

Relationship between Functional Urban Polycentricity and Spatiotemporal Pattern in Terms of Human Mobility in the Tokyo Metropolitan Area

A Dissertation Submitted to
the Graduate School of Life and Environmental Sciences,
the University of Tsukuba
in Partial Fulfillment of the Requirements
for the Degree of Doctor of Philosophy in Science
(Doctoral Program in Geoenvironmental Sciences)

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Abstract

A metropolitan area means a region consisting of a densely populated urban core and its less-populated surrounding territories, sharing the resource of residence, industry and infrastructure. Urban polycentricity is the pattern of networked socioeconomic activities and human mobility within a metropolitan territory instructed by multiple centers (central city and its satellite cities) instead of a single center (traditional CBD). In recent years, a metropolitan area usually has a multi-functional structure consisting of plural coordinated urban cores, as a hot topic on urban studies.

On the other hand, human mobility is a kind of micro phenomenon of urban's agglomeration and diffusion, whose characteristics can be applied for classifying an area's urban functions in one metropolis. Understanding the spatial pattern of functional urban polycentricity and its factor in the metropolitan area can help us to rethink the urban planning and to reveal the regional characteristics and differences of human mobility from the spatiotemporal perspective through a GIS microscope, under the layout of a polycentric urban structure.

Person-trip survey in the Tokyo metropolitan area describes the person's movement by one-minute break during one weekday (October 1st, 2008), that is to say, questions of "who he/she is", "for what purpose he/she travels a trip", and "where is start-point and where is end-point" can be known. This survey has many unique advantages compared with other data resources, and the author intends to use it to investigate the functional urban polycentricity in the Tokyo metropolitan area (TMA).

The objectives of this research are to clarify the spatial pattern of functional urban polycentricity, to elucidate the triple-side thinking on combining the pattern of functional urban polycentricity with the regional characteristics and differences of human mobility and the policy effect of the Tokyo Master Plan (TMP), and lastly to reveal the relationship between functional urban polycentricity and spatiotemporal pattern in terms of human mobility under the consideration of dynamic urban structure

in the TMA.

This research quantifies the functional urban polycentricity and uncovers the spatiotemporal pattern of human mobility in the TMA. Based on an original mesh-based GIS microscope created from the person-trip survey, this research has constructed a reasonable analytical framework for the functional urban area (FUA) detection within the TMA. It becomes possible for considering each FUA's indexes (e.g. scale, boundary, inflow/outflow amount, etc.) at the mesh scale. Moreover, this FUA detection process is developed and designed for fitting this research's situation. The author also designs a new definition of functional human mobility dominance (HMD) and makes an original recognition method for identifying it, by examining five different kinds of human mobility, i.e. home-returning, school-commuting, commuting, consuming and business activities. Then, based on the spatial pattern of functional HMD, regional characteristics and differences of human mobility in the whole study area are examined through the mesh-based GIS microscope. After highlighting the pattern of functional HMD in each FUA, this research discusses the policy effect of TMP. In brief, this research archives the recognition of functional HMD and the detection of FUA throughout a series of analyses by handling the geo-tagged big data in the TMA.

To achieve the research purpose, the author creates a reasonable GIS microscope based on an original mesh-based GIS database. Furthermore, using the Multi-step Decision-making Newman (MDN) Algorithm designed by the author, the FUA detection has been successfully performed. On the other hand, the triple-side thinking of combining the pattern of functional urban polycentricity with the regional characteristics and differences of human mobility and the policy effect of the TMP has originalities and practical significance. It is necessary to explore the spatial pattern of functional HMD by five different categories for assessing the functional allocations and identifying the regional characteristics and differences of human mobility. For highlighting the relationship between functional urban polycentricity and spatiotemporal pattern of human mobility in the TMA, this research applies several kinds of multivariate analysis methods.

Through a series of analyzes, firstly, this research identifies 20 functional urban areas within the TMA. Secondly, the author uncovers the spatiotemporal pattern of functional urban polycentricity in

each FUA by eight time-breaks (i.e. 00:00-02:59, 03:00-05:59, 06:00-08:59, 09:00-11:59, 12:00-14:59, 15:00-17:59, 18:00-20:59 and 21:00-23:59). Then, this research discusses the policy effect of the TMP, after highlighting the regional characteristics and differences in terms of five kinds of functional HMD. Lastly, this research uncovers the relationship between functional urban polycentricity and spatiotemporal pattern in terms of human mobility. The static-dynamic pattern of urban structure and the daily rhythm of functional connection pattern in the TMA are investigated together.

Based on the results, it is clear that the functional urban polycentricity (urban structure) of the TMA appear a four-level-annular concentric pattern. Furthermore, the relationship between functional urban polycentricity and human mobility pattern within each FUA reflects different spatiotemporal characteristics, depended on its different urban functional allocation and different development level. The dynamic pattern of urban structure and daily rhythm of functional connection pattern in the TMA show a loop of “simple; strongly linked; mixed & complex; complex & weakly linked; linked; simple”. Furthermore, functional complementarity, regional and temporal similarity and temporal symmetry can be read from the regional difference. Besides, the TMP, as a successful exemplification, still has room for the improvement towards the sustainable urban planning in the TMA.

This research provides some accomplishments on urban studies, focusing on the topic of functional urban polycentricity. Achievement of this research can bring urban planners academic references for rethinking Japan’s master plan. Moreover, this research possesses a value for transport geography and urban policy through a new research thinking.

Keywords: *functional urban polycentricity; functional urban area detection; geo-tagged big data; human mobility dominance; Tokyo Master Plan*

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List of Abbreviations

1. BCL: Beijing City Lab
2. CBD: Central business district
3. CSIS: Center for Spatial Information Science (The University of Tokyo)
4. CEC: Commission of the European Communities
5. DID: Densely Inhabited District
6. EU: European Union
7. ESDP: European Spatial Development Perspective
8. ESPON: European Spatial Planning Observatory Network
9. 4D-OD matrix: Four-dimensional Origin-Destination matrix
10. F-N algorithm: Fast-Newman algorithm
11. FUA: functional urban area
12. FUR: functional urban region
13. GaWC: Globalization and World Cities Research Network
14. GDP: Gross Domestic Product
15. GIS: Geographic information system
16. MDN algorithm: Multi-step decision-making Newman algorithm
17. MLIT: Ministry of Land, Infrastructure, Transport and Tourism
18. HMD: human mobility dominance
19. HSR: High-speed railway
20. IoT: Internet of things
21. IR: Information Revolution
22. ITE: Information-Technology Explosion
23. OECD: Organisation for Economic Co-operation and Development
24. OMC: The Open Method of Co-ordination
25. PTS: person-trip survey
26. TMA: Tokyo metropolitan area
27. TMP: Tokyo Master Plan
28. TPCTMA: Transportation Planning Council of Tokyo Metropolitan Area