Measuring the Polycentricity based on urban and intercity transportation networks in Greater Bay Area: a cross-scale method in the context of Node-Place model

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For a long time, the study of urban spatial structure, especially the relationship between cities, has been regarded as an important research field in urban planning and regional science. The study of urban spatial structure can be traced back to the beginning of the 20th century, which mainly originated from the theory of urban location (Alonso, 1964). As time enters the 21st century, the concept of monocentricity has gradually given way to polycentricity (Green, 2007; Meijers and Burger, 2010; Batty, 2016). There are various signs that people have perceived that polycentricity is happening in the city, but in fact this concept is vague (Burger and Meijers, 2011a; Brezzi and Veneri, 2014; Giffinger and Suitner, 2014). This ambiguity is mainly reflected in the cognition of the centre and spatial structure.

The Guangdong-Hong Kong-Macao Greater Bay Area (GBA) plan was promulgated by the State Council of China in 2015 (Walker and Schafran, 2015). As one of China's three Mega-City Clusters, GBA is considered an important innovation platform for national implementation of resource allocation, coordination, and division of labour (Hui et al., 2020). It is foreseeable that the spatial structure of GBA will gradually move closer to polycentricity in the future. Therefore, exploring the current spatial structure of GBA will provide a strong basis for a series of urban construction measures in the future. This is the primary motivation of this research from the perspective of practical application.

Therefore, this research will use the Node-Place model proposed by Bertolini in 1999 as an entry point to fill the above-mentioned research gaps in this field. This research proposes an extended model defined as Node-Place-Settlement-Container+Mobility (NPSC+M) to evaluate the different dimensions of urban station areas. Among them, the 'NPSC' dimensions are used to evaluate the morphological spatial structure, and the 'M' dimension is used to evaluate the functional polycentricity. We provide a multi-dimensional and comprehensive multi-index polycentricity evaluation framework based on this extended model, and further analyse the connections of morphological polycentricity and functionality polycentricity.

1.Visualize and analyse the spatial structure of GBA

In order to quantitatively evaluate the morphological polycentricity and functional polycentricity of GBA and its major cities, this paper processes the collected data to construct 19 indicators in five dimensions of NPSC+M. On this basis, the indicators are weighted by the CRITIC method and integrated into the index of each dimension. Finally, through Global Moran's I, we put forward a quantitative evaluation result of the Centralized-Dispersed degree for each city in GBA, and visualized their morphological and functional spatial structure through the LISA spatial autocorrelation method to evaluate their polycentricity. We found that currently only Shenzhen in GBA meets the definition of morphological polycentricity and functional polycentricity (Figure 1 and 2). Guangzhou is currently in the process of transforming from monocentricity to polycentricity. Compared with the former two, Foshan and Dongguan have weaker urban competitiveness. This results in them still being monocentric or even dispersed. At the regional level, GBA already possesses morphological polycentricity (although only Guangzhou and Shenzhen), but the flow of functions tends to gather in Shenzhen.

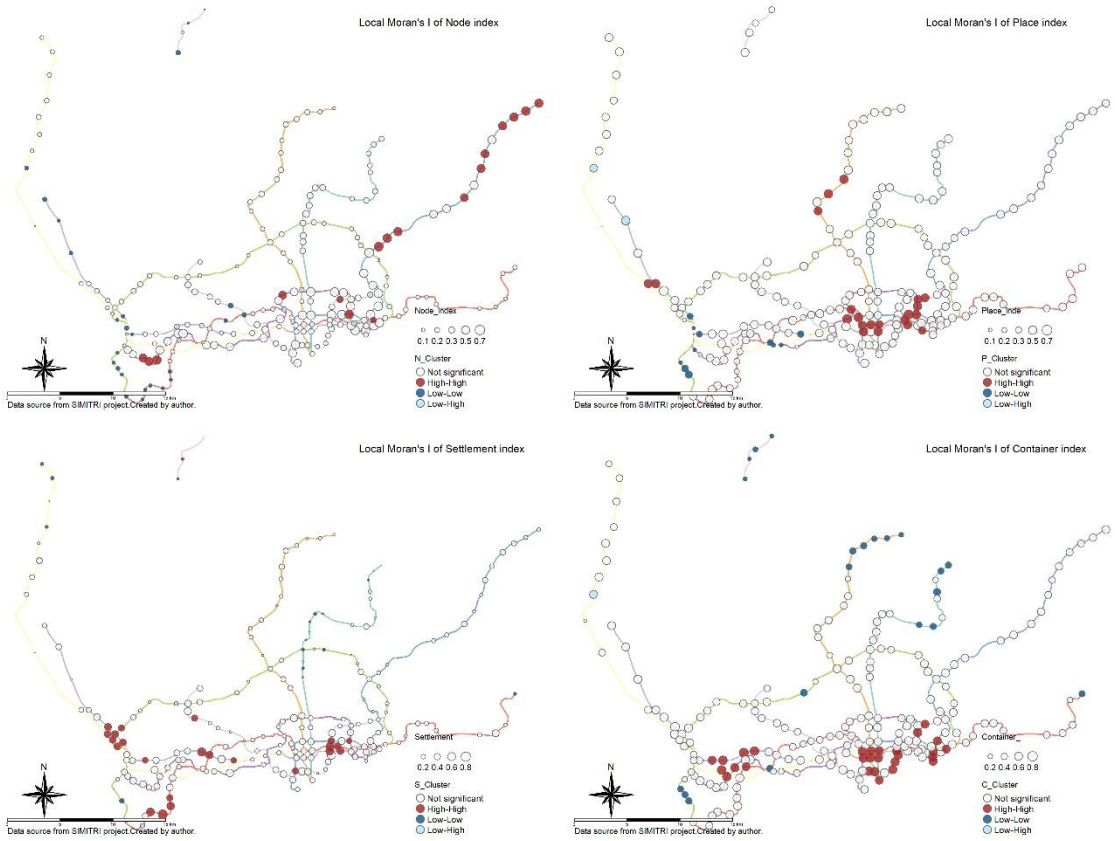

Figure 1: LISA maps of morphological spatial results in Shenzhen, based on the k2 matrix; 1) Node dimensional; 2) Place dimensional; 3) Settlement dimensional; 4) Container dimensional morphological spatial structure

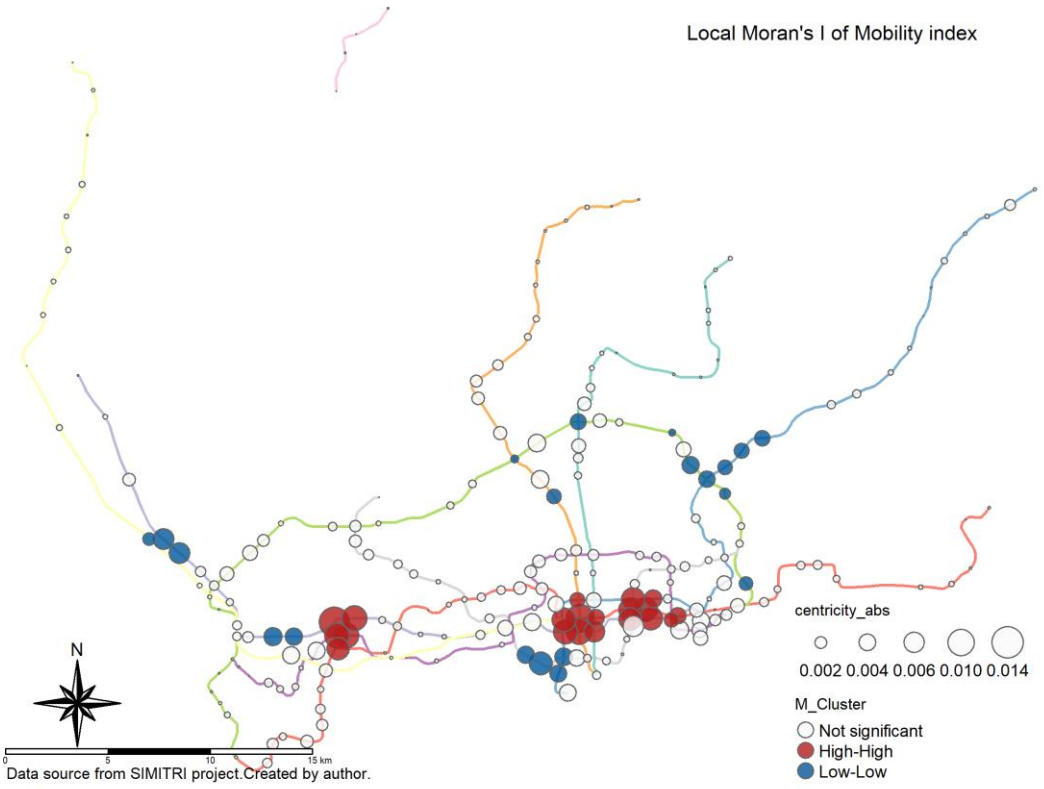

Figure 2: LISA map of Mobility dimensional results in Shenzhen, based on the k2 matrix

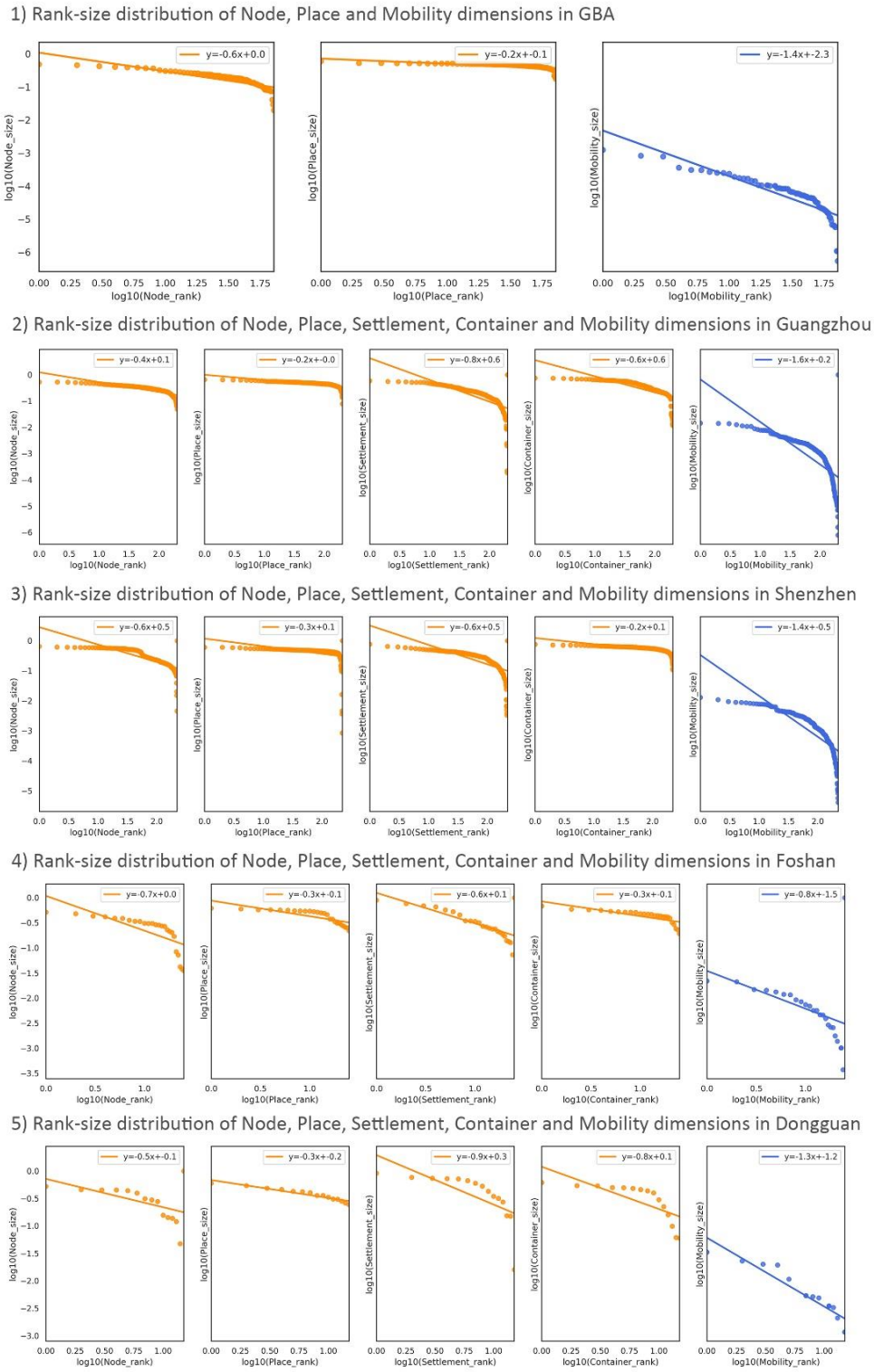

Figure 3: Rank-size distribution of 1) GBA, 2) Guangzhou, 3) Shenzhen, 4) Foshan, 5) Dongguan in NPSC+M dimensions;

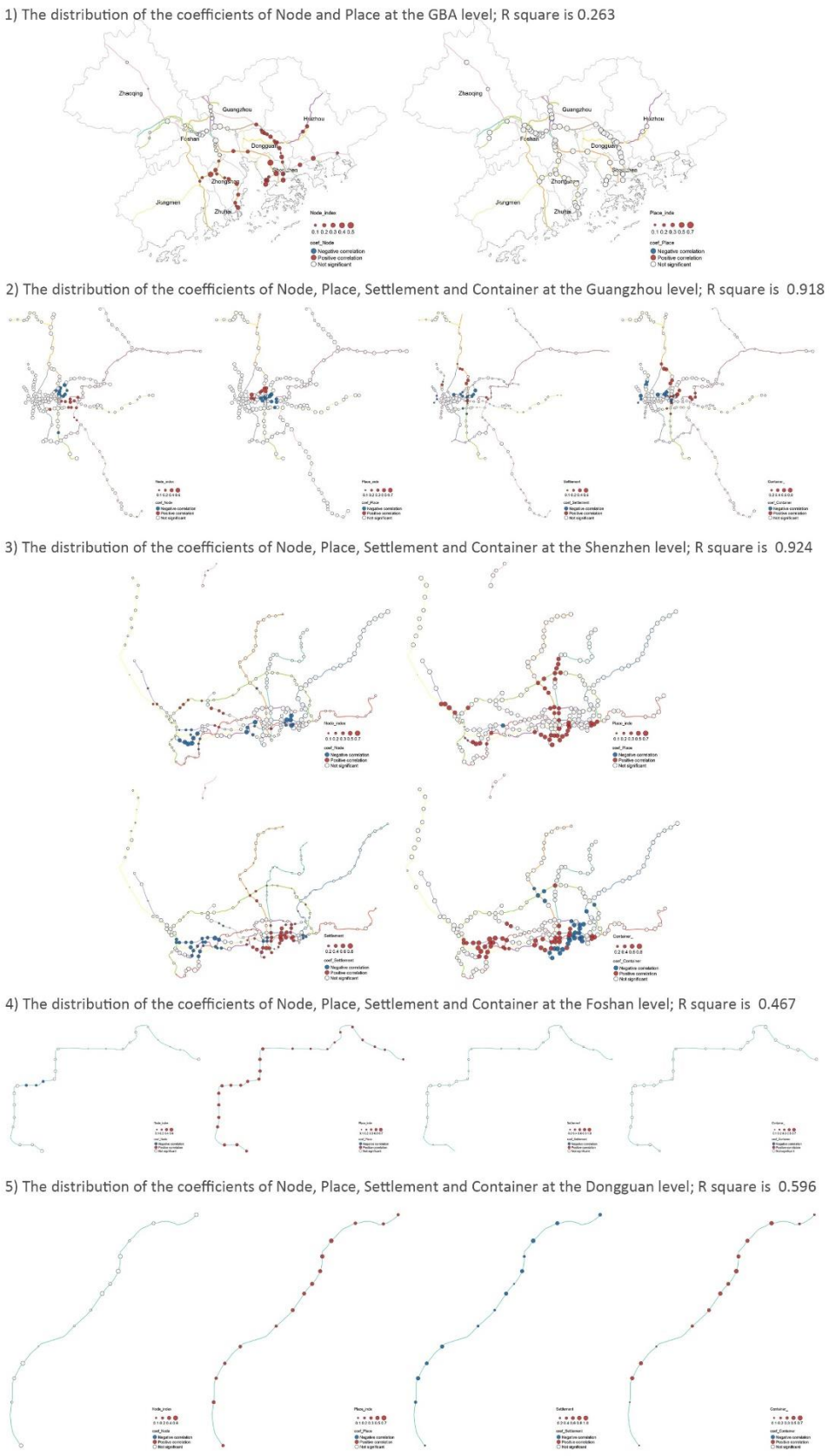

Figure 4: The coefficients of the GWR model are distributed in 1) GBA, 2) Guangzhou, 3) Shenzhen, 4) Foshan, 5) Dongguan. Node, Place, Settlement, Container are used as independent variables, and Mobility is used as dependent variable.;

2. Comparison of morphological polycentricity and functional polycentricity in GBA

On this basis, we further studied the relationship and mismatch between morphological polycentricity and functional polycentricity in GBA. For the former, we chose the Rank-size distribution method which has been confirmed by Meijers (2011) to be feasible. For visualizing the mismatch of morphological polycentricity and functional polycentricity, we tried to use geographically weighted regression (GWR) and confirmed the contribution of this method in this field. we made some conclusions from the results (Figure 3 and 4):

1) The development of physical space of GBA is more balanced than the development of functional connection, which is completely contrary to the conclusions obtained in the United Kingdom and the United States (Burger *et al.*, 2011; Arribas-Bel and Sanz-Gracia, 2014).

2) Morphological polycentricity and functional polycentricity have been shown to be interdependent. This finding also verifies the conclusion of Meijers (2011);

3) For regional sub-central cities (Foshan, Dongguan), Horizontal land use is the key to stimulating functional flow. For regional central cities (Guangzhou, Shenzhen), the flow of functions has a closer relationship with the urban spatial form.

4) Focusing on mismatches, the urban centres of Shenzhen and Guangzhou show that morphological elements are not enough to support high- strength functional flow. The main problem in Foshan is that the residential space dominates the vertical spatial form of the city. There is a serious imbalance between the distribution of communities in Dongguan and the flow of population.

In general, the concept of polycentricity is still vague (Möck and Küpper, 2019). Nevertheless, we have boldly attempted to combine the Node-Place model with the polycentricity evaluation and respond to the ambiguity with a fixed spatial unit (station) and multi-scale evaluation method. However, our current method still has many limitations, such as the ambiguity caused by the choice of analysis space unit. We encourage other scholars to look at polycentricity from the perspective of ‘evaluation’ rather than ‘identify’. In this way, not only will polycentricity not become a far-fetched and meaningless concept, but it will also help the city's cognition and reality transformation.

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