Doctoral Dissertation
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Living Circles Towards Green Travels: A Study on the Correlation Between Facility Layout and Travel Behavior

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Summary

Against the backdrop of global climate change, the high rate of motorization in community transportation and its associated carbon emissions are pressing urban problems that urgently need to be addressed. As the primary transition zone between walking, cycling, and driving, 15-minute living circles have the potential to promote green travel. This thesis addresses the question of how facility layout within 15-minute cycling living circles can promote green travel. Based on three types of travel behavior space, a hierarchical and phased theoretical framework is constructed for the correlation between facility layout and travel behavior. This framework includes hypotheses regarding how three travel behavior sub-goals (increasing the green travel proportion of all-type facilities, avoiding long-distance travel for single-type facilities, and promoting green travel choices for single-type facilities) are influenced by six dimensions of facility layout (attitude, density, scale, diversity, accessibility, and road condition). By three empirical studies, via mobile phone data from Tangshan and a regression-clustering methodology, the thesis reveals the influence mechanisms of facility layout on travel.

Part 1, using 634 15-minute cycling living circles, analyzes the correlation between residents' green travel levels to all types of facilities within the circle and facility layout. Regression results indicate that accessibility is generally negatively correlated, and moderate density promotes green travel. Vegetable markets and primary schools are key facilities; Learning (education) facility is driven by accessibility, enjoying (entertainment) facility relies on density, and shopping (commercial service) and caring (health) facility are driven by both. Cluster analysis shows that Near-rural Porous, Hollow-core, and Fan-shaped Radiation Living Circles have low density and poor accessibility, making them key optimization targets. Part 2 analyzes the correlation between single-category green travel and the spatial layout along the route using 31,301 residential-to-facility

OD flow clusters from eight types of facilities. Regression shows that OD distance was the dominant factor, with a significant decrease in green travel intention among residents within 1.2–2.3 kilometers. Street design variables exhibit consistent promoting effects across categories. For example, moderate street wall continuity and aspect ratios increase walking and cycling rates across multiple facility flow clusters. Cluster analysis identifies four typical street types: Multi-dimensional Promotion, Length-dominated, Leisure-enclosed, and Support-deficient Streets, providing a basis for differentiated renewal. Part 3, using 890 living circles encompassing two types of facilities, analyzes the correlation between the average travel distance for single-type facilities and the layout of that facility. Huff Models and other methods reveal that approximately half of trips to vegetable markets and over 70% of trips to supermarkets exhibit a tendency to favor more distant facilities over those located nearby. Regression analysis reveals that the largest and closest facilities within a living circle jointly determined residents' average travel distance: supermarket trips were dominated by larger, distal facilities, while vegetable markets relied on a multi-point, neighborhood-level layout. Cluster analysis identifies two types of short-trip structures: “Large nearby-small distant then short-distance convenience” living circle and “Small nearby-large distant then bypassing behavior” living circle; and two types of long-trip structures: “Flat structure then balanced distance” living circle and “Neighborhood absence then distal dependency” living circle, providing insights into optimizing facility hierarchies and alleviating long-distance travel.

Against the backdrop of global climate change and the increasing motorization of community travel, this dissertation focuses on one of China’s key spatial planning innovations—the 15-minute living circle. It proposes a hierarchical cognitive framework for understanding the spatial–behavioral correlations within living circles, and develops an efficient mobile-data–based method for identifying travel behaviors. The dissertation reveals how internal facility layouts influence green travel patterns and conducts a quantitative analysis of the long-overlooked relationship between facility supply and residents’ demands. It further identifies the key spatial samples and threshold conditions that promote walking and cycling, and formulates a multi-scale optimization strategy for facility layout—at the city, living-circle, and street levels—centered on critical dimensional thresholds. Overall, the dissertation provides a transferable methodological approach for identifying spatial–behavioral correlations and translating them into actionable planning strategies.