The Effect of COVID-19 on the Usage of 'Just Eat Cycles'

s1845360 and s1900682

1 Overview

In this investigation, we wanted to address how the usage of the 'Just Eat Cycles' was impacted by the COVID-19 pandemic, with reference to a change in the nature of trips taken. We expected to see that users of the bike sharing service would use the 'Just Eat Cycles' to visit scenic locations and to exercise, instead of commuting. To address this question, we first examined how the activity at various stations scattered across the city changed in the post-lockdown period when compared to pre-lockdown. We expected to see that 'Just Eat Cycles' trips would not cluster as tightly around the city centre as before. Rather, we would have increased activity outside this area, specifically near scenic locations. Our affirmed hypothesis can be visualised in Figure 2. As an example, the number of trips at Portobello beach increased by *11,575* in the post-lockdown period. This is contrasted to the activity at Bistro square, a popular student location in the city centre, decreasing by *4735*. We also hypothesised that the proportion of *long tips* in the post-lockdown period would increase. After conducting an A/B test with a bootstrap simulation, we accepted this claim with 100% confidence. Another indicator that trips were not for commuting purposes was the number of trips starting and ending in the same location. We observed that there was a 230.10% increase in such trips in in post-lockdown. This is contrasted to 58.73% increase in trips overall.

2 Introduction

In many metropolitan cities, there is usually a bike sharing service. In New York, there are the famous 'Citi Bikes'. London has their 'Santander Bikes' and in Edinburgh, we have the 'Just Eat Cycles'. To use this service, a user would log onto to the app and find a bike station nearest to their current location. To make use of the service, the customer would rent out the use of a bike based on predefined tariffs. There are options for: single trips, multiple trips and an annual pass. Customers also have the option of choosing whether they would want to use a regular or an electric bike. Once the pass has been purchased, the user would be able to unlock their bike and use it for the specified duration. Finally, the customer would be able to return the bike to any of the stations located around the city.

Context and motivation Our study is going to investigate the effect that the COVID-19 pandemic had on the popularity of the 'Just Eat Cycles'. The virus posed many health concerns for individuals as not only is the virus airborne, it is also able to survive on certain surfaces, such as stainless steel, for up to 72 hours [1]. With this in mind, we would expect that people would avoid the use of public spaces and surfaces in order to protect themselves from the catching the virus. However, since Edinburgh's citizens had to obey stay-at-home orders, we expect that the local population would want to maximise their time engaging in any physical activity outdoors during the pandemic. It is logical to infer that the popularity of the 'Just Eat Cycles' would increase as this service allows people a very accessible way to both exercise and enjoy nature. The bikes also offer an isolated form of transportation compared to the other popular forms of transportation in Edinburgh—buses, trams and taxis. The juxtaposition of these factors provides an interesting topic of data science investigation.

Previous work Since 'Just Eat Cycles' is a corporate entity that has an incentive to maximise their profits, we need to observe their actions as a business in relation to the data we are analysing. There are

three examples that were very pertinent to our investigation as they will affect the popularity of the service. Firstly, 'Just Eat Cycles' offered free passes to all NHS workers during the pandemic in order to help them commute to and from work [2]. Secondly, the company made the first 30 minutes of trips free for the general public between the 29th of June to 13th of July. After which, the general public were provided with discounted rates for a four month period [3]. Finally, the company also expanded their operations into Musselburgh as of the 21st of September 2020 [4]. Apart from this, we also viewed other data science investigations of bike sharing services for inspiration. We found a rather interesting academic article that examined the effect of COVID-19 on New York's 'Citi Bike'[5]. This is relevant to our investigation as the researchers have posed very similar questions, although in a different context. We were able to then use their ideas to complement our own findings.

Objectives Throughout this study we are ultimately looking to answer the question of whether the lockdown had an effect on the nature of trips taken by consumers. We will achieve this through exploring the difference between the activity at different 'Just Eat Cycle' stations around Edinburgh and the difference between the number of longer trips taken between the two periods.

3 Data

Data provenance The data sets, based on the 'Just Eat Cycles' trip data, were obtained directly from the company's web page [6]. The data is published under the Open Government Licence (OGL) v3.0 and it is is freely available. The data sets have also been anonymised in order to protect the private data of the company's consumers. We downloaded all the data from January 2019 to March 2021 as JSON files.

Data description Each data set, which corresponds to a calendar month between January 2019 and March 2021, contained trips with the following variables:
Each trip within the data has its start and end timestamp along with the duration of its use. The record also contains information about the start and end location for each trip. Each of these contain: the name of the location, a unique identification number (ID), a description of its location and the coordinates of its latitude and longitude. In 2019, there were *121,110* 'Just Eat Cycles' trips and in 2020, there were *226,547* trips. There were were *137,049* pre-lockdown trips and *217,535* post-lockdown trips [1].

Data processing Firstly, a major concern when using public data sets is whether they contain any sensitive or personal data. Fortunately for us, the data sets had already been anonymised, thus we did not have this as an overhead concern. When downloading all the JSON files, each file contains trips for an individual calendar month. Thus, we created three tables, one for 2019, one for 2020 and one for 2021 by joining all the month data sets within the respective year. After this, we created two data sets: one for the pre-lockdown period and one for the post-lockdown period. The pre-lockdown dates contain trips from the 25th of March 2019 to the 24th of March 2020. This latter date was the first day of the national lockdown in Scotland [7]. The post-lockdown set includes trips from the 25th of March 2020 to the 24th of March 2021. We chose these specific dates to ensure that the two time periods were comparable in their time span.

Following this, we wanted to cheek the data set for any missing values. Our 2019 data set was clean, whilst *5438* values in the 2020 data set contained null values. However, we verified all of these were located with in the start and end description fields. Since we made no use of this variables, we did not need to remove any records from our data. Finally, we wanted to ensure that all of our trip data occurred within the greater Edinburgh area (including Musselburgh) since the 'Just Eat Cycles' only operates out of this region. However, we observed that there were three trips that had end locations in Liverpool. Thus, we removed these erroneous trips from our data set as there are no 'Just Eat Cycle' stations in Liverpool.

[1] These data sets are with reference to the way we have split up the data, as seen in the 'Data processing' section.

Throughout our processing, we noticed that 'Just Eat Cycles' changed the names and/or exact coordinate locations for some of their stations as of December 2019. We observed that our pre-pandemic data set contained two coordinate versions of the same location, of which only one was present in the post-pandemic data set. This would have proven to be problematic as we were comparing how the bike usage at individual locations changed between these two periods. Thus, without addressing this formatting issue, certain locations would only have data from December 2019 onward. To address this concern, we conducted an extensive pre-processing step. We took each pre-pandemic location that was not present in the post-pandemic data set and found it's nearest post pandemic location. This was done through the use of the Euclidean distance formula. We then updated all of these pre-pandemic locations to have the coordinates of their nearest neighbour. In most cases, the coordinates we updated were modified by a negligible amount as the two coordinates referred to the same location. However, by adjusting the locations in this way, we were able to ensure fair comparisons between our two data sets which is crucial for our investigation.

4 Exploration and analysis

To begin our exploration, we wanted to observe what the difference was in the number of trips taken in 2019 and 2020 respectively. This comparative difference is seen in the bar graph below.

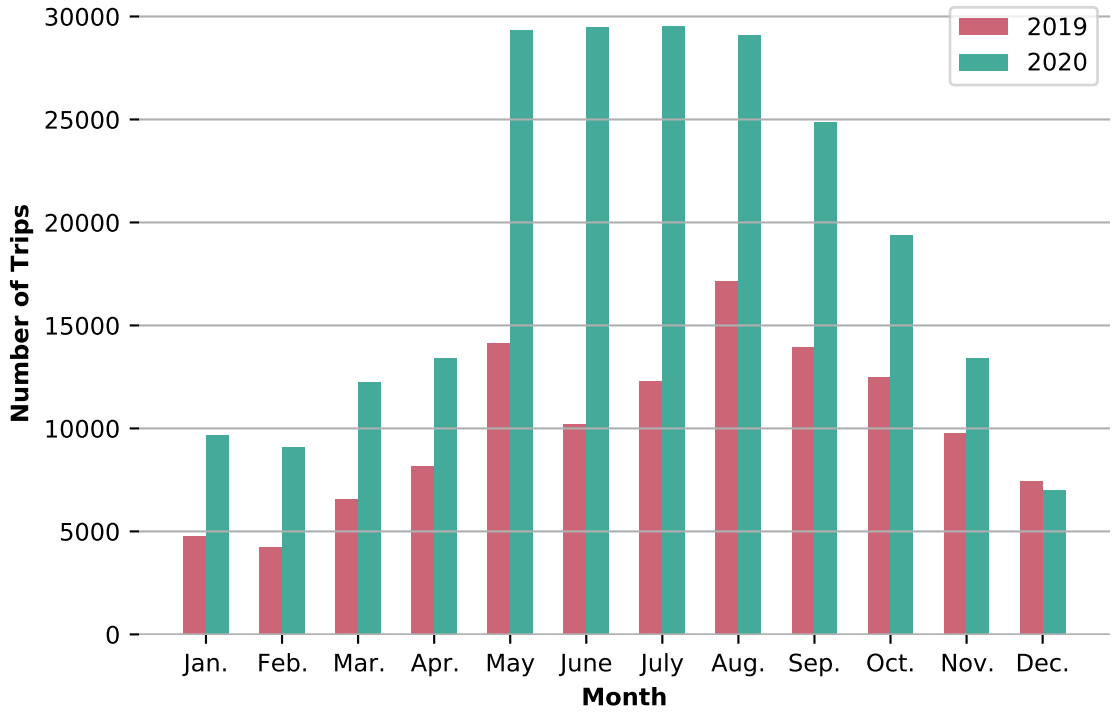
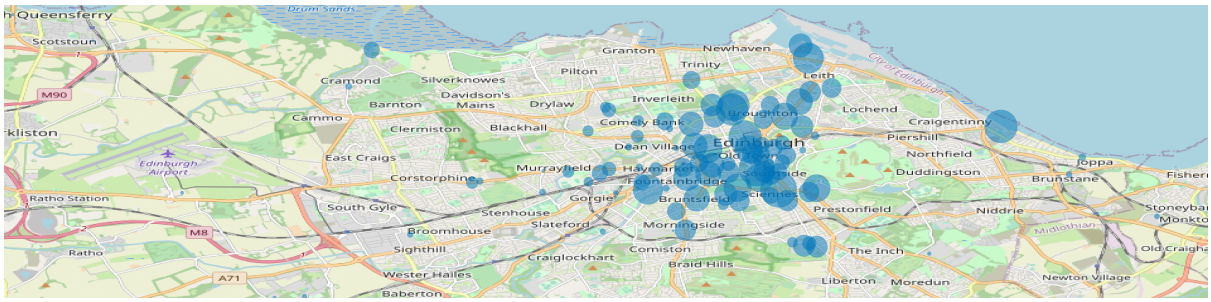


Figure 1: Bar graph comparing the number of 'Just Eat Cycle' Trips taken in 2019 and 2020.

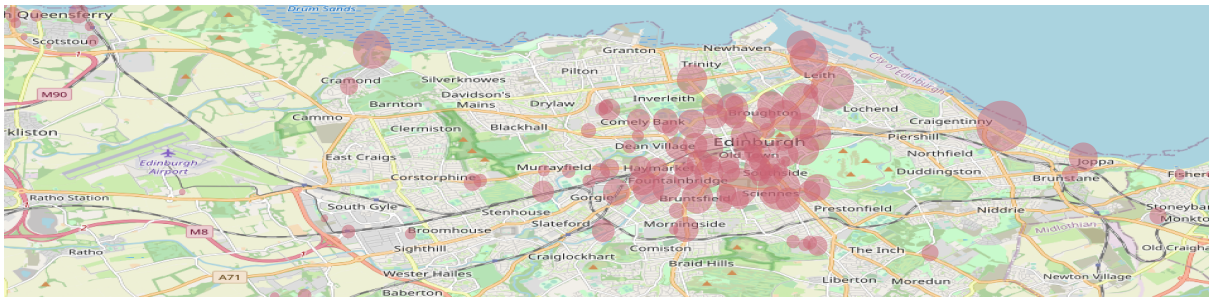
It is immediately visible that there are far more trips in the May to September period of 2020 when comparing it to 2019. This time period in 2020 corresponds to the the first major relaxation of lockdown rules in Scotland. People were allowed to go out for exercise once a day as of the 11^{th} of May. On the 8^{th} of July, people were allowed to meet outdoors in groups of eight from a maximum of two households [7]. This spike within in this period lead us to believe that the chief use of the 'Just Eat Cycles' was changing from a commuting service to one that would provide leisure and physical activity in nature. This is the main question that we look to address in this study: how did the nature of the trips change during the COVID-19 lockdown when compared to previous years.

Our initial hypothesis is that we expect that the trips during the COVID-19 pandemic would become longer, and that there would be more activity at stations near scenic locations. As the lockdown progresses with its stay-at-home recommendations, many people would experience a sense of "lockdown fatigue". This is a natural emotion after being stuck in a very monotonous routine without much opportunity to return to a sense of normality. We would expect that many people would gravitate towards the 'Just Eat Cycles' as a means of curbing this fatigue. The bicycle scheme provides a very accessible way for individuals without their own bicycles to get out of the house, into nature and to be active. We will address the changes in popularity of stations, trips starting and ending in the same location and the number of long trips in turn.

Changes in popularity of stations During the pre-lockdown time period, we would expect that the 'Just Eat Cycles' were mainly used to commute between locations. This would mean that the most active stations would be clustered around the city centre, with much less activity near scenic locations outside of this region. Individuals would need to be in centre of town as this is where many businesses, universities and restaurants are located. We would expect the converse to be true in the post-lockdown period; the popularity of stations near scenic locations would increase as there would be much less activity near the city centre due to lockdown restrictions and closures. To answer this question, we initially plotted each station with reference to its geographical location on a map of Edinburgh. The size of each station/data point reflects how much activity [2] there was at that particular station during the specified time period. A visualisation of our results are seen below.



(a) Pre-Lockdown



(b) Post-Lockdown

Figure 2: Bubble charts showing activity for each station in Edinburgh

Visually, we are able to observe that in the Figure 2, the radius of trips in the post-lockdown period increased significantly when compared to the pre-lockdown period. The trips are far less clustered around the city centre. Moreover, it is immediately clear that many locations outwith the city centre—and more scenic—grew substantially. This supports our initial hypothesis as we see that stations within the city centre have become less popular, relative to the overall increase in bike usage, after the lockdown came into effect in Scotland. The consumers of the 'Just Eat Cycles' have chosen to spend more time in scenic

[2] We take activity to mean any trip that has the particular station as its start or end point.

Station Name	Pre-Lockdown Activity	Post-Lockdown Activity	Activity Change (Post - Pre)
Duke Street	3080.0	15053.0	11973.0
Portobello - Kings Road	8770.0	20345.0	11575.0
Cramond Foreshore	2095.0	11560.0	9465.0
...	...	...	...
Bristo Square	10217.0	5482.0	-4735.0
Waverley Bridge	6028.0	842.0	-5186.0
Logie Green Road	7829.0	2567.0	-5262.0

Table 1: Top and bottom three station activity changes.

locations. We complement these visual results with the data seen in the table above. The three stations that saw the largest increase in activity were all locations within nature. The 'Duke Street' station is right beside the Leith Links park. Portobello and Cramond Foreshore are both beaches. The latter two are very popular destinations in Edinburgh. Contrasted to this, the three locations that changed the least are all within the city centre. Bistro Square is at the heart of the University of Edinburgh's central campus. Waverly bridge is right beside Edinburgh's central railway station and Logie Green Road is a station within a residential area in close proximity to a student accommodation, Beaverbank. Not only did these stations change the least, their usage decreased when compared to their pre-lockdown usage, even though the overall number of trips taken in the post-lockdown period increased significantly, as seen in Figure 1. These results support our main point of investigation as they showed that the consumers of 'Just Eat Cycles' chose to use the bike hire service as a leisurely activity and a means of exercise rather than for commuting. One should, however, be cognisant of trips near Queensferry; these stations did not exist prior to September 2020 [4].

Trips starting and ending in the same location Additionally, we wanted to compare the number of trips that started and ended in the same location across the two time periods. When you commute, you would travel to two distinct locations a and b. Trips that start and end in the same location c are generally not for this same purpose. It is more likely that they are used for leisure or exercise. Within the pre-lockdown period, there were *12,450* trips that started and ended in the same location. In the post-lockdown period, this number increased to *41,097*. However, this increase from 2020 could also be due to the company's natural rising popularity, irrespective of the nature of trips changing [3]. To control for this, we compared the percentage increase from the pre-lockdown period to the post-lockdown period for the total number of trips to the percentage increase of trips that started and ended in the same location. The percentage increase for total number of trips was 58.73%. The percentage increase for the number of trips that started and ended in the same location was 230.10%. This indicates that there was in fact an increased number of non-commuting trips due to the pandemic. If this was not the case we would expect the two percentage increases to be closer in value, controlling other factors.

Duration of Trips To test whether the trips were longer during the post-lockdown period, we decided to conduct an A/B test. In our test, we considered longer trips to be those greater than 30 minutes. Generally, a trip that was purely for commuting purposes would take less than 30 minutes on a bike. Due to the size of the city, you can comfortably get from one side of the city to another within this time frame. Our assumption is that trips longer than 30 minutes are for non-commuting purposes [4]. In our A/B test, A represented the post-lockdown period and B was the pre-lockdown period. We assume each trip to be independent and observed the Bernoulli random variable of a trip either being a *long trip* (greater than 30 minutes) or not a *long trip*. To obtain the probability of a trip being long for each period, we found the

[3] See *Evaluation of own work: strengths and limitations*

[4] Such examples include exercise, leisure etc.

number of long trips in each data set which was then divided by the total number of trips. As the number of trips in each period was large, we can take these probabilities to be the limiting relative frequencies, as in Figure 4. The probability of there being a *long trip* in post-lockdown, P_A, is 0.4401084882892408. The probability of there being a *long trip* in pre-lockdown, P_B, is 0.23704660376945472. We used the *bootstrap* method, sampling a number of *long trips* from a binomial distribution for each time period with their respective probabilities and n equal to the average number of trips per month, $13,643$. We then calculated the difference between the sampled number of long trips, normalised by n, which represented a single data point. We repeated this process 1000 times and plotted the resulting bootstrap distribution. The results are visualised below.

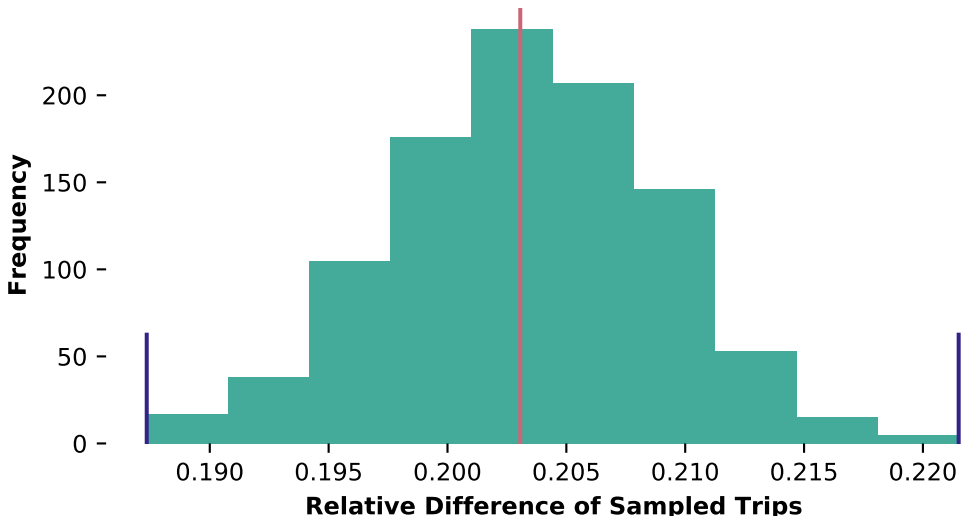


Figure 3: A/B test bootstrap simulation comparing the difference in number of *long trips* in the post-lockdown and pre-lockdown periods. P_A (post-lockdown) $= 0.4401084882892408$, P_B (pre-lockdown) $= 0.23704660376945472$, and n (average trips per month) $= 13,643$.

In Figure 3, the pink line represents the difference between P_A and P_B. The purple lines represent the *minimum* and *maximum* values obtained. We can see that 0, representing that there is no difference between the aforementioned proportions, is not included within our interval at all. Thus, we can say with 100% confidence that the trips during a month-long period in post-lockdown contain more *long trips* when compared to pre-lockdown. This supports our initial investigative question as it shows that consumers were spending a far greater duration of time on the 'Just Eat Cyles'. This, coupled with the station activity changes shown above, shows us that individuals were using the bike hire service as a means to visit more scenic locations. To complement our A/B test, we also calculated the limiting relative frequency of the number of *long trips* in pre-lockdown and post-lockdown. The visualisation of this is seen below.

In Figure 4, we will allow n to be the number of trips. As $\lim_{n\to+\infty}$, we see that the proportion of *long trips* in post-lockdown and pre-lockdown tend to two distinct asymptotes. These asymptotes correspond to the values of P_A and P_B respectively used in our AB test.

5 Discussion and conclusions

Summary of findings The effect of the COVID-19 pandemic had a profound impact on 'Just Eat Cycles' as it changed the bike sharing service's primary use. Preceding the lockdown regulations, the service was primarily used to assist commuters, as it does in many other metropolitan cities. The bicycles provide a very accessible and cost-effective means to get from point A to point B. It would be used by both business people and students alike, visible by the clustering of trips around Edinburgh's city centre.

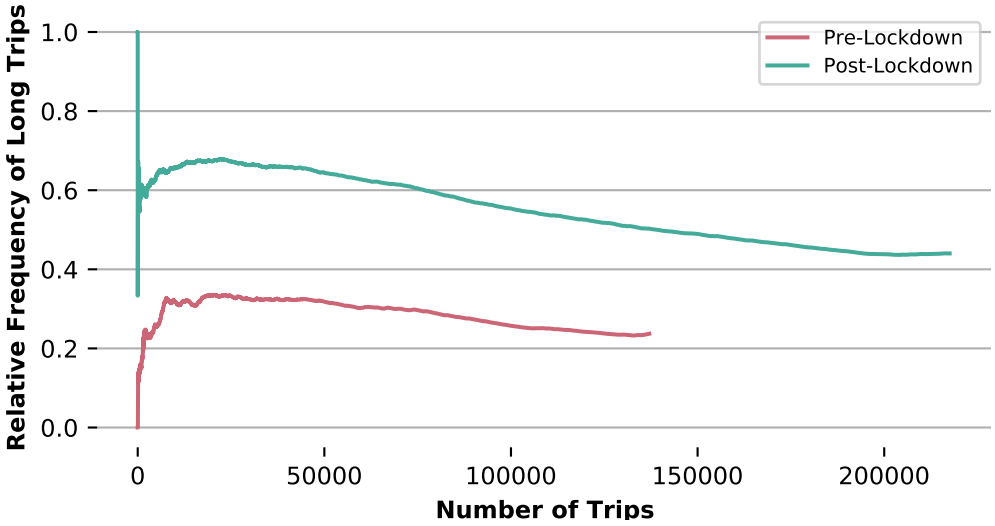


Figure 4: A visual of the relative frequencies for long trips in the pre-lockdown and post-lockdown periods.

However, the usage of the 'Just Eat Cycles' shifted to focus on leisure and exercise as shown by our investigation. This was apparent for two chief reasons. Firstly, the clustering of trips was no longer as tight around the city centre. This was seen in Figure 2 by the comparison between the pre-lockdown station activity to the post-lockdown station activity. Moreover, we also observed that users of the service increased their tendency to travel to more scenic locations. This was observed by increased activity at popular scenic locations in Edinburgh such as Portobello beach and various parks located around the city. This notion is also supported by our second experimental question that showed the likelihood of a long trip increased in post-lockdown when compared to pre-lockdown. It was observed that customers took much more *long trips* in the post-lockdown period. This, coupled with the increased number of trips starting and ending in the same location, indicated that the trips taken were no longer for commuting. Rather, the 'Just Eat Cycles' were used as an accessible means to break the 'lockdown fatigue' and escape into nature.

Evaluation of own work: strengths and limitations The first strength of our investigation is that we took care to mitigate the influence of confounding variables on our findings. Before conducting our study, we did some initial data exploration to see whether there was a general trend of increase in popularity. We observed that the popularity of the 'Just Eat Cycles' was naturally increasing over time [5]. Thus, when comparing the number of trips that started and ended in the same locations, we took measures to address this factor by comparing this to the percentage increase of trips between the pre-lockdown and post-lockdown periods. The second strength of our investigation was the extensive prepossessing we conducted before proceeding with our experiments. We observed that there were a number of locations that changed between pre-lockdown and post-lockdown due to 'Just Eat Cycles' expanding their operations. It was also observed that some locations ceased to exist. In order to ensure a fair comparison, we grouped the data for locations in the pre-lockdown data set with their nearest location in the post-lockdown data set. This would allow us to account for all trip data for stations within the 'Just Eat Cycle' bike hire service.

In our investigation, we have identified two main limitations. The first is that the popularity of the 'Just Eat Cycles' was already increasing prior to to the COVID-19 lockdown. This is seen in Figure 1 where the number of trips in January and February of 2020 where almost double the number of trips within the respective months in 2019. However, we believe that the COVID-19 pandemic actually amplified the

[5] See *Evaluation of own work: strengths and limitations*

company's success. As we have already shown above, the 'Just Eat Cycles' provided Edinburgh locals without their own bikes a very accessible way to both exercise and visit scenic locations. This would lead to the company being more popular overall as there is a increased demand for the bike sharing service. 'Just Eat Cycles' needed to expand their operations to cope with this demand, as seen by their expansion into Musselburgh [4]. A similar limitation would be viewed when we compared the percentage increase of trips that started and ended in the same location in the pre-lockdown and post-lockdown period. However, as we stated above, we made sure to compare this to the percentage increase of total number of trips. This comparison allowed us to show that the nature of trips were in fact changing, and that the percentage increase in the trips staring and ending in the same location was not just due to the increased popularity of the 'Just Eat Cycles'.

Comparison with any other related work A similar trend was viewed with New York's 'Citi Bikes' [5]. In the aforementioned study, João Filipe Teixeira and Miguel Lopes observed that that there was a 34% increase in the duration of trips in March 2020 compared to the duration of trips in March 2019. These dates correspond to our time periods of March 2020 being in post-lockdown and March 2019 being in pre-lockdown. Although we investigated the difference in number of *long trips* taken, our findings match with the findings of the New York 'Citi Bikes' as in both New York and Edinburgh, there were more trips with a longer duration as a result of the pandemic.

Improvements and extensions To extend our findings, we identified two interesting paths of exploration one could take. Firstly, our findings have shown that there is a definite shift in the nature of 'Just Eat Cycles' when comparing pre-lockdown to post-lockdown. It would be interesting to observe how this trend differed on weekdays compared to weekends rather than grouping the entire period as one.

Throughout the lockdown in Scotland, there have been various restrictions introduced that prevent certain activities in response to the rising COVID-19 cases. Such restrictions include the closure of bars and restaurants for example. In our investigation, we only considered the announcement of lockdown on the 24th of March 2020 and the allowance of outdoor exercise on the 11th of May 2020. It would be interesting to observe how the number of 'Just Eat Cycles' trips was affected by the announcements of additional lockdown restrictions. An example of such a restriction would be the curfew imposed on pubs and restaurants on the 22nd of September 2020 [7]. Similarly, it would be interesting to observe how the number of 'Just Eat Cycles' trips fluctuated in response to the number of COVID-19 cases at a particular time. The two trends could be plotted against one another and their difference observed.

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