Effect of COVID-19 Policy Intervention on MN Mobility

Spatial Computing Research Group

Weekly Update: May 22nd 2020
Time period covered: 03/01/2020 - 04/18/2020
Outline

1. Motivation
2. Background:
   a. Minnesota COVID-19 Policy Intervention Calendar
   b. SafeGraph Data
3. Trends in
   a. average distance traveled
   b. average time at home
   c. POI visits
4. Next steps
5. Acknowledgement
Motivation: Understand MN Effects of COVID-19

1. Minnesota Calendar
   a. March 9th: School closure, e.g., U of M Spring Break
   b. March 27th: MN Stay at home
   c. May 18th: MN Reopening Phase 1

2. Why monitor mobility? It's a proxy of
   a. economic activities
   b. social distancing.

3. COVID-19 hampers economic data collection.

4. Monitor MN effects
   a. Mobility metrics: Range, Time spent at Home
   b. Congregation metrics: POI visits
Outline

1. Motivation
2. Background:
   a. Minnesota COVID-19 Policy Intervention Calendar
   b. SafeGraph Data
3. Trends in
   a. average distance traveled
   b. average time at home
   c. POI visits
4. Next steps
5. Acknowledgement
Minnesota COVID-19 Policy Intervention Calendar

1. Mar 9, 2020: University of Minnesota Spring break
2. Mar 17, 2020: University of Minnesota school closing
4. May 18th, 2020: MN reopening Phase 1
5. June 1st, 2020: MN reopening Phase 2
6. ...
<table>
<thead>
<tr>
<th>Setting</th>
<th>Stay Home MN Phase I</th>
<th>Stay Safe MN Phase II</th>
<th>Stay Safe MN Phase III</th>
<th>Stay Safe MN Phase IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Social Settings</td>
<td>Stay at home except for essential activities</td>
<td>Gatherings of 10 or less Drive-in gatherings per MDH guidelines</td>
<td>Gatherings of 10 or less Drive-in gatherings per MDH guidelines</td>
<td>Gatherings of 20 or less Drive-in gatherings per MDH guidelines</td>
</tr>
</tbody>
</table>

Source: MN Stay Safe Plan
https://mn.gov/covid19/for-minnesotans/stay-safe-mn/stay-safe-plan.jsp
SafeGraph data summary

1. Summary:
   a. Aggregated mobile-device location traces.
   b. Raw data generated using a panel of GPS* pings from anonymous mobile devices.
   c. Number of devices**: 294,014 (MN), 154,467 (Metropolitan area)
   d. Number of POIs: 5.9M (US), 73,548 (MN)

2. Multiple datasets:
   a. Social distancing
   b. Weekly pattern
   c. Monthly pattern
   d. …

* Location services use WiFi in addition to GPS.

** The number of devices is derived from social distancing dataset.
SafeGraph social distancing dataset

1. Summary:
   a. Number of devices: 294,014 (MN), 154,467 (Metropolitan area)

2. Schema: https://docs.safegraph.com/docs/social-distancing-metrics
   a. Origin_census_block_group
   b. Device_count
   c. Distance_traveled_from_home
   d. Median_home_dwell_time
   e. ...
SafeGraph social distancing dataset (cont’d)

1. Data scope:
   a. Device's "home" determined by common nighttime location over a 6-week* period.
   b. Home location accuracy is at a Geohash-7 granularity (~153m x ~153m)**.
   c. Data is aggregated by the census block groups where the devices' homes are in.
   d. To preserve privacy, differential privacy is applied to all of the device count metrics other than the device_count ***.

* Home for college students may be inaccurate for a few weeks after spring break.

** This location is coarser than a city block in downtown.

*** Data suppressed for census block groups with few devices.
# Weekly Visits Data from SafeGraph

1. **Summary:**
   a. **MN:** 73,548 POIs across 261 NAICS Code
   b. **Time Frame:** Weeks March 1, 2020 - April 18, 2020

2. **Schema:** [https://docs.safegraph.com/docs/weekly-patterns](https://docs.safegraph.com/docs/weekly-patterns)

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>safegraph_place_id</td>
<td>Unique ID tied to POI</td>
<td>str</td>
</tr>
<tr>
<td>location_name</td>
<td>Name of POI</td>
<td>str</td>
</tr>
<tr>
<td>street_address</td>
<td>Add. Of POI</td>
<td>str</td>
</tr>
<tr>
<td>city</td>
<td>City where POI is located.</td>
<td>str</td>
</tr>
<tr>
<td>region</td>
<td>state or territory.</td>
<td>str</td>
</tr>
<tr>
<td>postal_code</td>
<td>zip code</td>
<td>str</td>
</tr>
<tr>
<td>brands</td>
<td>Name of business</td>
<td>List</td>
</tr>
<tr>
<td>naics_code</td>
<td>code describing business.</td>
<td>Int</td>
</tr>
<tr>
<td>date_range_start</td>
<td>Start time in ISO 8601</td>
<td>Str</td>
</tr>
<tr>
<td>date_range_end</td>
<td>End time in ISO 8601</td>
<td>Str</td>
</tr>
<tr>
<td>raw_visit_counts</td>
<td>Number of visits</td>
<td>Int</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>raw_visitor_counts</td>
<td>Number of unique visitors</td>
<td>Int</td>
</tr>
<tr>
<td>visits_by_day</td>
<td>Visits by each day</td>
<td>Json(int)</td>
</tr>
<tr>
<td>visits_by_each_hour</td>
<td>Visits by each hour</td>
<td>json(int)</td>
</tr>
<tr>
<td>visitor_home_cbgs</td>
<td>number of visitors whose home is in that census block group</td>
<td>{Str: Int}</td>
</tr>
<tr>
<td>visitor_country_of_origin</td>
<td>Country to visitors</td>
<td>{Str: Int}</td>
</tr>
<tr>
<td>distance_from_home</td>
<td>Median distance from home travelled by visitors</td>
<td>Int</td>
</tr>
<tr>
<td>median_dwell</td>
<td>Median dwell time.</td>
<td>Double</td>
</tr>
<tr>
<td>bucketed_dwell_times</td>
<td>Key: minutes, Val: visits</td>
<td>{Str: Int}</td>
</tr>
<tr>
<td>related_same_day_brand</td>
<td>Key: brands, Val: visits (by day)</td>
<td>{Str: Int}</td>
</tr>
<tr>
<td>related_same_week_brand</td>
<td>Key: brands, Val: visits (by week)</td>
<td>{Str: Int}</td>
</tr>
<tr>
<td>device_type</td>
<td>Android or iOS</td>
<td>{Str: Int}</td>
</tr>
<tr>
<td>iso_country_code</td>
<td>2 letter country Code</td>
<td>Str</td>
</tr>
</tbody>
</table>
Weekly Visits Data from SafeGraph

1. Data scope:
   a. Current data has US weekly visits during (March 1 - April 18), 2020.
   b. NAICS code: 5-6 digit code classifying POIs (e.g., Grocery Stores, Parks, etc.).
   c. Raw_Visit_Counts provides number of visits to a given NAICS code.
   d. POI location is specified by street address as well as (latitude, longitude).
   e. The street addresses can be aggregated by zipcode, city, and state.
   f. (Latitude, longitude) can be summarized into census block groups, counties, ...
Outline

1. Motivation
2. Background:
   a. Minnesota COVID-19 Policy Intervention Calendar
   b. SafeGraph Data
3. Trends in
   a. average distance traveled
   b. average time at home
   c. POI visits
4. Next steps
5. Acknowledgement
State-level daily average time at home

- Trends:
  - Before Mar. 27th, the average time increased;
  - Since mid April, the average time decreased.
Metropolitan-level daily average time at home

- Trends:
  - Before Mar. 27th, the average time increased;
  - Since mid April, the average time decreased.
State-level daily average distance traveled

- Trends: (1) Before Mar. 27th, the average distance decreased;
  (2) Since April, the average distance bounce back.
  (3) May data quality (?)
Metropolitan-level daily average distance traveled

- **Trends:**
  1. Before Mar. 27th, the average distance decreased.
  2. Since April, the average distance bounce back.
  3. May data quality (?)
State-level Weekly POI Visits in Minnesota

- Geographical Footprint: Minnesota (225,163 km²)
- Time Interval: 03/01 - 04/18
- Data is produced by aggregating visits within each NAICS Code.

<table>
<thead>
<tr>
<th>NAICS Code</th>
<th>Meaning</th>
<th>Counts</th>
</tr>
</thead>
<tbody>
<tr>
<td>722511</td>
<td>Full-Service Restaurants</td>
<td>43,689</td>
</tr>
<tr>
<td>531120</td>
<td>Lessor of Non-Residential Buildings (Malls)</td>
<td>3,801</td>
</tr>
<tr>
<td>722513</td>
<td>Limited Service Restaurants</td>
<td>18,336</td>
</tr>
<tr>
<td>611110</td>
<td>Elementary and Secondary Schools</td>
<td>19,748</td>
</tr>
<tr>
<td>452319</td>
<td>Other General Merchandise Store</td>
<td>5,249</td>
</tr>
<tr>
<td>713940</td>
<td>Fitness and Recreational Sports Centers</td>
<td>15,078</td>
</tr>
<tr>
<td>444130</td>
<td>Hardware Stores</td>
<td>14,299</td>
</tr>
<tr>
<td>445110</td>
<td>Supermarkets, Groceries</td>
<td>10,122</td>
</tr>
<tr>
<td>451110</td>
<td>Sporting Goods Stores (includes fishing equipment)</td>
<td>5,678</td>
</tr>
<tr>
<td>712190</td>
<td>Nature Parks and Other Similar Institutions</td>
<td>27,098</td>
</tr>
</tbody>
</table>

- Trends:
  - Temporary Increase: Hardware Store, Groceries (Mid March - Mid April)
  - Decreasing Visits: Fitness and Recreational, Schools.
  - Last week (04/12 - 04/18), the number of visits bounce back.
Top NAICS code at State-level POI Visits

- Geographical Footprint: Minnesota (225,163 km^2)
- Time Interval: 03/01 - 04/18 with temporal resolution of 1 week.

**Trends:**
- Increasing Visits (Smaller ranking): Convenience Store, and Hardware Stores.
- Temporary Increase: Grocery Store (Mid March), Other Gen. Mer. Store (Early April)
- Decreasing Visits (Larger ranking): Schools, Recreational visits.
City-level POI Visits in Minnesota (3/1 - 4/18)

- Geographical Footprint: Minnesota (225,163 km^2).
- Time Interval: 03/01 - 04/18

**Trends:**
- Focus on Top 10 cities based on most number of visits.
- Differs from population ranking (St. Cloud, Mankato before Bloomington, Plymouth).
  - ? check for sampling bias
City-level POI Visits in Minnesota (3/1 - 4/18)

- Geographical Footprint: Minnesota (225,163 km^2).
- Time Interval: 03/01 - 04/18

Trends:
- Focus on Top 10 cities based on most number of visits.
- Differs from population ranking (St. Cloud, Mankato before Bloomington, Plymouth). ? check for sampling bias
City-level POI Visits Trends in Minnesota

- Geographical Footprint: Minnesota (225,163 km^2).
- Time Interval: 03/01 - 04/18
- Data is produced by aggregating visits within each City.

- Trends:
  - Each city decreases in March, bounces up in early - mid April.
  - Temporary bounce at end of March: Bloomington, Mankato, Duluth, Coon Rapids.
  - No temporary bounce at end of March: Minneapolis, St. Paul, Maple Grove, Woodbury.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Minneapolis</td>
<td>530083</td>
<td>431935</td>
<td>266290</td>
<td>237158</td>
<td>196682</td>
<td>178770</td>
<td>154991</td>
<td>217853</td>
</tr>
<tr>
<td>St. Paul</td>
<td>229328</td>
<td>183873</td>
<td>112532</td>
<td>94664</td>
<td>82858</td>
<td>77036</td>
<td>71571</td>
<td>91809</td>
</tr>
<tr>
<td>Rochester</td>
<td>129579</td>
<td>115913</td>
<td>72512</td>
<td>57841</td>
<td>46709</td>
<td>46799</td>
<td>43366</td>
<td>56996</td>
</tr>
<tr>
<td>Maple Grove</td>
<td>75540</td>
<td>71491</td>
<td>36461</td>
<td>29633</td>
<td>25940</td>
<td>25625</td>
<td>24397</td>
<td>31461</td>
</tr>
<tr>
<td>Woodbury</td>
<td>69503</td>
<td>56579</td>
<td>34862</td>
<td>27165</td>
<td>23652</td>
<td>23142</td>
<td>22309</td>
<td>29474</td>
</tr>
<tr>
<td>Bloomington</td>
<td>84280</td>
<td>74737</td>
<td>33333</td>
<td>21269</td>
<td>18590</td>
<td>18690</td>
<td>16485</td>
<td>21685</td>
</tr>
<tr>
<td>Mankato</td>
<td>72212</td>
<td>55638</td>
<td>33394</td>
<td>27815</td>
<td>24622</td>
<td>25364</td>
<td>21778</td>
<td>29564</td>
</tr>
<tr>
<td>Coon Rapids</td>
<td>59604</td>
<td>54492</td>
<td>30264</td>
<td>27197</td>
<td>23495</td>
<td>24752</td>
<td>22589</td>
<td>29879</td>
</tr>
<tr>
<td>St. Cloud</td>
<td>72940</td>
<td>64385</td>
<td>39296</td>
<td>34647</td>
<td>29367</td>
<td>28320</td>
<td>26178</td>
<td>32953</td>
</tr>
<tr>
<td>Duluth</td>
<td>76210</td>
<td>59789</td>
<td>35135</td>
<td>26017</td>
<td>23502</td>
<td>24071</td>
<td>21608</td>
<td>26653</td>
</tr>
</tbody>
</table>
City-level POI Visits Trends in St. Paul

- Geographical Footprint: Saint Paul (145.50 km^2).
- Time Interval: 03/01 - 04/18
- Visits aggregated by NAICS Code.

Trends:
- Temporary Increase: SuperMarkets, Groceries (March, Early April),
- Decreasing Visits: Schools, Fitness & Recreational visits, Full-Service Restaurants.
- Last week (04/12 - 04/18), the number of visits bounce back.
City-level POI Visits Trends in Minneapolis

- Geographical Footprint: Minneapolis (148.89 km²).
- Time Interval: 03/01 - 04/18
- Visits aggregated by NAICS Code.

Trends:
- No. 1: Nature Parks
- Temporary Increase: Nature Parks (Mid March - Early April), Groceries (March)
- Decreasing Visits: Full Service Restaurants, Schools, Recreational visits.
- Last week (04/12 - 04/18), the number of visits bounce back.

### NAICS Code Summary

<table>
<thead>
<tr>
<th>NAICS Code</th>
<th>Meaning</th>
<th>Counts</th>
</tr>
</thead>
<tbody>
<tr>
<td>722511</td>
<td>Full-Service Restaurants</td>
<td>6,524</td>
</tr>
<tr>
<td>531120</td>
<td>Lessors of Non-Residential Buildings (Malls)</td>
<td>196</td>
</tr>
<tr>
<td>722513</td>
<td>Limited Service Restaurants</td>
<td>1,324</td>
</tr>
<tr>
<td>611110</td>
<td>Elementary and Secondary Schools</td>
<td>1,230</td>
</tr>
<tr>
<td>452319</td>
<td>Other General Merchandise Store</td>
<td>418</td>
</tr>
<tr>
<td>713940</td>
<td>Fitness and Recreational Sports Centers</td>
<td>2,529</td>
</tr>
<tr>
<td>444130</td>
<td>Hardware Stores</td>
<td>715</td>
</tr>
<tr>
<td>445110</td>
<td>Supermarkets, Groceries</td>
<td>1,077</td>
</tr>
<tr>
<td>451110</td>
<td>Sporting Goods Stores (includes fishing equipment)</td>
<td>519</td>
</tr>
<tr>
<td>712190</td>
<td>Nature Parks and Other Similar Institutions</td>
<td>11,785</td>
</tr>
</tbody>
</table>
Outline

1. Motivation
2. Background:
   a. Minnesota COVID-19 Policy Intervention Calendar
   b. SafeGraph Data
3. Trends in
   a. average distance traveled
   b. average time at home
   c. POI visits
4. Next steps
5. Acknowledgement
Next Steps

- **Rank Census Tracts**
  a. Avg. Distance Traveled to POIs of critical NAICS code (e.g., grocery).
  b. Percentage change in Avg. Distance Traveled to POIs of critical NAICS code.
  c. Challenges: deeper analysis of weekly POI visit dataset by estimating O-D matrix, where O is the home census tract, and D is the POI.

- **Detect anomalous counties and census tracts**
  a. By POI visits, e.g., avg. distance traveled to POIs of critical NAICS code.
  b. By social distancing measure, e.g., range and hours at home.
Notes from the meeting

- Hotspot Analysis on the Map
- Visits Threshold by time
- Normalizing Visits by Population
Acknowledgements

This slides are based upon helps of colleagues from University of Minnesota, including Ms. Laurie McGinnis from Center for Transportation Studies, Dr. Eva Enns, Dr. Shalini Kulasingam, and Dr. Kelly Searle from School of Public Health, Mr. Len Kne and Mr. Adam Null from U-Spatial, Dr. Ankur Mani from Department of Industrial and Systems Engineering. We also would like to thank SafeGraph, Dr. Esteban Moro Egido and Dr. Alex Pentland from MIT media lab, Dr. Ashley Asmus and Dr. Sean Barton from Metropolitan Council and the state of Minnesota for their support.