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Equity Effects of Bike-Sharing Deployment on Public-Service Accessibility in Older Communities: A Conceptual Analysis in Wuhan

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Abstract. As a short-distance connection, bike sharing has expanded the coverage of public transportation and optimized the supply of public services in old neighborhoods. Taking the Wuhan community as the research unit, this paper discusses the accessibility of medical, educational, and leisure public services under the two travel scenarios of "bus+walking" and "bus+walking+bike sharing". The conceptual analysis system can be compared and analyzed by community completion age, location, railway distance, and road network grouping. The article speculates that bike sharing can expand residents' time-limited travel range, and that accessibility improvements to public services in underserved old neighborhoods may be greater than those in new commercial residential areas. It is further inferred that bike sharing may narrow the gap between communities in access to public services, but with notable spatial heterogeneity. Older neighborhoods near rail transit with a well-connected road network may gain greater accessibility dividends, while accessibility improvements in remote areas with poor cycling conditions are likely to be limited. The pure market-oriented bicycle deployment has obvious defects. On the basis of these conceptual inferences, differentiated government regulation and improved slow-traffic facilities may help promote transportation connectivity and equalize public services in old communities.

Keywords: bike-sharing deployment, public-service accessibility, old community

1. Introduction

Bike sharing is a core shared-economy transport tool supporting urban residents' short-distance trips and public transit transfers. Unlike fixed-route public transport, shared bikes feature flexible usage and wide coverage, linking residential zones, transit stops and public facilities to broaden public transport's effective service range. Old communities, built early, generally suffer from inadequate public and transport facilities, long walking distances to amenities, and weak bus connections. Bike sharing can fill the travel gap between walking and public transit, expanding residents' reachable space within fixed travel time and potentially boosting old communities' access to medical, educational and leisure public services. However, shared bikes are unevenly distributed across cities, and their service efficiency is affected by community location, road networks, transit infrastructure,

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and surrounding facility layout. This paper thus explores whether bike-sharing layout lifts old communities' public service accessibility, reduces accessibility gaps between communities, and generates differentiated equity effects for old communities under distinct spatial conditions.

The spatial fairness of public services does not merely rely on equal facility quantity or geographic coverage. Its core lies in the coordination of facility supply, population demand, and residents' travel accessibility [1]. Even with local public facilities, residents can face large gaps in actually obtainable service resources. Modern public service evaluation has shifted from measuring facility scale to analyzing accessibility balance, supply-demand matching, and spatial equity [2]. Accessibility reflects how easily residents obtain public resources under set travel time and transport modes, and transport tools and research scales directly alter equity evaluation outcomes [3]. Traditional public transport expands service boundaries but is constrained by facility capacity, population layout, and travel time [4]. Shared bikes rebuild residential-rail transit links and extend rail radiation coverage [5]. Their spatial distribution is restricted by location, transit infrastructure, built environment, and other factors [6]. Unregulated market-only deployment causes vehicle overcrowding and roadside parking chaos, demanding policy guidance and supervision [7].

Existing studies are analyzed from the aspects of fair allocation of public services, accessibility of multiple transportation modes, rail transit connection, and space distribution of shared bicycles [8]. Less bike-sharing layout, community type, and public service accessibility equity in the same framework, and there is a lack of systematic comparison of the benefit differences between old communities and new commercial housing communities. Taking Wuhan as an example and taking the community as the basic unit, this paper analyzes the accessibility of medical, educational, and leisure public services under the two scenarios of "bus+walking" and "bus+walking+bike sharing", and compares and evaluates the fairness effect of bike sharing in groups. In theory, this paper further expands the study of bike sharing from travel efficiency and spatial distribution to community public service equity. In practice, the research can provide reference for the release of shared bicycles, the transportation connection of old communities, and the optimization of public services in Wuhan.

2. Research methodology

2.1. Proposed quantitative analytical framework

Taking the community as the basic research unit, this paper sets up two travel scenarios of "bus+walking" and "bus+walking+bike sharing". Three core public service facilities, medical, education, and leisure, were selected for analysis. The first step is to take public facilities as the core, define the threshold of fixed travel time, screen the covered communities, and calculate the ratio of supply and demand according to the scale of facilities and the demand population of the area. The second step is to take a single community as the center, count all the public facilities reachable within the time limit, and accumulate the corresponding supply and demand ratio to obtain the comprehensive accessibility index of the community. By comparing the changes in the accessibility index in each community under the two scenarios, it can get the effect of bike sharing on the expansion of residents' public service acquisition boundary.

In terms of fairness evaluation, comparing the changes in the overall accessibility gap before and after joining the bike-sharing can decompose the overall difference into differences between different community types and differences within similar communities. According to the age of community completion, the sample was divided into old communities and new commercial housing communities, and the average accessibility and equity changes of the two types of communities were compared. Further grouping within older communities according to location, rail transit

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proximity, and road network conditions to identify spatial differences in the fair effect of bike sharing.

Limited by sample selection and data conditions, the empirical analysis of this paper is exploratory. The existing sample can not fully represent all communities in Wuhan, and there are also some fluctuations in bike-sharing and traffic data. Therefore, this research method does not carry out specific data analysis in this study, but only serves as a methodological reference for analysis and speculation.

2.2. Evaluation and classification indicators

The main indicators of the study are divided into three categories: the supply scale of shared bicycles, the accessibility index of public services, and the spatial equity index. The supply level of bicycles is characterized by the number and density of parking spots in and around the community. The accessibility index is divided into medical, educational, and leisure facilities. The equity indicators are the Gini coefficient and the Thiel index. Grouping variables include community completion years, residential house prices, and geographical location: the completion years are divided into old and new communities, house prices reflect the socioeconomic stratification of the area, and the spatial effects of location identification are different. The control variables include population density, road network density, bus stop density, facility density, and distance between rail transit and downtown.

In terms of data sources, bicycle points are taken from the public data of Meituan and Hello Bike platforms. Vector data of roads, public transportation, rail transit, and facilities are obtained by relying on open-source maps. Community population is obtained from census statistics, boundary, construction years, housing price integration planning, and public information on housing construction. Data preprocessing unifies the geographic coordinate system and community units, and eliminates duplicate points, abnormal coordinates, and missing samples. Affected by the tidal scheduling of single vehicles, there are time series fluctuations in the points, so the average value of multi-period points in the same period is selected to weaken the calculation deviation caused by temporary parking.

3. Conceptual analysis of equity effects

3.1. Public service accessibility

Taking Wuhan community as an example, this study explores the community accessibility level of medical, educational, and leisure public services based on two travel scenarios of "bus+walking" and "bus+walking+bike sharing". By comparing the accessibility index and change range of each community under the two travel scenarios within this conceptual framework, the potential improvement effect of bike-sharing on residents' public-service access can be explored theoretically. This analysis focuses on three dimensions: the accessibility of three public services, the characteristics of spatial differences between different urban areas, and the corresponding relationship between the original accessibility basis and the accessibility increment of communities.

According to the existing research, it can be speculated on the travel connection mechanism of shared bicycles: after the shared bicycles are included in the travel chain, residents can complete the short-distance connection between the community and bus stations, rail transit stations, or public service facilities through cycling, effectively expanding the service scope of facilities reachable within the established travel time [9]. Affected by differences in service radius, spatial distribution

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patterns, and residents' modes of use of medical, educational, and leisure facilities, there is obvious heterogeneity in the improvement of accessibility of the three types of public services [10]. Based on conceptual analysis of the average accessibility, relative change ratio, and spatial distribution characteristics of various facilities before and after the introduction of shared bicycles, this paper infers that areas with originally low accessibility levels are likely to see accessibility gains after adding shared bicycles.

3.2. Conceptual assessment of equity effects

From a conceptual perspective, the distribution fairness of accessibility gains brought by shared bikes across different communities can be assessed through the proposed framework using community spatial and travel data. In the proposed evaluation framework, the implications of equity index changes are as follows: a decline in the equity index would indicate that shared bikes could improve overall accessibility and narrow gaps between districts, while a rising index would indicate that new resource dividends flow more to areas with better transport and supporting facilities. Conceptually, the comparison between old communities and new commercial housing areas covers the gap in baseline scenarios, the expected average growth rate after bike deployment, and the differentiated performance of the three types of public services. Given that old communities generally have prominent shortcomings in transport connections and public support, the marginal increase brought by shared bikes is expected to be higher.

This paper further examines the spatial heterogeneity of equity effects in old communities. Around the three aspects of location difference, rail transit proximity and road network conditions, the accessibility increment of old communities under different conditions is compared. Old communities close to rail transit stations and with perfect road network conditions should be easier to complete travel connections with shared bicycles and obtain higher accessibility benefits. The same level of improvement may be difficult to achieve if you stay away from communities with rail transit, poor road connectivity, or limited cycling conditions. Therefore, the improvement of old communities by bike sharing is not necessarily balanced, and its actual effect depends on the matching degree between bike supply and existing traffic conditions, road environment, and public service layout.

4. Discussion and optimization strategies

The fair effect of bike sharing on the accessibility of public services in old communities may be limited by space conditions, user groups and service time. At the spatial level, only by effectively linking up with public transport stations, road networks and public service facilities can shared bicycles really expand the scope of service access for residents. Some older neighborhoods, although adjacent to downtown or public services, have narrow internal roads and intermittent slow traffic systems that may restrict vehicle access and cycling. Older neighborhoods in peripheral areas may also face problems such as long-distance facilities, insufficient supply of public transportation, and low density of shared bicycles. At the group level, bike sharing is affected by age, physical conditions, payment methods, and the ability to use digital devices, so spatial improvements in accessibility do not necessarily mean that all residents receive the same benefits. At the time level, the supply of shared bicycles fluctuates significantly, and vehicle concentration, tide scheduling, and temporary parking in peak periods may lead to differences in actual availability in different periods of time.

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Combined with the above constraints, the optimization of single vehicle layout cannot pursue the operation turnover alone. Instead, it is necessary to incorporate the accessibility of public services and the fairness of community space into the core objectives of delivery and dispatch. First, it should delimit the weak areas of medical, educational, and leisure facilities as the key guarantee areas, and build continuous slow connection channels between old communities, rail transit stations, and public facilities. Secondly, differentiated delivery standards should be implemented according to community population, road network, and time-sharing needs to avoid excessive agglomeration of vehicles in business districts and high-end residential buildings. Thirdly, standardize parking spots, transform slow streets and alleys, optimize community entrances and exits, implement cross-regional dynamic scheduling, and enhance the accessibility and supply stability of bicycles in old communities. In view of the old areas with narrow road networks and inconvenient riding for the elderly, bicycles are only used as a supplementary means, and community microbuses, walking environments, and public facilities need to be improved simultaneously.

The fairness effect of bike sharing also needs to be analyzed in combination with its market-oriented attributes. Operating companies usually allocate vehicles based on order demand, turnover efficiency, and maintenance costs, making it easier for high-demand areas to obtain sustained supply, while communities with low potential demand but poor access to public services may be further ignored. Therefore, relying solely on market allocation makes it difficult to ensure the spatial fairness of bike-sharing services, and the government needs to intervene moderately through operation licensing, delivery indicators, key regional security, and data supervision. At the same time, bike sharing relies on smartphones, electronic payments, and platform operations, which may form a digital threshold for the elderly, low-income groups, and residents with weak ability to use digital technology. Fair-oriented bike-sharing governance should not only pay attention to whether vehicles enter old communities, but also whether residents can actually use them. Urban management departments and operation platforms can explore simplifying certification methods, retaining diversified payment channels, and integrating barrier-free slow travel, public transportation, and bike sharing into the community public service accessibility improvement system.

5. Conclusion

Based on the basic research unit of the Wuhan community, this paper discusses the accessibility differences of medical, educational, and leisure public services under the two travel scenarios of "bus+walking" and "bus+walking+bike sharing". Based on conceptual reasoning, adding bike-sharing services has theoretical potential to improve community public-service accessibility, with relatively larger potential benefits anticipated for communities with low baseline accessibility. This conceptual analysis further infers that older communities could see higher hypothetical accessibility growth relative to new commercial residential communities. In theory, bike-sharing might partially compensate older neighborhoods for poor public-transit connections and inconvenient public-service access. Conceptually, bike sharing may not only improve overall accessibility, but also narrow the gap in service opportunities between communities. However, this equity effect is expected to present spatial differences: accessibility improvements may be relatively significant for old communities close to rail transit stations, with a sound road network and stable shared bike supply, while improvements may be relatively limited for communities with remote locations, poor road conditions, and insufficient vehicle supply. Therefore, the layout optimization of shared bicycles should give priority to covering old communities with low accessibility and coordinate with rail transit connections, slow transit system improvement, and public service facilities allocation.

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The core contribution of this paper is to integrate the layout of shared bicycles, the accessibility of public services, and the fairness of community space into a framework. By discussing the grouping of various travel scenarios, the uneven distribution of ride sharing accessibility benefits is analyzed. Previous studies have mostly focused on bicycle demand, vehicle distribution and traffic efficiency, with limited discussion on public service equity in old communities at the conceptual level; this study supplements this gap by proposing an integrated analytical framework. The analysis method can be used as a reference for other cities to evaluate the social benefits of bike sharing. Bike sharing should no longer be seen only as a short-distance market transportation, but should be integrated into the balanced governance system of urban public transportation and basic public services. The study had limitations, including time fluctuations in bicycle parking data and difficulty identifying population differences. Follow-up studies can use bicycle tracking data and resident travel surveys to explore dynamic equity changes, group gaps, and the effectiveness of policy interventions.

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