relate to daily activities and movement(Chorus & Bertolini, 2011; Huang, Grigolon, Madureira, & Brussel, 2018; Reusser, Loukopoulos, Stauffacher, & Scholz, 2008; Singh et al., 2017; Vale, 2015). Other activities, such as sports, education, are also essential. Some studies look at the jobs-housing balance, which can well express people's selection of accommodation and work (Alayli, 2006; Curtis and Scheurer, 2017). Besides the number or area of activities, there are also some indicators to represent the diversity of all types of land uses, such as the Simpson Diversity Index. It was initially introduced for assessing ecological diversity (Simpson, 1949). Recently, plenty of research applies the index as an indicator for the measurement of the land use development.

The function is: $D = E(n / N)^2$

Where 'n' is the total number or area of one particular type of land use: and 'N' is the total number or area of all types of land uses (Kajtazi, 2007).

For this study, number of different types of land useswasconsidered and categorizedinto five following types:

1. Commercial: The number of retails, shopping malls and offices;
2. Residential: The number of residential buildings;
3. Sport: The number of outdoor activities;
4. Community: The number of education places and community centers;
5. Others: The number of other activities.

The Simpson Diversity Index was applied,and spatialevaluation were conducted using ArcG1S 10.5 for the measurement of the land use development.

Model selection for the performance evaluation

Node-place model was applied for evaluation of transport and land use development synergy. The node value was evaluated in terms of 'level of accessibility', and the place value was measuredin terms of 'land use development'. After calculating the value of the accessibility and the land use development, performance of metro station areas was evaluated from the five conditions of node-place model. The Principal Component Analysis was used for reducing the accessibility indicators and land use development indicators into one separately (Jolliffe, 1986). There are two indicators for accessibility and six indicators for land use development. From the results of the Principal Component Analysis, summative values were calculated for accessibility and land use development to construct the synergic model.

Performance Evaluation of the case stations

Pedestrian catchment area, also known as Pedshed is theoretically an actual area that can be covered by walking within a defined Euclidian distance (Comission, 2015; Porta & Renne, 2005; Schlossberg & Brown, 2004). Figure 3 shows the 800m impedance catchment area around 84 stations.Higher the Pedshed ratio, higher the walkability for the pedestrian, a Pedshed ratio of ≥ 0.6 is said to be a good target for walkable catchment (Comission, 2009). Most of the stations indicate good accessibility value which is above the standard value 0.6.Stations along the island line and central urban area in Kowloon part shows more walkable catchment than others.

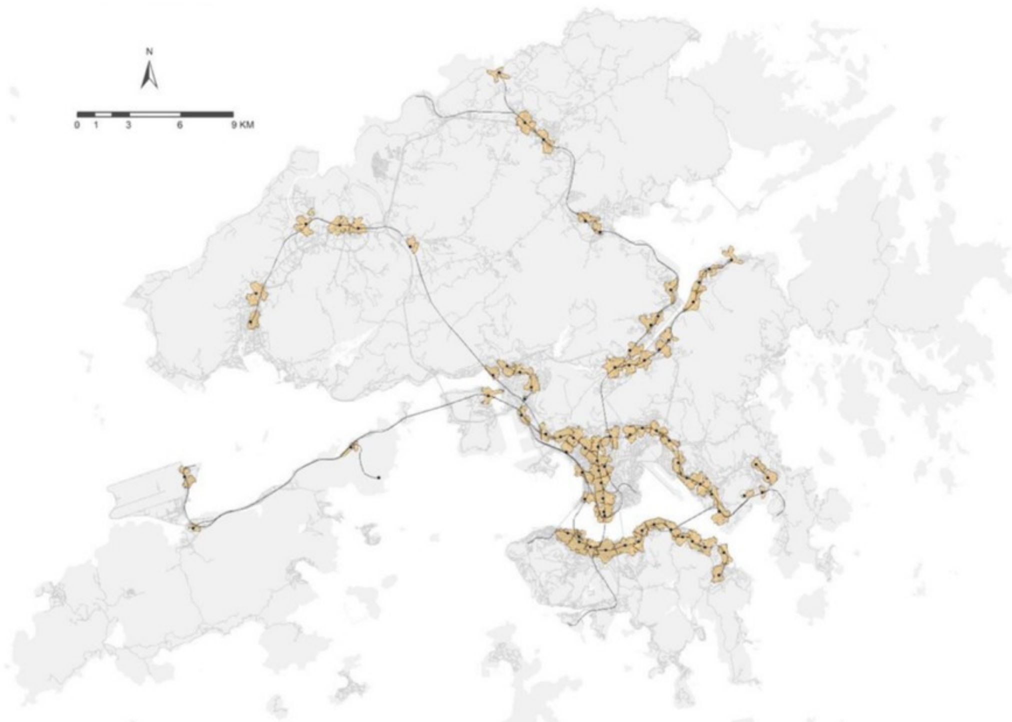


Figure3: TOD precinct around metro stations in Hong Kong

Accessibility Values

By applying the Spatial Design Network Analysis (sDNA), the value of the Angular Betweenness Centrality was calculated.

Accessibility of walking

After getting the value of Angular Betweenness Centrality for the whole Hong Kong, this papersum-up the Angular Betweenness Centrality values of those links within the study area of each metro station and get the average value to show the accessibility of walking. In general, the areas with high level of accessibility are concentrated around the metro stations. The areas around the metro stations in a higher level of accessibility are mostly in the urban core areas, marked as dark, shows in figure 4. Stations along the island line and Tsuen wan line shows thehighest walking access whereasLo Wu and Wu kai Sa line show moderate accessibility in terms of walking. Tseung Kwan O line has the least accessibility comparing others.

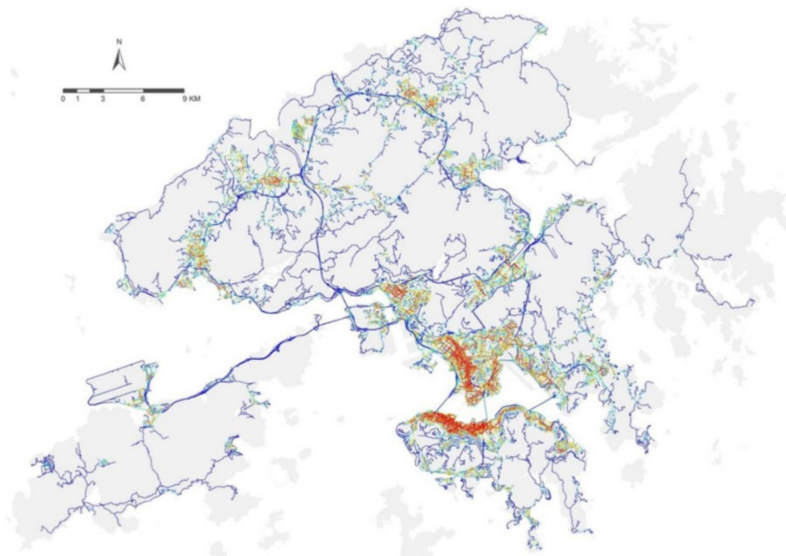


Figure4: Accessibility scenario (walking)

Accessibility of Metro network

Value of accessibility for each station was calculated by the average Angular Betweenness Centrality value of all the links passing through the station. Stations along the island line and the Tsuen Wan Line are more accessible comparing to the other lines on the whole network, shows in figure 5.

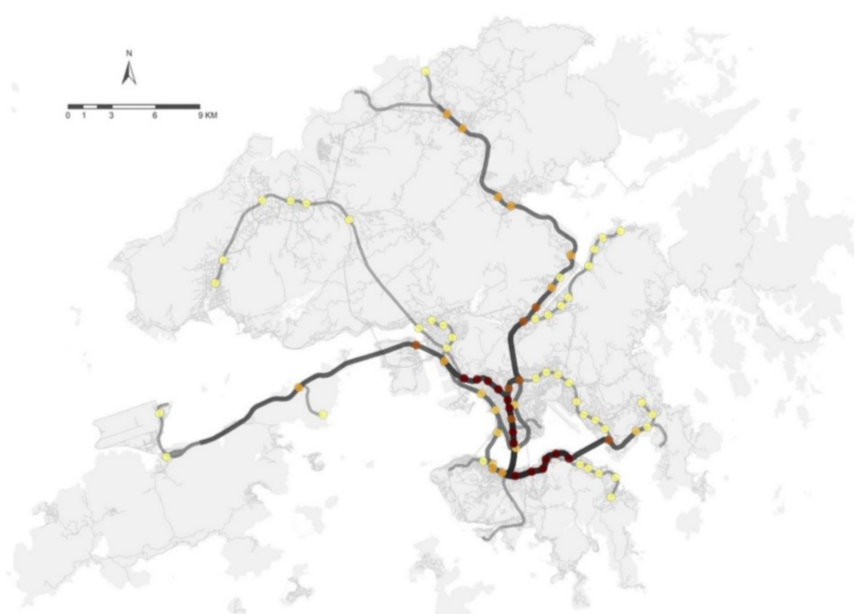


Figure 5: Accessibility of metro network

Land use development values

The number of different land uses

Figure 6 shows intensity of the number of different landuse around different stations that were previously categorized under five types.

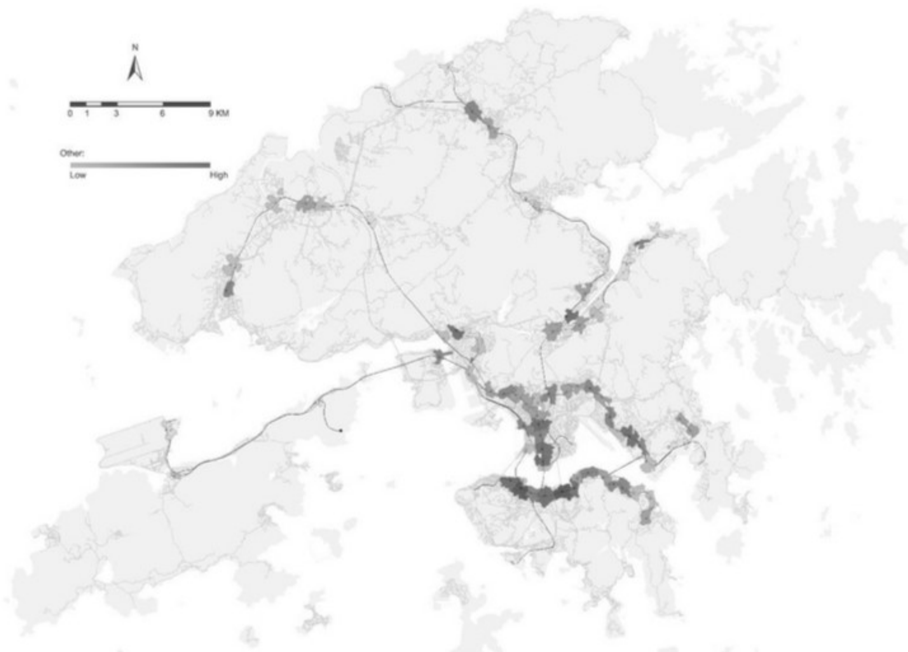


Figure6(a): Number of different land uses (others)

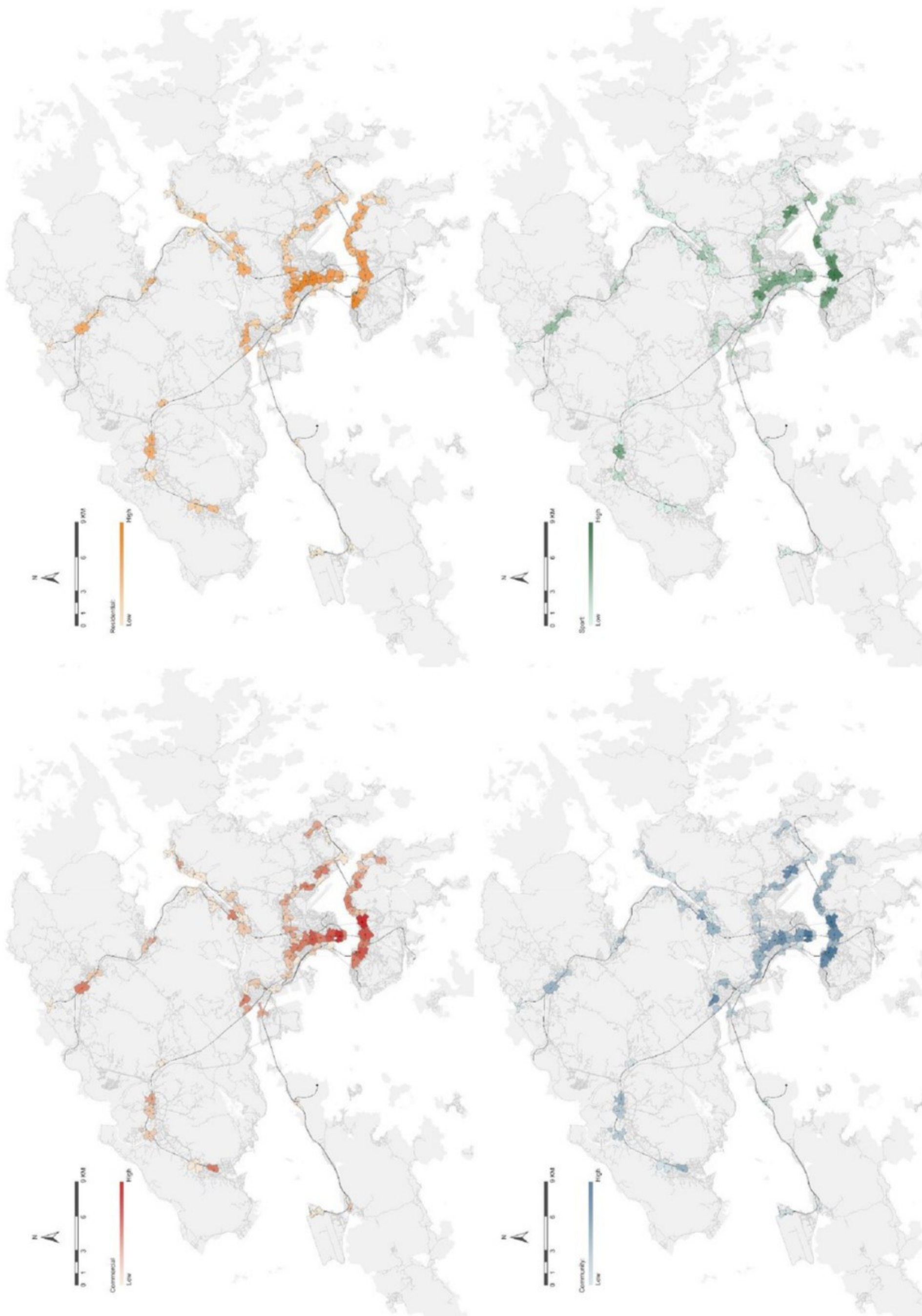


Figure 6(b): Number of different land uses(commercial, residential, sports and community)

The Diversity Index

The Simpson Index helped to compute the landuse diversitywhich has been visualized in the following figure 7 using ArcGIS.It represents that land use diversity around stations are higher in case of Island and Tsuen Wan line, similar to the result of accessibility. This demonstrate the positive relation between accessibility and land use diversity.

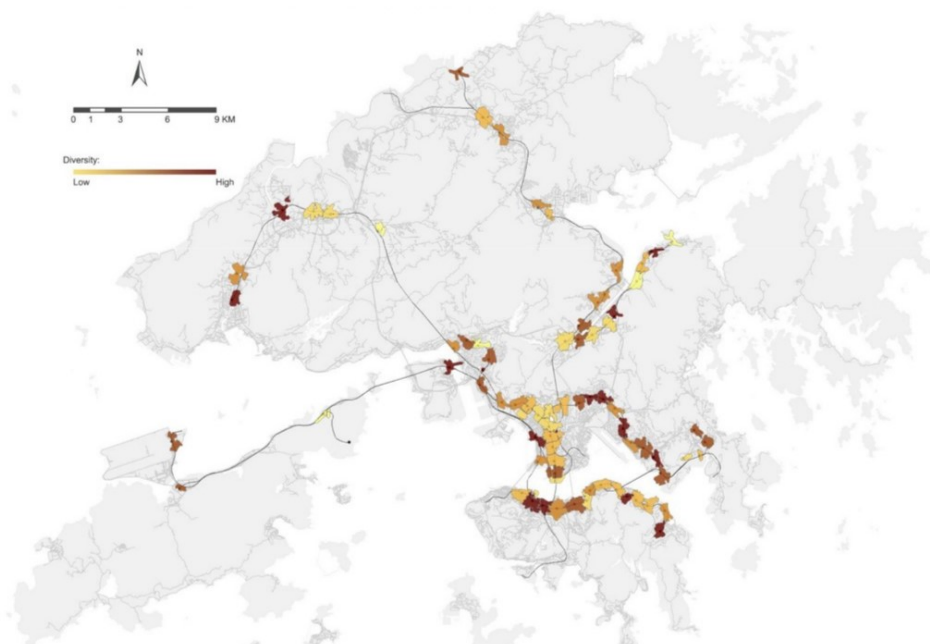


Figure7: The diversity mix

Evaluation by the synergic model

The principal component analysis to reduce indicators

As for reducing two indicators of accessibility, since the KMO value will always be 0.5 when there are only two variables. The Bartlett's Test was used for testing, if the Principal Component Analysis is appropriate or not. In this case, the significance level of Bartlett's Test is 0.000, which indicates that it is reasonable to carry out the analysis. After the analysis, there was one new component to represent about 70% of two indicators for accessibility.

Table 1: KMO and Bartlett's test

Kaiser-Meyer-Olkin measure of sampling adequacy		.500
Bartlett's test of sphericity	Approx. Chi-square	12.981
	df	1
	Sig.	.000

Table 2: Total variance explained

Component	Initial Eigenvalues			Extraction sums of squared loadings		
	Total	% of variance	Cumulative %	Total	% of variance	Cumulative %
1	1.395	69.753	69.753	1.395	69.753	69.753
2	.605	30.247	100.000			

Table 3: component matrix

	Component
	1
Accessibility of metro network	.835
Accessibility of walking	.835

In the Principal Component Analysis for the six indicators of the land use development, both KMO value and Bartlett's Test indicate that the analysis is appropriate. The six indicators can be reduced into two new components. The component loadings can calculate the overall value of these two components.

Table 4: KMO and Bartlett’s test

Kaiser-Meyer-Olkin measure of sampling adequacy		.788
Bartlett’s test of sphericity	Approx. Chi-square	379.368
	df	15
	Sig.	.000

Table 5: Total variance explained

Component	Initial Eigenvalues			Extraction sums of squared loadings			Rotation sums of squared loadings		
	Total	% of variance	Cumulative %	Total	% of variance	Cumulative %	Total	% of variance	Cumulative %
1	3.786	63.106	63.106	3.786	63.106	63.106	3.774	62.902	62.902
2	1.231	20.510	83.616	1.231	20.510	83.616	1.243	20.714	83.616
3	.483	8.049	91.665						
4	.287	4.776	96.441						
5	.145	2.410	98.851						
6	.069	1.149	100.000						

Table 6: Rotated component matrix

	Component	
	1	2
Number of residential areas	.759	-.477
Number of sport areas	.827	
Number of community areas	.955	
Number of commercial areas	.886	
Number of other areas	.895	
Simpson diversity index		.934

The overall value for land use development is:

$$\frac{3.774}{3.774+1.243} \times component\ 1 + \frac{1.243}{3.774+1.243} \times component\ 2$$

Synergic Model

After summarizing the indicators into one component for accessibility and one for land use development, a new application of the node-place model was carried out for this study. The node value is the new component for accessibility, and the place value is the new component for land use development.

According to the five conditions of the node-place model, the points around the middle of the diagonal line in the figure are at a high level of accessibility and land use development, which means that the areas around those metro stations are performing well in the synergic effect. Points around the two ends of the diagonal line are in the condition of over-developed or underdeveloped. As for points above the line, the areas around those metro stations perform well in the land use development but fail to promote the accessibility level. For those below the line are areas around metro stations high in accessibility but low in land use development.

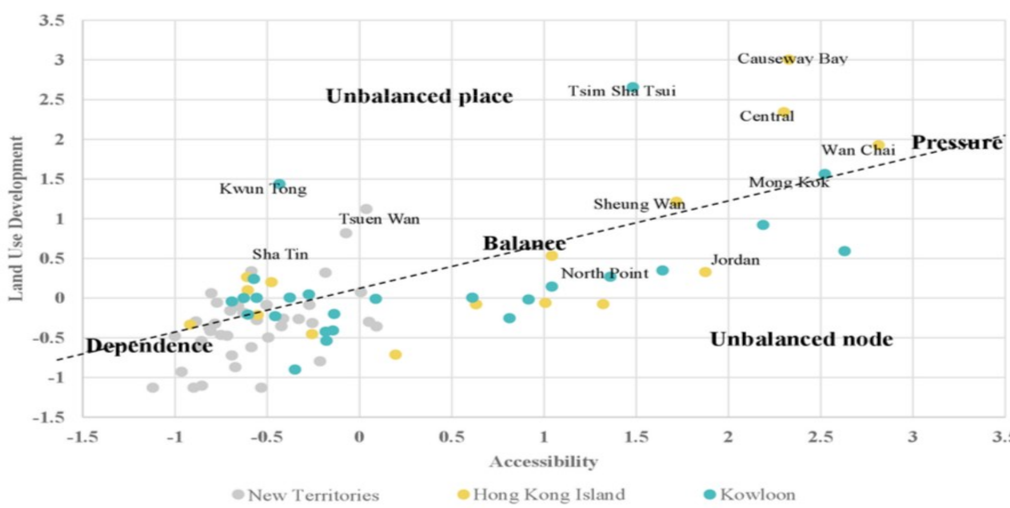


Figure 7: Synergic model for case stations

For the analysis in Hong Kong, a large part of the metro station areas is along the diagonal line, which indicates that most stations can keep a balance between the accessibility and land use development, even the synergic effect is too strong or weak. By categorizing the metro stations from the districts of Kowloon, Hong Kong Island, and New Territories, the studyget a clear understanding of the result. This study finds that most areas around the metro stations in new territories are at a low performance of synergic effect and areas in Kowloon and Hong Kong Island are mostly performing well, such as North Point station and Jordan station. There are some areas where accessibility cannot catch up with the development of land use and few areas facing the problem that the land use development falls behind the accessibility. Some metro station areas in the urban core area are under high pressure for further development, such as MongKok station and Wan Chai station. Some of them have a high requirement for the improvement of accessibility due to the rapid land use development, such as Tsim Sha Tsui station and Kwun Tong Station. Also there are metro station areas between two conditions, such as Causeway Bay station and Central Station.

Discussion and Conclusion

Synergic model reveals that, the performance of the metro stationsisgreat where the accessibility and landuse development synergy are well balanced. The result can provide useful suggestions for the future improvement of the areas around the metro stations. The synergic model can be useful to monitor the latest performance of each station. From the analysis above, the study can conclude that the areas around the metro stations in new territories need to be improved firstly. The metro stations in new territories sent thousands of people commuting between the urban core area and new territory every day. They have the enormous potentials for offering better passenger experiences in accessibility and activity provision. There is no need to improve these stations to catch up with the stations, like Jordan station, but to achieve the condition of balance at least. Although most areas around the metro stations in Kowloon and Hong Kong Island are performing well, there are still some areas in the condition of dependence. Attention should also be paid to those areas. For those station under pressure, like MongKok station and Wan Chai station, it is better to decentralize the population to prevent overcrowding and release the pressure. For those metro station areas in the condition of unbalance in Hong Kong, most of them face the problem of low accessibility. The accessibility might be hard to improve, since it is not easy to construct new roads, especially for those built-up areas in the urban core area. For areas in the new territories, the low accessibility might due to the surrounding highways. Thus, for the areas around the metro stations having the condition of Unbalanced Place, better foot over bridge or pedestrian facilities can solve the problem and increase the accessibility level to some degree.

In brief, the synergic model can provide a new assessing dimension for the performance of the areas around metro stations, which is a straightforward way to monitor the latest performance for each station and provide suggestions for future improvement.

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