AGILE: GIScience Series, 3, 39, 2022. https://doi.org/10.5194/agile-giss-3-39-2022
Proceedings of the 25th AGILE Conference on Geographic Information Science, 2022.
Editors: E. Parseliunas, A. Mansourian, P. Partsinevelos, and J. Suziedelyte-Visockiene.
This contribution underwent peer review based on a full paper submission.

Effects of traffic perturbations on bike sharing demand – a case study of public transport strikes and protests in Paris

Stefan S. Ivanovic[1] and Ross Purves[1]

[1] Department of Geography, University of Zurich, Zurich, Switzerland

Correspondence: Stefan Ivanovic (stefan.ivanovic@uzh.geo.ch)

Abstract. This paper aims to contribute to a better understanding of the interactions between traffic perturbations and bike sharing use. More specifically we propose a framework for comparative spatial temporal analyses of public transport strikes and massive protests effects on bike sharing program in Paris. We find opposite effects on bike sharing demand due to public transport strikes and protests. The former causes a considerable rise in bike sharing demand particularly during the daily rush hours, while the latter precipitates a drop of activity constantly during the protest day. Our approach allows tracing bike sharing demand changes induced by traffic perturbations on an hourly level.

Keywords. Traffic perturbations, protests, public transport strike, bike sharing, spatial-temporal analysis

1 Introduction

Traffic perturbations are everyday events in European cities at multiple scales. Local events, such as collisions, typically have more limited effects than city-wide events like public transport strikes. Strikes can be a major cause of disruption, especially in cities which base transportation strategies on public transport modes, and aim to reduce use of private transport. One way of making such networks resilient are bike sharing systems, which "could act as a viable alternative in the case of public transit disruptions given its flexibility and various social, environmental, and economic benefits" (Cheng et al., 2021). Shifts from public transport to bike sharing during strikes have already been studied (e.g. Zhu et al., 2017; Younes et al., 2019).

The Autonomous Parisian Transportation Administration (RATP) provides an integrated public transport system in the Greater Paris area. The RATP operates and maintains a network of subway, tram, bus, and RER (regional express trains). In 2019, the number of trips reached 3.3 billion per year on a network consisting of 16 subway, 5 regional express train, 11 tram and 64 bus lines. However, the history of public transport strikes in Paris is very dynamic. In recent years, RATP employees took industrial action multiple times with 2019 experiencing the longest public transport strike of the last three decades[2].

In this study we aim to explore the links between cycling demand and large scale traffic perturbations caused by two socio-economic events: public transport strike and protests. Limited research has explored the effects of these two events on traffic and cycling demand. Public transport strike effects have been explored in research works of (Fuller et al., 2012; Fuller et al. 2019; Younes et al., 2019), however, protest's effects have attracted much less attention (Loo and Leung, 2017).

The primary goal of our work is to understand and measure the effects of public transport strike and protests on cycling in Paris, and particularly to fill the gap in the very understudied research of protests effects on urban transport resilience. The secondary goal is to quantitively and qualitatively compare the effects of these two events.

2 Related work

A growing research body deals with the effects of traffic disruption, particularly public transport strikes on cycling (Fuller et al., 2012; Saberi et al. 2018; Fuller et al. 2019; Yang et al., 2022). Fuller et al. (2012) conducted a case study on how two 24 hour public transport strikes on London's tube in 2010 affected the use of the London bike sharing program. The results showed that the number of trips increased by 3864 because of the first strike and 11293 per day because due to the second. Almost a decade later, Saberi et al. (2018) examined the effects of a 3 day London tube strike in 2015 on bike sharing. The study found the tube strike resulted in an increase in the number and duration of bike trips, with these mobility changes not uniform in space. This result can be explained by the heterogeneous spatial distribution of tube vs bike sharing stations in London.

Fuller et al. (2019) explored the impact of a 7-day long public transport strike in Philadelphia, not only during the strike but also in a post-strike period. During the strike period a rise of 57% in bike sharing use was observed. Since Philadelphia's bike sharing system provides its service to non-members as well, it was also possible observe an increase in use by non-members. The results demonstrated that bike sharing could be an alternative option not only for frequent users, but also for people who were less oriented to bike-sharing and potentially cycling in general. The considered post-strike time showed however that bike share use returned to normal values.

While the previous three studies relied mostly on the number of bike sharing trips and trip duration, recent research from Yang et al. (2022) employed richer origin-destination bike sharing data which also provides the locations of the stations where a bike was rented and dropped off after a ride. The case study considered four tube strikes in London. Overall, it confirmed previous findings that in general bike sharing demand rose in response to public transport strikes. Furthermore, the authors proposed an indicator measuring station pressure in case of an increased use. It indicated that in case of public transport strike, in some parts of the city the bike sharing infrastructure quickly reached full capacity and thus ceased to be a viable alternative transport mode.

Protests as a potentially significant form of transport disruption have attracted much less attention from the research community. Loo and Leung (2017) studied the impact of the Occupy Central Movement (OCM) 1 in Hong Kong on overall traffic resilience. The OCM civil disobedience campaign took place in Hong Kong, and in its first phase, protesters occupied the central government complex and blocked major roads and streets in the city. The study showed motorized traffic was particularly affected, with tram services experiencing the highest drop in patronage (35%) compared to the data before the event. Buses and taxi services experienced a similar drop of 10% in ridership. Pedestrian mobility behavior change was observed within fieldwork 'before-and-after pedestrian count survey' in some blocked streets, however cycling traffic was out of the scope of the study.

3 Method

3.1 Datasets

For this study we retrieved publicly available bike sharing data for 2019 from Vélib' Métropole[2], the company that has run the Paris bike sharing system for the past decade. We selected 2019 as the last year before Covid-19 pandemics, and the year with the most distinctive strikes and protests in the past decade in Paris

The selected bike sharing dataset provides information about the number of available and rented bikes at each station every ten seconds. In this research, we aggregated this information to the count of total rental bikes per hour. We used this variable in modelling bike sharing demand for the purposes of our study.

We compared bike sharing demand during three public transport strikes and three protest days to corresponding baseline days. Baseline days were selected as follows. For public transport strike days, baseline days are based on bike sharing demand from two nearest rain-free days of the same day of the week as proposed by Saberi et al. (2018). Because protests took place on an almost weekly basis every Saturday in Paris in 2019 – the so-called *gilets jaunes* movement – we had to take another approach to identifying baselines. We did so by identifying three rain free Saturdays in November 2019, when the protests were over. Our assumption was that November Saturdays would fit the selected three protest Saturdays, since the selected protests days were in February and March 2019, months with similar weather conditions to November. The *gilets jaunes* protest events were on the 16th and 23rd February, and the 23rd of March 2019. The selected public transport events took place on the 13th of September and the 6th and 17th December 2019.

3.2 Analysis

To better understand bike sharing users' behaviour during the traffic perturbations we explored time-series of average hourly bicycle trip counts. First, we used boxplots to summarise the differences between the selected public transport strike and protest averaged hourly counts, and their corresponding baseline days. Second, we plotted time series to compare strike and protest days hourly counts to their corresponding baseline days. For each protest and strike day, and for baselines, average hourly counts were aggregated across Paris. Finally, we used heatmaps to visualise absolute counts of system use and allow exploration of the behaviours over periods of a day and a week respectively.

[1] Retrieved from https://en.wikipedia.org/wiki/Occupy_Central_with_Love_and_Peace

[2] Retrieved from https//velib-metropole.fr

4 Results

4.1 Box plot analyses

Figure 1 illustrates differences in distribution of average hourly counts of all Paris bike sharing system stations during the selected protest days and their baselines. In all three cases we see similar global declines in the use of the system on days with protests.

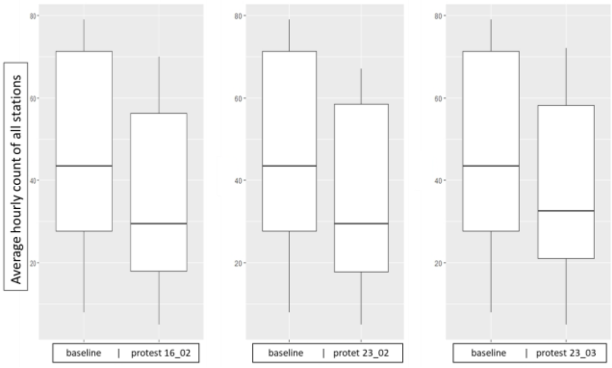

Figure 1: Boxplot based distributions comparison between protest and the corresponding baseline day

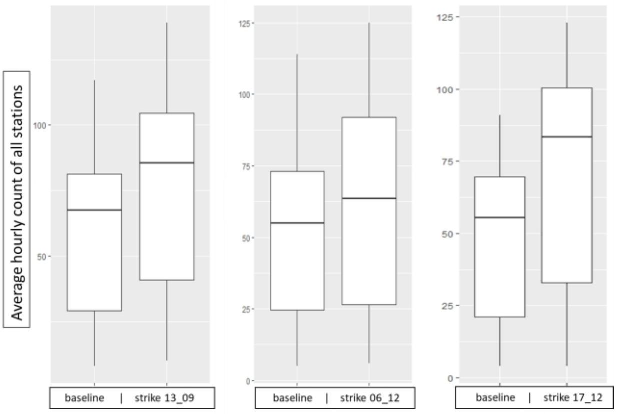

Figure 2: Boxplot based distributions comparison between strike and the corresponding baseline days

On strike days, which were not at weekends, we firstly observe that baseline use of the system is higher than for protest days (Figure 2). However, this usage increases considerably on strike days, showing the opposite effect to that we observed due to protests. The strike of 17th December caused the greatest increase in bike sharing activity, probably because the strike on this day affected more public transport lines. We then conducted paired-sample t-tests for the differences between protest and baseline days bike trip hourly counts. Same we did for public transport strike days. The results showed all tested differences proved to be statistically significant ($p<0.05$).

4.2 Time series – protests

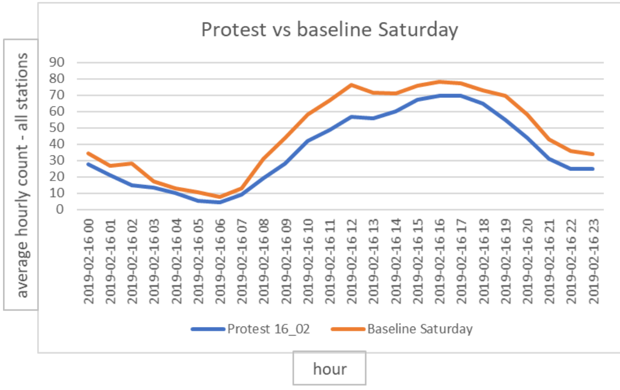

Figure 3: Average hourly counts distribution - protest Saturday vs baseline Saturday 16th February

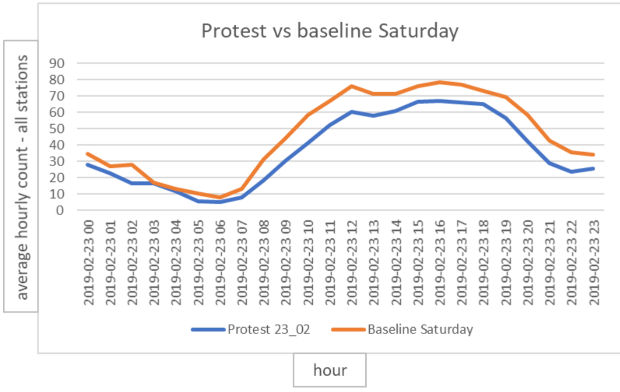

Figure 4: Average hourly counts distribution - protest Saturday vs baseline Saturday February 23rd

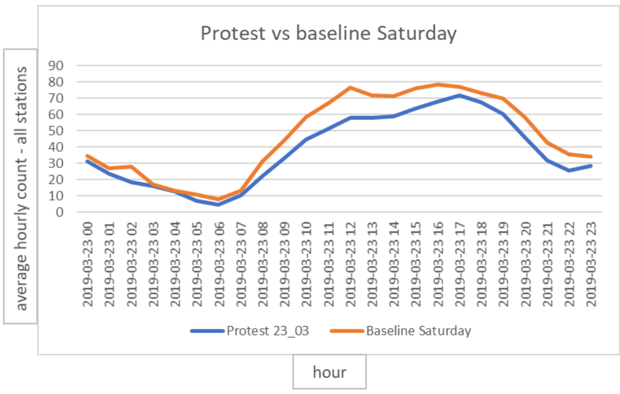

Figure 5: Average hourly counts distribution - protest Saturday vs baseline Saturday 23rd March

Figures 3, 4 and 5 allow us to break down the temporal variation of behaviour for the three strikes summarised by daily boxplots in Figure 1. Several general findings can be made. First, large-scale protests like those organized by *Gilets jaunes* movement in France in 2019 discourage use of the bike sharing system generally. The drop in cycling activity is visible from the morning until the end of the day. The biggest drop in use is around noon, a common protest milestone +/- 1 hour. We can also see that as the afternoon continues, the discrepancy between baseline days decreases, however, the effects of the protests are visible until the end of the day in the case of all three analysed protest days.

4.3. Time series – public transport strikes

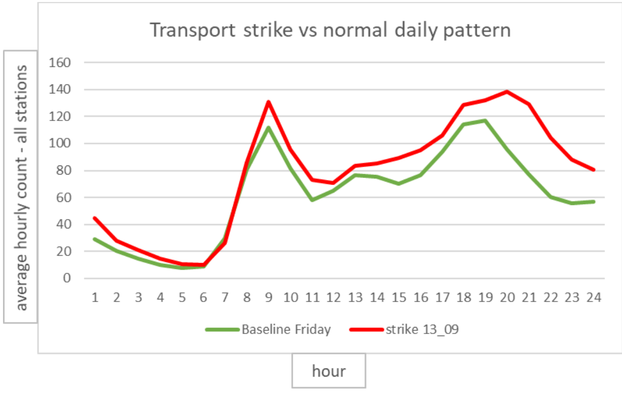

Figure 6: Average hourly counts distribution – baseline Friday vs protest Friday 13th September

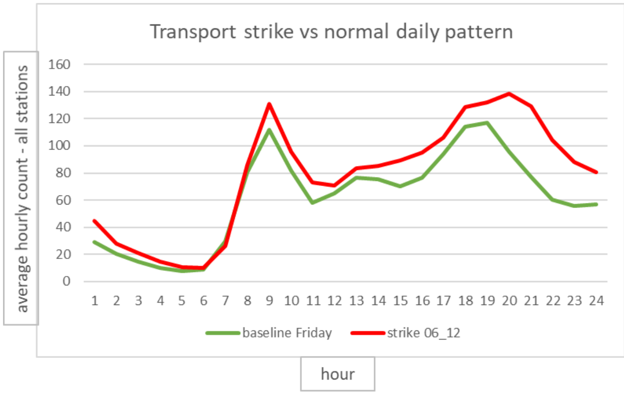

Figure 7: Average hourly counts distribution - baseline Friday vs protest Friday 6th December

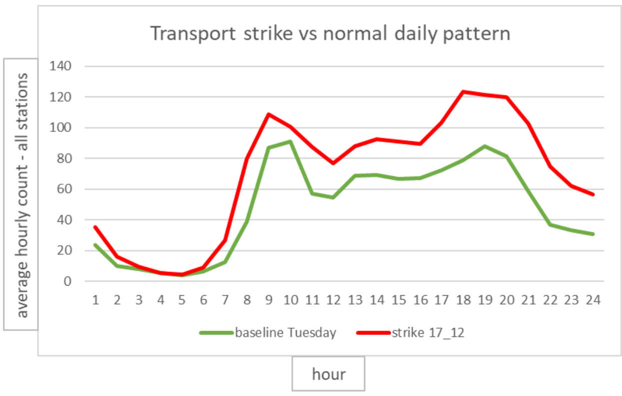

Figure 8: Average hourly counts distribution - baseline Tuesday vs protest Tuesday 17th December

Figures 6,7 and 8 show time series for public transport strikes. Once again, these show uniform trends regarding variations of bike sharing demand in Paris during public transport strikes. Overall, transport strikes induce an increase in bike sharing use from the early morning and maintain the increase until the end of the strike day. Surprisingly, on all three tested strike days the induced increase in bike sharing use is higher in the evening hours than during the rush hours when most of the people are going to/coming back from work during the working days (usually between 7am - 10am and 3 pm – 6pm). This difference is particularly visible in case of the first two selected transport strikes held on 13th September and 6th December. The strike from 17th December, where more lines were closed, showed generally higher discrepancies in use than previous two compared to baseline days. What's more the highest discrepancy was spotted during the evening rush hours when the average hourly count reached more than 120 compared to 80 during the baseline day, an increase of 50%.

4.4. Heatmaps – protests

Figure 9 shows two heatmaps of bike sharing activity, first the activity during protest affected week and the second the activity during the baseline week.

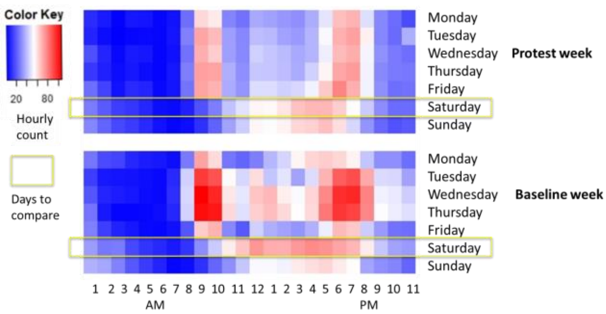

Figure 9: Bike sharing activity protest of 16th February 2019 vs baseline week

Knowing that the selected protests were taking place always on Saturdays, here we compare Saturday activities. It is clear from the Figure 9 that Saturday activity during baseline week was far more intensive than the activity on the protest Saturday. Similar results can be seen in Figures 10 and 11 that contain other two selected protest activity caparisons with the baseline week.

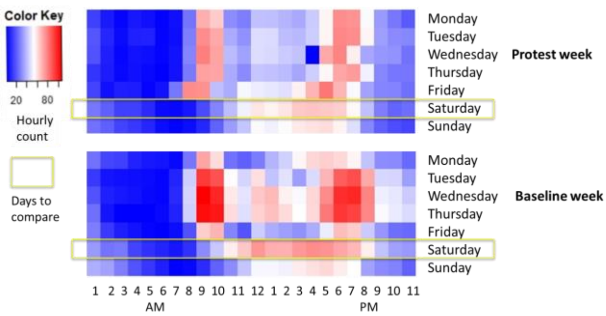

Figure 10: Bike sharing activity protest of 23rd February 2019 vs baseline week

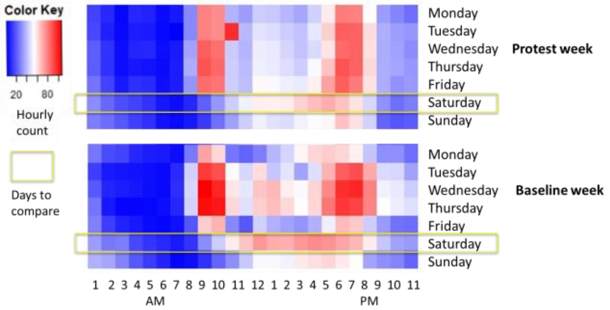

Figure 11: Bike sharing activity protest of 23rd March 2019 vs baseline week

4.5 Heat maps – public transport strike

Figure 12 shows two heatmaps of bike sharing activity, first the activity during the week hit by the public transport strike from 16th September 2019 and second the activity during the baseline week.

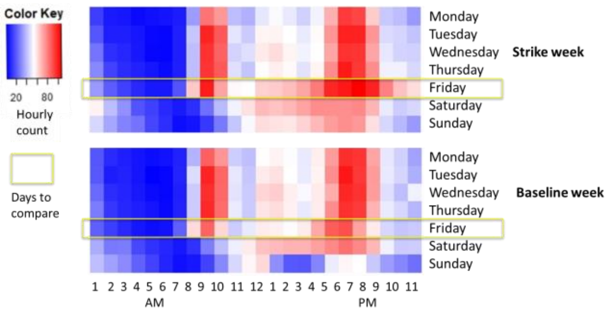

Figure 12: Bike sharing activity strike of 13th September 2019 vs corresponding baseline week

Here we compare Friday from the strike week since the strike occurred on Friday and Friday from corresponding baseline week. The rise of bike sharing activity during the strike Friday is noticeable compared to the baseline one, particularly in the second part of the day. It is also important to underline that 16th September public transport strike in Paris was a single day strike.

Figure 13 shows two heatmaps of bike sharing activity, first the activity of the public transport strike from 16th September 2019 affected week and second the activity during the baseline week.

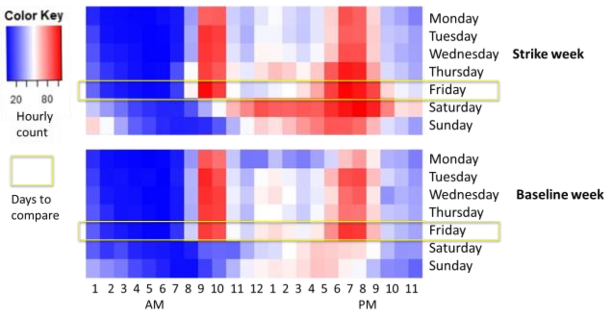

Figure 13: Bike sharing activity protest of 06th December 2019 vs corresponding baseline week

The strike from 6th December took place on Friday, however it was a first day of multiple days Paris public transport strike. Hence, the greater bike sharing activity can be identify not only on Friday but also in the two remaining days of the week compared to the corresponding baseline week.

Figure 14 presents two heatmaps of bike sharing activity, first the activity of the week hit by public transport strike from 17th December 2019 and second the activity during the baseline week.

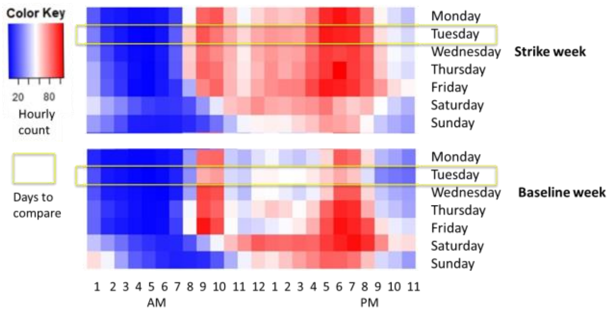

Figure 14: Bike sharing activity protest of 17th December 2019 vs corresponding baseline week

The strike day in question was a Tuesday, however this day was a part of a week long strike in Paris. Thus, the considerable increase of activity can be seen during all five working days during the strike affected week compared to the baseline one. The increase was more or less equally spread over rush and non-rush hours during the workdays.

5 Conclusion

In this study explored variation in the use of Paris' bike sharing system due to protests and strikes in 2019. These two forms of perturbation had quite different effects on the system. During strikes, use of the bike sharing system increased, as people sought alternative modes of transport. This confirms that bike sharing systems can be an effective means to increase overall resilience in transport networks, though it is important to note that the bike sharing system could only replace a relatively small number of journeys. However, on days when the gilet jaunes protests took place in Paris, use of the system dropped, suggesting that people chose not to visit or travel around the city during these protests. In future work we will explore the spatial signatures of these perturbations to the transport system.

6 References

Cheng, L., Mi, Z., Coffman, D., Meng, J., Liu, D., Chang, D.: The Role of Bike Sharing in Promoting Transport Resilience, Networks and Spatial Economics, 10.1007/s11067-021-09518-9, 2021.

Zhu, H., Masud, C., Xiong, Z., Yang, Y., Pan, L. Zhang.: Travel behavior reactions to transit service disruptions: study of metro SafeTrack projects in Washington, DC, Transp. Res. Rec., 2649 (1) 2017.

Younes, H., Nasri, A., Baiocchi, G., Zhang, L.: How transit service closures influence bikesharing demand; lessons learned from SafeTrack project in Washington, DC metropolitan area, J. Transp. Geogr., 76, 2019.

Fuller, D., Sahlqvist, S., Cummins, S., Ogilvie, D.: The impact of public transportation strikes on use of a bicycle share program in London: interrupted time series design, Prev. Med., 54, 10.1016/j.ypmed.2011.09.021, 2012.

Fuller, D., Luan, H., Buote, R., Auchincloss, A.H.: Impact of a public transit strike on public bicycle share use: an interrupted time series natural experiment study, J. Transp. Health, 13, 137-142, 10.1016/j.jth.2019.03.018, 2019.

Loo, B. P.Y. and Leung, K.Y.K.: Transport resilience: The Occupy Central Movement in Hong Kong from another perspective, Transportation Research Part A: Policy and Practice, 100-105, 2017.

Saberi, M., Ghamami, M., Gu, Y., Shojaei, M.H.S., Fishman., E.: Understanding the impacts of a public transit disruption on bicycle sharing mobility patterns: A case of tube strike in London J. Transp. Geogr., 66, 154-166, 2018.

Yang, Y., Beecham, R., Heppenstall., A., Turner, A., Comber, A.: Understanding the impacts of public transit disruptions on bikeshare schemes and cycling behaviours using spatiotemporal and graph-based analysis: A case study of four London Tube strikes, Journal of Transport Geography, 2022.