canaccessR: An open data product for analyzing transportation accessibility to employment and grocery stores in Canada's largest metropolitan areas.

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Abstract

In this paper, we describe the {canaccesR} package, an open data product (ODP) created in R that contains public transit travel time estimates to employment locations and grocery stores across Canada's 12 largest metropolitan areas. We calculate travel time matrices (TTM) from and to each Dissemination Area (DA) within these regions for the years 2019 and 2023. We add value to the urban analytics community by processing and integrating raw data, and disseminating user-ready data in the domain of transportation accessibility in Canada. To do so, we use the {r5r} R package, General Transit Feed Specification (GTFS), OpenStreetMap (OSM), DMTI's Enhanced Points of Interest, and Statistics Canada Census data. This data package can be used by researchers, practitioners, and transit agencies to estimate accessibility levels to these two essential destinations within these urban areas. Moreover, these estimations can be used as inputs in equity and inequalities assessments, through the comparisons of within and across accessibility levels found throughout Canada's largest metropolitan areas. Consequently, we expect to contribute to informed and data-based decision making in transportation by disseminating these data. We hope that these datasets can substantiate future improvements in policy-making that may lead to greater justice in the country's urban transportation systems. The package is still in its initial phase and may undergo expansions in the future by adding TTM's for other destinations (e.g., schools, healthcare facilities). Finally, as an ODPs, the {canaccess} package allows for open exploration, use, and contribution by users through its GitHub repository.

Keywords

Public transit accessibility; open data products (ODPs); R data package; travel time matrices.

Introduction

The objective of this paper is to describe the {canaccesR} open data package. Its main contents are a set of public transit travel time matrices (TTM) estimates to employment and groceries stores from the 12 largest Canadian metropolitan areas in 2019 and 2023. The results are stored at the Dissemination Areas (DA) * level, yielding origin-destination pairs containing information on travel time by public transit, population, and total employment within each metropolitan area. These estimates were created by leveraging expertise in data science, computer programming, and transportation accessibility using the {r5r} package (Pereira et al., 2021b). We used public transit schedule, transport network, population, and business location data from different sources to estimate these TTM's datasets.

*Dissemination Areas are the smallest publicly available spatial unit provided by Statistics Canada (Government of Canada, 2021).

Estimating accessibility - the potential offered by the transportation system to reach destinations (Páez et al., 2012) - requires specialized datasets and technical expertise. Recent efforts following an open-source and transparent philosophy have been made to disseminate useful data and information on transportation in the Canadian context (Soukhov and Páez, 2023). However, despite these initiatives, pre-processed and available data that allow for the ease estimation of accessibility indicators are still scarce. Within this context, we expect to help filling this gap by the processing raw into user-ready data and making them publicly available to advance knowledge on the field. Our main contribution is to provide analysis-ready data for Canada's largest cities on the topic of transportation accessibility, thus making urban analytics in the country more accessible and contributing to future research and data-based decision making.

The package's main audiences are Canadian researchers in urban planning and transportation and transportation system agencies. We anticipate three primary uses for the open data product (ODP) described in this paper. First, the datasets allow for static assessment of the level of public transit accessibility across the country's largest cities before and after the COVID-19 pandemic. In other words, {canaccesR} makes it easier for those interested in comparing cities regarding their level of public transit accessibility to essential destinations (such as employment centers and groceries stores) to do so. Second, the temporal and spatial characters of the datasets made available here allow researchers to evaluate accessibility changes through time and across space within the largest Canadian urban areas. Third, as is now common practice in transportation accessibility research, used as inputs, these estimates can substantiate broader investigations on transportation justice and equity (Higgins et al., 2021; Humberto, 2023; Pereira et al., 2021a). For example, the TTM estimates allow for evaluating the evolution of public transit's accessibility by income or spatial distribution across all Dissemination Areas (DA's) of each of the 12 cities in the sample (Parga et al., 2024). In other words, the package's contents can be used from straightforward assessments of accessibility in Canadian urban areas to more theoretically and morally complex evaluations of justice in the country's urban transportation system.

Besides this introduction, we organize this paper as follows. The next section contains a description of the data sources we used to construct the data package. Then, we recount the data processing necessary to create the package. Next, we go through the main contents of the data package, i.e., the travel time matrices estimated through our analysis. We present some basic descriptive statistics of these datasets, and elucidate how one can use them in accessibility analysis. Finally, we conclude by explaining how we expect {canaccesR} to contribute to the urban analytics and science community.

Data and methods

Raw data sources

The locations included in the data package comprise the 12 largest (population-wise) Census metropolitan areas (CMA's) based on the 2016 Canadian Census (Government of

Canada, 2016) [†]. These locations are Toronto, Montreal, Vancouver, Ottawa-Gatineau, Calgary, Edmonton, Quebec City, Winnipeg, Hamilton, Kitchener-Cambridge-Waterloo, London, and Halifax. We used four main data sources to construct the {canaccesR} data package: General Transit Feed Specification (GTFS), OpenStreetMap (OSM), DMTI's Enhanced Points of Interest, and Statistics Canada Census data.

We manually collected and processed the GTFS files from all transit agencies within the selected CMA's to use their information on the public transit schedule in 2019 and 2023. The OpenStreetMap data for the selected areas were collected through the {osmextract} package (Gilardi and Lovelace, 2025). We used OSM data from 2019 and 2023, which provided information on the areas' transit network in two points in time. We collected data from the 2016 Canadian Census using the {cancensus} package (von Bergmann et al., 2022) and used its information on the spatial distribution of the population and the number of workplace locations (employment) across the CMA's (Government of Canada, 2016). Finally, we gathered and cleaned the 2023 DMTI's Enhanced Points of Interest dataset to obtain the location of the groceries stores within every urban area selected (Inc., 2015). We filtered the locations within the DMTI dataset using the grocery stores code from the North American Industry Classification System (NAICS) and the Standard Industrial Classification (SIC). {**THE CODE FOR THIS ESTIMATIONS AND THE TRAVEL TIME MATRICES IS ON THE transit_death_spiral github repo. 1) SHOULD WE CITE IT? 2) IS THAT A PROBLEM?**}

Methods: travel time matrices processing

Using the {r5r} package, we estimated public transit travel times for two destination types, grocery stores and jobs. For each amenity type, we chose a likely travel time and day of the week. We set a 15 minutes time window and the maximum trip duration to 120 minutes. The estimated times are the median of the 15 minute time window. For groceries stores, we set the departure date to a weekend afternoon and the departure time to between 12:00 PM to 12:15 PM on April 20, 2019 and April 22, 2023. For employment, we ran the analysis on a typical weekday morning rush-hour commute, more specifically 8:00 to 8:15 AM departure on Tuesday, April 16, 2019 and Tuesday, April 18, 2023 [‡]. In both cases, we assumed that walking was the mode of travel from origin to transit stop and from transit stop to destination. We aggregated all the resulting travel time matrices at the Dissemination Area (DA) level, which comprise the fundamental unit of analysis in data package.

[†]We included Oshawa, Ontario, as part of the Greater Toronto Area (GTA) because of the former's proximity to the latter. We also included Abbotsford-Mission, British Columbia, as part of the Vancouver metropolitan area because of the former's proximity to a transit station on the region's West Coast Express commuter rail line.

[‡]The one exception is Quebec City, where the routing for 2019 occurs on a Saturday and Tuesday in June (instead of April) due to the GTFS data unavailability.

{canaccessR}'s contents

The package contains the following contents: travel time matrices, socio-economic and demographic data disaggregated at the DA level, the CMA areas' boundaries and backgrounds for plotting the data spatially, and aggregated statistics.

The main contents of the {canaccessR} package are the travel time matrices. These matrices (datasets) comprise the estimated travel time by transit from and to each origin and destination Dissemination Area pairs. The datasets also feature the total population in the origin DA and the total employment in the destination DA. Besides these information, the matrices contain the unique origin and destination DA codes, region and name identifiers, the year in which the travel times refers to, and the date and time of departure for a trip that originates at the Dissemination Area of origin. There are two matrices for each metropolitan area, one containing the travel times to jobs and the other to groceries stores [§]. These information can be turned into spatial data using the socio-economic and demographic datasets.

The socio-economic and demographic data contain other information disaggregated at the DA level for each CMA. These refer to total population by age groups, number of dwellings, number of individuals below the Low Income Measure, etc. The aggregated statistics refer to population aggregates (for the selected CMA's) and transit revenue and ridership data aggregated by regional and national scale.

Below, we present some descriptive statistics from the travel time matrices contained in the {canaccessR} package.

How to use {canaccessR}

This section presents some potential applications of the data package.

Concluding remarks

In this paper, we describe the {canaccesR} data package, created using the {r5r} package and transit schedule, street network, employment, and population data. The package's main contents refers to the ready-to-use travel time matrices for public transit to reach employment and groceries stores in Canada's 12 largest urban areas. We expect the contents of the package to be used in transportation accessibility evaluations within and across those regions. Moreover, these datasets can be used in further equity assessments that evaluate the distribution of accessibility across space and between social groups. Furthermore, in the spirit of open data products (Arribas-Bel et al., 2021), the package can be expanded through collaboration with other researchers by, for example, including travel time matrices to other essential destinations within the DMTI's dataset (*e.g.*, schools, healthcare, etc.). In other words, we hope that by making these datasets publicly available, future analysis can contribute to making Canada's transportation system

[§]The information from Toronto, Hamilton, and Waterloo are aggregated at the Greater Golden Horseshoe travel time matrices, making it 20 datasets in total.

more just and fair, considering accessibility's as the main social good of transportation (Martens, 2016), and the inherent connection between public transit and the "right to the city" (Coggin and Pieterse, 2015).

Declaration of Conflicting Interests

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Data availability statement

The {canaccessR} data package can be found and installed on its Github respository.

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