

# Influence Factors of Bike-Sharing System and Sustainable Strategies: A Case Study in Jersey City, USA

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**Abstract.** Bike sharing system, as a sustainable mode of urban transportation, plays a significant role in urban sustainability. This study, takes the bike-sharing system, Citi Bike, in Jersey City, USA as an example, and discusses the influence factors, such as time, user profiles, and geographical considerations, based on the analysis of Citi Bike ride data and geographical information. The findings underscore the significant impact of these factors on bike-sharing utilization. Results show that utilization patterns of Jersey City's bike-sharing systems vary significantly depending on the time, season, membership status, and location. Based on these results, a series of optimization strategies are proposed, encompassing adjustments to deployment timing in response to seasonal demands, tailored promotional strategies for diverse user segments, and a focus on supply in high-demand areas. These strategies are poised to enhance bike-sharing system utilization rates, meet the varied needs of users, and further advance sustainable urban mobility. This research provides valuable insights for urban transportation authorities and bike-sharing operators, aiding in the refinement of urban transportation, and fostering the development of low-carbon cities.

**Keywords:** Influencing Factors, Bike Sharing, Jersey City.

## 1. Introduction

Global urban planning and sustainable development now place a high priority on the creation of low-carbon cities and sustainable transportation systems. Reduced urban carbon emissions, reduced negative environmental effects, and sustainable growth are the goals of the low-carbon city idea [1]. By providing practical rental services, bike sharing, as an example of urban green mobility, has helped to advance the growth of low-carbon cities. Globally, bike-sharing programs have exploded in recent years, giving city dwellers an easy and economical way to get around, easing traffic congestion, enhancing air quality, and enticing people to choose healthier forms of transportation.

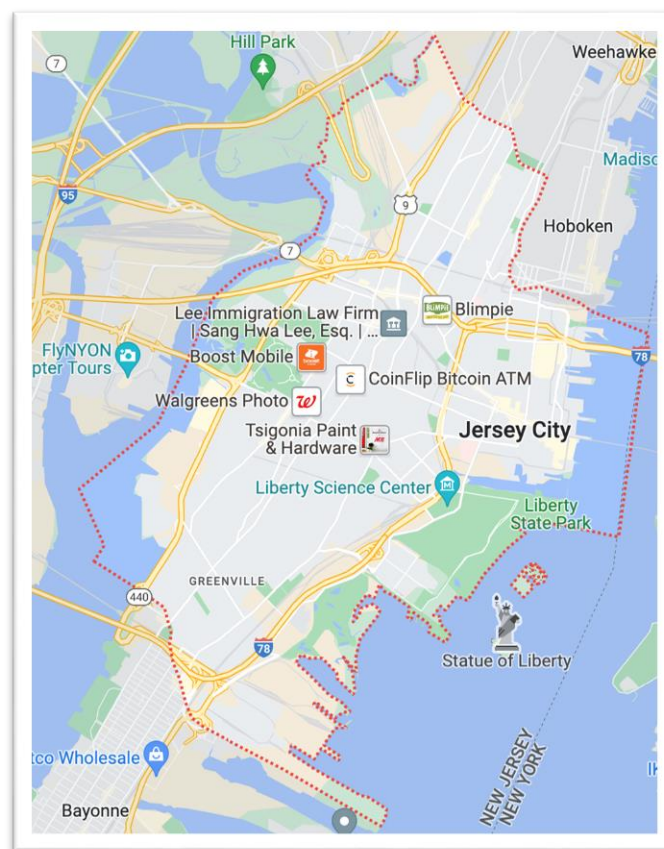
Numerous studies have demonstrated distinct spatial clustering patterns within bike-sharing systems, primarily concentrated in high-traffic zones such as commercial districts and transportation hubs [2]. Moreover, research has highlighted issues of resource oversupply in some areas while others grapple with shortages, underscoring the uneven distribution and utilization efficiency stemming from the large-scale deployment of bike-sharing systems [3]. Such disparities can result in overcrowding and resource wastage, necessitating more precise management and planning strategies. Furthermore, Ouyang's study shed light on the influence of user usage patterns and preferences on bike-sharing utilization to some extent [4]. Additionally, Cho's research revealed that factors like weather conditions, social events, and holidays might exert an impact on bike usage [5]. Nevertheless, it's important to note that this research hardly provide thorough and detailed findings.

By using data visualization approaches, this paper uses Jersey City as a case study to address the advantages and disadvantages of earlier studies, and examines several factors affecting bike utilization, such as time, location, and user types, using Citi's bike trip data for Jersey City from January to July 2023 along with geographic data. This study also suggests related tactics for improving Jersey City's bike-sharing program. The main goals are to improve bike-sharing use rates, encourage low-carbon commuting, and supply insightful information for the creation of a more sustainable urban transportation system. These recommendations are intended for urban planners and policymakers.

## 2. Background

Jersey City, located in the northeastern part of the U.S. state of New Jersey, lies along the banks of the Hudson River and is one of the largest cities in the state. With its strategic geographical location adjacent to New York City (Figure 1), Jersey City has long been a significant residential and work hub for residents and commuters. However, as the city's population has grown and traffic congestion has worsened, urban authorities have continuously sought innovative transportation solutions to meet residents' travel needs [6].

Citi Bike, the biggest bike-sharing system in the US, began operations in New York City in May 2013 and provided 100 million rides in 2020 [7]. The Jersey City Citi Bike system now has 82 docking stations and more than 800 bikes after the system's expansion across the Hudson River in 2015 [8]. The average daily use of each bike in the Jersey City system is 2.2, compared to an average of 4.4 daily uses in New York City [9]. This shows that there is a lot of room for development in Jersey City's bike-sharing program to increase both its sustainability and travel efficiency.



**Figure 1.** Location of Jersey City

(Sourced from: <https://www.google.com/maps/place/Jersey+City,+NJ/@40.7152445,-74.0687309,>

[12z/data=!3m1!4b1!4m6!3m5!1s0x89c250d225bfafdd:0x249f013a2cd25d9!8m2!3d40.7177545!4d-74.0431435!16zL20vMHhuN3E?entry=ttu](https://www.google.com/maps/place/Jersey+City,+NJ/@40.7152445,-74.0687309,12z/data=!3m1!4b1!4m6!3m5!1s0x89c250d225bfafdd:0x249f013a2cd25d9!8m2!3d40.7177545!4d-74.0431435!16zL20vMHhuN3E?entry=ttu))

## 3. Methods

### 3.1. Data sources

The data for this study is comprised of two main components: geographical data for Jersey City and bike-sharing data. Shapefiles containing the geographic information for Jersey City are available and were downloaded from the Jersey City Open Data Portal [10]. This dataset contains geographic

boundaries and polygons that reflect census tracts in Jersey City. It is an essential source of geographic information and the foundation for further spatial analysis. The bike-sharing data is in CSV format and sourced from the official Citi Bike website [11]. This dataset encompasses records of bike-sharing trips from January to July 2023, with detailed information available for each trip. Each trip record includes data such as trip ID, vehicle type, start time, end time, trip duration, start station information, end station information, and member type. We have created a solid foundational dataset for later spatial analysis and the investigation of bike-sharing behaviors by combining and preprocessing these two datasets.

### 3.2. The analytical approaches

The analytical approach employed in this study encompasses data acquisition, data filtering, data enrichment, and subsequent analytical steps.

(1) The raw data, including ride records and geographical information data, were obtained.

(2) Data filtering was performed after data collection to verify data quality and relevance. Firstly, redundant ride\_id identifiers were detected and eliminated, ensuring that each ride record had a unique identification. Next, the format of station IDs was validated, retaining only valid station IDs and eliminating records that did not meet the criteria. Finally, records with trip durations ranging from 60 seconds to 2 hours were filtered, excluding extreme and illogical numbers. These filtering steps contributed to the creation of a high-quality dataset for subsequent analysis.

(3) After data filtering, data enrichment was performed to extract additional valuable information. This study, in particular, extracted the hour of the day in which each ride happened based on the ride's start time, allowing for an investigation of the temporal distribution of rides throughout the day. Furthermore, ride distances were calculated using geographical information data, allowing them to be used in geographical distribution analyses. This information enriched the analysis and allowed for a more comprehensive understanding of the characteristics of Jersey City's bike-sharing ride data.

(4) Several features of the ride data were evaluated, including time, comparisons between member and casual users, and geographical distribution. These analyses contribute to a deeper exploration of Jersey City's bike-sharing ride data and further discussion.

## 4. Results

### 4.1. Time distribution of rides

In the analysis of time distribution within the bike-sharing dataset, this study initially examined the distribution of ride counts every 24 hours from January to July 2023. The results revealed that peak bike usage occurred in the late afternoon, particularly around 5 to 6 p.m., corresponding to the typical evening commute hours. Additionally, there was a secondary peak during the early morning hours of 7 to 8 a.m., which was most likely related to people using bike-sharing as a mode of transportation. Furthermore, the temporal distribution trend remained relatively consistent across the seven months, suggesting that the influence of time on bike-sharing behavior was relatively stable. However, it is worth noting that ride counts were comparatively lower in January and February, with peak values not exceeding 5,000 rides. As the weather gradually warmed, ride counts increased steadily, with May, June, and July exhibiting a significant upward trend, reaching its peak in July (Figure 2).

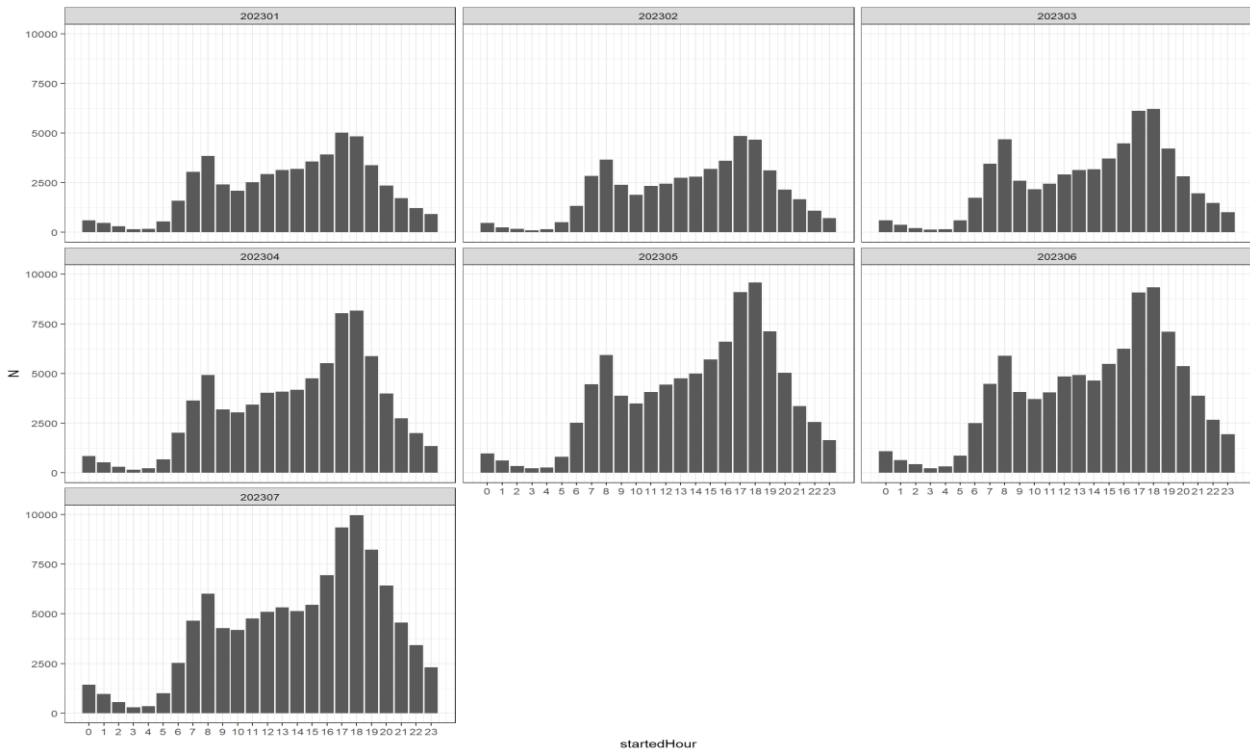


Figure 2. Time distribution of rides

## 4.2. Rides distribution for member and casual users

### 4.2.1. Bike types

By comparing the quantities and proportions of classic bikes and electric bikes among member and casual user (non-member) groups, it can discern the preference patterns of these two user groups regarding different bike types. Firstly, it is evident that the total number of member users significantly outweighs that of casual users, indicating a greater inclination of member users towards utilizing the bike-sharing service. Secondly, concerning the bike types, regardless of membership status, classic bikes outnumber electric bikes by a considerable margin. It's worth noting that electric bikes constitute approximately 24% of the total bikes among casual users, while the proportion is around 15% among members. This suggests that casual users are more inclined towards choosing electric bikes in comparison to members (Figure 3).

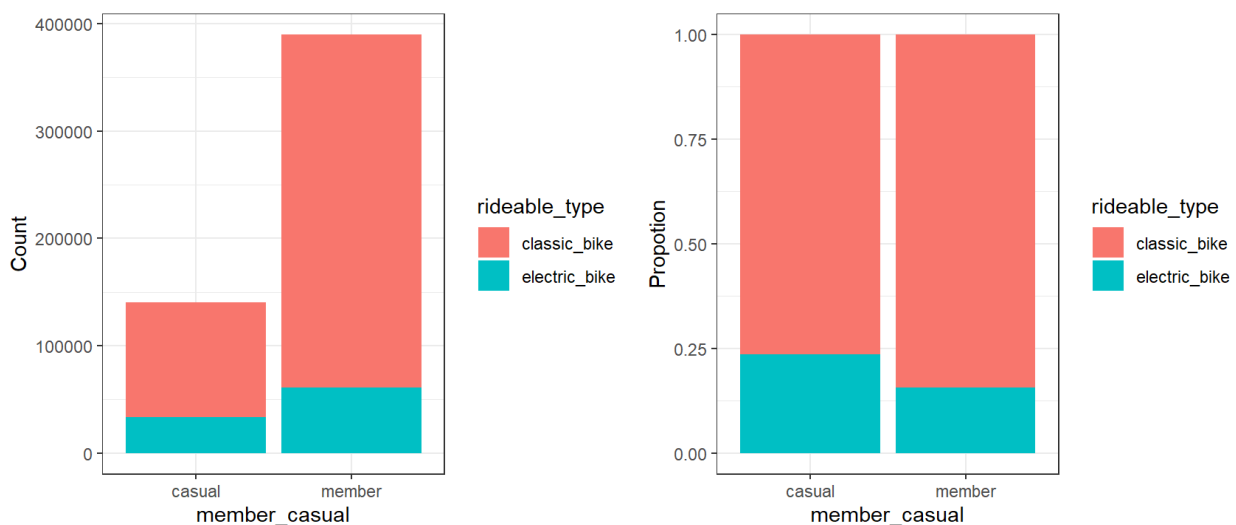


Figure 3. Bike types in member & casual users

#### 4.2.2. Relationship between trip duration and distance

Through a linear regression analysis, we explored the relationship between trip duration and ride distance to gain insights into user riding behavior. The results indicate that, for members, there is a positive correlation between trip duration and ride distance. This suggests that members tend to engage in longer rides, possibly for commuting or leisure purposes. In contrast, casual users exhibit a different pattern as there is no significant linear relationship between trip duration and ride distance, and it may even show a negative correlation. This may reflect the diverse riding behavior of casual users, who are more inclined towards short-distance rides (Figure 4).

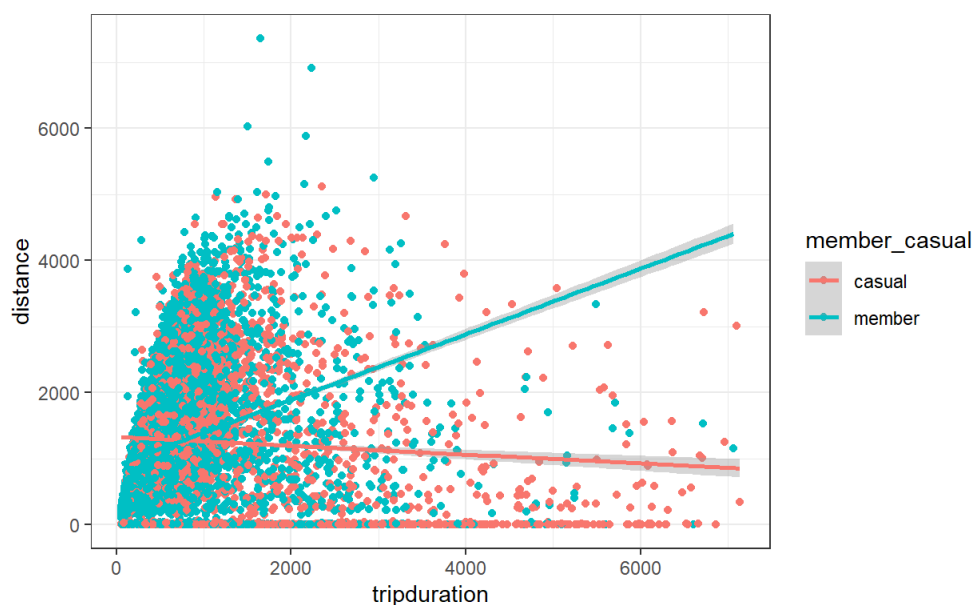


Figure 4. Relationship between trip duration and distance

#### 4.3. Geographical distribution of rides

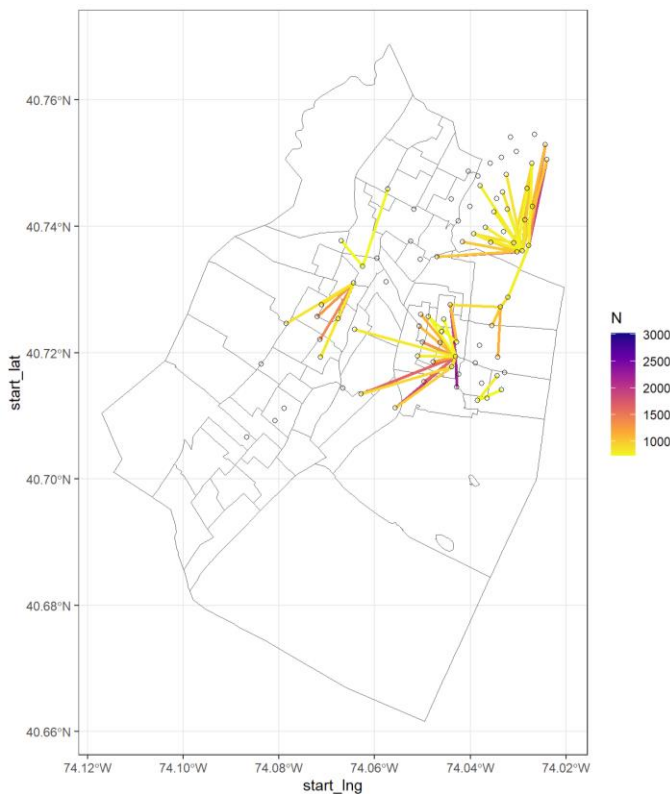
Geographical distribution analysis helps reveal the popular biking areas, user travel patterns, and traffic hotspots within the city, supporting the optimization of the bike-sharing system and fostering urban sustainability. Firstly, we focused on the distribution of bike trip start and endpoints. Through data analysis, we identified the top 100 most common start-end station pairs within Jersey City, visualizing their distribution on the Jersey City map (Figure 5). Further utilization of 2D kernel density estimation unveiled areas with high biking densities (Figure 6). Upon comprehensive analysis and map observations, we found that popular bike-sharing stations are predominantly concentrated in the northeast of the city, particularly around the Hoboken Path Station, and within the city's core areas, notably JC Downtown. Notably, bike riding activity around the Grove Station area is particularly pronounced.

### 5. Discussion

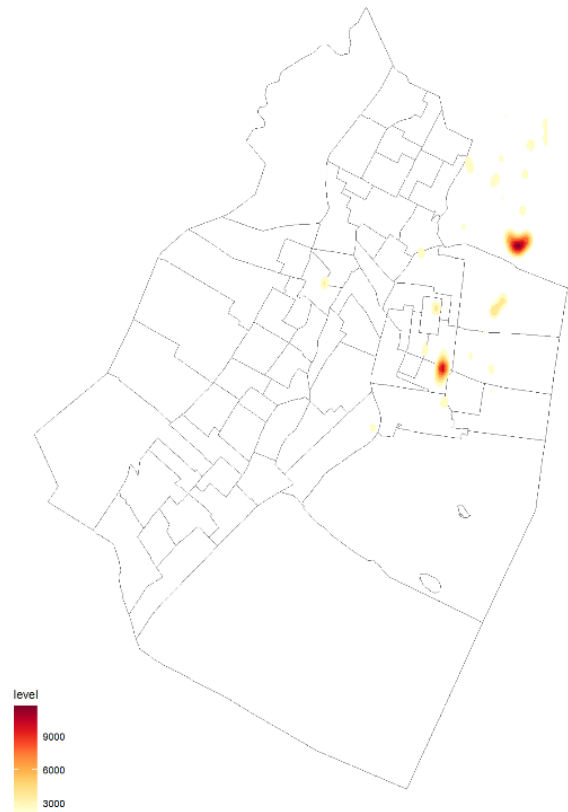
#### 5.1. Influencing factors of bike-sharing usage

This study conducted an in-depth exploration of several key factors influencing bike-sharing usage, including time, disparities between members and casual users, bike type preferences, and geographical distribution. Time stands out as a critical factor because different periods reflect varying travel demands and behavioral patterns. For instance, early mornings and evenings typically correspond to commuter rush hours when bike-sharing is primarily utilized for commuting purposes. In contrast, leisurely rides are more common during midday and the afternoon. Additionally, seasonal variations impact riding demand, with a decrease during cold winters and an increase in warm summers. Winter reduces riding danger and comfort significantly because it is typically colder, there

may be snowfall, and the number of sunshine hours is reduced. People are more likely to exercise by cycling or visiting the city in the early summer when the weather is great and the scenery is beautiful.



**Figure 5.** The start-end pair site distribution (top100)



**Figure 6.** 2D kernel density estimation of spatial distribution

Significant distinctions exist between members and casual users. Electric bikes are more popular among non-members in certain situations, while members tend to engage in longer rides, and casual users prefer shorter trips. The geographical distribution analysis enabled the identification of traffic hotspots and user travel patterns within the city. By synthesizing these factors, we formulated a series of strategic recommendations for urban transportation management and bike-sharing operators. These recommendations aim to better cater to user needs, enhance system efficiency, and promote the development of sustainable urban mobility.

## 5.2. Strategies for bike-sharing usage

### 5.2.1. Deployment timing

To optimize the operation of the bike-sharing system, we recommend the implementation of differentiated deployment timing strategies. Firstly, during peak hours on workdays, it is advisable to increase the deployment of bike-sharing resources to meet the demands of commuters, thus enhancing the system's efficiency. Secondly, as seasons change, particularly in the summer, there should be an augmentation in deployment to cater to increased outdoor activities and leisure biking desires. Such deployment timing strategies could better align with the varying needs of users across different seasons and periods, ultimately enhancing the utilization of the bike-sharing system.

### 5.2.2. Deployment locations

Regarding deployment locations, we suggest focusing on two key aspects. First, prioritize areas around office districts and transportation hubs as these are typically the most concentrated areas of user demand. Second, consider future transportation hub planning and proactively establish shared bike stations to meet future travel needs. Additionally, based on user types and riding preferences, it may be beneficial to deploy different types of bikes in different areas to better cater to user needs.

Thoughtful planning of deployment locations can enhance the availability and appeal of the bike-sharing system.

In addition to the considerations of deployment time and location, other strategies can be implemented to further optimize the bike-sharing system. These strategies aim to enhance user engagement, increase ridership, and promote the sustainability of the program. The following strategies should be considered:

(1) **Membership and Casual User Strategies:** It is suggested to implement differentiated strategies for members and casual users, such as offering regular member promotions, rewards programs, and discounts to incentivize membership and boost member engagement. For casual users, it is suggested to consider attractive incentives to encourage registration and first-time usage.

(2) **Introduction of Electric Bikes:** It is suggested to embrace innovation by introducing electric bikes into the fleet. Electric bikes can attract a broader user base, particularly those seeking a faster and less physically demanding cycling experience. They are especially appealing to commuters with longer distances to cover.

(3) **Collaborative Partnerships:** It is suggested to establish partnerships with local businesses, events, or public transportation systems to cross-promote bike-sharing services. Collaborations can significantly enhance visibility, attract new users, and contribute to the overall sustainability of the program.

(4) **Marketing and Awareness Campaigns:** It is suggested to invest in marketing and awareness campaigns to educate the public about the advantages of bike-sharing. For example, we could utilize various channels, including social media, local events, and community outreach, to reach a wider audience and encourage adoption.

(5) **User Experience Enhancements:** It is suggested to continually improve the user experience through mobile app enhancements, user-friendly interfaces, and feedback mechanisms. A seamless, convenient experience not only retains existing users but also encourages them to use the service more frequently.

(6) **Performance Monitoring and Adaptation:** It is suggested to regularly monitor the bike-sharing system's performance by tracking relevant metrics such as ridership rates, user feedback, and revenue generation. People could adapt strategies as necessary based on data-driven insights to ensure continuous optimization.

By implementing these strategies in conjunction with thoughtful planning and execution, cities can unlock the full potential of bike-sharing for urban mobility and sustainability. These approaches cater to diverse user preferences, promote the service actively, and contribute to a more successful and sustainable bike-sharing system.

## 6. Conclusion

Based on the Citi Bike trip data in Jersey City, this study conducted an in-depth exploration of various factors influencing bike-sharing usage and proposed relevant optimization strategies. The significance of this research lies in its contribution to advancing urban sustainability and improving shared transportation systems. Through the analysis of factors such as time, seasonality, geographical locations, and member and casual user behavior, this study has reached the following conclusions:

Firstly, time and seasonality exert a significant influence on bike-sharing utilization. Peak usage occurs around 5-6 p.m., coinciding with typical office hours' end, while morning peaks around 7-8 a.m. suggest commuting patterns. These findings underscore the importance of adjusting deployment strategies based on seasonal demand variations. Notably, during the summer months, there is a substantial increase in bike usage, necessitating increased bike deployments to cater to outdoor leisure biking. Secondly, disparities exist in biking behaviors between members and non-members. Members tend to engage in longer and more extended-distance rides, while non-members prefer shorter trips. These findings provide opportunities for tailoring targeted promotions and incentives to different user segments to enhance the system's attractiveness. Lastly, geographic location plays a pivotal role in

bike-sharing utilization. Our study revealed that popular bike-sharing stations are concentrated in the northeast region, particularly around Hoboken Path Station, and the city's core areas, notably JC Downtown. These locations warrant increased resource allocation and attention to meet user demands effectively.

Drawing upon these insights, we have formulated a series of optimization strategies, including season-based adjustments to deployment schedules, distinct promotion policies for members and non-members, and prioritized service provisions in high-demand biking areas. These strategies aim to elevate the bike-sharing system's utilization, meet diverse user needs, and propel the development of sustainable urban mobility. Ultimately, this research offers valuable insights for urban planners, policymakers, and bike-sharing operators, facilitating the optimization of urban transportation systems and the promotion of low-carbon urban development.

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