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Electric Scooters' Trip Data Collection and Analysis

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Summary

Electric scooters or e-scooters are a transport mode that has increased rapidly but with mixed reactions. In this paper, we present aggregated usage data and some basic analysis from four European cities: Berlin Madrid, Paris and Stockholm. We have analyzed the utilization rate, trip duration and straight-line distance, and where and when they are used in the observed cities. The maximum utilization rate is between 2 and 4% with a declining trend towards winter. Not surprisingly, the scooters are used for short trips mainly in the afternoon and evenings, and mostly on Fridays and Saturdays. However, we do observe variations between the cities. Stockholm, e.g., has a morning peak absent in the other three cities.

Keywords: micro-mobility, electric scooter, data acquisition, shared, mobility system

1 Background

Electric scooters or e-scooters are a new transport mode that has increased rapidly in several cities around the world. This rapid spread has led to mixed reactions.

The positive perspective is their potential to contribute to a more sustainable transport system by serving as a complement to public transport, walking and cycling and thus being an attractive alternative to privately owned cars.

The negative aspects are that they on the contrary might compete with public transport, walking and cycling and may also contribute to increased congestion and traffic accidents as well as their, at least so far, short life expectancy which has a negative climate impact. Figure 1 shows one problem with electric scooters namely that they sometimes are dropped or end up at unsuitable places. Although some cities and operators have started designating specific spots for scooter parking, most still allow the scooters to be left at any place.

To understand the role electric scooters play in the transport system we need to understand how they are used. A study from Portland, USA [1] states that a third of the trips made with e-scooters replaced car travels. Similar results are found in a survey from New Zealand [2], where 28% of the e-scooter trips replaced car travels. A study of the usage patterns in Indianapolis, USA [3], shows that the e-scooter trips in average took

8 minutes and covered 1.13 km. But to our knowledge, there are no studies of e-scooters usage in European cities that have a different urban structure and public transport network. This is a first descriptive approach to bring some clarity on utilization, trip duration and length and when and where the scooters are used.

Figure 1: A scooter left on the sidewalk. Photo taken by Johan Wedlin.

2 Method

In earlier studies, the authors have analyzed usage patterns of free-floating car sharing services (FFCS) [4, 5], using data collected from millions of trips. A similar approach is taken here.

To enable free-floating rental of electric scooters, users must be made aware of the position of available vehicles. The positions and status information of available scooters are collected and shown to the user through the operators' mobile apps. Sampling this publicly available information, using a sampling time of 1 minute, provides the data used for the analysis of e-scooters in this paper. So far, we have collected data for roughly four months, from August 2019 to February 2020. Unfortunately, there is a lack of data during some time intervals (see Figure 2). We have sampled one or two operators in four cities. More specifically, two operators in Stockholm with 251768 respectively 781871 trips; one operator in Berlin with 322070 trips, one operator in Madrid with 31481 trips and two operators in Paris with 42044 respectively 10039 trips, adding up to a total of 1.44 million trips analyzed in this paper.

The data shows the parking positions and status of the scooters but says nothing about the users, which means that the data collection does not handle any personal data. Examples of data that are collected are location information, time stamp and state-of-charge (SOC) of the battery at the beginning and end of a trip. It should be noted that we do not have access to data of the actual distance of each trip but only the origin and destination of each trip and therefore, the geo (straight line) distance between them.

To prepare the data for analysis, we needed to clean the data from outliers. We identify charging trips as those in which the state of charge is higher at the end of the trip than at the beginning. These trips are removed from the study. Trips with a distance longer than 50 km or with a duration longer than 60 minutes were removed in most of the analysis except in the left figures in Figure 3 in which data longer than 60 minutes also are included for visualization purposes.

On the cleaned data, we performed a statistical analysis to identify the utilization rate, trip duration and length and when and where the e-scooters are used. The results are presented in the following section.

3 Results

3.1 Utilization rate

The utilization rate is defined as the total time all e-scooters in the fleet are used each day divided by total time they could potentially be used, i.e., 24 hours * 60 minutes. To estimate the number of scooters in the fleet, we use a window of 6 days to cancel out the noise caused by non-used scooters. It should be noted that we only observe e-scooters that are rented. Daily utilization rates of e-scooters are shown in Figure 2.

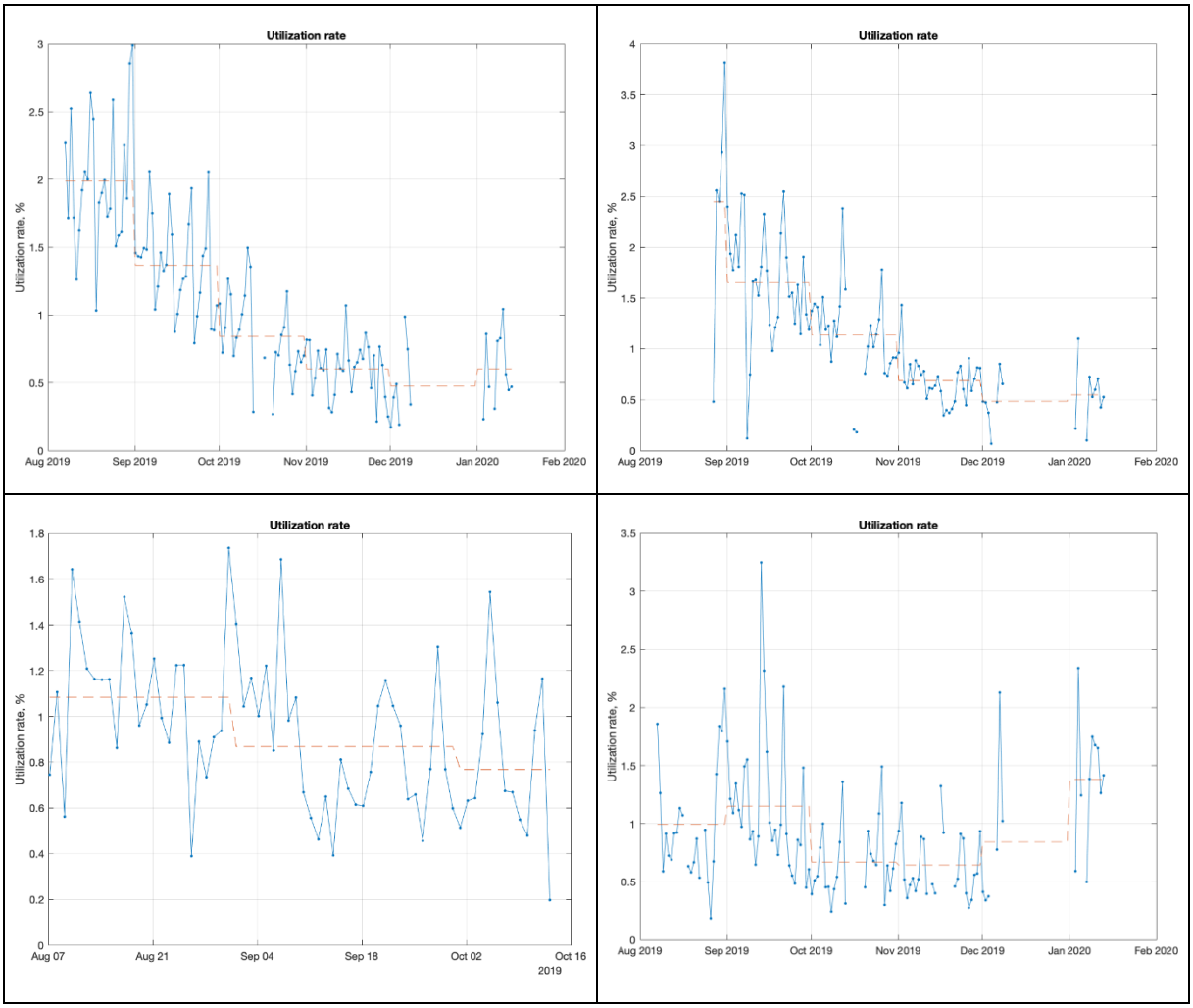

Figure 2: Variation of daily fleet utilization rate for Stockholm (upper left), Berlin (upper right), Madrid (lower left) and Paris (lower right). The dashed red line is monthly averages. Note that the Madrid data are only collected until October; data for the other cities are until February.

The maximum observed utilization rate is in Berlin, almost 4%, and in Madrid the maximum is almost 1.8%. In Stockholm and Berlin, the utilization rate has a declining trend from summer to fall 2019, while in Paris and Madrid it is less varying. However, for Madrid we only have data until October. From our data, we can see that the number of e-scooters is reduced by the operators during autumn/winter, especially in Stockholm and Berlin, so the decrease of utilization rate most likely depends on less usage during autumn/winter.

The figures in general show that the e-scooters are parked, and thus not used, most of the time. However, there is a trade-off between utilization rate of these services and their availability. Service availability is linked to the reliability of services and influences long-term demand.

3.2 Statistical data on trip duration and lengths of the trips

In Figure 2, the histogram of the trip duration is given where the left figure indicates all trips and the right figure zooms in on trips shorter than 1 hour which are the majority of the trips and the most reasonable rental time. Longer trips are most probably charging, maintenance, and redistribution trips.

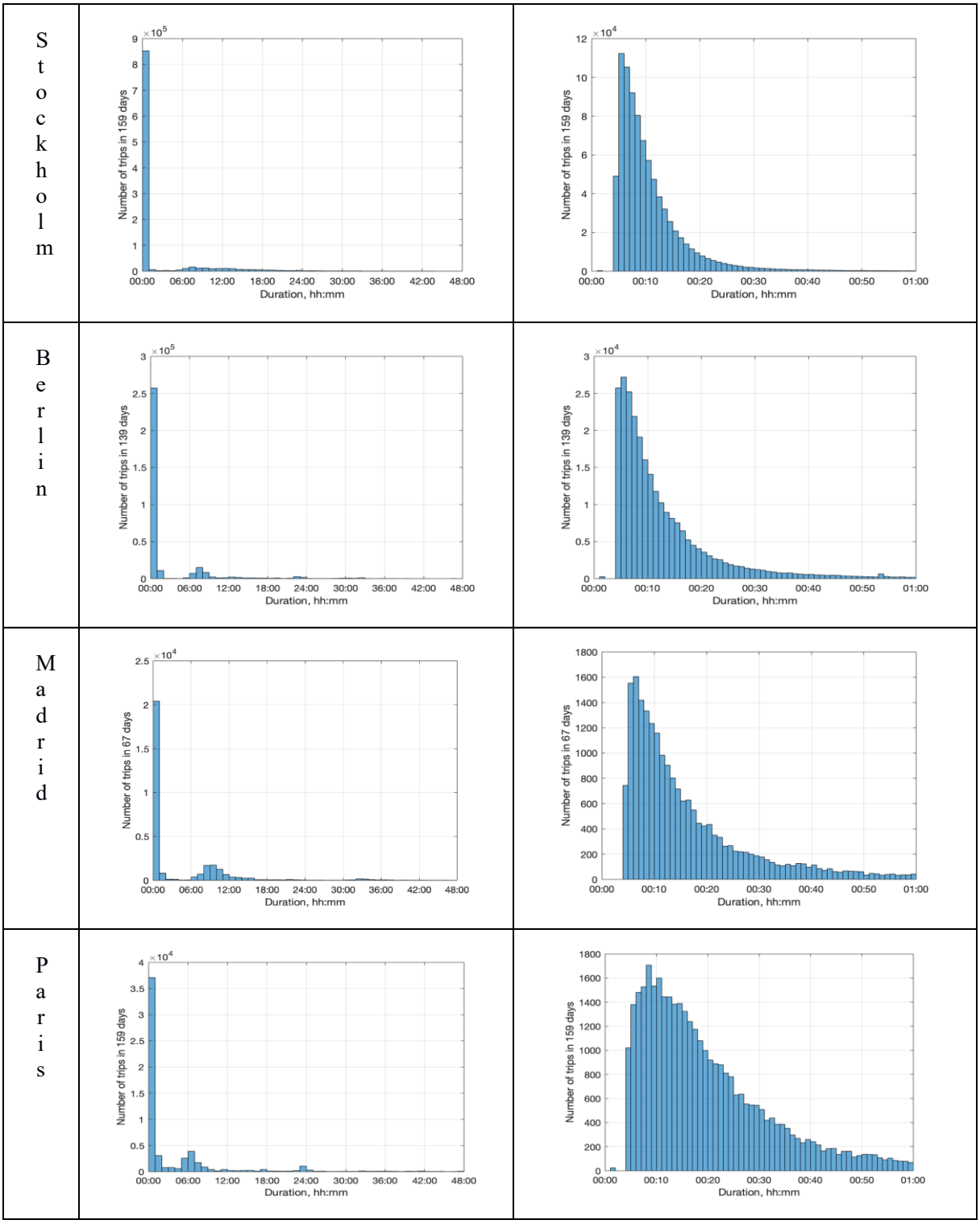

Figure 3: Trip duration: Left: all trips; Right: only trips shorter than 1 hour. Note that the number of trips differ between cities.

The mean and median value of the trip duration for the right hand figures in Figure 2 are around 10 minutes and 8 minutes respectively for Stockholm, 12 minutes respectively 9 minutes for Berlin, 16 minutes respectively 12 minutes for Madrid, and finally 19 minutes respectively 16 minutes for Paris. Concludingly, for all cities, the mean value is higher than the median value. The distribution of trip length is slightly different for Paris where the peak is around 10 minutes, while being approximately 5 minutes in the rest of the cities.

Figure 4 shows the histogram of the length of the trips in kilometers. Note that this is the straight-line distance and not the actual trips distance, which we cannot observe from the collected data.

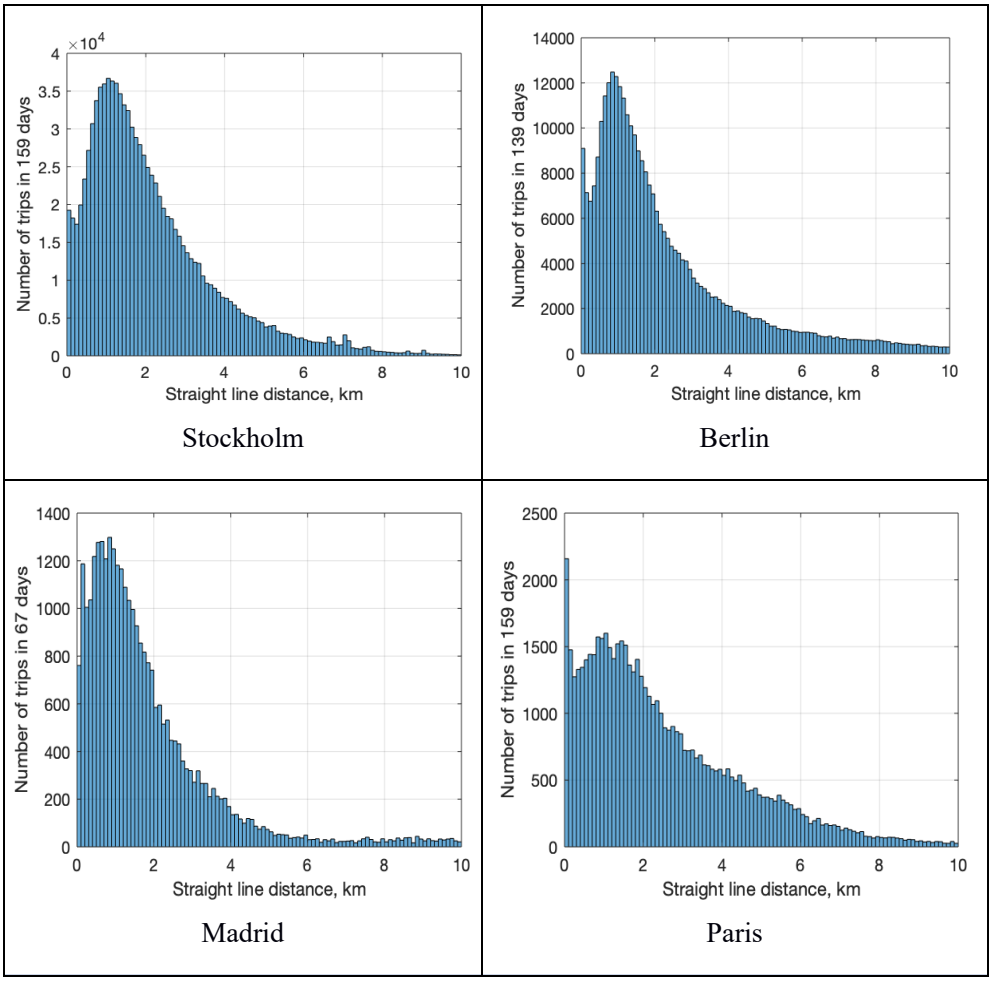

Figure 4: Trip straight-line distance. Note that the number of trips differ between cities.

As can be seen in the histograms, there is a peak at zero distance, which is the highest for Paris, followed by Berlin and Madrid, and Stockholm has the smallest one. The peak at zero distance means that there are many trips that start and ends in almost the same location. These trips are for sure not part of a potential transport chain where the electric scooter trip is just one part of the total trip. They can either be trips that are not followed through or round trips where the scooter is used and then returned to the same place.

The mean and median trip distance for Stockholm are 2.55 km and 1.75 km respectively. For Berlin they are about the same: 2.60 km and 1.64 km respectively, while they are shorter in Paris with 2.64 km and 1.99 km respectively. Madrid has the shortest distance with 2.11 km and 1.37 km respectively. Concludingly, for all cities, the mean value is higher than the median value. Similar to the trip duration histograms, Paris has a distribution that is more spread out toward longer trip distances.

Figure 5 shows two-dimensional histograms of trip duration versus trip straight-line distance for the four cities. These plots indicate how fast the trips are in a city and the colors show the frequency of the trips; darker color means more trips.

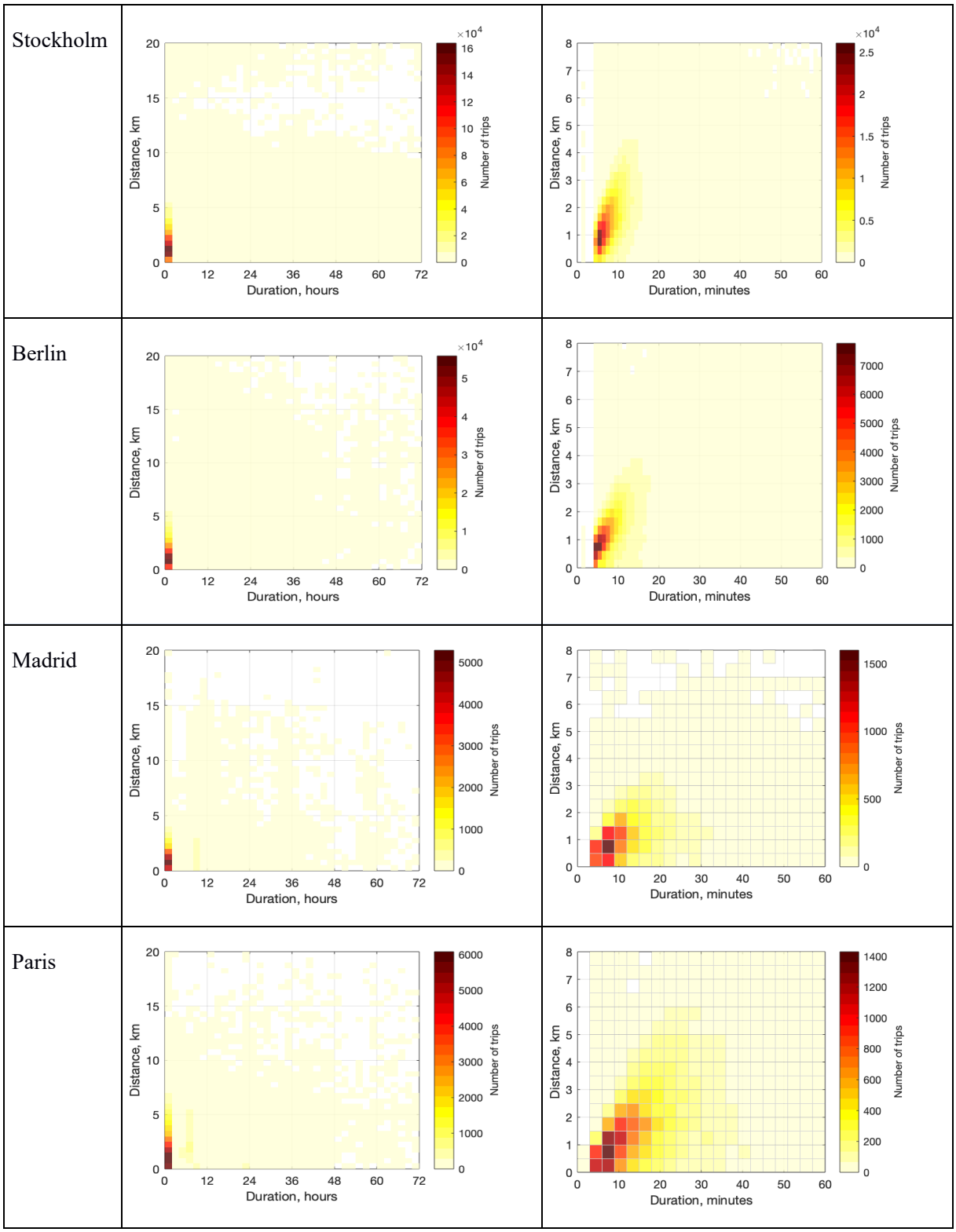

Figure 5: Two-dimensional histogram showing trip duration versus trip straight-line distance.
Left: all trips, Right: trips shorter than 1 hour.

Since the figures give trips with distances versus time, all lines going from the origin have an inclination equal to a velocity; all trips lying above the line have a higher speed and all trips under the line have a lower speed. Drawing speed lines through the darkest areas means that we can estimate the speed for the most frequent trips. For Stockholm the peak trips have a speed of around 1 km/5 minutes which equals to 12 km/h. For Berlin, the peak trips are around 0.8 km in 6 minutes which equals around 10 km/h, i.e. slightly less than Stockholm. For Madrid and Paris, there are less data, so it is harder to calculate but the speed seems to be around 0.75 km / 7.5 min which equals 6 km/h, i.e., slower compared to Berlin and around half the speed compared to Stockholm.

3.3 When and where are the scooters used?

To understand where the e-scooters are used, we have analysed the accumulated positions of parked e-scooters during the sampled time, see Figure 6.

Figure 6: Location of the electric scooters parking positions over the sampled time in Stockholm, Berlin, Madrid, Paris. Visualized using Kepler.gl. Map data: Mapbox and OpenStreetMap.

As can be seen, most of the scooters are found along the main streets in city centers. This is natural, since the operators restrict the pick-up and return of scooters to specific areas, typically in the city centers. However, Berlin and Paris seem to have more spread towards suburban areas than Madrid and Stockholm. One possible explanation could be that these cities have more suburbs within the allowed parking area, while for instance Stockholm's suburbs are outside the allowed parking area. Of course, the scooters could be used outside the allowed parking areas, but since most of the trips are only about 10-15 min and 1-2 km according to above,

most scooters are probably used within these areas. Since the operators seem to continually evaluate and adapt the parking areas according to the users' and the cities' needs, there are indications that the scooters in Paris and Berlin might be used slightly differently than in Stockholm and Madrid. In this analysis, we have investigated origins and destinations of the trips but found no patterns; it seems the scooters are used for all types of (short) trips.

The diagrams in Figure 7: Number of trips every hour per day in week for Stockholm (upper left), Berlin (upper right), Madrid (lower left) and Paris (lower right). Note that the number of trips differ between cities. shows the distribution of trips over 24 hours and day of week of the sampled weeks. There are some interesting differences: while all four cities show a clear peak in the evenings, only Stockholm has a morning peak as well. Also, Stockholm has a more pronounced afternoon peak. Comparing with our earlier analyses of free-floating car sharing (FFCS) [5], we can assume that the e-scooters could be used for the morning commute in Stockholm, while mainly used for errands and evening activities (the most prominent peak in all cities is after 18-19 hours) in all cities. The high evening peak remains to be explained; one possibility is that users take e-scooters after restaurant and pub visits.

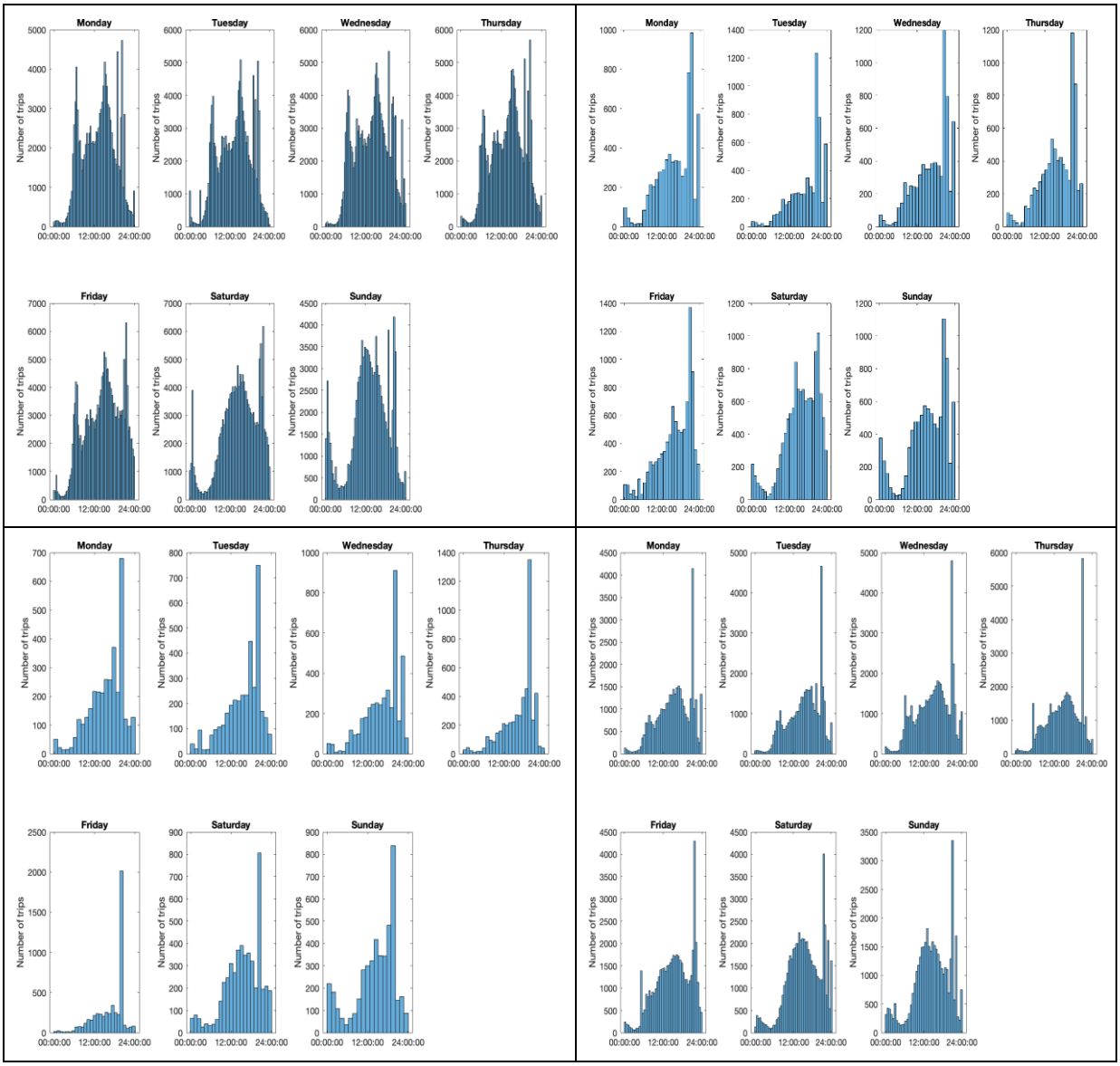

Figure 7: Number of trips every hour per day in week for Stockholm (upper left), Berlin (upper right), Madrid (lower left) and Paris (lower right). Note that the number of trips differ between cities.

Comparing the usage per weekday, see Figure 8, Stockholm and Madrid have the highest usage on Fridays while in Berlin and Paris the e-scooters are used most on Saturdays. However, the usage patterns in Stockholm and Berlin are more even. This indicates that although the e-scooters may be used during the morning commute in Stockholm, the main usage seems to be during the weekends and evenings.

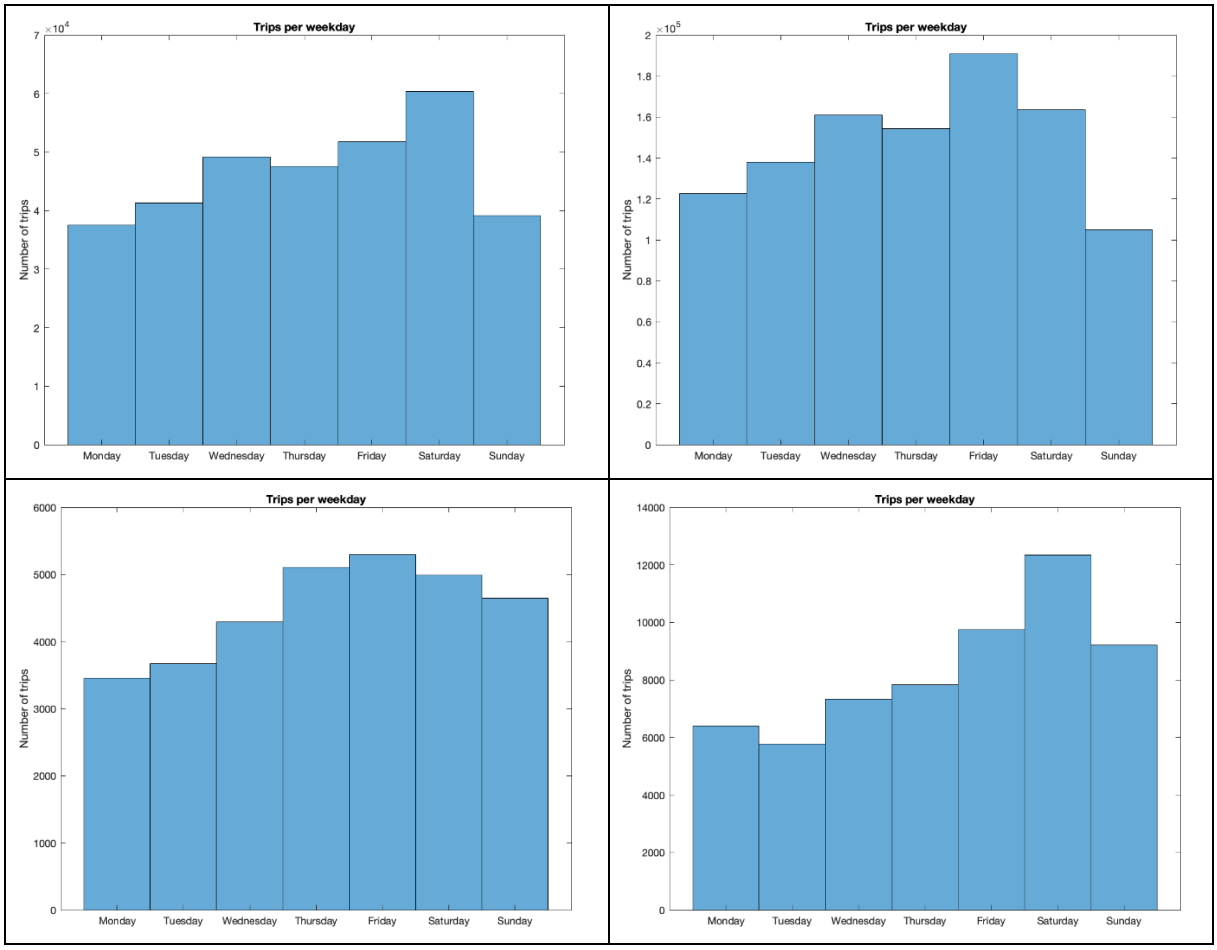

Figure 8: Number of trips per weekday for Stockholm (upper left), Berlin (upper right), Madrid (lower left) and Paris (lower right). Note that the number of trips differ between cities.

4 Summary and discussion

We have analyzed data on the usage of e-scooters in four different European cities. We find that the maximum utilization rate is the largest in Berlin with 4% and while it in Madrid is 1.8%. We also find a declining trend toward winter, especially in Stockholm and Berlin. As expected, the average e-scooter trip is fairly short, around 10-15 minutes. Of the observed cities Paris has the longest trips. The scooters are mainly used in the afternoon with a prominent evening peak in all cities. Stockholm also has a morning peak, implying that the e-scooters might be used as part of the commute there. In all cities Fridays and Saturdays show the highest number of rentals.

Our analysis only builds on data on the start and end point of the e-scooter rental. We thus don't have any information about the actual route taken, the users, their underlying motive and what type of modes would have been used otherwise. We also cannot explain the observed differences between the cities. More data and in-depth analysis are needed to answer those type of questions. Still this study provides a first step of understanding when, where and how much these services are being used. This can be valuable information for further studies of users, but also for operators, city planners and officials.

References

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