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canaccessR: An open data product for transit accessibility analysis in Canada's largest metropolitan areas.

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Abstract

In this paper, we describe the {canaccessR} 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, travel time matrices are computed from DA centroid to DA centroid, which means that they can be adapted for use in applications with any type of destination that is aggregated at the DA level. Finally, as an ODP, 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 {canaccessR} open data package. Open data products are a core element of reproducible research in the spatial sciences (Páez, 2021), and facilitate access while adding value to data (Arribas-Bel et al., 2021). The main contents of {canaccessR} are a set of public transit travel time matrices (TTM) estimates to Dissemination Areas (DA) * as a set of standard Census zones, as well as to grocery stores as points. In addition, employment data at the level of DAs are also furnished. These matrices are provided for the 12 largest Canadian metropolitan areas in 2019 and 2023, representing approximately 55% of the Canadian population. The matrices include travel time for origin-destination pairs containing associated travel time by public transit, population, total employment, mode share, and other relevant census variables and spatial shape boundaries for each metropolitan area. This data package was created by leveraging expertise in data science, R programming, and transportation analysis. It includes .Rmd notebooks written for computing travel time matrices for large sets of destination pairs using the {r5r} R package (Pereira et al., 2021b). Overall, {canaccessR} offers 52 complementary objects ready for temporal and spatial analysis and, between groceries and DAS, travel times for almost 120 million origin-destination pairs. The package is an analysis-ready product based on a fusion of data sources, including public transit schedules (GTFS files), road and transit networks, census data, and filtered business location data.

TTMs are a core piece of information required for many tasks in transit and transportation planning. As an example, TTMs are essential for the analysis of accessibility—the *potential* for spatial interaction offered by the transportation system (Páez et al., 2012). 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, readily available pre-processed data that facilitate the estimation of accessibility indicators remain scarce. Within this context, we aim to help fill this gap by processing raw data into analysis-ready formats and making them publicly available to advance knowledge in the field. Our main contribution is to provide easily accessible transportation accessibility data for Canada's largest cities, thus making urban analytics in the country simpler and more affordable, thus contributing to future research and data-driven decision-making.

The package's main audiences are Canadian researchers in urban planning and transportation, as well as transit agencies. We anticipate three primary uses for the open data product (ODP) described in this paper. First, the data sets 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, {canaccessR} makes it easier for those interested in comparing cities regarding their level of public transit accessibility to essential destinations (such as employment centers and grocery stores) to do so. Second, the temporal and spatial characters of the data sets made available here allow researchers

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

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). As an example, the TTM estimates allow for the evaluation of the evolution of public transit’s accessibility by income or spatial distribution across all Dissemination Areas (DAs) 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.

After this introduction, the paper is organized as follows: the following 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 data sets and elucidate potential uses. Finally, we conclude by explaining how we expect {canaccessR} to contribute to the urban analytics and city science community.

Data and methods

Raw data sources

The locations included in the data package comprise the 12 largest (population-wise) census metropolitan areas (CMAs) based on the 2016 Canadian Census (Government of Canada, 2016) [†]. These locations are the surrounding Toronto, Montreal, Vancouver, Ottawa-Gatineau, Calgary, Edmonton, Quebec City, Winnipeg, Hamilton, Kitchener-Cambridge-Waterloo, London, and Halifax areas. We used four main data sources to construct the {canaccessR} 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 CMAs 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 CMAs (Government of Canada, 2016). Finally, we gathered and cleaned the 2023 DMTI’s Enhanced Points of Interest dataset to obtain the location of the grocery stores within

[†]We included Oshawa as part of the Greater Toronto Area (GTA) because of its proximity. Similarly, we included Abbotsford-Mission as part of the Vancouver metropolitan area due to its proximity to a transit station on the region’s West Coast Express commuter rail line.

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).

Methods: travel time matrices processing

We used the {r5r} R package to estimate public transit travel times for two destination types, grocery stores (points) and DA centroids (zones). For each we chose a likely travel time and day of the week. We set a 15-minute time window and the maximum trip duration to 120 minutes. The estimated times are the median of the 15 minute time window. For grocery 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 DAs, 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 DA level, which comprise the fundamental spatial unit of analysis in the data package.

{canaccessR}'s contents

Specifically, the package contains the following contents: 10 *data.frame* objects containing the calculated public travel times from DA centroids to grocery stores and another 10 for DA centroids to DA centroids. Notably, the {travel_matrix_grc_ggh} *data.frame* is named after the acronym for the Greater Golden Horseshoe area, which includes the CMA regions of Toronto, Hamilton, and Kitchener-Cambridge-Waterloo. The 20 travel time *data.frames* represent public transit travel times for all 12 CMAs across two sets of destinations. Next, 10 *sf* objects represent census data for each DA, including dwelling counts, population by age bracket, single-parent-headed households, low-income prevalence, official language knowledge, housing quality, ownership and affordability variables, visible minorities, newcomer- and immigration-related variables, educational attainment, and commuting mode shares. Furthermore, 10 and 10 *sf* objects represent the CMA areas' boundaries and backgrounds for plotting the data spatially, respectively. Finally, 2 *data.frames* contain aggregated population and transit statistics at the CMA level.

We now present some descriptive statistics from the travel time matrices contained in the {canaccessR} package. Table ? summarizes the travel time estimates. The travel time objects contain, in total, 97,784,850 origin-destination pairs (observations) from population to employment locations for all the DAs in the sample and 18,519,897 pairs from population to grocery stores. Considering all areas combined, the mean travel time to jobs was 78 and 76 to grocery stores.

[‡]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.

Study Region Name	Destination	Observations	Mean	Sd	P25	P50	P75
All regions	Employment	97,784,850	78	25	59	80	99
Toronto	Employment	41,038,062	82	25	64	85	103
Montréal	Employment	30,091,411	76	25	57	77	97
Vancouver	Employment	12,254,478	76	25	58	77	96
Calgary	Employment	3,022,244	75	23	59	75	91
Ottawa	Employment	2,936,912	74	24	56	74	93
Edmonton	Employment	2,057,486	70	23	53	70	87
Québec City	Employment	1,473,702	72	25	54	72	93
Winnipeg	Employment	1,574,205	62	22	46	61	76
Hamilton	Employment	2,089,172	82	28	61	87	106
Waterloo	Employment	552,826	71	27	49	69	93
London	Employment	415,174	61	21	46	60	74
Halifax	Employment	279,178	66	25	47	65	84
All regions	Groceries Stores	18,519,897	76	26	56	76	97
Toronto	Groceries Stores	8,512,874	80	25	61	82	101
Montréal	Groceries Stores	2,993,965	73	26	53	74	94
Vancouver	Groceries Stores	4,540,106	73	25	53	74	93
Calgary	Groceries Stores	502,757	70	22	54	70	86
Ottawa	Groceries Stores	619,791	72	24	55	72	91
Edmonton	Groceries Stores	324,030	68	23	51	67	84
Québec City	Groceries Stores	234,600	70	26	51	70	89
Winnipeg	Groceries Stores	362,566	58	21	43	57	72
Hamilton	Groceries Stores	281,118	84	29	60	91	110
Waterloo	Groceries Stores	44,726	66	28	44	62	90
London	Groceries Stores	52,617	55	19	42	55	67
Halifax	Groceries Stores	50,747	63	26	42	63	83

{canaccessR} usage

This section presents a usage example of the package through a visual representation of its data. In Figure ?, we show the spatial distribution of the travel time matrices for the metropolitan region of Montréal. In it, we see the median travel time from each DA to employment (left) and to grocery stores (right). The plot shows that moving away from the city core increases the necessary travel time by public transit to reach both employment locations and grocery stores. This result is expected for employment, given the typical concentration of this type of opportunity in downtown centers, but it also points out at a distribution of grocery stores that also requires increased travel for non-central city residents.

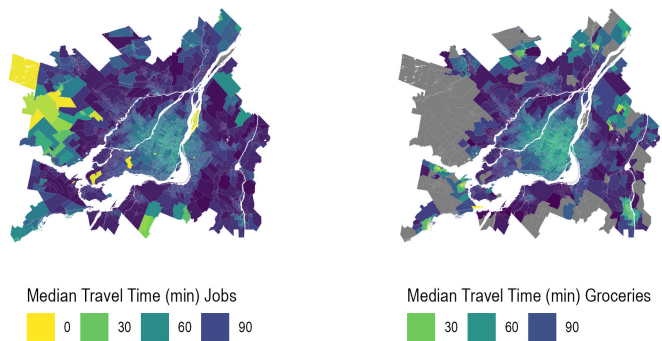


Figure 1. Estimated median travel time (minutes) per Dissemination Area to jobs (left) and grocery stores (right). Public transit travel times are calculated using *r5r* (Pereira et al., 2021), and DA and planning boundaries of the Montréal metropolitan area use Statistics Canada data (Statistics Canada, 2016).

A more thorough example of the package’s use can be found in the School of Cities’ recent report on Canada’s Urban Infrastructure Deficit. In its 11th Chapter, we use the travel time matrices to estimate accessibility metrics to jobs and grocery stores before and after the pandemic (Parga et al., 2024). We then compare how changes affected groups differently according to their spatial distribution and income level, thus making explicit the connection between the package’s information and matters of equity in transportation. The report is freely available for download at the State of Cities Summit [website](#).

Since a set of travel time matrices (those labeled as *employment*) were computed from DA centroid to DA centroid, users of the package can easily incorporate any other type of opportunity aggregated at the DA level to expand the range of possible applications of the data package.

Concluding remarks

In this paper, we describe the `{canaccessR}` data package, created using the `{r5r}` package and transit schedule, street network, employment, and population data. The package’s main contents refer to the ready-to-use travel time matrices for public transit to reach employment and grocery 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 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

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Data availability statement

For peer-review purposes the package is shared as a source package. Once anonymity can be lifted, the address of the repository will be published.

The package can be installed locally in R from file canaccessR_0.0.1.tar.gz in this way:

```
install.packages("path_to_file/canaccessR_0.0.1.tar.gz",
  repos = NULL,
  type="source")
```

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