introduction about share bike

* global trends of share bike
* benefits
  + environment
  + some social benefits, like help the poor area?
* limitations

As concerns over climate change and global warming continue to rise, bike-sharing systems (BSS) have rapidly developed worldwide in recent years. BBS offers people safer, cheaper, and more convenient transportation options, so bike-sharing has become one of the fastest-growing modes of transportation. The number of BSS has grown significantly, from 13 systems in 2004 to over 2,000 in 2019 globally. In North America, station-based BSS continued to grow, and 67 million trips were taken in 2022, a 17% increase from the previous year. Of these, 52 million trips were in the United States and 15 million in Canada. On the other hand, in China, by the end of 2021, BSS operated in over 400 cities and had 15 million active bikes and 47 million daily orders.

Bike-sharing systems (BSS) play an important role in improving transportation systems and promoting sustainability. They help reduce the negative environmental impact of transportation, make daily life more convenient, and bring various economic, environmental, and social benefits. For example, studies have shown that bike-sharing can lower carbon emissions and air pollution in some cities (Zhang, 2018). At the same time, it can improve public health and boost local economic activities). For example, Nice Ride Minnesota boosted economic activity near bike-sharing stations and added about $1.29 per week on average, or around $29,000 from April to November (De Chardon, 2019; Schoner et al., 2012). However, the actual benefits of BSS vary across different regions and operating models. Some studies also suggest that its impact on reducing transportation-related carbon emissions may be limited (D’Almeida et al., 2021).

Some studies say BSS can make things harder for marginalized groups, because these systems mainly help people who can afford to use them. When governments or companies set a new BSS location BSS often focus on helping commuters and wealthier users. Besides, low-income families often live far from city centers because of high living costs and fewer job options, so they cannot easily access BSS. Racial and gender factors also limit the benefits of bike-sharing BSS. Because racial and cultural segregation contribute to crime and attitude imbalances people in high-crime areas are more fearful of encountering criminal behavior while cycling. Likewise, women are more vulnerable to verbal and physical harassment while they are riding bikes (De Chardon, 2019).

BSS has the potential to be more than just an independent mode of transport in urban mobility. BSS significantly reduces the time needed to reach public transport stations compared to walking. It also eliminates some inconveniences when people drive their own cars, such as the risk of theft and the hassle of finding parking. Additionally, unlike regular bikes, BSS not only can connect to public transport but also support transfers between stations. It works better together with public transport systems. This makes BSS an attractive option for people who do not drive and those who do not have a driver’s license or rely on public transport. Although several papers have explored the relationship between bike-sharing usage and public transport, this connection is still not well understood (Radzimski et al., 2021; Böcker et al., 2020). [To be continued, gap we want to make a contribution…]

This study aims to analyze the spatiotemporal characteristics of bike-sharing trips and explore their impact on public transport. The structure of the paper is as follows: Section 2 provides a literature review and summarizes the progress and gaps in existing research. Section 3 introduces the data and methods that are used in this study. Section 4 presents a qualitative analysis, using heat spot analysis to examine the usage of dockless bike-sharing systems. Section 5 offers a quantitative analysis to evaluate the impact of bike-sharing on public transport coverage and operational efficiency. [To be continued, what about part 3 ]

literature review

1.related researches(public transportation)

* shanghai
* chicago
* why we choose these two cities as our research objective

The rapid expansion of bike-sharing systems (BSS) worldwide has attracted significant academic interest, particularly in their integration with public transport to promote sustainable urban mobility. Numerous studies have explored this relationship, highlighting BSS's potential to reduce reliance on private vehicles and its complementary or substitutive role in addressing the "last mile" problem in public transport (Z. Wang et al., 2018).

Traditionally, cycling has been regarded as an alternative to public transport (Jäppinen et al., 2013). However, BSS possess unique advantages for bridging trips to and from public transport stops, effectively addressing the “first and last mile” challenge. Unlike private bicycles, which may face restrictions during peak hours or be entirely excluded from public transport vehicles, shared bikes offer a practical solution when available at end stations. Research has validated the complementary role of BSS in cities like Vienna, where bike-sharing supports the public transport system effectively (Leth et al., 2017). Similarly, in Nanjing, China, the spatial distribution of bike-sharing systems aligns with “first and last mile” usage patterns (Yao et al., 2019). Studies also reveal high levels of integration between bike-sharing and metro stations, influenced by factors such as education, income, travel purpose, metro travel time, workplace location, and bike lane infrastructure (Y. Liu et al., 2020).

Conversely, some studies suggest that BSS can substitute public transport usage. For instance, New York saw a decline in bus ridership following the introduction of a bike-sharing system (Campbell & Brakewood, 2017). Depending on the context, between 20% (Minneapolis/St. Paul) and nearly 60% (London) of BSS users previously relied on public transport. Walking was the second most substituted mode, while fewer users shifted from private cars, personal bicycles, or taxis. Nonetheless, most studies indicate that BSS contributes to a reduction in car usage, albeit to varying extents (Fishman, 2016). Additionally, BSS has been shown to compete with cars in terms of travel time, particularly in urban centers (Jensen et al., 2010).

City-level analyses have further demonstrated that BSS usage is higher in areas with strong public transport systems. However, some cities with a high public transport share exhibit only moderate levels of BSS adoption (Audikana et al., 2017). Residents in low-density areas are more likely to increase their public transport usage due to the availability of BSS (Martin & Shaheen, 2014). In Dublin, where the bike-sharing network is concentrated in the city center and provides easy access to multiple public transport options, the system’s success is attributed to its effective coordination with public transport networks (Jiménez et al., 2016).

Several studies have examined the relationship between user characteristics and BSS integration with public transport. For instance, Faghih-Imani and Eluru (2015) found that annual members tend to use BSS as a complement to public transport, while casual users often substitute one for the other. Some researchers have questioned whether BSS truly improves mobility for transit-dependent populations or primarily serves individuals who are already highly mobile (Médard de Chardon, 2019). Surveys have revealed that BSS users are predominantly male, of higher socio-economic status, with access to private cars, and not typically reliant on public transport (Raux et al., 2017). Similarly, males are more likely than females to use BSS for commuting and integrate it with public transport (K. Wang & Akar, 2019). In Vancouver, frequent users of bike-sharing systems, often referred to as "super-users," were found to be predominantly young males with above-average incomes who lived or worked near docking stations and had fewer transport options (Winters et al., 2019).

Temporal factors also influence the interaction between BSS and public transport. In Seattle, adverse weather and peak hours encouraged a shift toward bus usage (Sun et al., 2018), while in London, BSS usage surged during a Tube strike (Saberi et al., 2018). Ma et al. (2019) demonstrated that BSS can either complement or compete with public transport depending on the time of day or week.

Some studies have incorporated the location and density of public transport stations into models of BSS usage. For example, Levy et al. (2019) analyzed data from 181 stations in Tel Aviv and found no direct relationship between public transport frequency and BSS activity using correlation analysis. However, a spatial autoregressive model accounting for spatial effects revealed a positive relationship. In Seattle, the failure of the Pronto bike-sharing system was attributed to factors like rainy weather, hilly terrain, and a limited station network. Nonetheless, integration with bus services was shown to positively impact BSS usage (Sun et al., 2018).

In summary, while the relationship between BSS and public transport has been extensively studied, conclusive findings remain elusive due to variations in factors such as city size, public transport density, user demographics, weather, and specific events. Comparative studies systematically evaluating this integration across different urban contexts with different levels of BSS development are also limited. While many studies have highlighted BSS's benefits in extending public transport networks, the reverse influences of public transportation factors on BSS usage have been explored to a much lower extent. Therefore, this study addresses these gaps by analyzing BSS usage patterns and the impact of public transport factors in Shanghai, China, and Chicago, USA.

As two of the largest nations in the developing and developed world, China and the USA offer different travel behavior patterns, which would be useful to study and improve the universality of the research conclusions. Shanghai, one of the largest cities globally, serves as a key industrial and commercial hub in China. With a population of approximately 25 million and a population density of 3.9 persons per square kilometer (ShangHai Statistical Yearbook 2023), it is also one of the largest and earliest adopters of bike-sharing programs in China. Chicago, the largest city in Illinois and the third most populous city in the United States, spans 606.2 square kilometers and generated a GDP of $753.1 billion in 2022 (Chicago Metro Area GDP U.S. 2023, Statista). It hosts the second-largest public transportation system in the U.S., serving the city and 35 surrounding suburbs. These contrasting contexts make Shanghai and Chicago representative study areas for exploring the integration of BSS and public transport.

This study seeks to answer two key questions: (1) What are the spatial distribution patterns of BSS usage in Shanghai and Chicago? (2) What public transport factors most significantly influence BSS usage? By identifying these factors, the study aims to provide actionable recommendations for cities with less-developed systems, drawing lessons from more mature systems to create more sustainable and efficient urban transport networks.

2.method

the related studies using the same methods

* mclp
* hotspot analysis

Kernel Density Estimation (KDE) is a widely used non-parametric method for estimating the probability density function of random variables. It uses kernel functions to estimate the distribution of data points and is useful for analyzing spatial data and identifying hotspots. Besides, Hotspot analysis is a spatial analysis and mapping technique interested in the identification of clustering of spatial phenomena. For example, Liu et al. investigated how to identify parking hotspots in new cities that have yet to implement dockless shared bikes. They used KDE to calculate road hotness based on bike density and identify potential parking hotspots (Z. Liu et al., 2018). Similarly, Cao et al. adopted KDE and hotspot analysis to explore the spatiotemporal characteristics of shared bike usage in Beijing. They found that shared bikes are mainly used for commuting on weekdays and for leisure activities on weekends. Furthermore, shared bikes are strongly linked to public transport, having metro and bus stations among the most important areas of connection and clustering(Cao et al., 2019). These studies demonstrate that KDE and hotspot analysis are valuable tools for studying the spatial distribution and usage patterns of shared bikes. They help identify hotspot areas and provide recommendations for transportation policies or operational strategies (Gao et al., 2022).

The Maximum Coverage Location Problem (MCLP) is a classic optimization model that considers a set of discrete demand points and a set of candidate facility locations. The goal is to chooset facility locations from the candidates to maximize the weighted total coverage of the demand points within a given number of facilities. As a foundation for many sharing economy models, MCLP is commonly used for layout optimization and is aim to cover more customers by specifying the number of centers and their service radius (Muren et al., 2020) . For example, Park & Sohn analyzed taxi trajectory data in Gangnam District, Seoul, and used two models: the p-median model (minimum impedance) and the MCLP. They selected candidate sites and identified the best locations for shared bicycle stations. Their results showed that the p-median model distributed stations more evenly and promoted spatial fairness, while the MCLP model concentrated stations in central areas and effectively met the maximum potential demand (Park & Sohn, 2017). In another study, Wang et al. Genetic Algorithm (GA) to address the MCLP problem and optimize the deployment of shared bicycle in Wuhan City, thus giving a viable strategy of the location site selection that is based on the demand intensity (S. Wang et al., 2023). On the other hand, Cao et al. applied the MCLP to calculate the shared bicycle origin-destination (OD) points that could be covered within a specified network distance of subway and bus stations. Their findings highlighted that shared bicycles in Beijing primarily serve as connectors for public transit, especially during short-distance trips at subway and bus stations(Cao et al., 2019).

*2023上海统计年鉴(英文版)*. (n.d.). Retrieved December 7, 2024, from <https://tjj.sh.gov.cn/tjnj/tjnj2023e.htm>

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