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# Incorporating Trip-Chaining in Access to Cash Metrics

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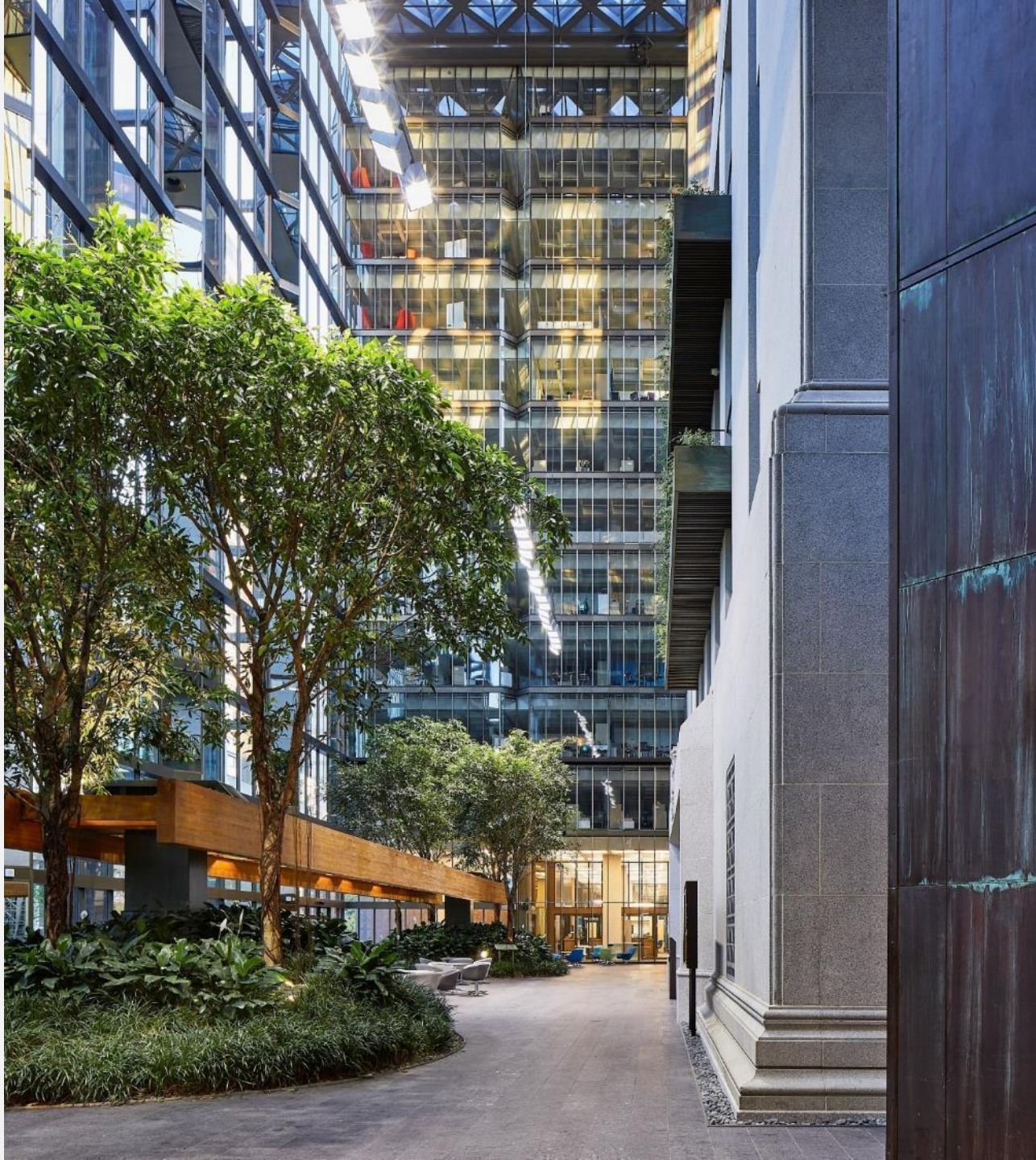


# Trip-Chaining is Widespread

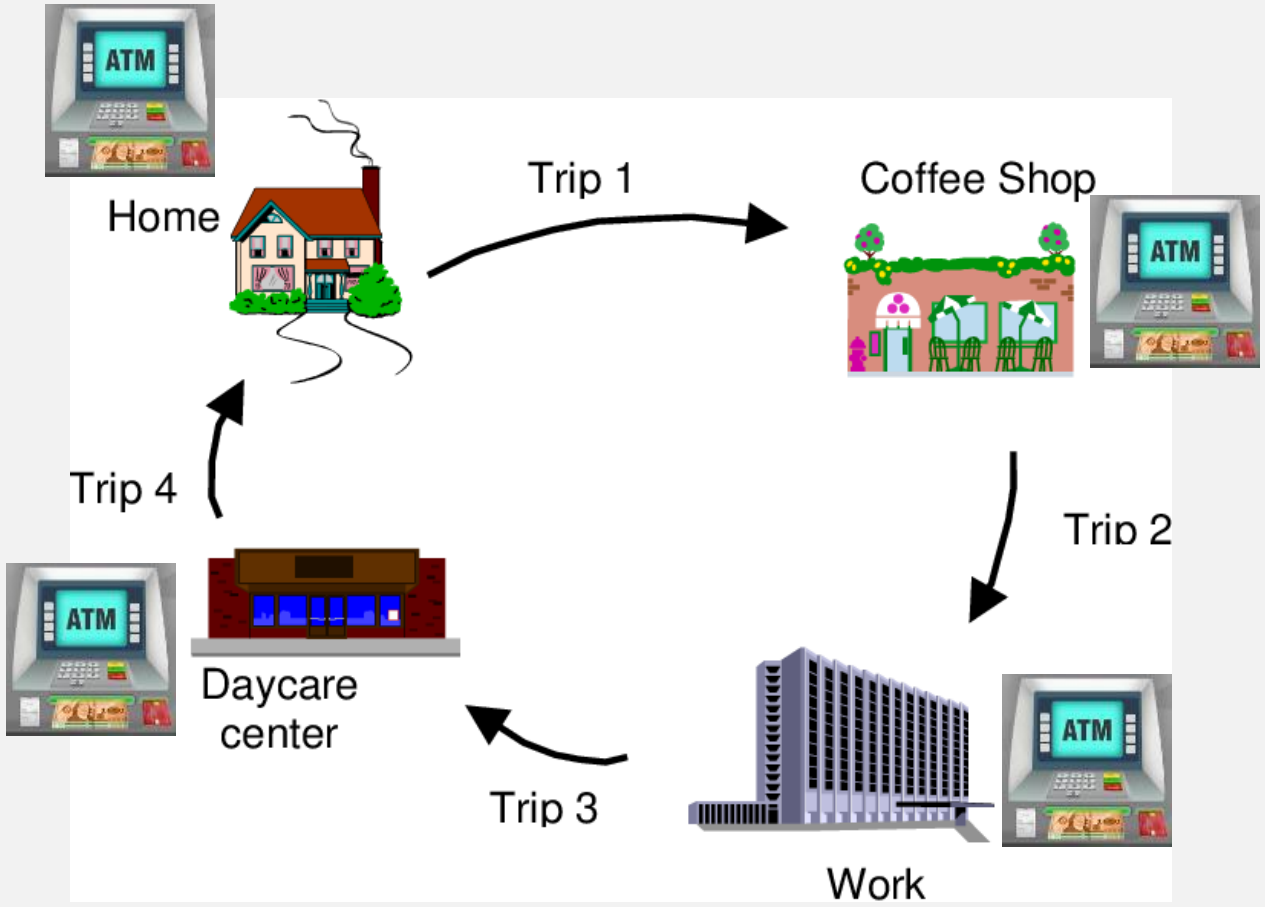
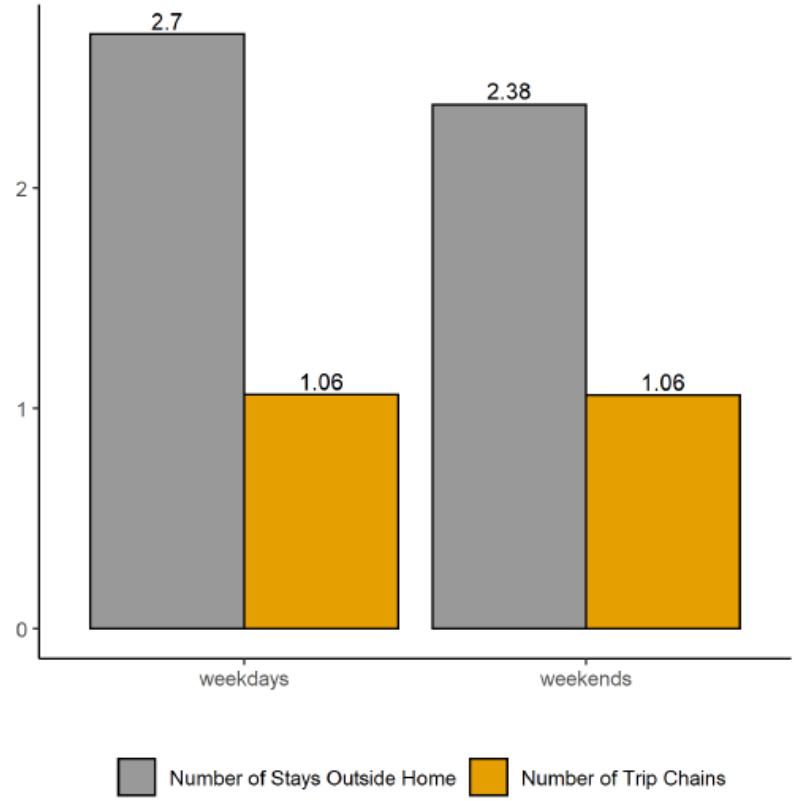



Figure 7: Frequency of Trip Chains

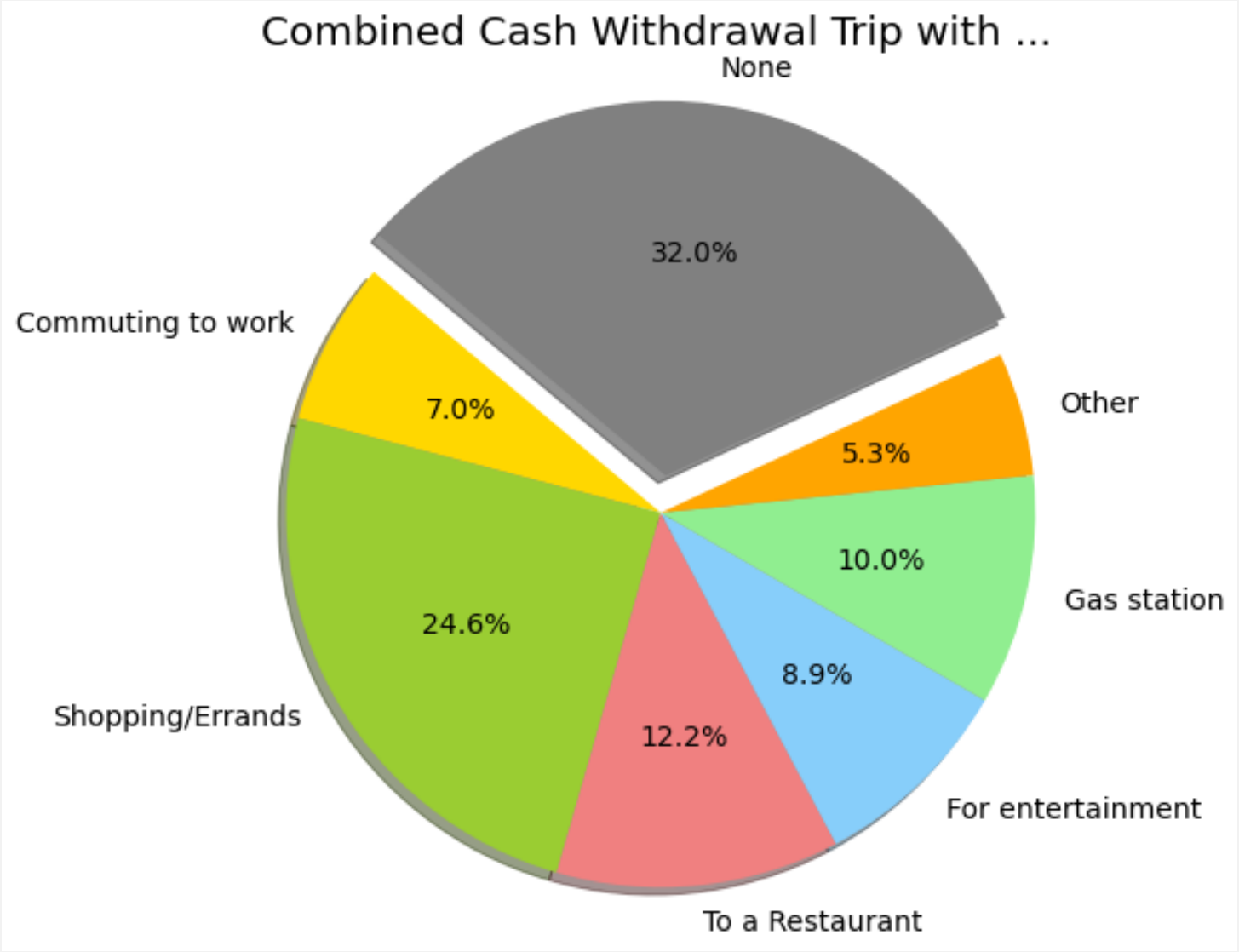
Miyauchi et al. (2022)



# Trip-Chaining affects Access to Cash

- 2023 MOP question for people who withdrew cash over the past week:

Did you **combine making a cash withdrawal with any of the following activities**?



# Current Access to Cash Metrics Ignore Trip-Chaining

- Usually, cost of accessing cash is computed **from the home location** to the nearest cash access point (ATM or Branch).
- By ignoring trip-chaining, these metrics **overestimate the cost of accessing cash for Canadians**.

# Research Objectives

Propose a methodology that incorporates trip chains to the travel-based access to cash metrics common in the literature ➔ Access to cash metrics 2.0

Apply the new metrics in the Canadian context.

# Table of Contents

# Access to Cash Metrics Comparison

| | Metrics w/o Trip-Chaining | **Metrics with Trip-Chaining** |
|---|---|---|
| Origin Points | Home locations | Home locations<br>or **popular Points-of-Interest (POI)** |
| Destination Points | ATM/Branch locations | ATM/Branch Locations |
| Travel metric | Driving Distance/Time | Driving Distance/Time |
| Data Needed | • Pseudo-population distribution<br>• ATM/Branch locations | • Pseudo-population distribution<br>• ATM/Branch locations<br>• **Consumer Mobility data to POIs** |

# Table of Contents

# Three Data Sources

- Distribution of household home locations from the Pseudo-Household Demographic Distribution from Statistics Canada (Data from the 2016 Census) => One set of potential origin points.

- Weekly Points-of-Interest (POI) visit data from Advan Patterns => The other set of potential origin points (explained in next slide), and household mobility data to understand households' travel patterns to POIs.

- Self-compiled ATM and branch locations from a variety of sources (Mastercard, FCAC, webscraping, etc.) => Set of destination points.

# Consumer Mobility Data from Advan

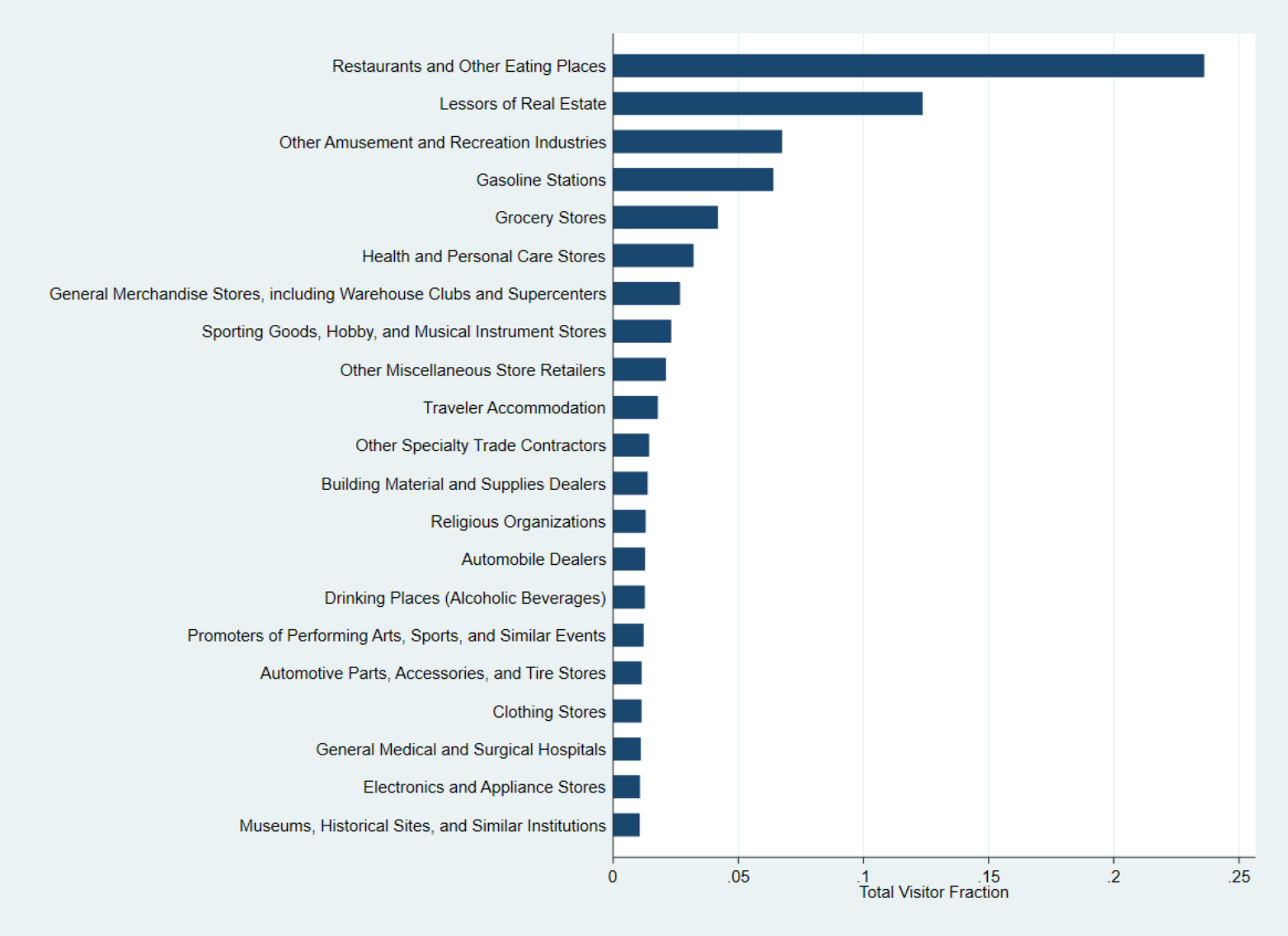
- Aggregated tracking data on a panel of around half a million mobile devices across Canada.
  - Each observation: weekly visits / visitors data for a point-of-interest (POI).
  - Use data from 11 consecutive weeks in 2022Q4.
- **Do observe the home dissemination areas (neighbourhoods of 400 to 700 people) for visitors. Example below:**

| Week Date | Location Name | Category | POI DA | Visitor Home DAs |
|---|---|---|---|---|
| October 27 | McDonald's | Restaurants | 24730150 | {24730163:4} |
| October 27 | Shoppers Drug Mart | Drug Stores | 24870064 | {24870050:4, 24870067:4, 24870096:4} |

Data limitation:

- **Do not directly observe sequence of stops for each tracked mobile device (i.e. trip chains).**

# Visitor Share by POI Category



Category/Catégorie: Non-Sensitive/Non-Délicat

# Table of Contents

# Step 1: Use household mobility data to compute the outflow probabilities across entire Dissemination Areas (DAs)

**No Trip-Chaining**

| Home DA | % staying home | % going to POIs in DA 1 | % going to POIs in DA 2 | % going to POIs in DA 3 |
|---|---|---|---|---|
| DA 1 | 100% | 0% | 0% | 0% |
| DA 2 | 100% | 0% | 0% | 0% |
| DA 3 | 100% | 0% | 0% | 0% |

**With Trip-Chaining**

| Home DA | % staying home | % going to POIs in DA 1 | % going to POIs in DA 2 | % going to POIs in DA 3 |
|---|---|---|---|---|
| DA 1 | 75% | 15% | 10% | 0% |
| DA 2 | 50% | 5% | 30% | 15% |
| DA 3 | 25% | 0% | 0% | 75% |

# Outflow probability $P(j'|j)$ Details

$$P(j'|j) \equiv \frac{\sum_{j'(k)\in\Omega_{j'}} v_{j\to j'(k)}}{Device_j}$$

- $Device_j$: number of devices residing in the DA j from the smartphone data
- $\sum_{j'(k)\in\Omega_{j'}} v_{j\to j'(k)}$: summation of unique visitors from the home DA j to the regularly visited POI $j'(k)$ in the DA j'
- Unique visitors are distinguished from raw visitors by 3 constraints:
  - Only counts regularly visited POIs, not one-time destinations. (Details)
  - Only counts DA pairs j and j' where there are regular flows between them. (Details)
  - Control for double counting of the same visitor to multiple POIs (trip-chaining) (Details)

# Step 2: Compute the trip-chaining metric as the weighted travel distance/time whose weights are the outflow probabilities

- For a given household $i$ in the Dissemination Area (DA) j, her trip-chaining (TC) distance to the nearest ABM (FI branch) $d_{ij}^{TC}$ is computed as:

$$d_{ij}^{TC} \equiv \sum_{j'=1,\cdots,j,\cdots,J} \left[ P(j'|j) \times \min\left(d_{j'(popular)}, d_{i(home)}\right)\right] + \left[1 - \sum_{j'=1,\cdots,j,\cdots,J} P(j'|j)\right] \times d_{i(home)}$$

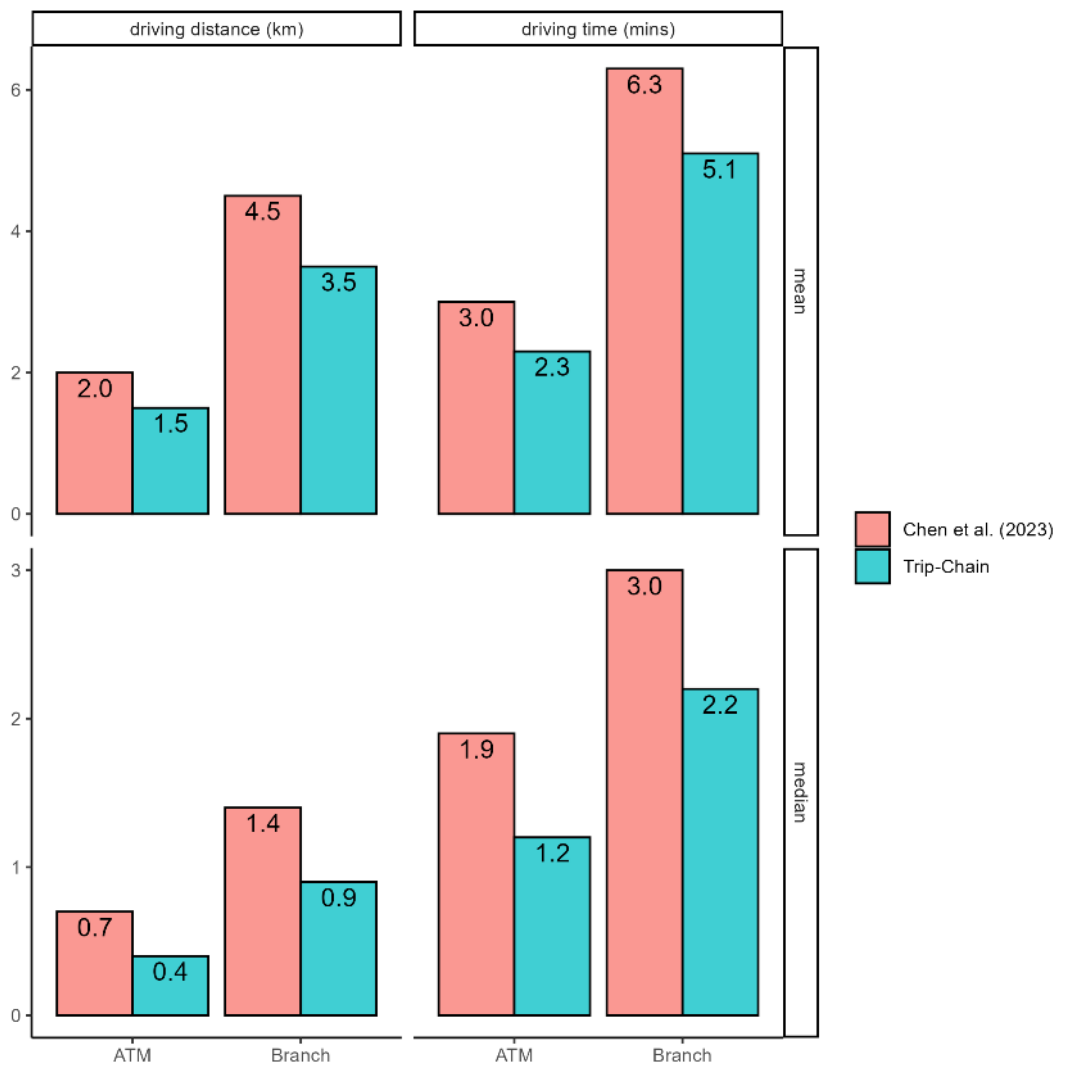
- $P(j'|j)$: Outflow probability from the DA $j$ to the DA $j'$
- $d_{j'(popular)}$: Travel distance to the nearest ABM (FI branch) from the most popular POI in the DA $j'$
- $d_{i(home)}$: Travel distance to the nearest ABM (FI branch) from the household $i$'s home. Note that for the previous metric that does not include trip-chaining:

$$d_{ij}^{non-TC} \equiv d_{i(home)}.$$

# Table of Contents

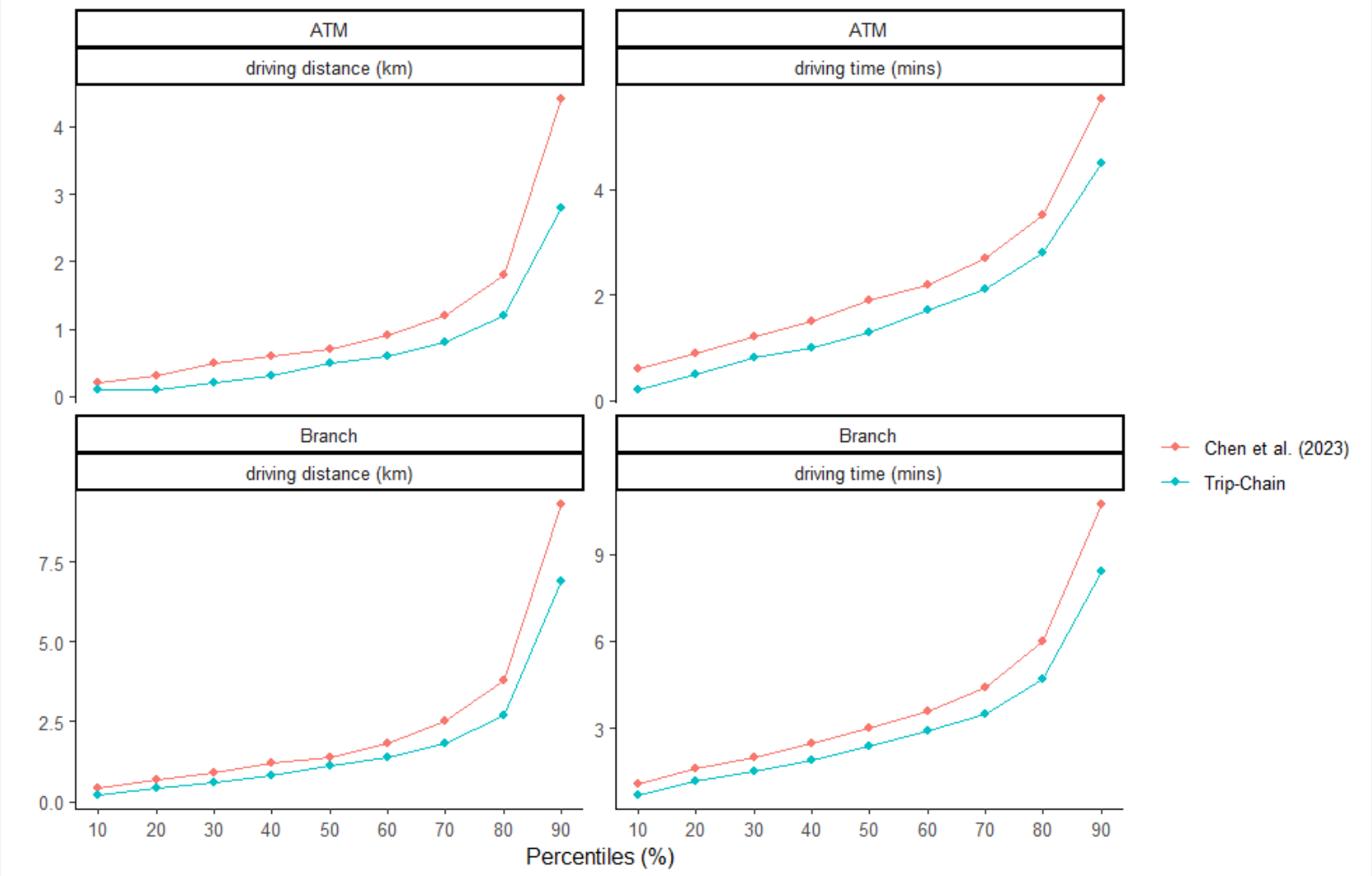
Category/Catégorie: Non-Sensitive/Non-Délicat

# Travel Cost of Accessing Cash is around 25% lower with trip-chaining

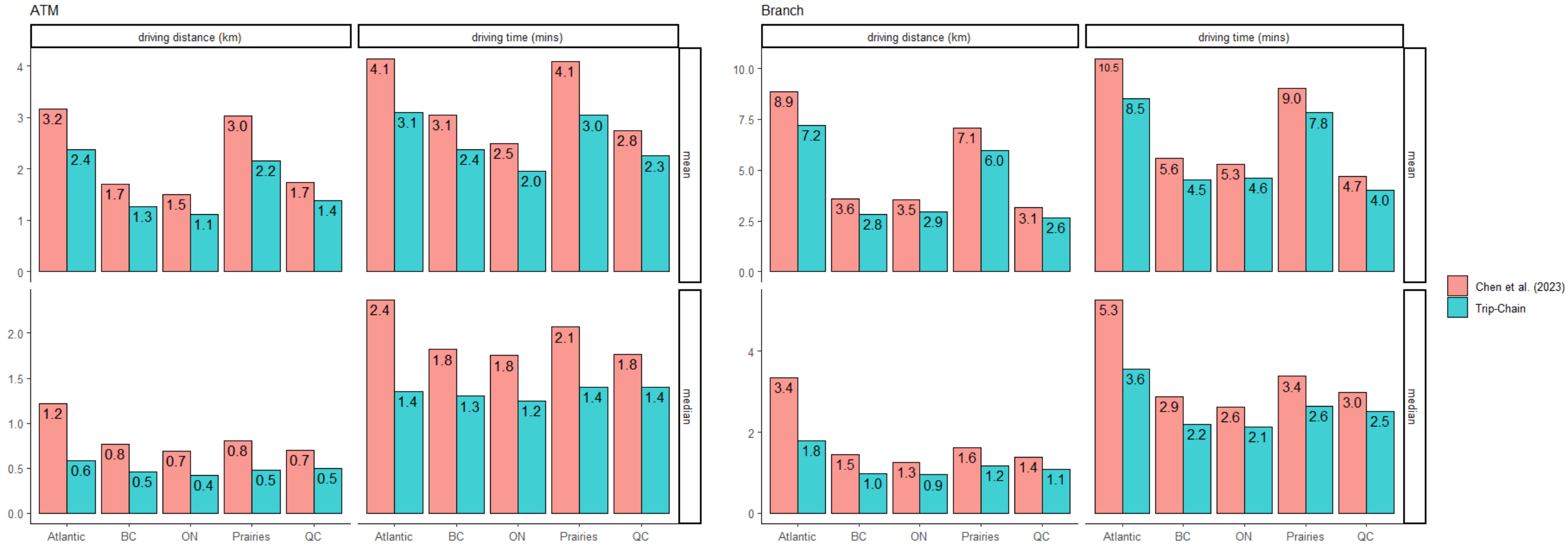


Category/Catégorie: Non-Sensitive/Non-Délicat

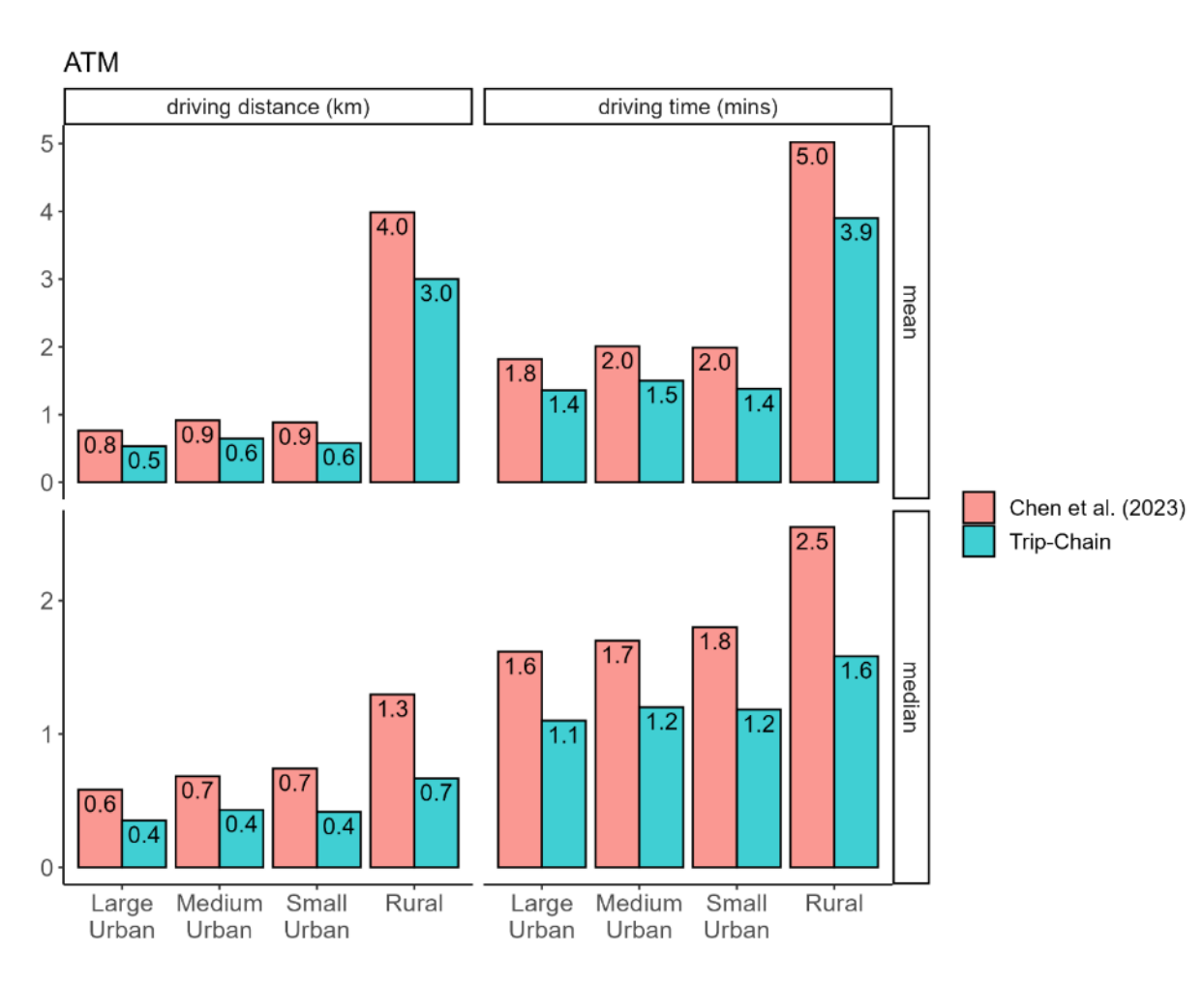
# Decrease in Travel Cost Covers Entire Household Distribution

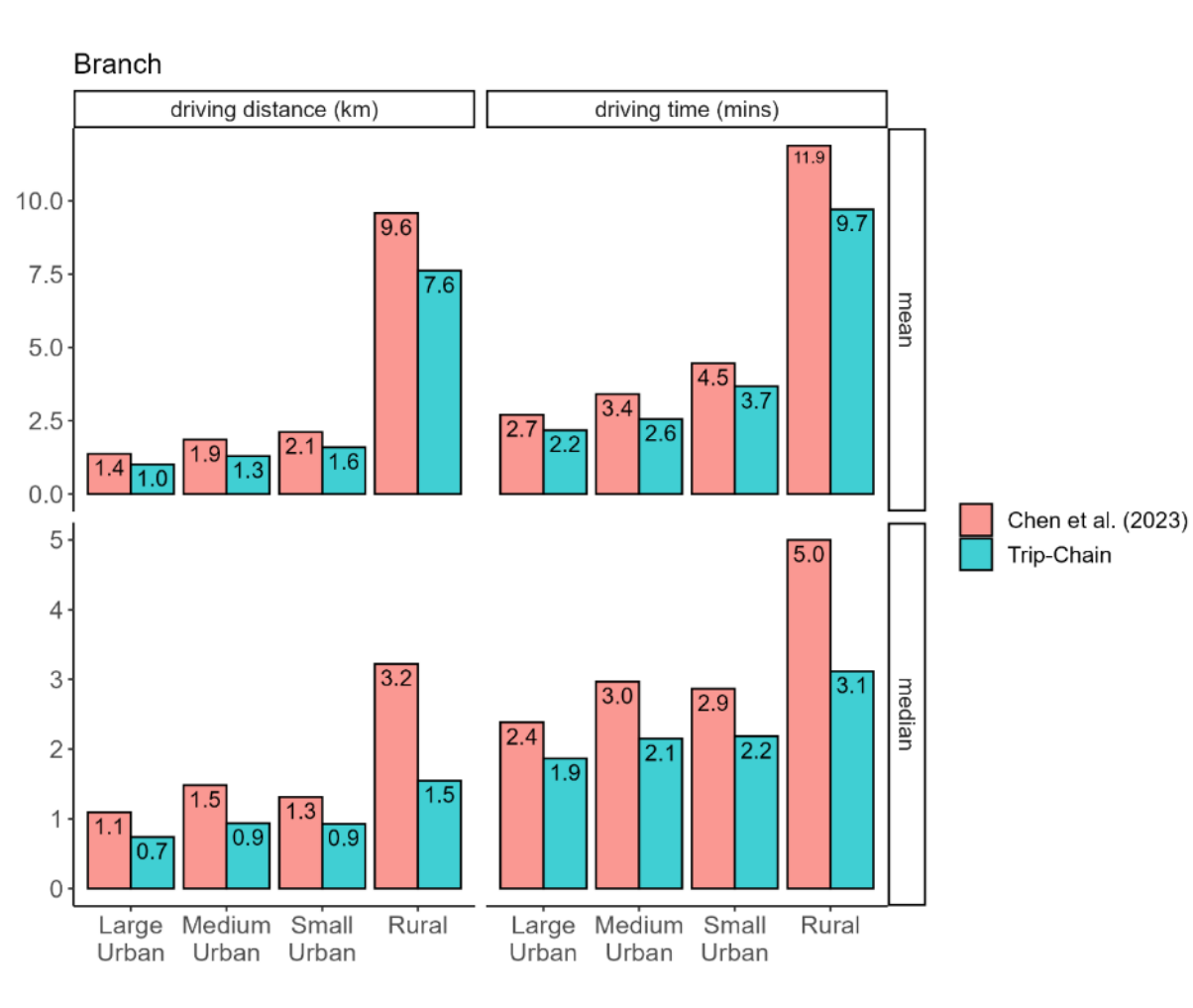


# Decrease in Travel Cost Across All Regions



# Cost Decrease is Greater in Rural Areas



# Conclusion + Looking Forward

- Taking trip-chaining into account decreases the estimated travel cost for Canadians to access cash by around 25%.

- This decrease is driven by disproportionately larger changes in rural areas.

- Future research and policy applications of access to cash metrics:
  - Identify “access to cash deserts” and potentially vulnerable areas.
  - Explore other modes of transportation such as public transit and walking.
  - Application of these results into consumer cash cost studies.

# Merci/Thanks!

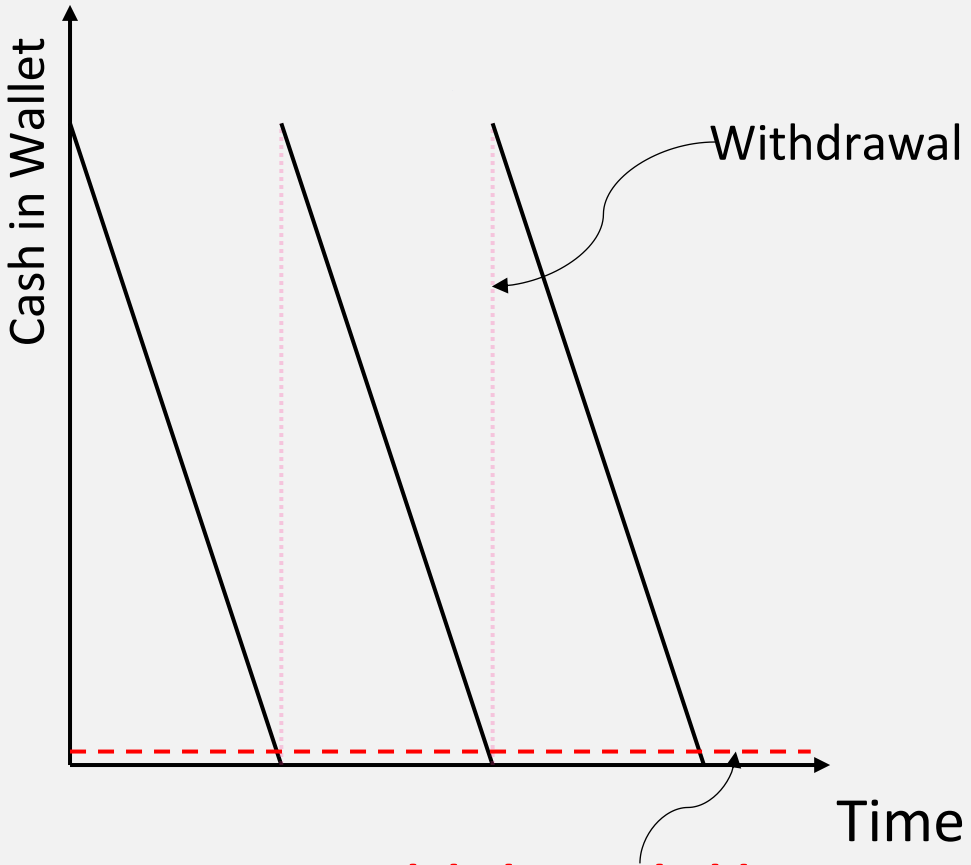

- More research is available at:

Bank notes: Research and reports

Category/Catégorie: Non-Sensitive/Non-Délicat

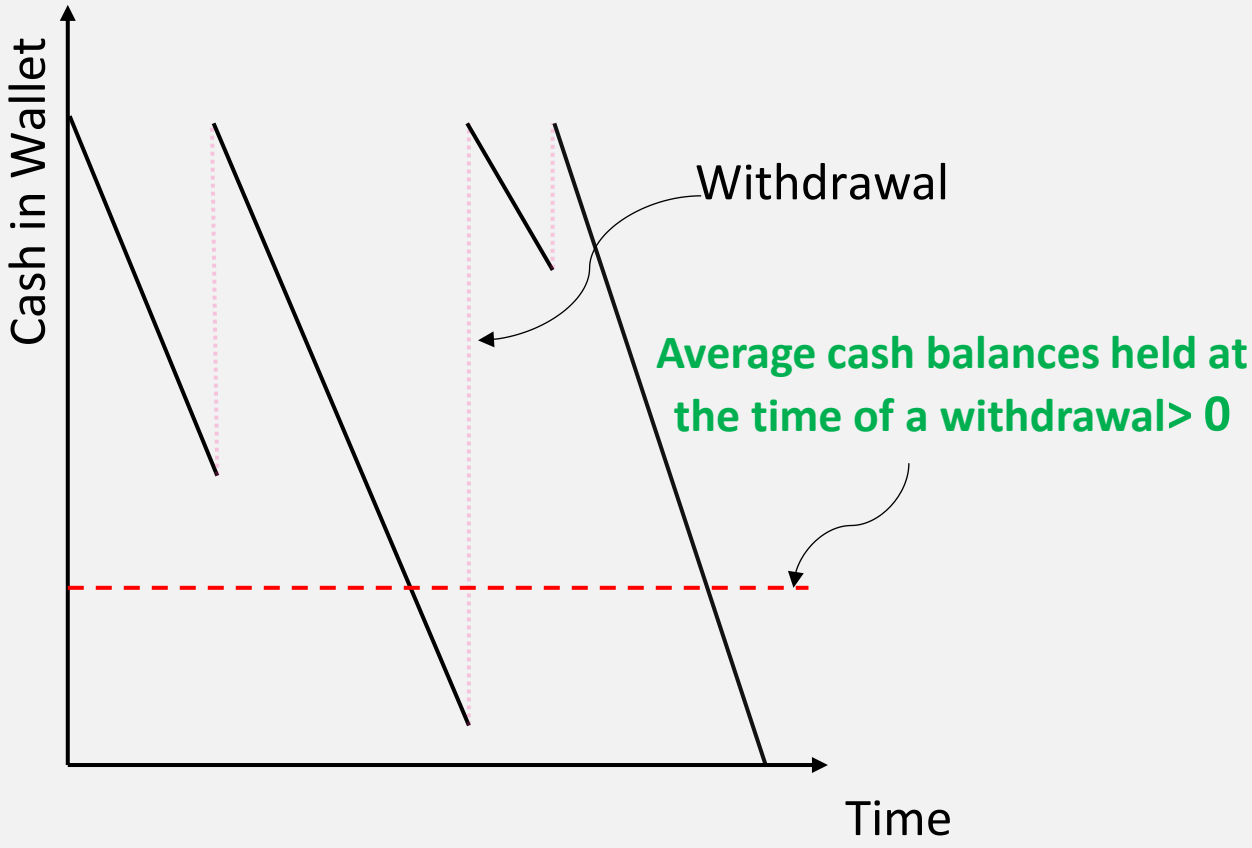
# Observations on Consumer Cash Management from 2009, 2013 and 2017

## Type A



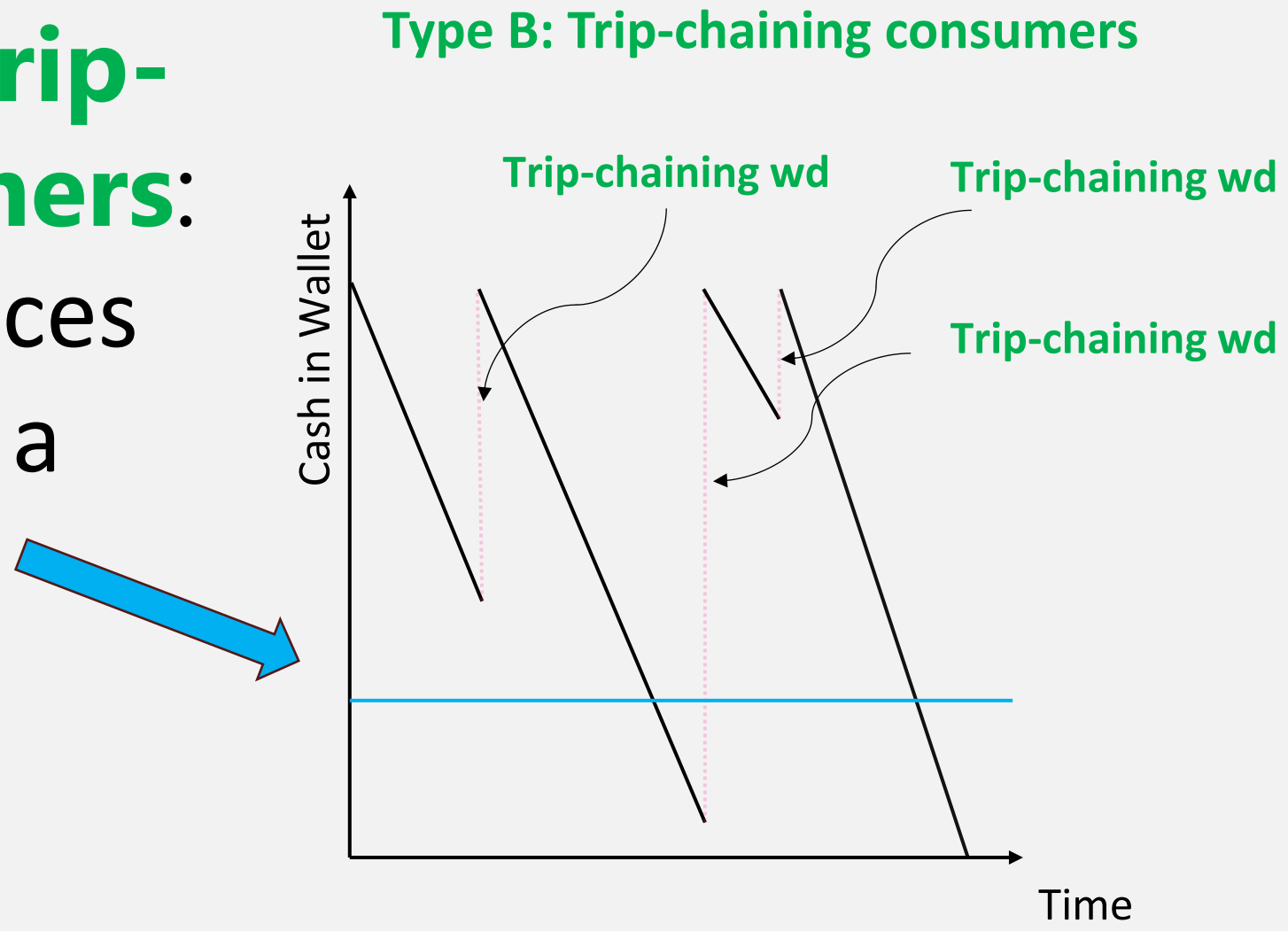

**Average cash balances held at the time of a withdrawal= 0**

## Type B

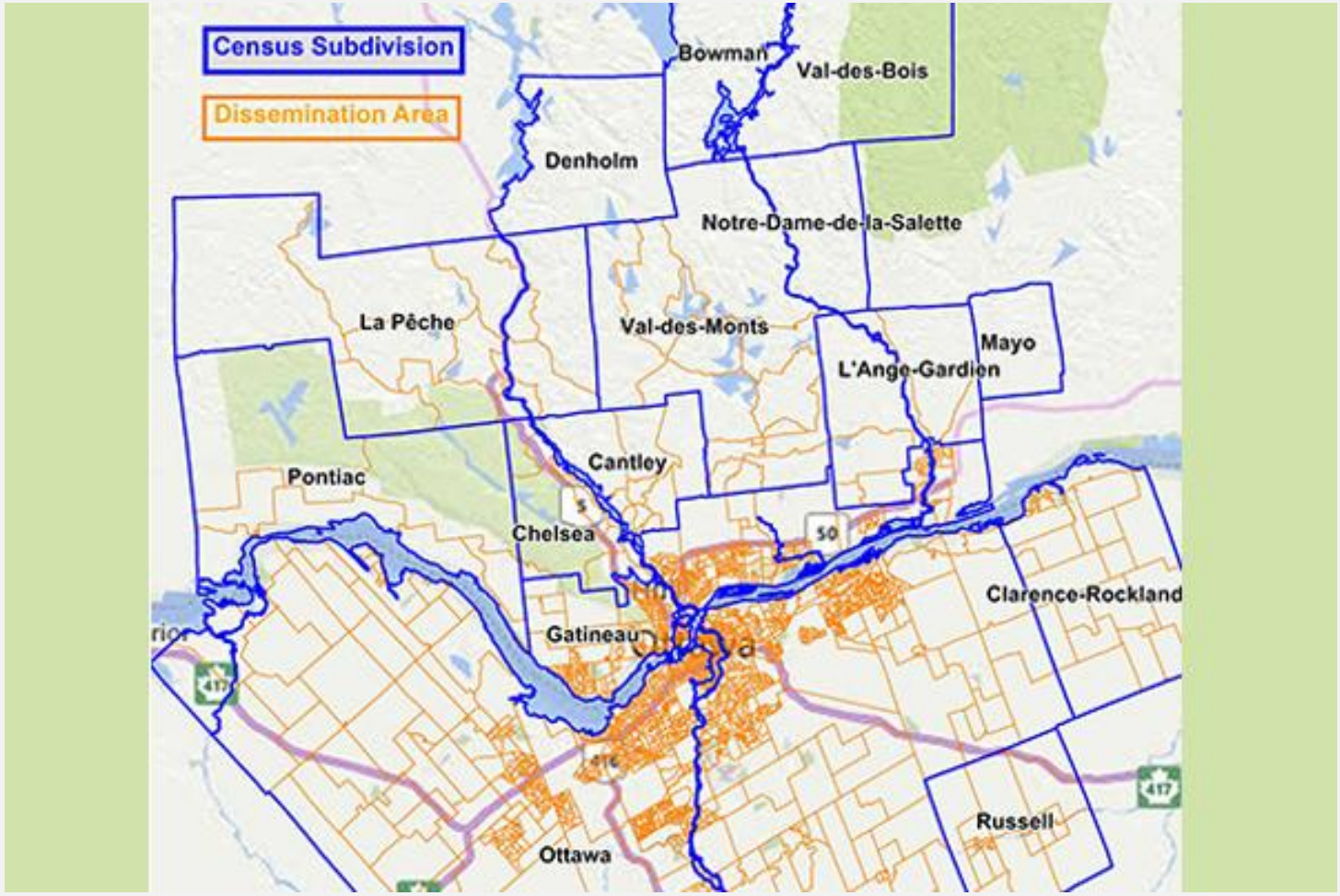



**Average cash balances held at the time of a withdrawal> 0**

Identification of **trip-chaining consumers**: average cash balances held at the time of a withdrawal >0



# Census Subdivision vs. Dissemination Area

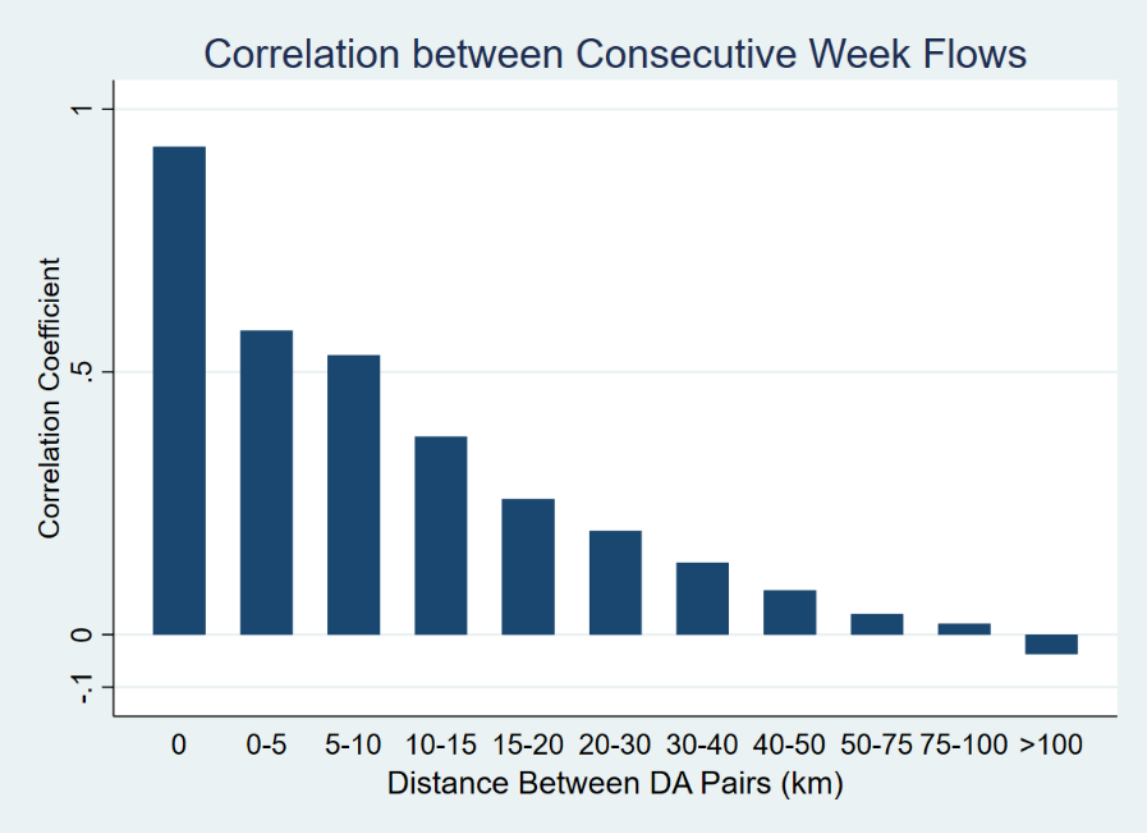



There are more than 55,000 Dissemination Areas in Canada. Each DA represents 400 to 700 people.

Back

# Set Distance Threshold

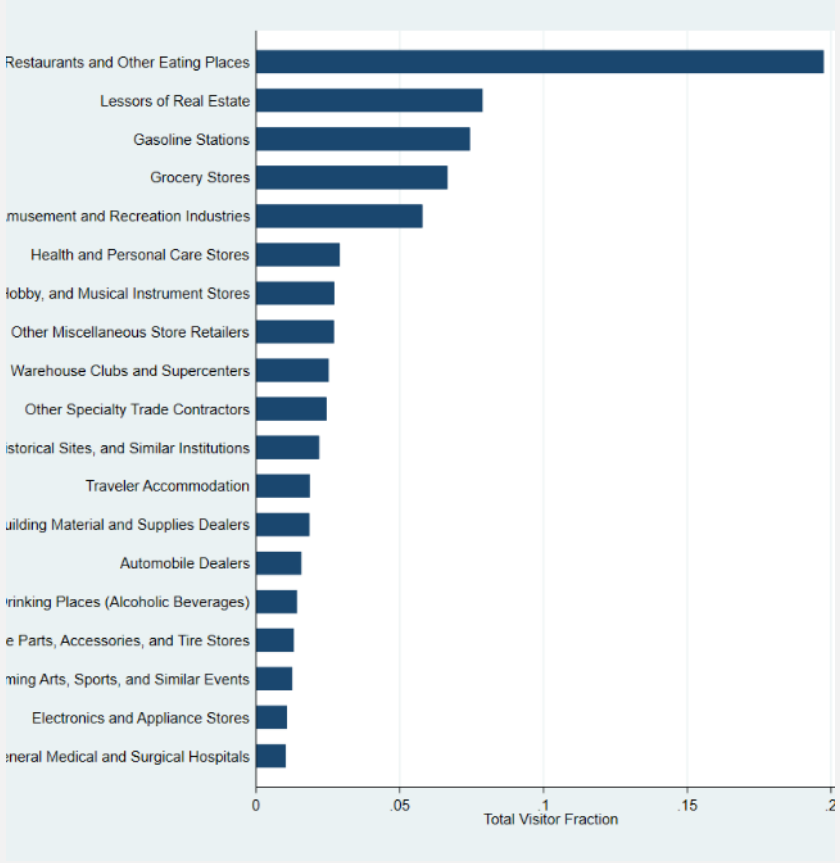
- Sum up visits by origin and destination DA.
- Autocorrelation (1 week lag) in flows between home/destination DAs:
  - Positive correlation => regular trips.
  - Negative correlation => one-time trips.
  - Correlation declines with larger distances.
- **Automatically include all flows for DA pairs within 1km of each other.**




Back

# Regularly Visited POIs Exclude One-Time Destinations

- **Exclude the following categories where one-time trips predominate:**
  - Airports, Ports, Train stations
  - Hotels, Motels, Campgrounds and Travel Agencies
  - Hospitals and Clinics
  - Funeral homes
  - Real estate agents
  - Amusement parks, Museums, Historical sites
  - Concerts and Sports stadiums
  - Auto dealers and Repair shops
- **These POIs are not included in $\Omega_{j'}$**
- Excluded POIs account for 10.9% of all visitors in 2022Q4




Back

# Regularly Visited POIs Must Have Detectable Flows > 50% of Weeks

- **Automatically include all flows for DA pairs within 1km of each other. (Details)**
- Detectable flows for most weeks during the sample period (6 out of 11) => Matches the biweekly frequency of cash withdrawals.
- **If condition not satisfied between DA pairs j and j', Set $\mathbf{P}(j'|j) = 0$**
- This condition drops 62.8% of the remaining visitor flow from the sample.

$$v_{j\to j'(k)} = \frac{v^{*}_{j\to j'(k)}}{89.1\% \times 37.2\% \times 7.84} \quad \forall\, j, j' \text{where } P(j'|j) > 0$$

Back

# Map to Unique Visitors using US Data

- From the 2017 National Household Travel Survey:
  - Each person makes 3.37 one-way trips per day on average.
  - 17.4% of all trips were to/from the workplace. Assume that trips to workplace must be followed by trips from the workplace, 17.4%/2 = 8.7% of all trips were to the workplace.
  - Weighted average of 1.40 trips going back to home per person per day from the public-use dataset.
  - Number of trips to other POIs than homes and workplaces per day can be given by:

$$\#\ of\ trips\ to\ other\ POIs = \#\ of\ trips\ total\ - \#\ of\ trips\ to\ home\ - \#\ of\ trips\ to\ work$$

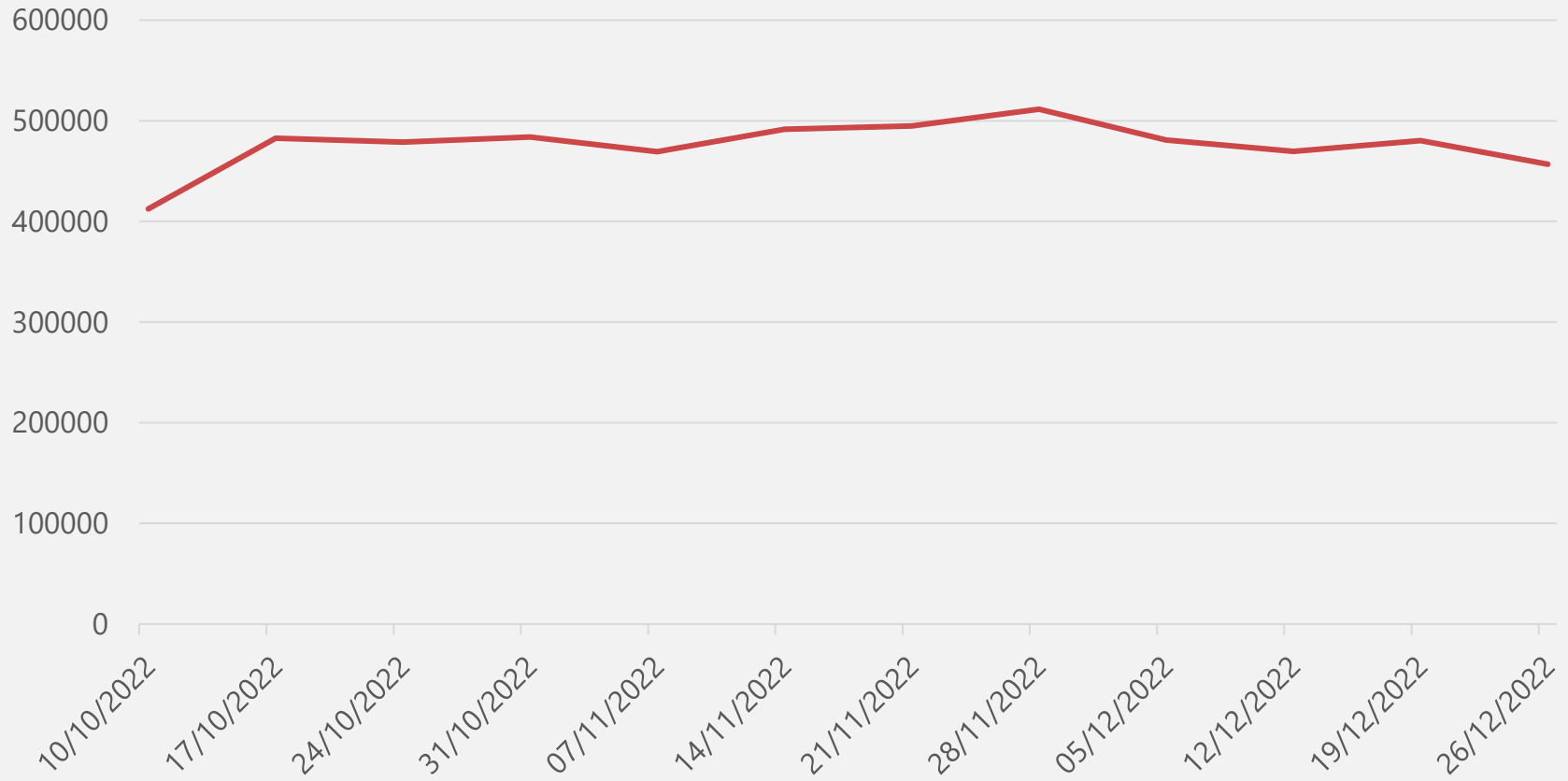
$$\#\ of\ trips\ to\ other\ POIs = 3.37\ - 1.40\ - 3.37 * 8.7\% = 1.68\ stops\ at\ POIs\ per\ day$$

  - Number of POI stops per week is 1.68*7 = 11.76 stops per week.
  - To obtain the number of unique travelling households in a week, we need to use the ratio between the average number of visits and the number of visitors derived from the Safegraph Patterns data, which equals to 1.5. As a result, each household visit 11.76/1.5 = 7.84 unique POIs during a week

Back

# Total Number of Devices Tracked is Stable

- Around 480,000 across Canada with recognized home locations from October to December 2022.




Back