



Tracing the effects of COVID-19 on short and long bike-sharing trips using machine learning

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Highlights

- We defined bike-sharing trips into short and long bike-sharing trips.
- Long bike-sharing trips are more prominent during the pandemic than the pre-pandemic.
- Long and short bike-sharing drips grew significantly in the pandemic's third year.
- The concentration pattern of short and long bike-sharing trips remained the same.
- The growth of bike-sharing is the result of our resilience in human mobility.

Abstract

COVID-19 drastically changed human mobility, including bike-sharing usage. Existing studies found positive impacts of COVID-19 on bike-sharing use. However, their analysis focused on the first year of the COVID-19 pandemic. This study traces the effects of COVID-19 by including the bike-sharing data

of the second and third years of the pandemic to provide more empirical evidence. We pre-defined short and long bike-sharing trips. Data collection and the effects of COVID-19 on both trips were separately addressed using public bike-sharing data in Seoul, [South Korea](#). We conducted a [time series](#) and hot spot analysis to trace temporal and spatial bike-sharing usage changes. Our study applied a machine learning tool with Random Forest regression modeling to examine COVID-19 effects on two types of bike-sharing trips. Its impact is measured by looking at feature importance and calculating the SHapley Additive exPlanations (SHAP) value. The amount of bike-sharing usage continued to grow during the pandemic, with long bike-sharing trips being more prominent. A significant increase in the number of short bike-sharing trips was observed in the second year. Both short and long trips showed growth in the third year, even with a high number of COVID-19 cases reported. There were no significant seasonal changes in the spatial concentration of both trips. COVID-19 and the vaccination response positively impacted bike-sharing use in Seoul, highlighting our resilience in adapting to changes in human mobility.

Introduction

The COVID-19 pandemic resulted in significant changes to human mobility worldwide. Studies have found evidence of reduced usage of public transit (Aloi et al., 2020, Park, 2020) and an increase in the use of bicycles and walking over subway and bus travel (Jenelius and Cebecauer, 2020, Nikiforiadis et al., 2020). In addition, the effects of vaccination and social distancing have been found to be significant (Kim et al., 2022).

Bike-sharing has gained particular interest during the COVID-19 pandemic as users avoid the proximity to others, which is inherent in public transit or ride-hailing services. Travelers understandably report a decreased desire to use public transit during pandemics (Zhang et al., 2021). Given the possible benefits of bike-sharing, such as financial savings, first- and last-mile connectivity, and flexibility (Nikitas, 2019, Shaheen and Chan, 2016), it is reasonable to hypothesize that with social distancing recommendations and growing awareness of the risks of COVID-19 transmission, travelers would avoid modes of transportation that require proximity to others while increasing their use of bike-sharing or other outdoor/solitary transport modes.

Studies have reported a significant increase in the use of bike-sharing (Jiao et al., 2022), longer average trip durations (Teixeira and Lopes, 2020), and favorable opinions from bike-sharing users (Campisi et al., 2020). Changes in travel behavior during bike-sharing trips have also been observed (Chen et al., 2022, Jiao et al., 2022, Xin et al., 2022). However, previous literature has focused mainly on the first year of the pandemic, and it may not be feasible to generalize the prolonged effects of COVID-19 on bike-sharing use while considering changes in distancing measures and our ongoing efforts to combat the spread of the virus to return to daily life. Additionally, the initiation of COVID-19 vaccination in August 2021 may have further impacted the use of bike-sharing.

This study aims to investigate the effects of the COVID-19 pandemic on bike-sharing use by analyzing four years of bike-sharing data from the pre-pandemic period (2019) to the near endemic period

(2022). To determine whether COVID-19 led to an increase in bike-sharing usage and longer trip durations during the pandemic, we differentiated between short and long bike-sharing trips and collected their usage data separately. The length of bike-sharing trips is closely associated with travel behavior, with longer trips typically taken on bicycle lanes and shorter trips concentrated in the city center (Levy et al., 2019). Short-duration trips are typically used for first/last-mile transportation to transit stops, while long-duration trips are often associated with recreational and leisure purposes (Xin et al., 2022). Riding behavior is closely linked to spatial and temporal distribution patterns (Xu et al., 2019). If more people are using bike-sharing for longer durations during the pandemic, changes in the spatial pattern of travel behavior should be apparent. In this study, we used machine learning tools to analyze the impact of bike-sharing use factors on bike-sharing usage.

The remainder of this paper is structured as follows. First, the existing literature on bike-sharing-related factors is summarized. Next, the empirical methods used to examine changes in bike-sharing use are described. A Random Forest (RF) regression method was adopted. It underwent a hyperparameter optimization process to examine the COVID-19 effects on bike-sharing. The results are then discussed in the context of COVID-19 case counts and changed circumstances throughout the pandemic. Spatial usage changes of short and long bike-sharing trips are examined. Feature importance associated with bike-sharing factors is measured by pulling out feature importance from trained RFs. To measure the feature's directional impact on separate bike-sharing use, this study calculated the SHapley Additive exPlanations (SHAP) value. Lastly, the findings are summarized, and the implications for bike-sharing use during pandemics are discussed, highlighting the potential for resilience in travel behavior and the importance of bike-sharing in promoting public health and sustainable urban mobility.

Section snippets

Literature review

Bike-sharing systems have a history of about a decade and are considered a form of micromobility. Their benefits, including the provision of first- and last-mile connections to other transportation modes, have led to their recent growth (DeMaio, 2009). Micromobility modes like bike-sharing can help to reduce the demand for private automobiles, leading to environmental benefits such as fewer vehicle miles traveled and reduced greenhouse gas emissions (Abduljabbar et al., 2021, DeMaio, 2009, ...

Study area

The study area is Seoul, the capital city of S. Korea, which covers an area of approximately 605 square kilometers. The city is divided into 25 districts (known as “*gu*” in local terms), and within each district, there are 424 administrative boundaries (known as “*dong*” in local terms). Three prominent

business districts in Seoul are Yeouido, Gangnam, and the Central Business Districts (known as YBD, GBD, and CBD, respectively), and the *Han River* runs through the city.

According to the 2019...

Bike-sharing trip changes from pre-pandemic, pandemic, and near endemic

Fig. 3 illustrates the weekly total and an average number of bike-sharing trips from 2019 to 2022. Each dot on the graph corresponds to one week's observation. The record shows that the second year of the pandemic (2021) had more bike-sharing trips than in 2019 and 2020. However, during the winter months, there was a decrease in bike-sharing trips in 2021 compared to the first year of the pandemic (2020), although the number was still higher than in 2019. More importantly, the third year of the ...

Discussion and conclusion

During the COVID-19 pandemic, people were not hesitant to use bike-sharing, with more users willing to use it year-over-year. Researchers have focused on the effects of COVID-19 on bike-sharing, as it has caused significant changes in human mobility. Studies have shown evidence of the positive impacts of COVID-19 on bike-sharing, with users expressing affirmative opinions (Campisi et al., 2020, Jenelius and Cebecauer, 2020, Jiao et al., 2022, Nikiforiadis et al., 2020, Teixeira and Lopes, 2020...

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper....

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