An origin-destination level analysis on the competitiveness of bike-sharing to underground using explainable machine learning

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SHORT SUMMARY

Governments around the world have attempted to alleviate urban traffic congestion and pollution by developing public transportation. Public transport, especially the underground system, has been regarded as a sustainable travel mode, accommodating larger volumes than cars, thus alleviating traffic problems. However, public transport also suffers from various issues such as budgets constraints and limited urban infrastructure, the first- and last-mile connection of accessibility, and within-carriage crowdedness (Kim and Cho, 2021). On the other hand, bike-sharing, as a shared mobility, has attracted adequate attention for its beneficial health effects and low-cost (Fishman, 2016). More importantly, it can serve as an alternative to public transport, especially for short-distance trips (El-Assi et al., 2017).

Rather than complementing underground system, bike-sharing competes with the underground in specific regions and periods (Guo et al., 2022). Such phenomenon is observed in the context of London, where 35% of bike-sharing users replace underground usage with bike-sharing during rush hours and reducing overcrowding public transport (Transport for London, 2014). Therefore, the competition between bike-sharing and underground cannot be ignored. However, there are several issues which have not been fully addressed in the literature. First, bike-sharing is often examined as a flexible mode to access transit (Fan and Zheng, 2020; Kong et al., 2020), yet the competitive mechanism between bike-sharing and the underground system remains under-explored. Moreover, existing studies that investigated the relationships among multiple travel modes are mainly based on user survey data and/or aggregated trip data, while few studies have utilized OD-level actual ridership data. In addition, although previous studies have explored various factors that influence bike-sharing usage at the station-level, there have been limited attempts to understand the effects of route-level characteristics (e.g., travel time/cost) on bike-sharing ridership. Finally, bike-sharing competitive trips is dependent on not only the distance between ODs, but also the cycling environment, etc. To capture such dependency, linear models are often used but the linear assumptions underlying the typical linear models may lead to biased estimates of the impact of determinants (Ding et al., 2019).

The current study explores the competitiveness of bike-sharing to the underground using bike-sharing and underground trip data between OD pairs. In addition, this study proposes a framework to estimate the most likely route for bike-sharing competitive trips between OD underground stations. To avoid biased estimates and capture non-linear associations, Light Gradient Boosting Machine (LightGBM) model and SHapley additive explanations (SHAP) model are combined to explore the factors affecting the competitiveness of bike-sharing to underground. Our results found that bike-sharing can serve as a competitor to the underground, especially in denser urban areas and peak periods. The competitiveness of bike-sharing is associated with the attributes of trips' origins and destinations, route characteristics, and time. In particular, the route

characteristics of travel duration/distance, road gradient, bike infrastructure availability and the number of crossings is correlated with the competitiveness of bike-sharing to the underground. Moreover, it is found that users pay more attention to the characteristics of origins rather than destinations. Our findings can provide valuable implications for encouraging greater use of bike-sharing and underground in different scenarios, and ultimately reducing car dependency.

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