Searching for parking: The case of Zurich

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SHORT SUMMARY

This study analyzes the extent of parking search behaviour in Zurich, Switzerland using segmented and labelled GPS data collected from a smartphone-based GPS tracking app. The GPS data corresponding to over 1,000 car trips ending within the city of Zurich are map-matched to the underlying OSM road network, and the least-cost path between the trip start and end points are then computed on the same network, with the difference in path length assumed to be attributed to parking search behaviour. This excess travel distance is found to be marginal across all trips and equal to 100 m. However, it depends on both trip purpose and parking availability. Work trips exhibit the shortest excess distance (76 m), whereas leisure trips the longest (128 m). The availability of parking at home and type of parking at work also play a strong role, with on-street parking leading to longer excess travel.

Keywords: GPS tracking, map-matching, parking search

1. INTRODUCTION

Parking continues to be a source of problems in cities for different reasons. Abundant parking supply in cities attracts more car users and thus encourages more car use (McCahill, Garrick, Atkinson-Palombo, & Polinski, 2016). Increasing parking supply in downtown areas has negative effects on the urban environment, discourages the use of slow-modes and reduces the economic success of business districts (Manville & Shoup, 2005; McCahill & Garrick, 2010; Voith, 1998). In addition, parking takes away valuable space from people and gives it to cars, which sit idle for most of the day. This space could be used instead to increase the quality of life in urban areas by providing green spaces or higher concentration of amenities. This would, as a consequence, encourage walking, cycling and public transit.

Searching for parking in downtown areas is yet another negative consequence of poorly managed parking supply. In a review of several studies on parking search, (Shoup, 2016) concludes that between 8% and 74% of the total traffic in downtown areas was caused by cruising for parking, for an average of 30% corresponding to an average search time of 8 minutes. Shoup argues that large quantities of free on-street parking and mispriced parking garages are the main causes of parking search traffic in downtown areas, further causing congestion and negative externalities.

The development of technologies such navigation devices and smartphones capable of collecting GPS data have allowed for conducting new parking search data collection. (Montini, Horni, Rieser-Schüssler, & Axhausen, 2012) carried out a smartphone-based GPS tracking study to understand the parking search process in both Zurich and Geneva. Their results show that parking search traffic is not substantial and depends largely on the district in the case of Zurich. However, the data neither contains information on the purpose of the trip nor socio-demographic attributes of the drivers.

(Weinberger, Millard-Ball, & Hampshire, 2020) examines parking search behaviour in San Francisco, CA and Ann Arbor, Michigan using both vehicle- and smartphone-based GPS data. Their results show that parking search occurs in less than 6% of vehicle trips and accounts for less than 1% of vehicle travel. However, as the data is pseudonymized, it also lacks socio-demographic information. Also, for the vehicle-based data, information on the trip destination is also not available.

This paper presents the first results of our analysis parking search behaviour in Zurich, Switzerland using already segmented and labelled GPS data collected from a smartphone-based GPS tracking app. In addition, the data includes both trip purpose, socio-demographic and mobility tool ownership information, allowing for the analysis of parking search as a function of both trip purpose and parking availability at the destination.

2. METHODOLOGY

This section briefly presents the methodology used for estimating parking search from GPS data. The approach requires GPS data segmented into trips, in turn subdivided into stages, and activities, each labelled with the transport mode used and trip purpose, respectively. In this study, the data was segmented and labelled with the transport mode by the GPS tracking app "Catch-my-Day" (MotionTag GmbH, 2019a) developed by MotionTag GmbH (MotionTag GmbH, 2019b), whereas the trip purposes were imputed using machine learning as described in (Gao, Molloy, & Axhausen, 2021).

The segmented and labelled trips, that is the series of stages between two activities, are processed and filtered such as to extract reasonable car trips to further analyze for parking search behaviour. First, all car stages are filtered based on their average speed, total length and duration. In this study, car stages with an average speed between 1 and 150 km/h, a minimum distance of 500 m and a minimum duration of 5 minutes are considered valid. Entire trips are then considered valid only if they consist of a single valid car stage, including one preceding and/or following walk stage. Trips consisting of any additional stages are discarded. Finally, entire trips of over 5 hours are also excluded.

Given that car trip distances can be particularly long, only the GPS data within a buffer radius around the destination activity are considered for further parking search analysis, as this is assumed to be the area where actual parking search actually happens. In this study, a buffer radius of 1 km is used. The car-labelled GPS points within this buffer are subsequently map-matched to the underlying OSM road network using the pgMapMatch algorithm proposed by (Millard-Ball, Hampshire, & Weinberger, 2019), which also provides a likelihood measure of the match. Only matches with a likelihood above 90% are kept. The least-cost path in terms of travel time is then computed between the start and end points of the map-matched path using the pgRouting Turn Restriction Shortest Path algorithm (pgRouting, 2021).

Finally, the excess travel distance d_{excess} is computed as the difference between the map-matched and least-cost path distances as:

$$d_{excess} = d_{map-matching} - d_{least-cost} \tag{1}$$

3. RESULTS AND DISCUSSION

The parking search analysis is conducted on GPS data obtained via the MOBIS study (Molloy, Castro Fernández, et al., 2021; Molloy, 2021). This large-scale randomized controlled trial of transport pricing in Switzerland was carried out between September 2019 and January 2020, where individual mobility behaviour was recorded using a smartphone-based tracking app. The app groups the recorded GPS points into stages and activities, and imputes travel modes. Over 3,500 participants using a car at least two days a week, aged between 18 and 65 and living within the German- or French-speaking regions of Switzerland participated in the tracking study. Additional surveys were administered to collect socio-demographics, mobility tool ownership and parking availability information at home and at work, among others.

For the current study, the described parking search methodology is applied to a random sample of 1'166 trips all terminating within the city of Zurich. The excess travel distance d_{excess} is computed as in (1) and the resulting distribution is shown in Fig. 1. For 73 trips (6.3% of the sample), $d_{excess} < 0$, meaning that $d_{least-cost} > d_{map-matching}$. This can occur in cases where a slight deviation in the trip end point yields two different least-cost routes, for example, due to turn restrictions or one-way streets. These negative d_{excess} values are thus the result of an overestimation of $d_{least-cost}$ due to these deviations, and d_{excess} should in fact be zero. However, since it is equally possible that some of the positive d_{excess} values should also be zero due to an underestimation of $d_{least-cost}$ using the same reasoning, these negative values are not removed from the data. When taking the average over all trips, these effects cancel out, resulting nevertheless in a positive excess travel distance of 100 m.

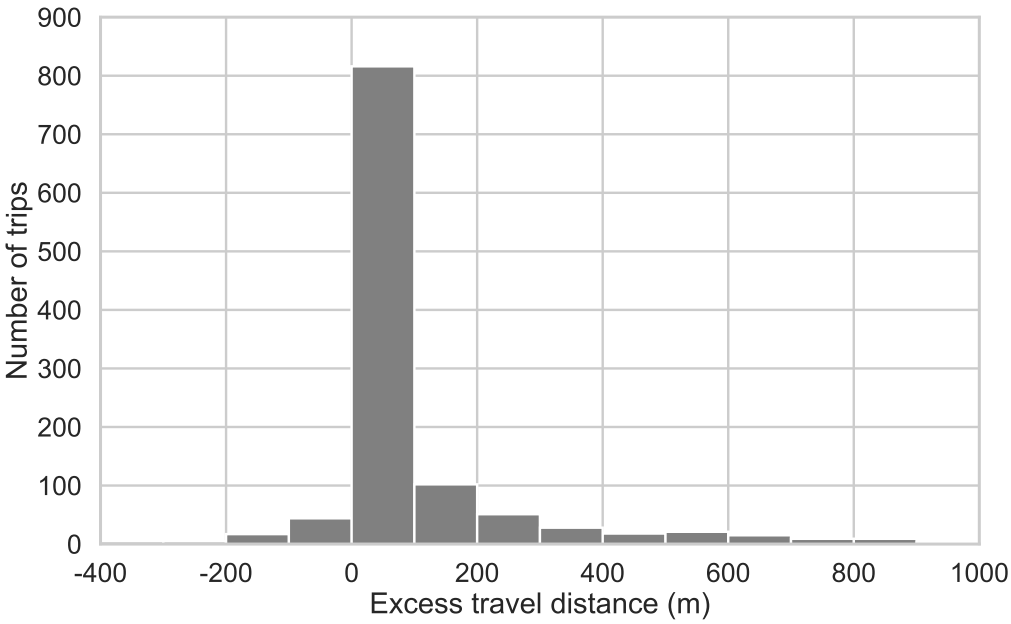

Figure 1: Distribution of excess travel distance across sample trips

However, parking search distance is expected to depend on the availability of parking at the destination, which in turn depends on the destination activity itself. Indeed, one might expect parking search to be less pronounced in areas with high parking availability (e.g., at work where dedicated parking is more common, or at home) and more pronounced in areas with low parking availability (e.g., at shopping or leisure activities in the city centre). Table 1 shows the average computed excess travel distance by activity purpose along with the corresponding number of trips, with the distances in ascending order. Trips performed to work and home exhibit the shortest excess travel distance, at 76 m and 104 m respectively, whereas leisure trips show the longest distance at 128 m, corresponding to a 68% relative increase.

Table 1: Excess travel distance by activity purpose

Activity purpose	Excess travel distance (m)	# trips
Work	76	422
Home	104	235
Other	109	147
Shopping	111	131
Leisure	128	231

The data is further analyzed in terms of parking availability at home and type of parking used at work. An additional survey was sent to participants after the tracking study asking them questions related to their parking situation both at home and at work. Respondents were asked if they had parking available at home or whether they parked on-street, and whether they most often parked on-street, in a parking lot or in a parking garage when driving to work. Of the 547 participants in the sample, 209 responded to the additional parking survey, corresponding to 170 work trips and 74 home trips.

Table 2 shows the excess travel distance for work trips differentiated by the most-used type of parking as specified in the survey, along with the corresponding number of trips. Participants who claim to most often park in a parking garage exhibit the shortest excess travel distance attributed to parking search at 46 m, closely followed by those who park in a parking lot at 66 m. However, participants who claim to most often park on-street show a substantially longer excess travel distance of 175 m, nearly 3 times more than those who park in a parking lot and nearly 4 times more than those who park in a parking garage.

Table 2: Excess travel distance for work trips by parking type

Type of parking	Excess travel distance (m)	# trips
Parking garage	46	39
Parking lot	66	86
On-street parking	175	45

Similarly, the excess travel distance for trips to home dependent on parking availability are presented in Table 3. Participants who claim to either own or rent a parking space at or near their place of residence are considered to have parking available at home, whereas the others are assumed to have to rely on on-street parking. Participants without parking available to them at home show an average excess travel distance of 101 m, nearly double the distance of those who have parking available (53 m).

Table 3: Excess travel distance for home trips given parking availability

Parking available at home	Excess travel distance (m)	# trips
Yes	53	67
No	101	7

Although the current study focuses on a sample of trips ending within the city of Zurich, more data is available, both for Zurich as well as throughout Switzerland. Future work would thus focus on the entire data set, allowing the analysis of both spatial and temporal variability as well as the consistency of parking search behaviour for a given driver. In addition, parking location data is available for the city of Zurich, allowing for the analysis of parking search behaviour as a function of the density of available parking. At the onset of the Covid-19 pandemic, participants were invited to participate in the follow-up MOBIS:COVID-19 study (Molloy, Schatzmann, et al., 2021), aimed at understanding the impacts of the pandemic on mobility in Switzerland. Thus, it would be possible to examine whether parking search behaviour was affected by the shifts in mobility behaviour during the pandemic.

4. CONCLUSIONS

Using segmented and labelled GPS data collected from a smartphone-based GPS tracking, this study analyzes the extent of parking search behaviour in Zurich, Switzerland, as well as how this depends on the purpose of the trip and the availability of parking at the destination. GPS data corresponding to over 1,000 car trips ending within the city of Zurich are map-matched to the underlying OSM road network, and the least-cost path between the trip start and end points are then computed on the same network, with the difference in path length assumed to be attributed to parking search behaviour.

The computed excess travel distance, attributed to parking search, is found to be marginal when computing the average across all trips, and equal to 100 m, indicating that parking search is not prevalent in Zurich. However, the analysis also shows that this excess travel distance also depends on both trip purpose and parking availability.

Trips performed to work and home exhibit the shortest excess travel distance, at 76 m and 104 m respectively, whereas leisure trips show the longest distance at 128 m, corresponding to a 68% relative increase. The availability of parking at home and type of parking at work also play a strong role, with on-street parking leading to longer excess travel. More precisely, participants who park on-street at work show a substantially longer excess travel distance of 175 m, nearly 3 times more than those who park in a parking lot and nearly 4 times more than those who park in a parking garage. Participants who park on-street at home show an average excess travel distance of 101 m, nearly double the distance of those who have parking available.

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