Introduction

In a context where technology evolves rapidly, modes of transportation are diversifying and interactions between them are becoming more complex. In case of an event such as a metro service disruption, users sometimes turn to other transportation alternatives to complete their trips. Therefore, such an event is expected to impact travel demand of various transportation modes such as transit. Availability of continuous data flow from many modes enables the quantification of this fluctuation in ridership.

The objective of this analysis is to evaluate the impact of events on ridership fluctuation of several modes. Events considered include transportation service disruptions, weather events and various activities (sporting events, festivals and concerts). It is expected that the effect of an event varies according to the location, the time period and the duration of each event. Such an analysis allows a better understanding of how such phenomena influences travel demand. This information could allow a more dynamic adaptation of the transportation service supply to match travel demand based on those events. It could enable transportation operators to improve their service and reduce operation costs.

Data

The case study focuses on the city of Montreal given that there are various transportation alternatives and trip data availability. The analysis period runs from 2015 to 2017 inclusively and relies on working days only. Transactional data include trip information from metro and bus smart card validation system, Bixi bikesharing transactions and Taxi Diamond rides (about 25% of the total taxi fleet). Trip information include the date, time and the origin-destination location (except for bus and metro where only boardings are available).

External data include meteorological data collected hourly at Pierre-Elliott-Trudeau airport station. Meteorological data contains information such as temperature, humidity, wind speed and a qualitative description of the weather. Another database includes 3,051 metro service disruptions between 2015 and 2017 lasting 5 minutes or more. Moreover, a database of 1,323 activities (such as sporting events, festivals and concerts) around the metro network compiled by the Transit Authority is used to identify major events, their location and their duration.

Methodology

To analyse ridership at the system level, trips are aggregated by hour and by metro station neighbourhood. A metro station neighbourhood is defined as the area within an 800-meter network distance from its location. Aggregating trips by metro station neighbourhood simplifies the spatial component of the analysis by reducing the number of possible locations. Those areas are not mutually exclusive which means that areas might overlap for stations that are close to each other, so that trips can be influenced by what is happening at two different metro stations.

Explanatory models are developed in order to evaluate the impact of different factors on ridership fluctuation. Different models are calibrated for each combination of mode and station, in order to observe spatial and modal correlations. The dependant variable is the number of hourly trips initiated for a mode at a specific station, whereas the independent variables are related to weather, service disruptions and events around the station. According to the mode, some dummy variables are added to account for trip fluctuations due to daily and weekly cycles. Significant variables are selected using cross-validation.

Two types of models are compared: a multiple linear regression model and an ARIMAX model. The ARIMA model is an autoregressive model for time series that accounts for seasonality effect, in this case the hours of the day. The ARIMAX model is an extended version of it that also includes explanatory variables. Performance of the two models is estimated by cross-validation, using two years of data as the training set and the remaining year as the test set.

Preliminary results

Models have been calibrated for bikesharing and taxi trips originating around one metro station located in a central area (Mont-Royal metro station). Linear regression and ARIMAX models lead to similar results, but the ARIMAX model seems better since the cross-validation error is slightly lower. Around the Mont-Royal metro station, a service disruption longer than 8 minutes seems to have a significant impact on bikesharing trips. During service disruptions, the hourly number of bikesharing trips increases by 16% around the station. Bikesharing trips also increase with temperature, except for temperatures higher than 26 °C (79 °F) where it starts decreasing. The presence of rain in the past 3 hours reduces the number of bikesharing trips by about 20%.

For taxi trips around the Mont-Royal station, a service disruption longer than 6 minutes seems to have a significant impact. The number of taxi trips increases by about 14% during an hour when such a disruption happens. The presence of rain increases the number of trips by 14% while snow causes a 6% increase.

Comparing results from different stations will allow to identify spatial trends across the island of Montreal. Also, developing similar models for metro and bus trips will help identify interactions between several modes.