The Impact of COVID-19 Pandemic on Mobility Systems

an analysis on traffic related data

Presentation for Department of Civil and Environmental Engineering, University of Delaware
Presentation complied with support from National Renewable Energy Laboratory (NREL) COVID data team

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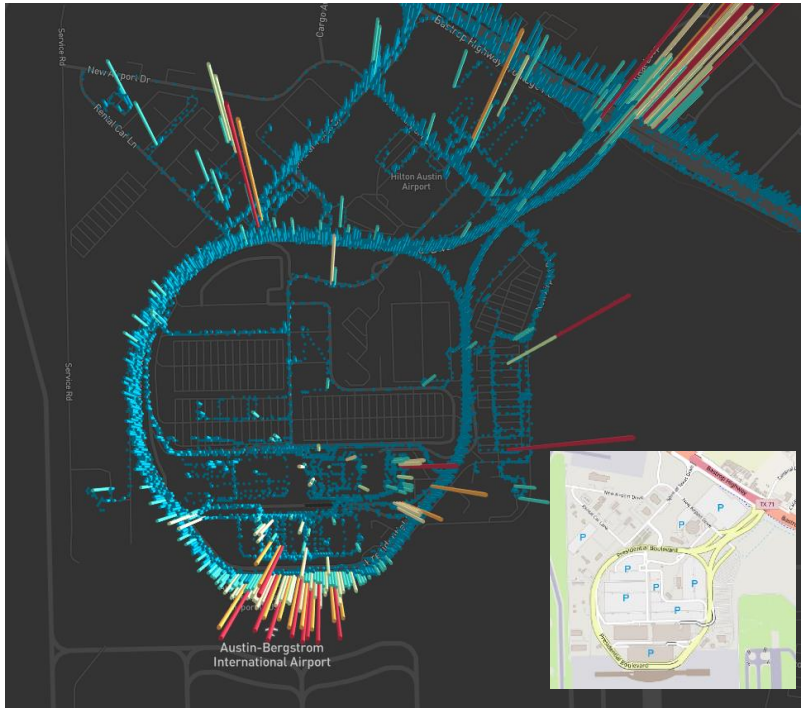
Background

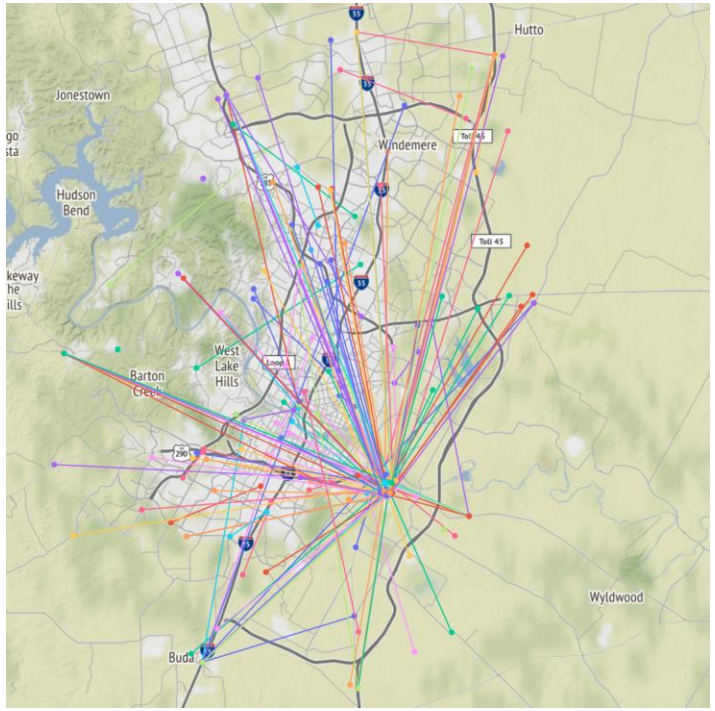
- During the COVID-19 global pandemic, travel behavior has changed due to regulations or personal choices
- Monitoring our transportation/mobility systems has become increasingly important not only for allocating resources but also understanding the transmission vector for COVID-19
- Fleet and smartphone-based telematics could provide surrogate path for the monitoring
- DOE Initiative: Transportation Systems COVID-19 Rapid Reponses for Safe and Efficient Mobility for Return to Operations
  - Multiple national laboratories (NREL, LBNL, ORNL, and ANL)
  - 90-day sprint (July 1, 2020 – Sept 30, 2020)
- Presentation complied with support from the NREL COVID Data Team

Mobility Data: Vehicle Telematics/Connected Vehicle Data



vehicle waypoint →

data coverage →



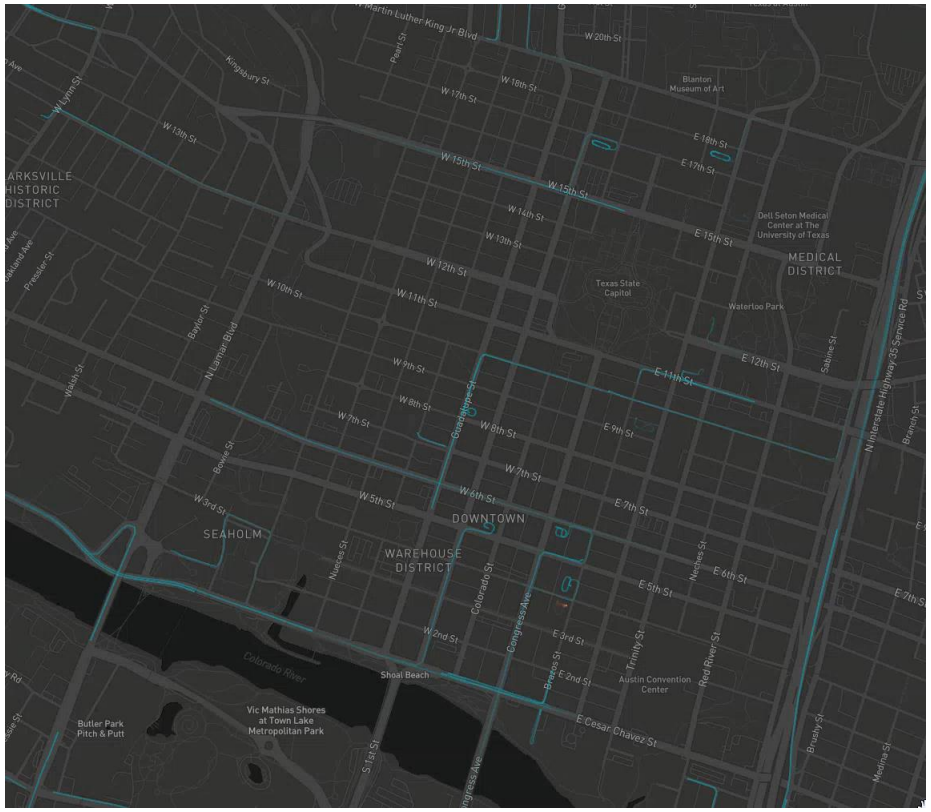
Individual vehicle trip

Example: Vehicle Trajectory Data

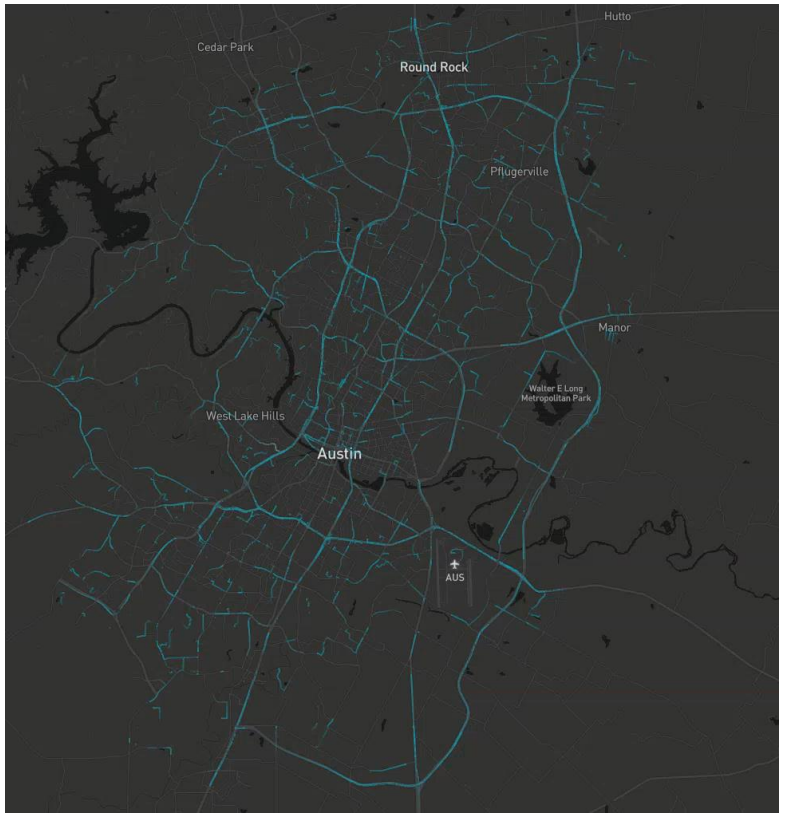
wejo

INRIX

otonomo



Vehicle trajectory visualization
(Austin downtown)



Vehicle trajectory visualization
(Austin region)

Mobility Data: Point of Interest Mobility Data

AIRSAGE

Maps Mobility Trends

SAFEGRAPH

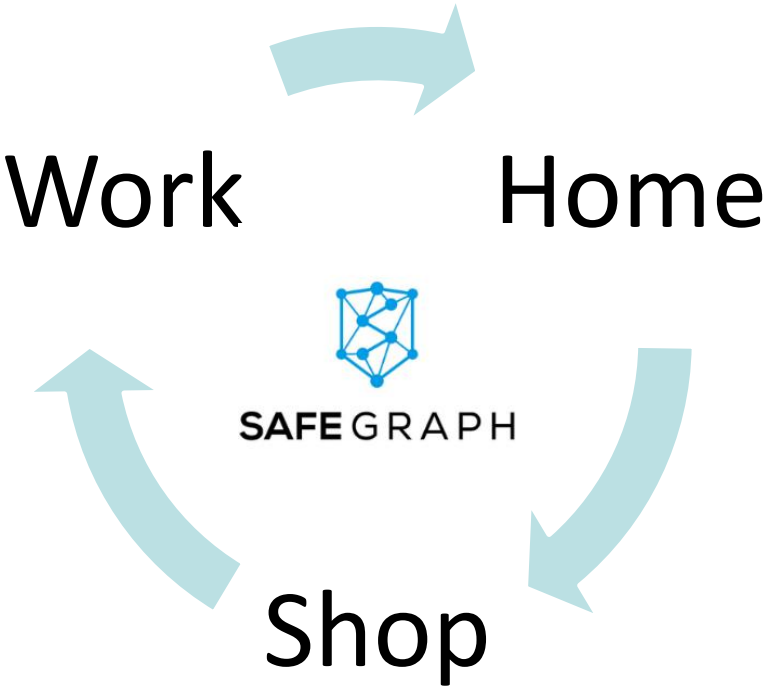
factual

REPLICA

unacast.

cuebiq

Example: SafeGraph POI Data Schema

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visitor_home_cbgs,visitor_daytime_cbgs,visitor_country_of_origin,distance_from_home,
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SafeGraph POI foot-traffic available for ~3.6MM POI in the USA

Travel Pattern Analysis using INRIX® Data

USDOE / USDOT Collaborative Data Procurement

- **INRIX® Traffic Volume Trends Dashboard**
  - Seasonally adjusted
  - National, state, metro aggregated
- **INRIX® National O/D Trip Data**
  - ~100M trips/day, 10% Sample across US
  - Range Jan 1, 2020 – Jun. 30, 2020 (Jul. – Step. Data forthcoming)
  - Light-, Medium-, Heavy-Duty vehicles
  - Supports COVID and EEMS Research
- Other data sets for validation and cross-reference

IRNIX Individual O/D Trip Data

```
1  trip_id,device_id,provider_id,mode,start_date,start_dow,
   end_date,end_dow,start_lat,start_lon,end_lat,end_lon,
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   vehicle_weight_class,probe_source_type,dest_zone,
   endpoint_type,trip_mean_speed_kph,trip_max_speed_kph,
   trip_distance_m,movement_type,start_tz,end_tz,wp_freq_sec,
   start_qk,end_qk,start_zcta,start_cbg,end_zcta,end_cbg
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```
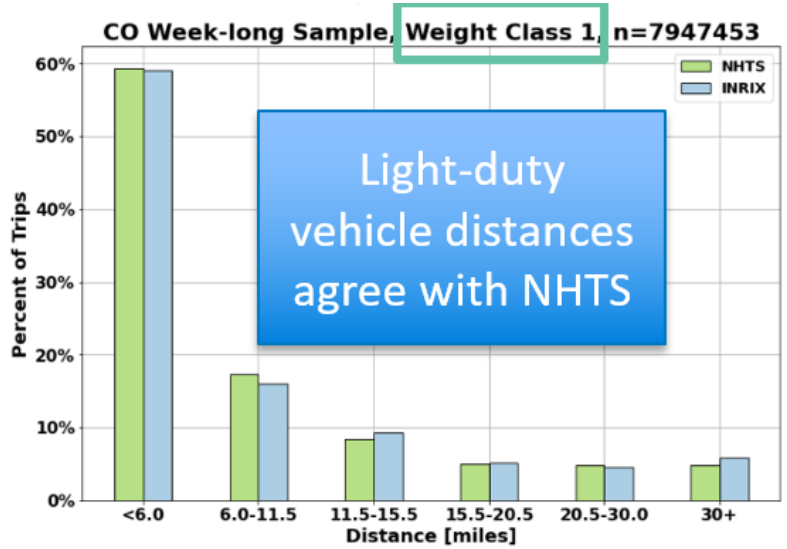
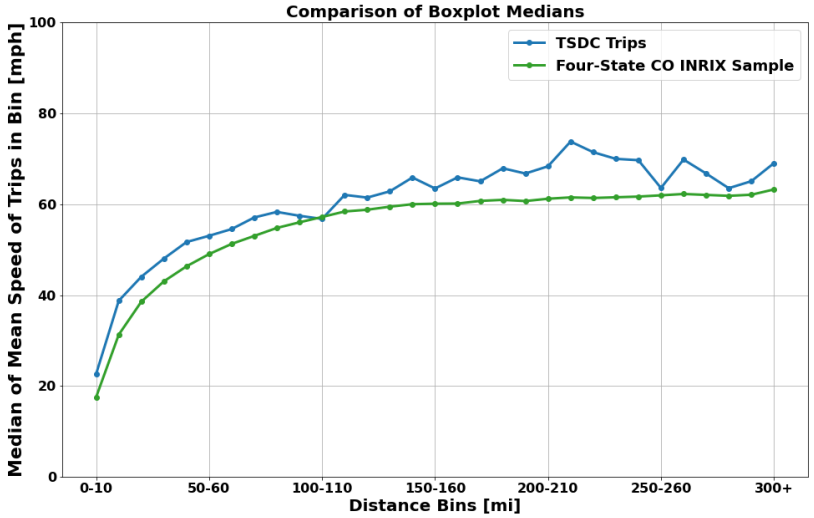
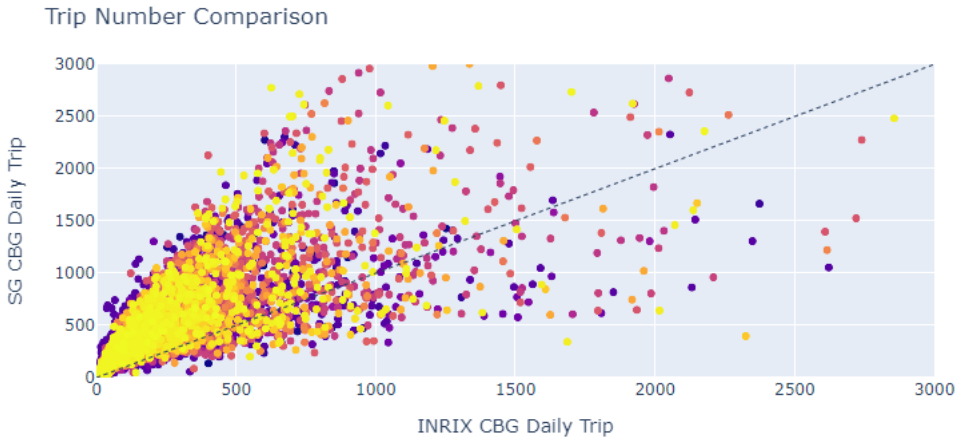

INRIX O/D trip data example

- Each record represent one trips make by a vehicle
- Geo-coordinates of trip start and end (15-decimal point)
- Date range: Jan 1st – Jun 30 (Jul-Sept forthcoming)
- Coverage: nationwide
- Pre-processing
  - census block group
  - local time zone
  - zip code

Validation of INRIX Data

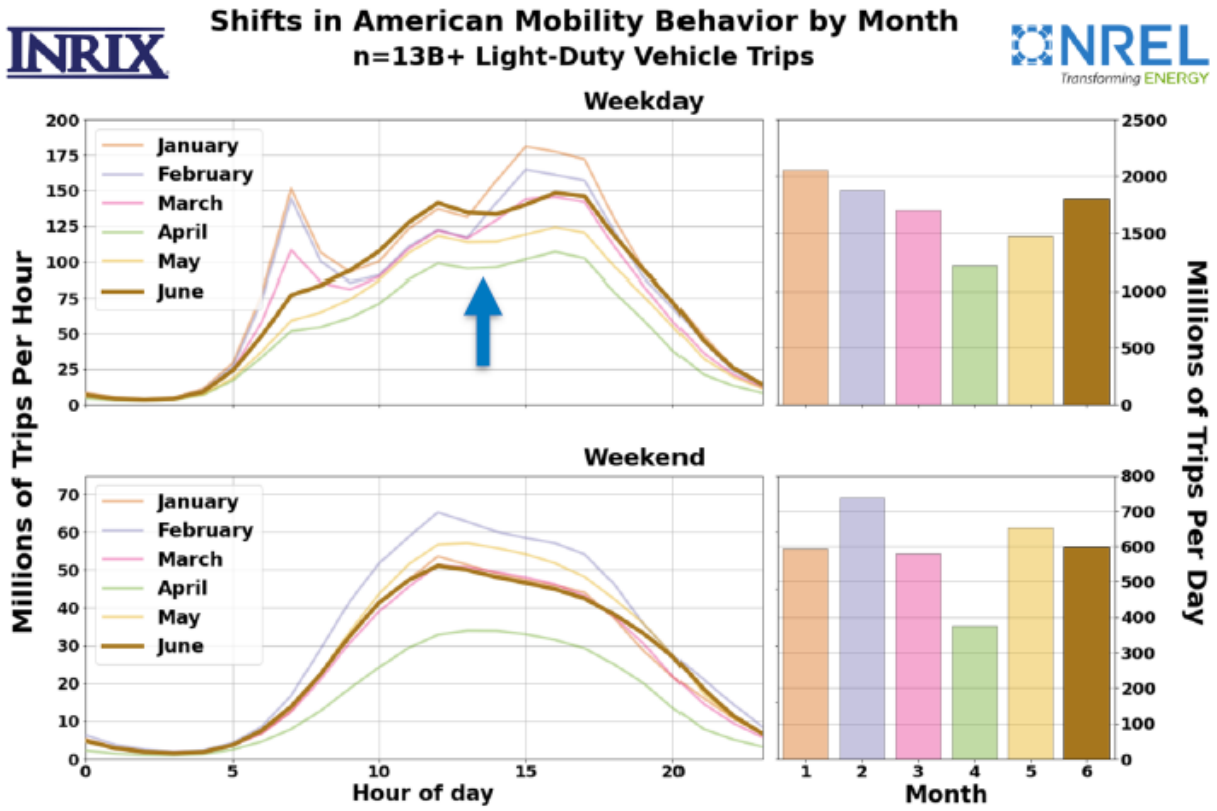






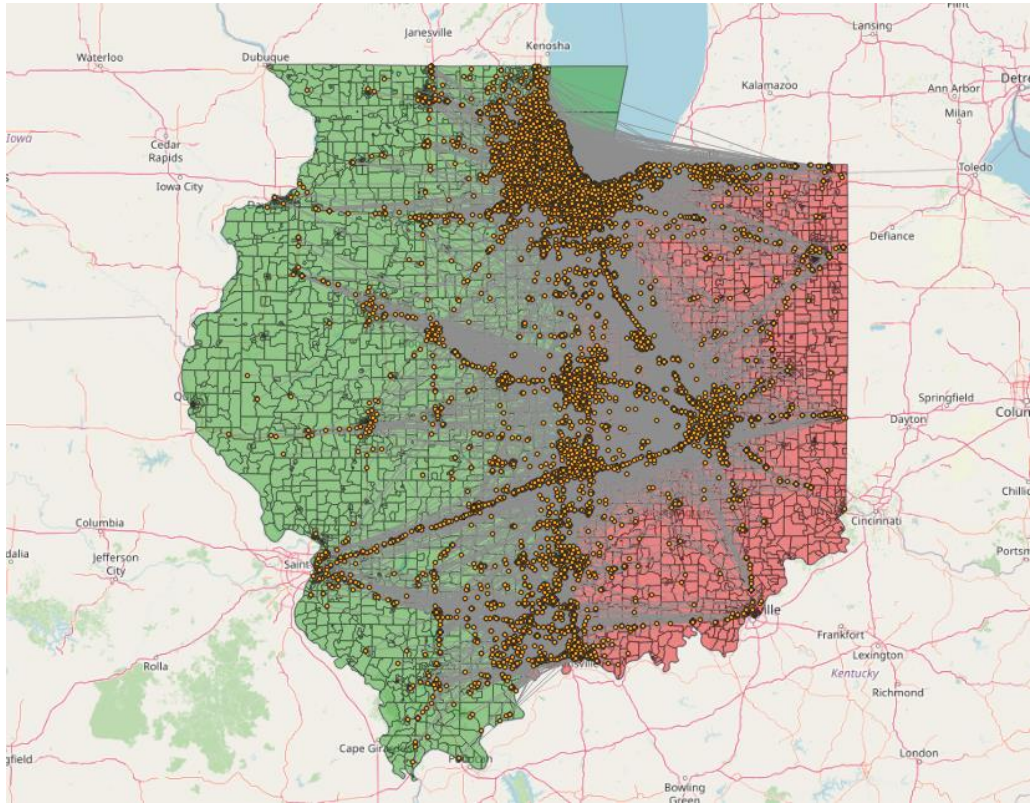
- Compare INRIX O/D data to other mobility data sets
  - National House Household Survey: LDV distance
  - NREL's GPS travel surveys: trip speed distribution
  - SafeGraph: census block group (CBG) trip number

National Mobility Trend



- National mobility behavior for light-duty vehicle trips
  - April marks the lowest observed volume nationwide
  - Significant reduction in AM peak after the pandemic
  - Relative volume remain the same for weekends

Trip classification (based on FIPS geographic area)



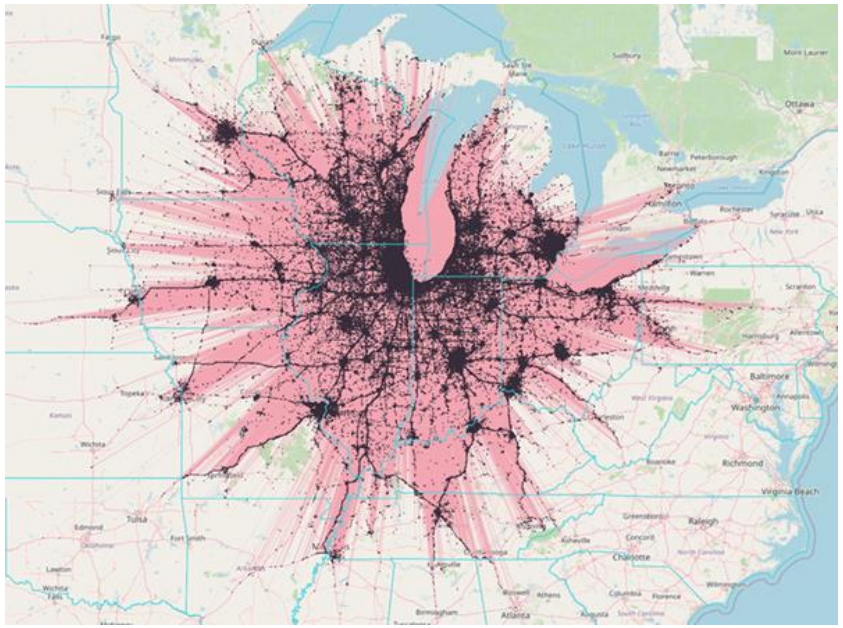
Example: one-day O/D trips originated from Indiana to Illinois

- Legend:
  - Point: trip origin or destination
  - Line: one origin-destination pair

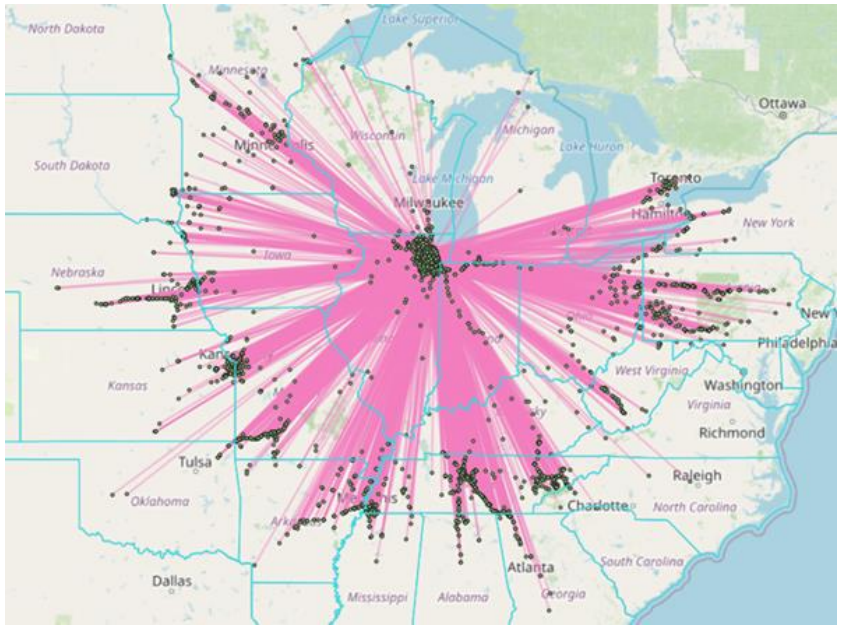
- Trip filtering: based on OD coordinates with TIGER Geodatabases (U.S. Census Bureau)
- Trip extraction: one-day trips originated from Indiana and ended in Illinois

FIPS: Federal Information Processing Standards

Trip Classification (based on travel time)



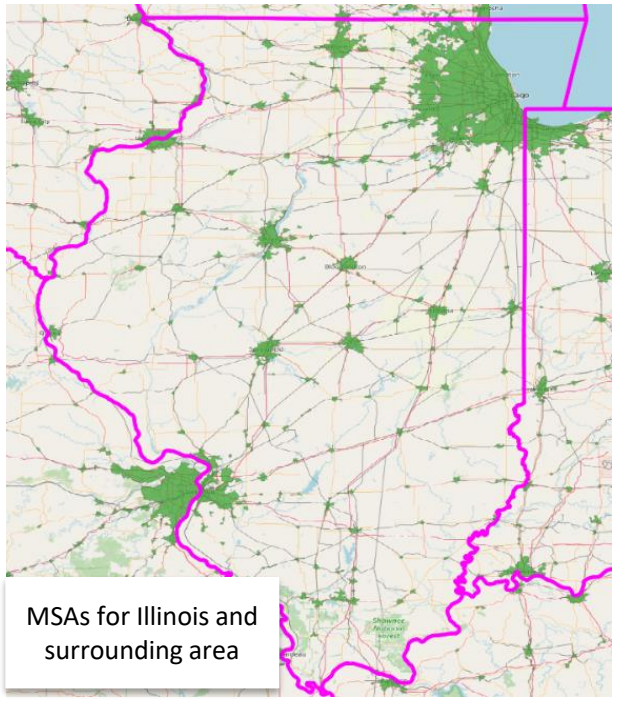
trip spatial distribution from/to Cook County, IL (2~16 hr.)



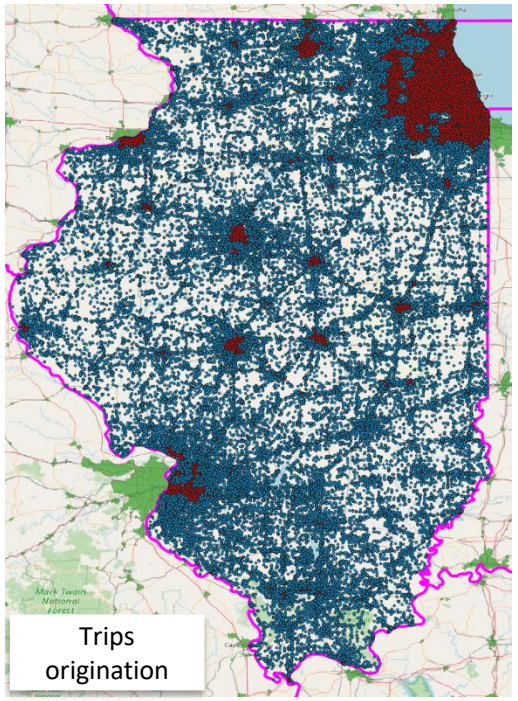
trip spatial distribution from/to Cook County, IL (8~10 hr.)

- Long-distance trip is suspected to be a transmission *vector* by epidemiological modeler
- Trip originated outside Cook County, IL and ended in Cook County, IL

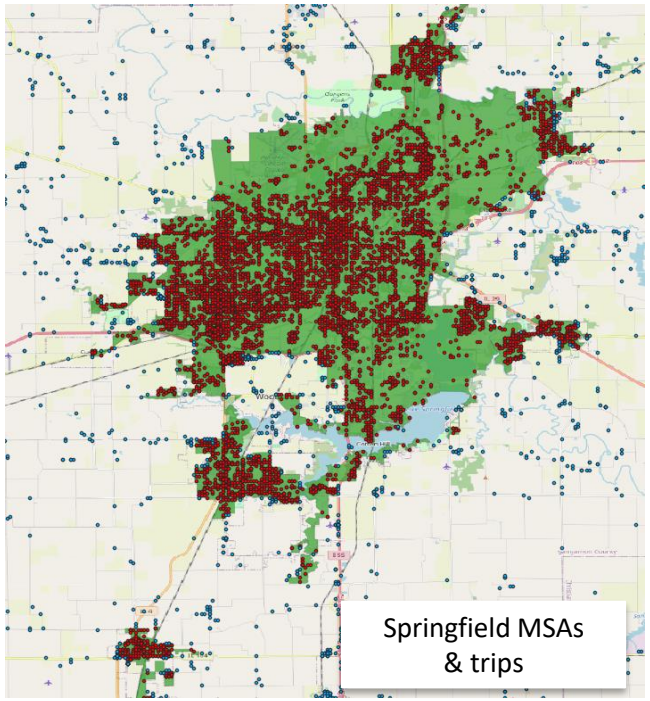
Trips classification (based on MSA layer)



MSAs for Illinois and surrounding area



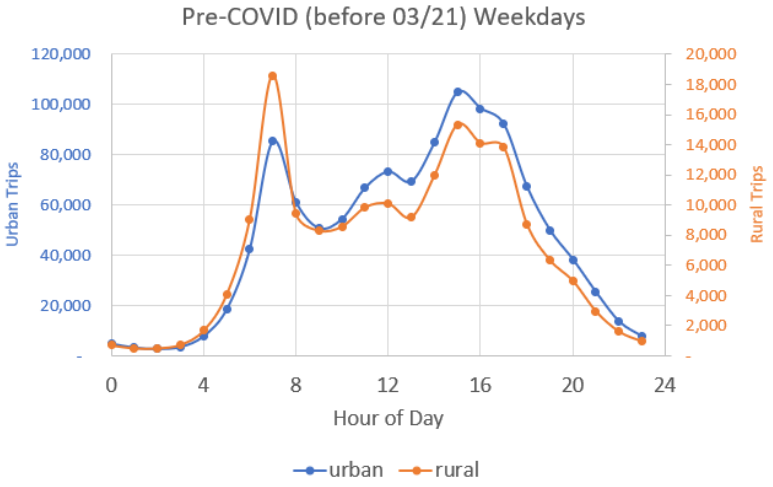
Trips origination

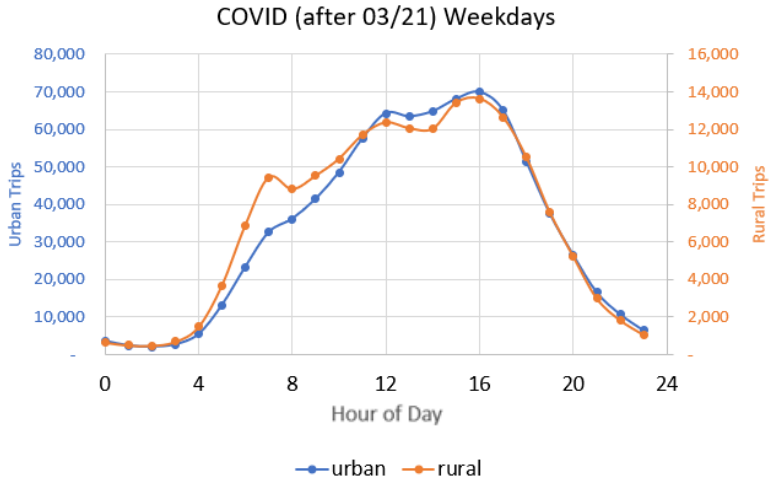


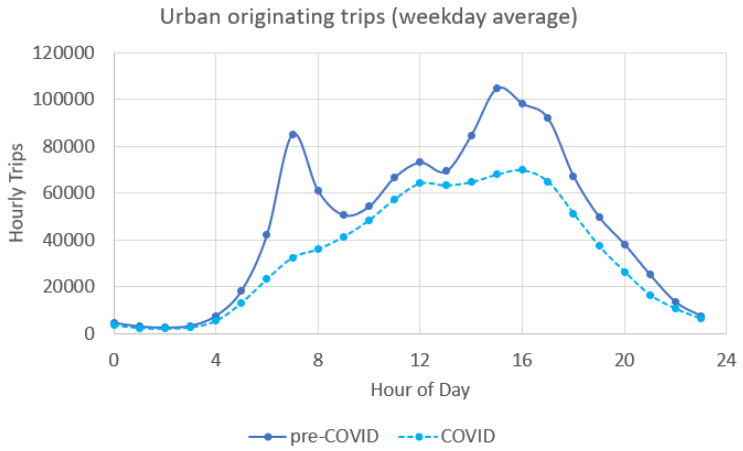
Springfield MSAs & trips

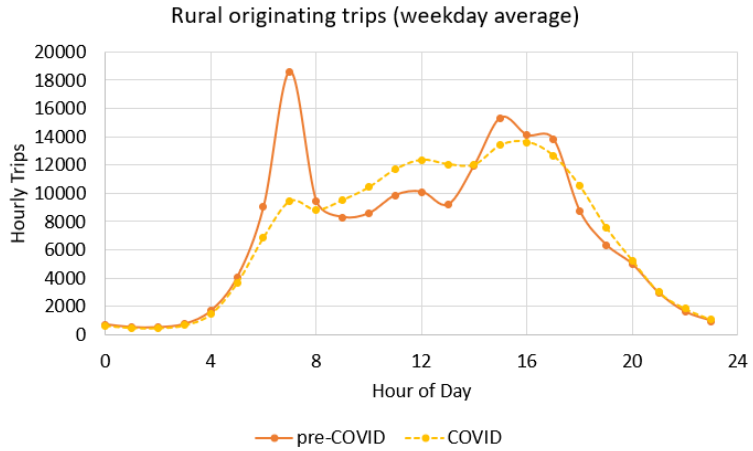
- Use the Metropolitan Statistical Areas (MSAs) layer to identify trips originated in urban areas
  - MSA >50k inhabitants
  - Micropolitan area (CBSA) 10k< inhabitants < 50k

Trip Classification (based on MSA layer)





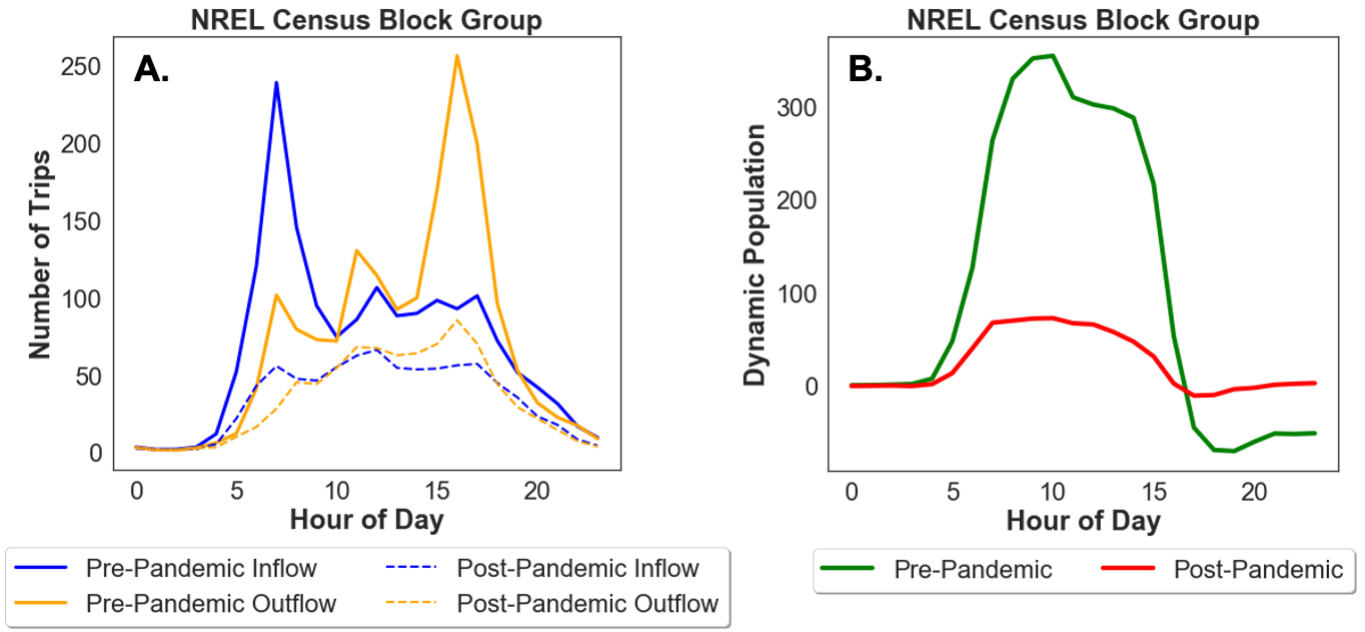




- Aggregated data for the entire state of Illinois, weekdays only
  - The urban area, though with much smaller area in combination, has 5x of the trips made
  - The decline in morning peak is less significant than that in the urban trips

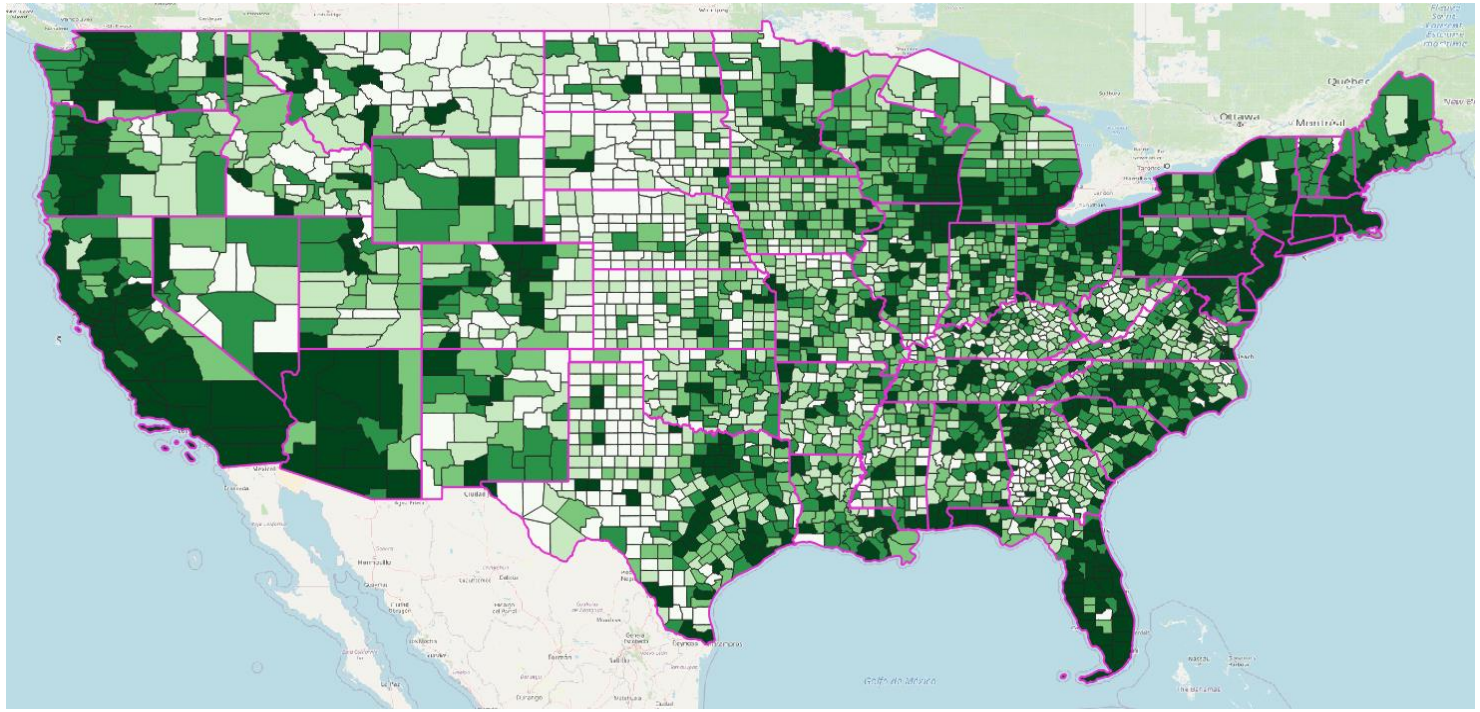
Location Analysis (NREL example)

- Inflow and outflow data from INRIX provide insight into when and where people are going
- Curves displays pre-COVID data for NREL campus census block group (CBG)
  - Pre: weekdays before 03/01
  - Post: weekdays after 04/01



NREL CBG Population Dynamics

Merge INRIX Data w/ Trip NAICS Code



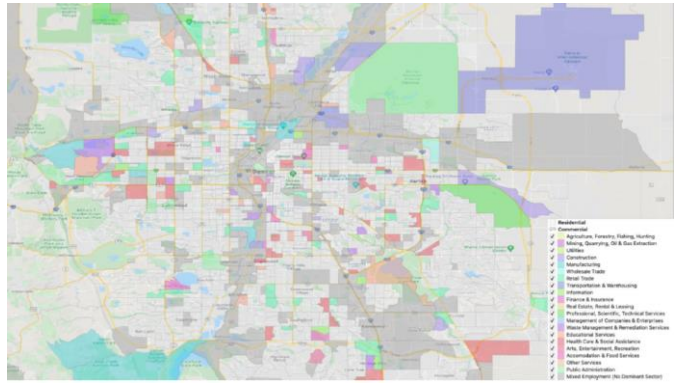
SafeGraph POI Coverage for Essential Business

- Enhancing INRIX O/D data with NAICS code information, which provide business information to further infer trip purpose
- SafeGraph point-of-interest database with 3.6 MM POIs within US with 5-digit NAICS codes
- Census Bureau LODES (LEHD Origin-Destination Employment Statistics) with 2-digit NAICS codes

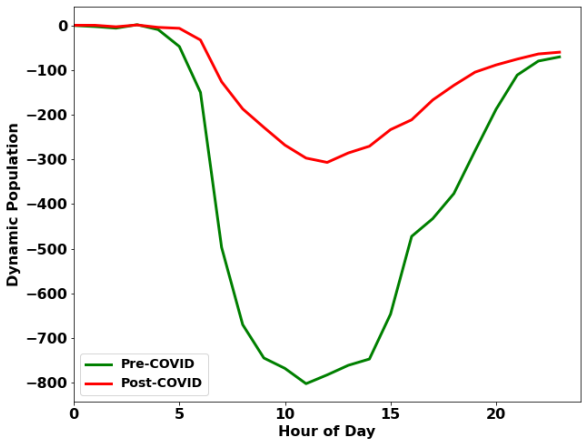
POI: point of interest
LEHD: Longitudinal Employer-Household Dynamics
LODES: origin-destination employment statistics
NAICS: North American Industrial Classification Systems

Population Flow for Industrials

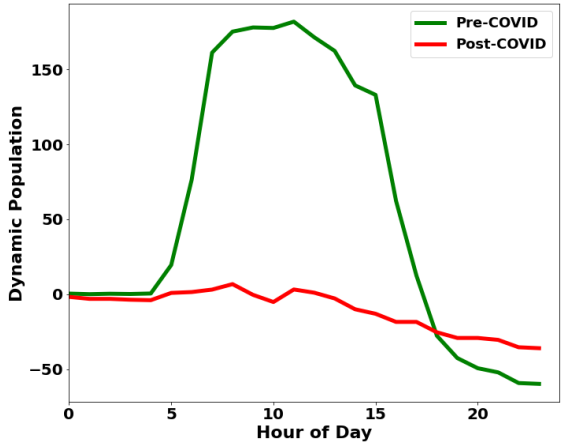
- Classified census block groups using employment data from the Bureau of Labor Statistics



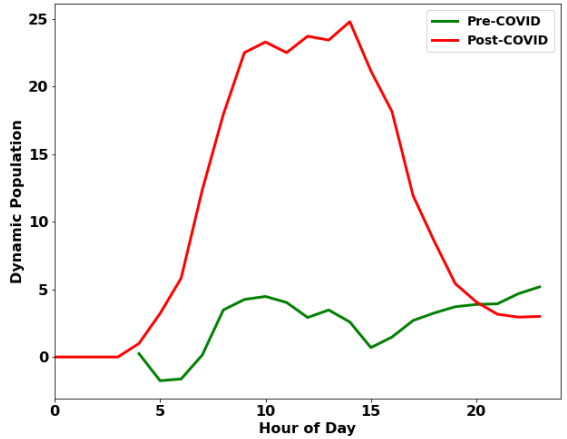
Residential



"Information"



"Recreational"



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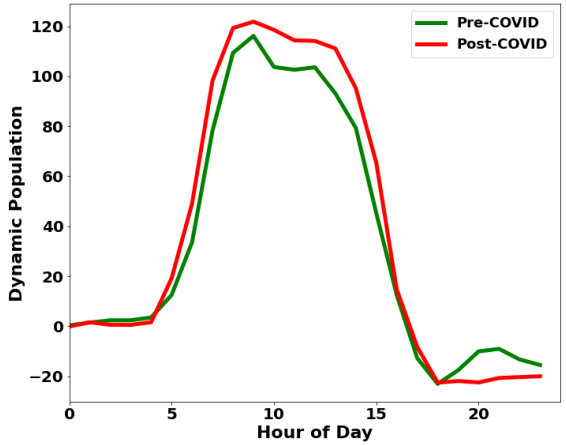
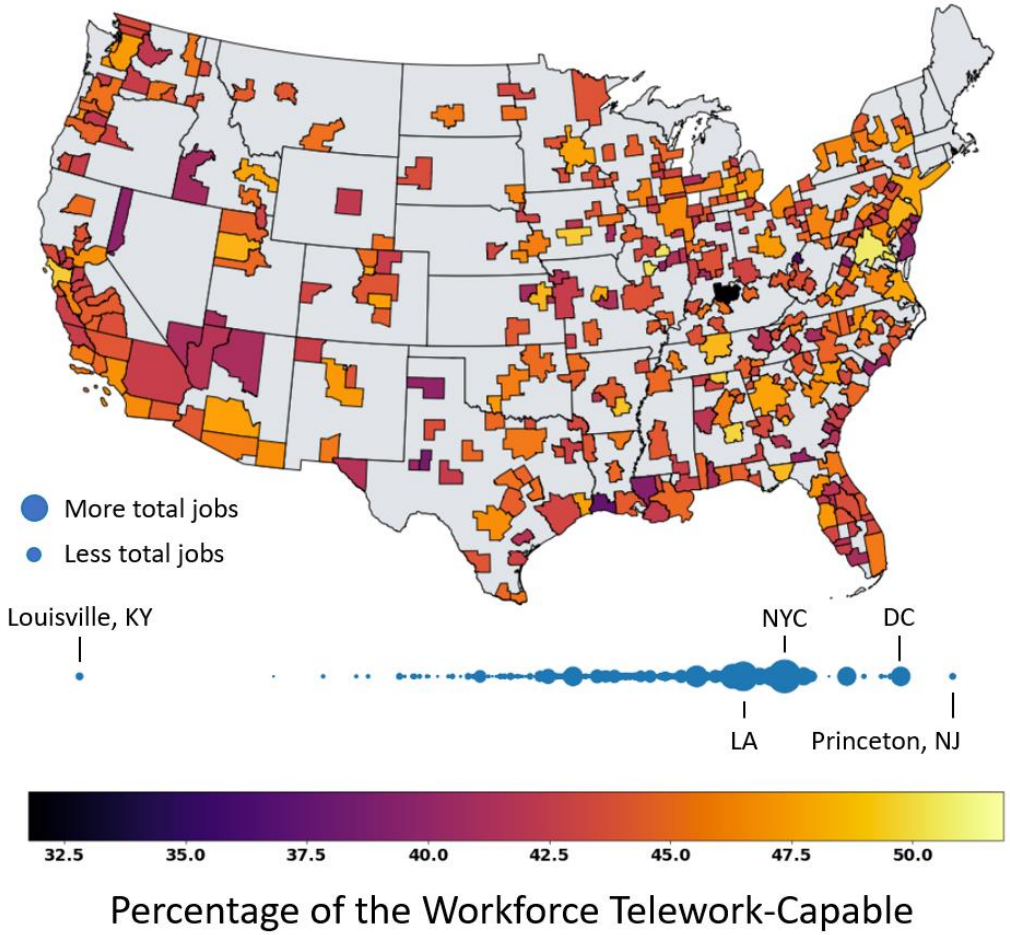


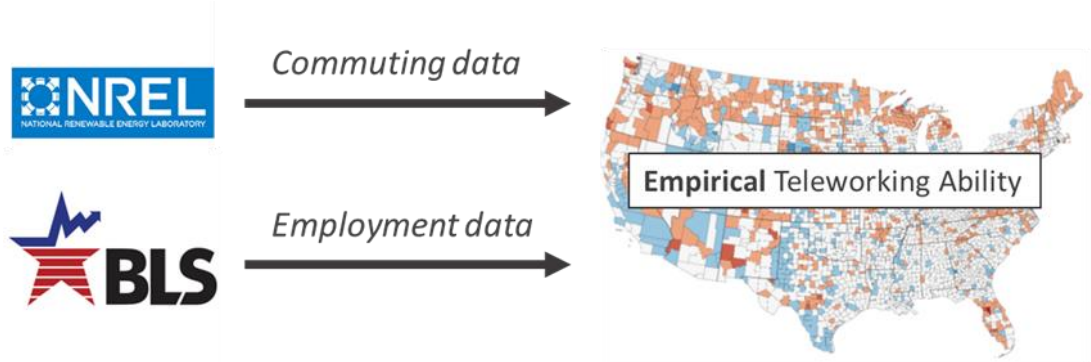
CBG Population Dynamics for Different Industries

Propensity for Teleworking



Left: Sourced data from the Bureau of Labor Statistics (BLS) to understand telework-likelihood by metropolitan statistical area (MSA). Combined sources suggesting likelihood of teleworking capability by industry and labor market composition specific to each city.

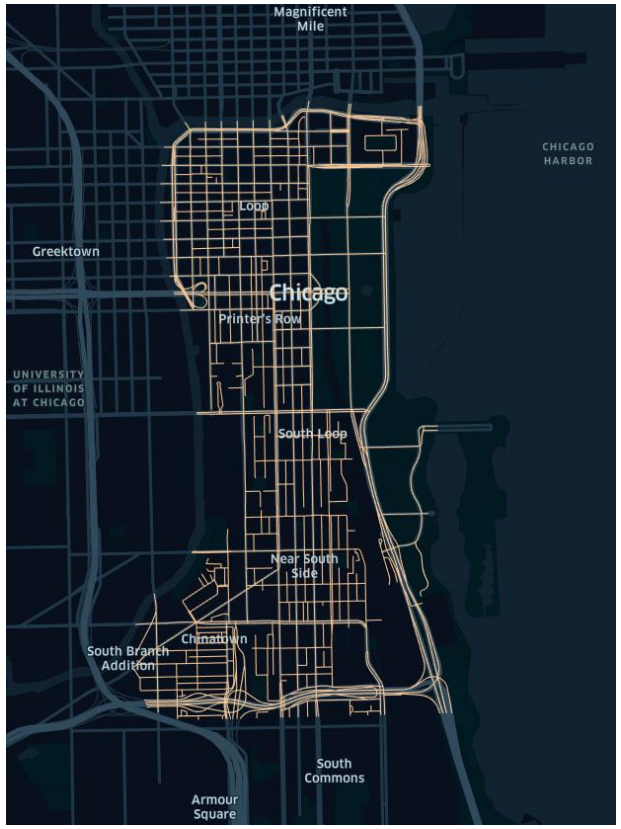
Below: Engaged with labor economists at BLS with expertise in teleworking. Identified opportunity to collaborate by blending highly resolved employment data with commuting patterns observed through mobility data.



Urban Mobility w/ Additional Data Sources: Chicago-NYC Comparison

Midtown Manhattan vs. Chicago Downtown

Midtown Manhattan

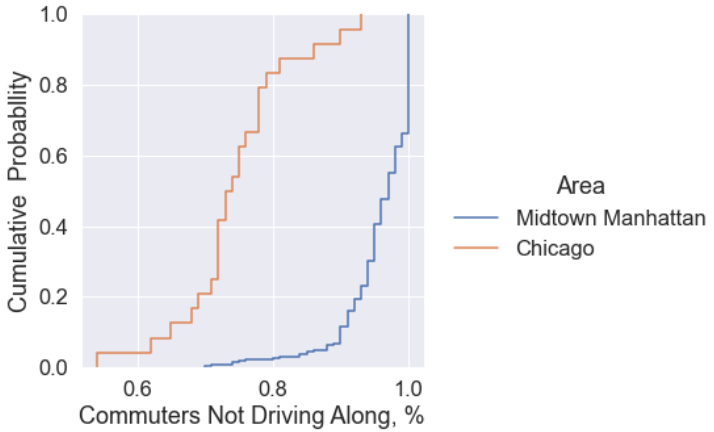


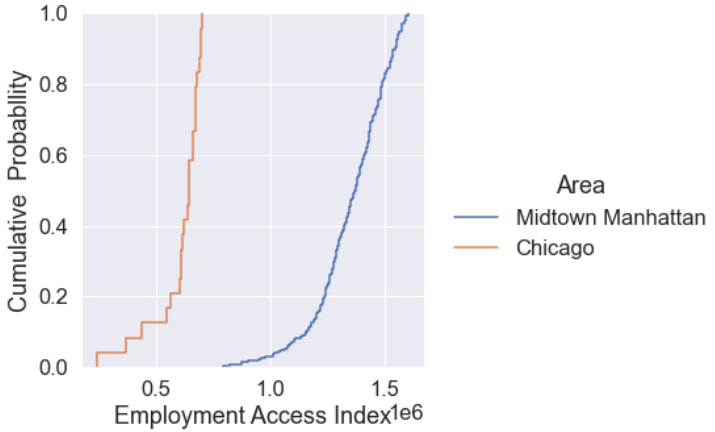
Chicago Downtown

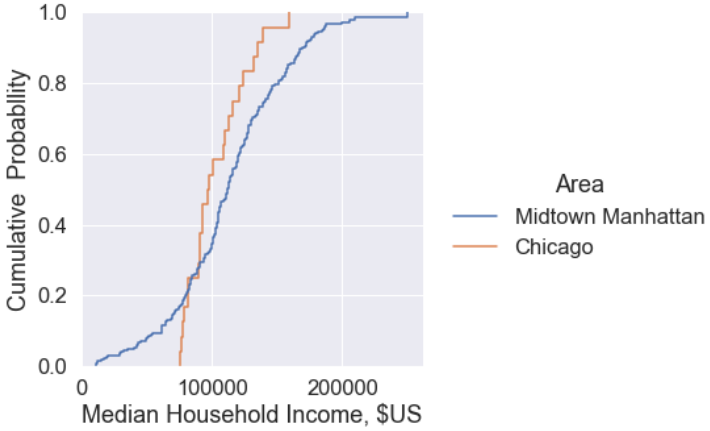
- Midtown Manhattan vs. Chicago CBD comparison
- TIGER database from U.S. Census Bureau
- All the sociodemographic metrics in the **American Community Survey**
  - census block group (CBG) level
  - 2012 -2016

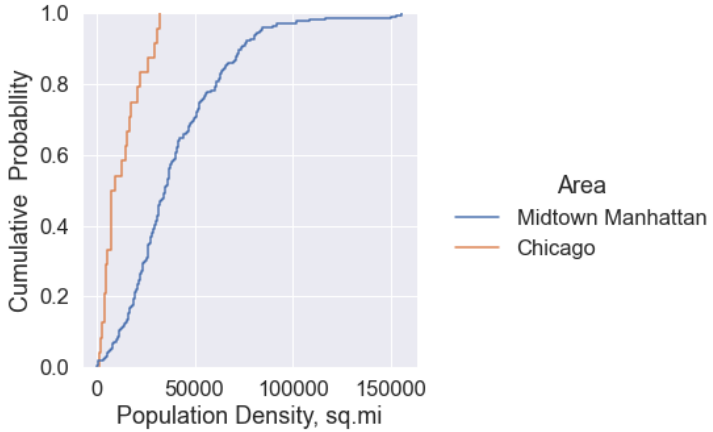
TIGER: Topologically Integrated Geographic Encoding and Referencing

Midtown Manhattan vs. Chicago Downtown









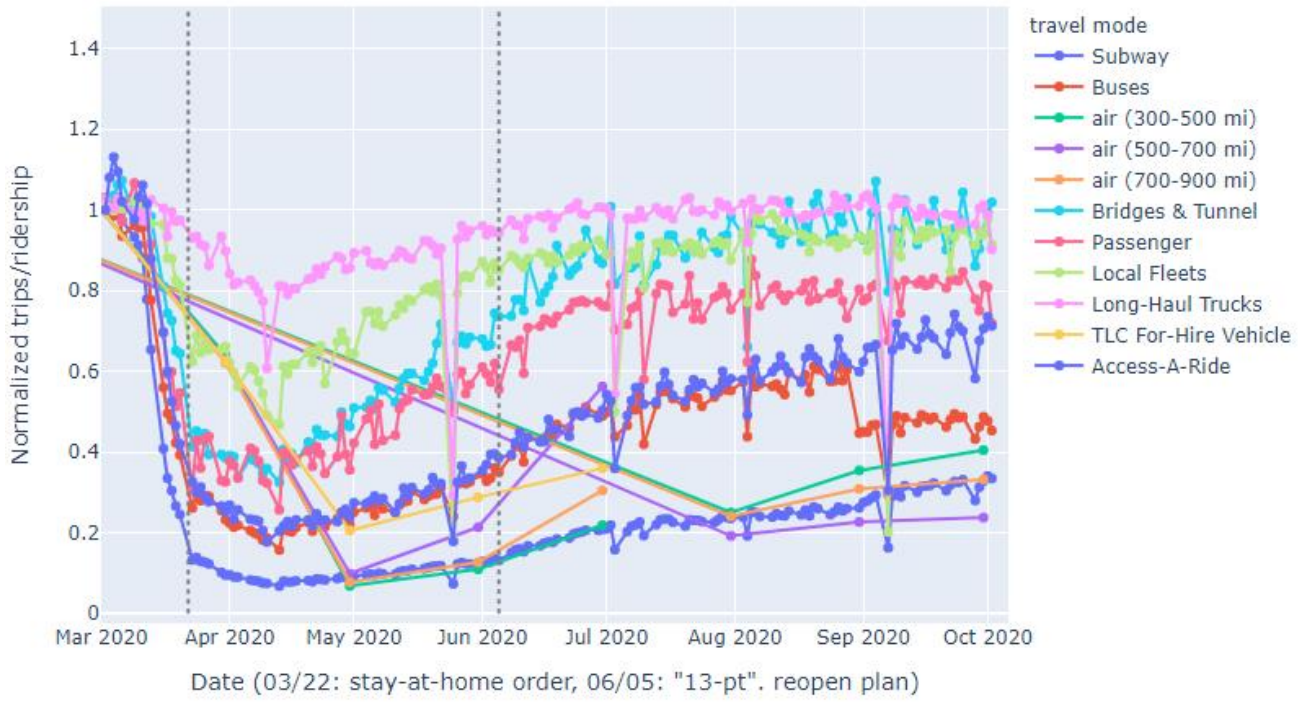
- Each sample represents one census block group (CBG)
- Most portion of residents in the Midtown do not use SOV to commute.
- The median household income in the Midtown is more spread out compared to that of Chicago
- NYC has higher overall employment access index (residents are closer to most of the jobs)

Employment access index: number of jobs / the square of the distance to jobs

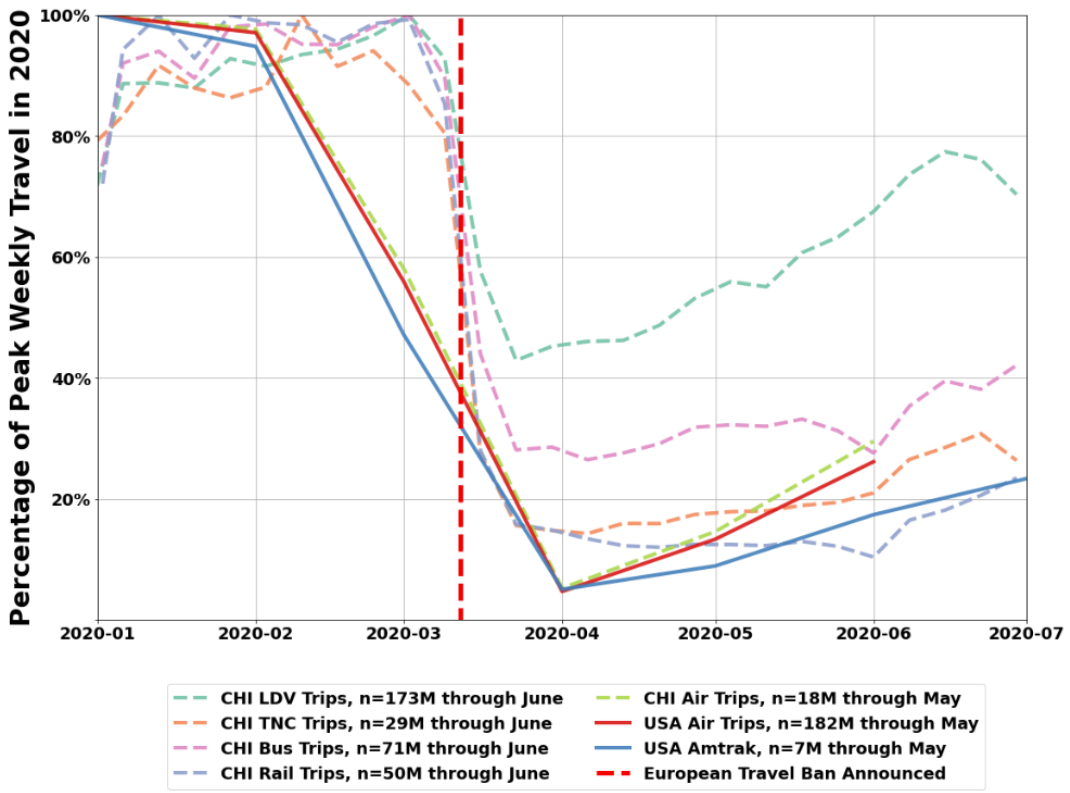
Data source: American Community Survey

Mode of Travel Comparison

New York City



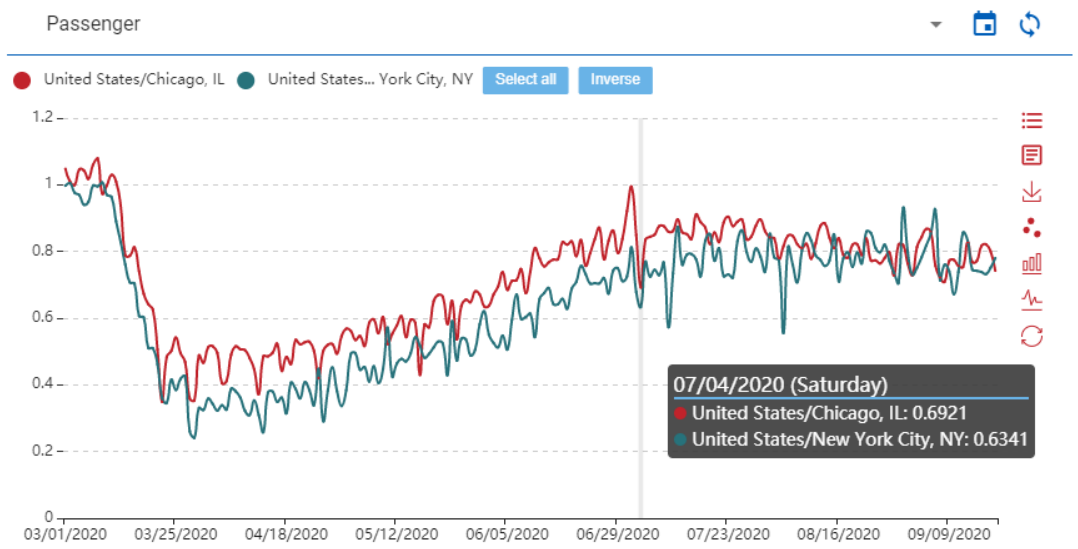
Chicago



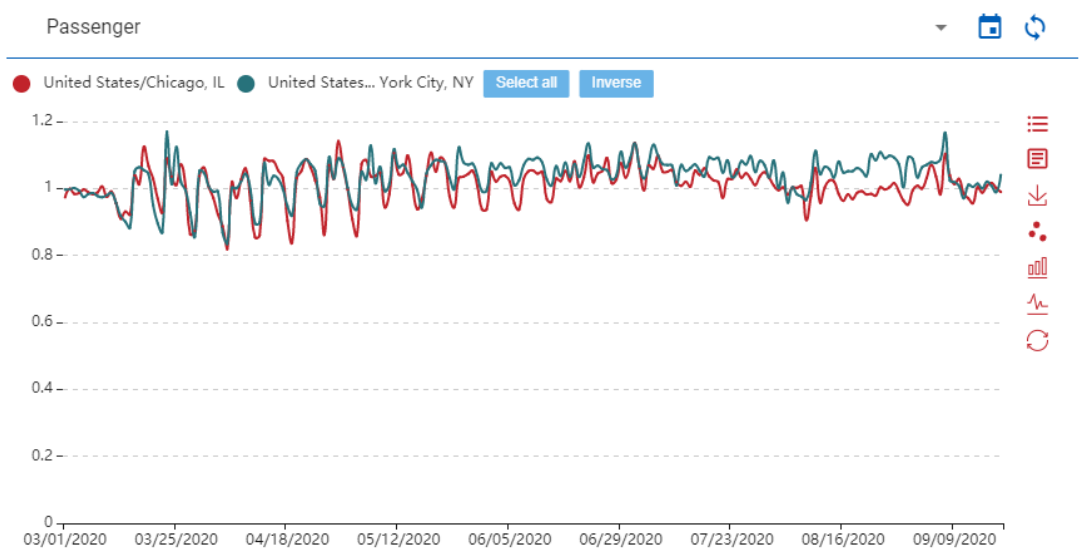
- Sharp decline for travel in both cities since Mar 2020

Road Travel

Normalized Vehicle Miles Traveled

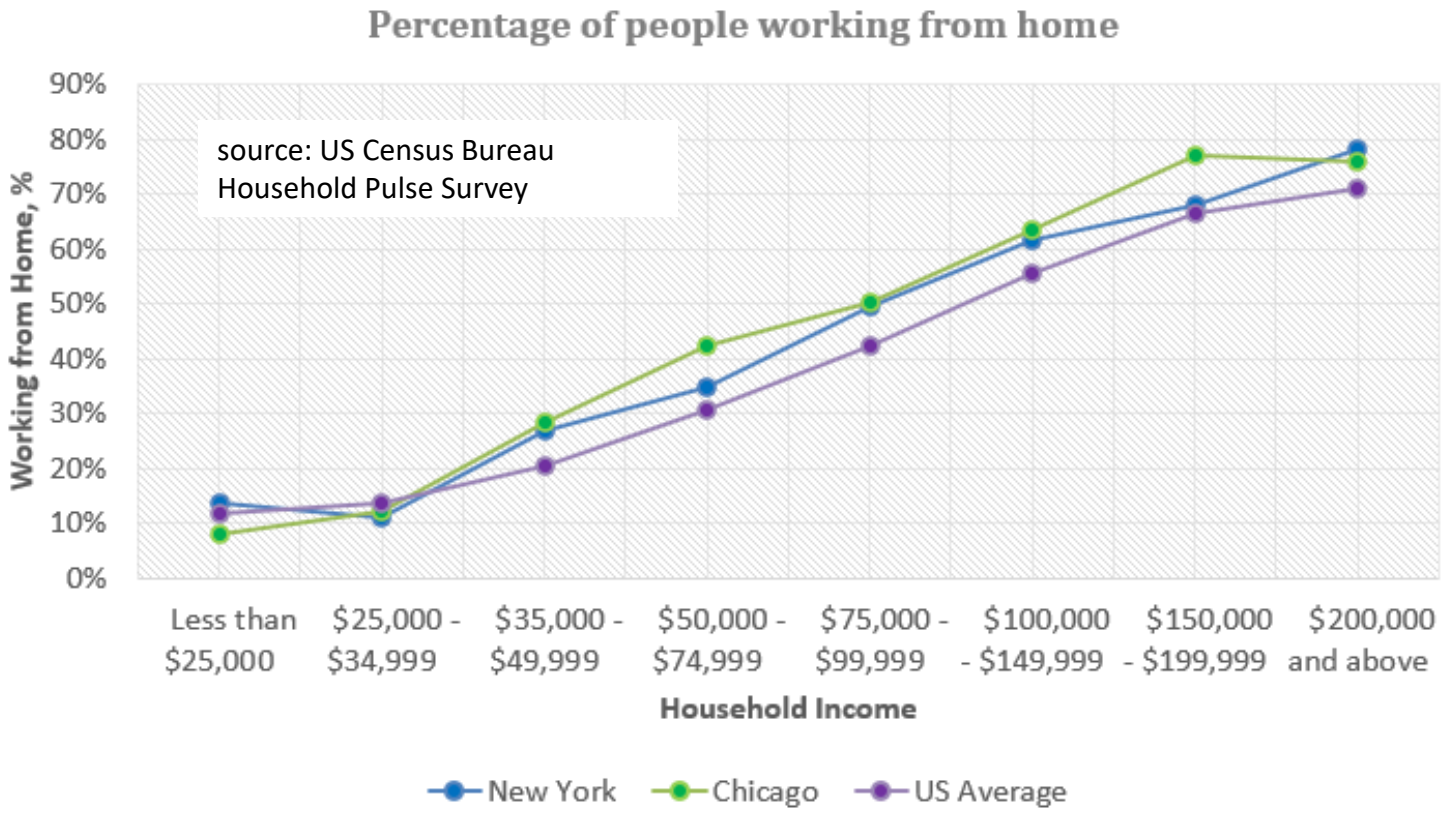


Normalized Average Trip Distance



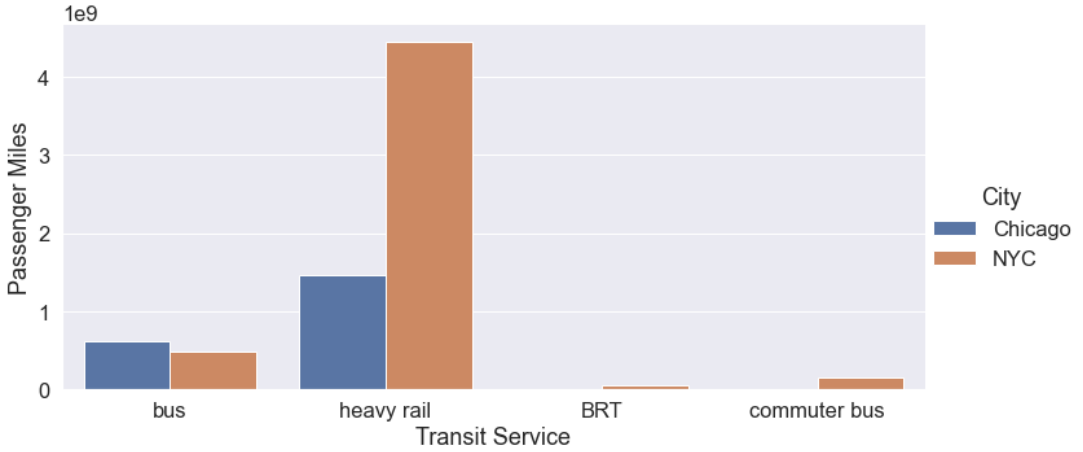
- For seasonally-adjusted passenger VMT (**IRINX**), neither city has resumed the pre-COVID level travel. The summer travel has been suppressed throughout summer.
- Both cities experienced essential-trip pattern from Mar to Jun: weekend trips were reduced significantly.
- NYC has higher average trip distance than Chicago during the summer months.

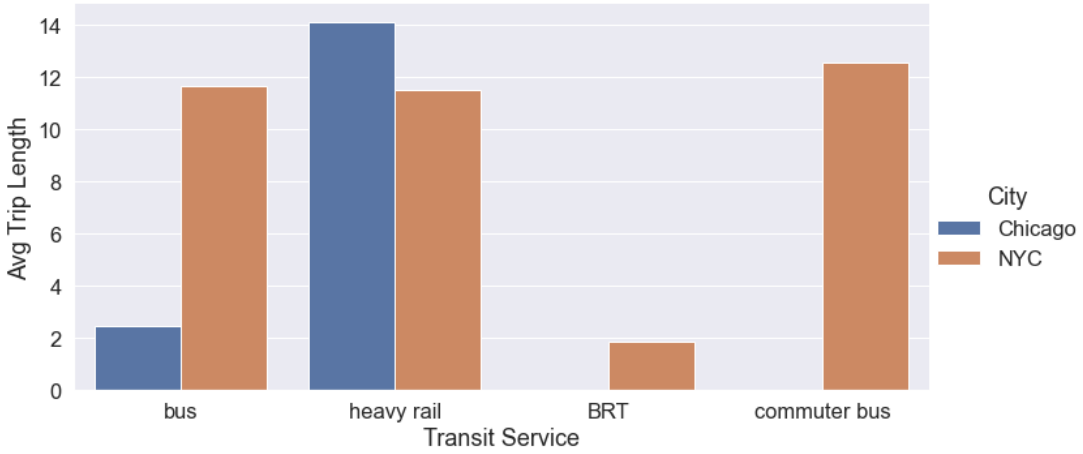
Midtown Manhattan vs. Chicago Downtown



- **USCB Household Pulse Survey** designed to collect how people's live impacted by COVID-19
- More people are working from home in either cities, compared to the US average
- Propensity of teleworking positively correlates to household income level

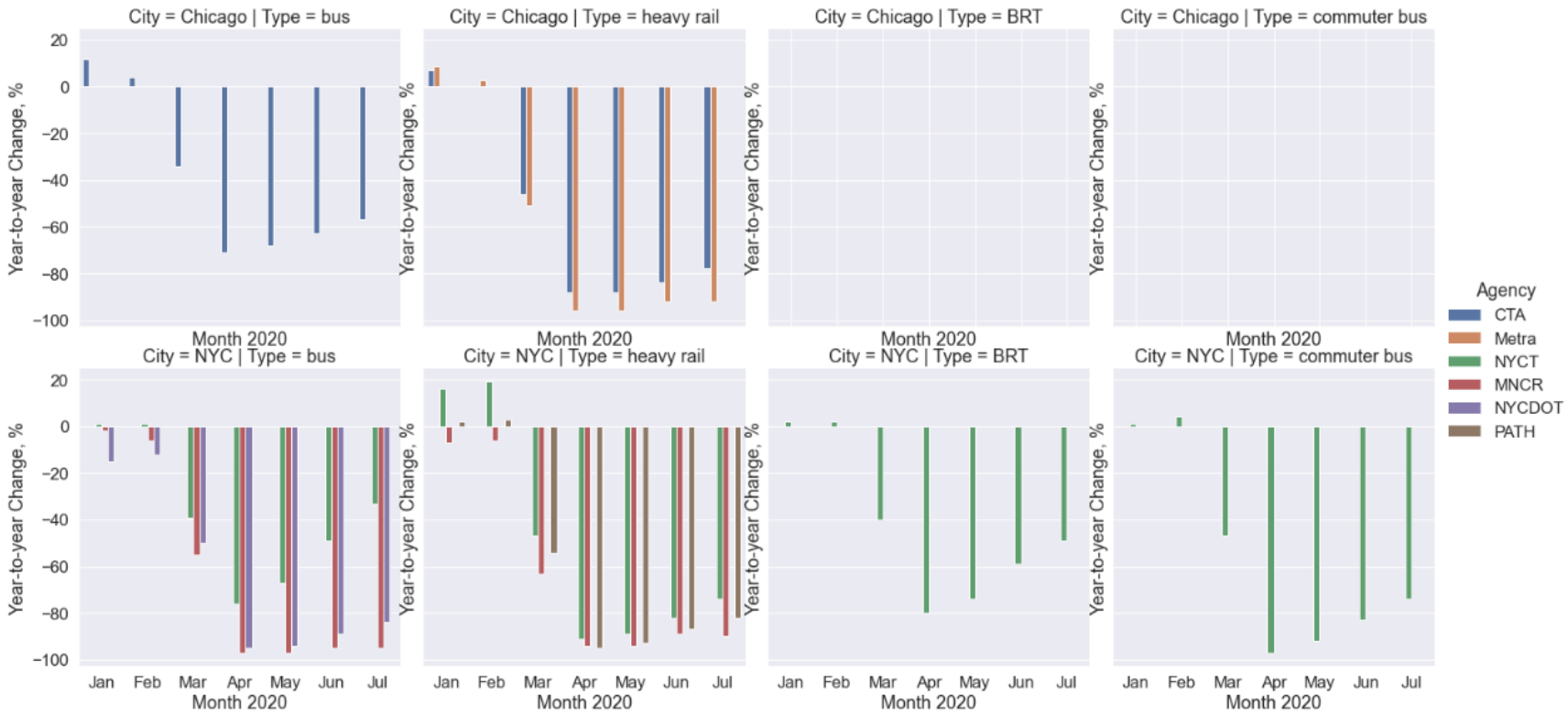
Transit System Profile





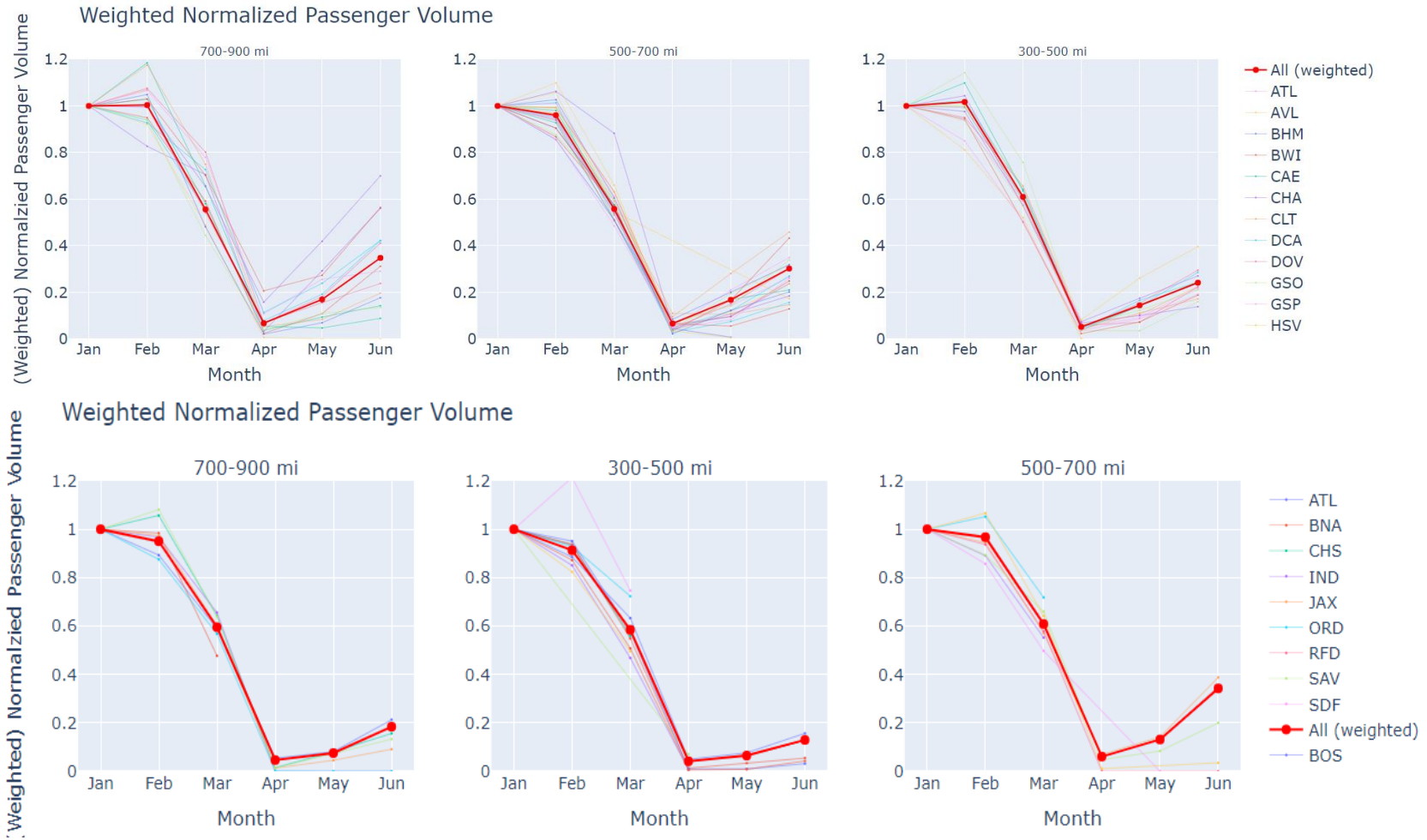
- Passenger miles in FY2017 reported to **FTA National Transit Database**
- Transit agencies:
  - Chicago: CTA, Metra Rail
  - NYC: MTA-NYCT, MTA-MNCR, MTABUS, NYCDOT, PATH
- NYC has significantly greater ridership compared to that of Chicago
- The average trips length for NYC is around 12 mi. in bus, heavy rail, and commuter bus modes

Transit Ridership in 2020



- Year-to-year ridership change for transit services in NYC and Chicago areas
- Ridership decline across the board since Mar 2020

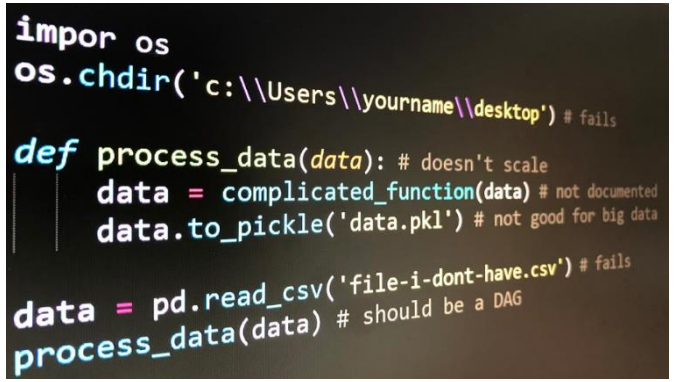
Air Travel (outbound flights)



- Merge **OpenSky** airport database with **BTS airport passenger flow**
  - thin line: airport O-D pair
  - solid red line is weighted outbound flows
- Long-distance travel rebounded the quickest for both ORD and JFK within the 3 bins

Conclusions

- Probe vehicle and smartphone application data can provide a surrogate path to monitoring our mobility systems
  - Near ubiquitous geographic coverage
  - Cost-effectiveness
- A more comprehensive and timely picture of our mobility system when fused with other existing data sources (e.g., census data)
- Synergy of data and our transportation systems shows its increasing importance, despite hurdle to overcome (e.g., privacy preservation)
- Various data sources and open-source data initiatives are freely available even for students

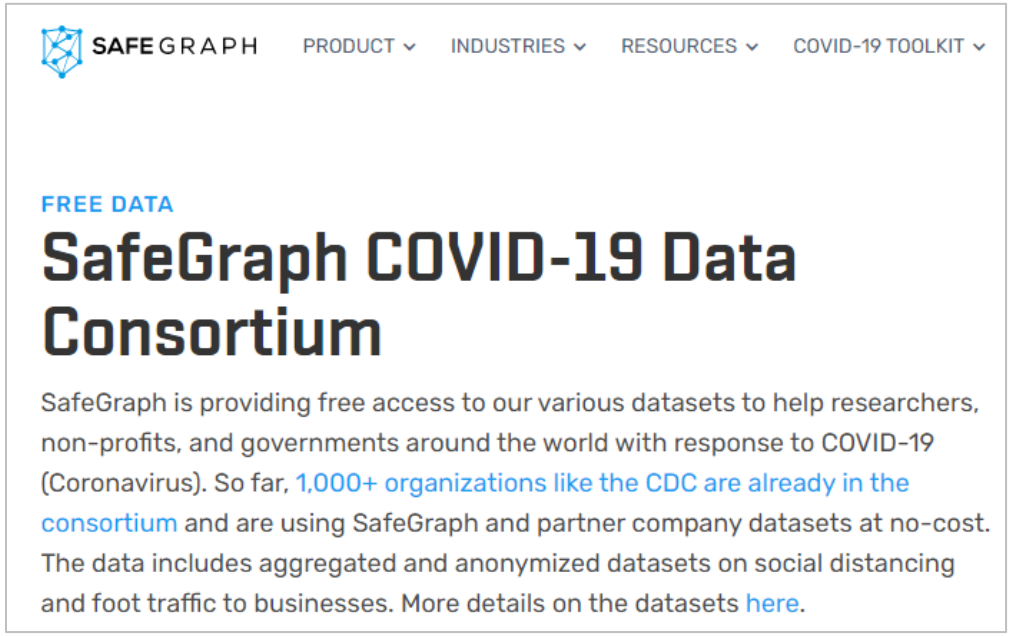


Data Resources

- Mobility data publically available
  - SafeGraph COVID-19 Data Consortium: https://www.safegraph.com/covid-19-data-consortium
  - UMD COVID-19 Impact Analysis Platform: https://data.covid.umd.edu
  - Google Mobility Data: https://www.google.com/covid19/mobility
  - Unacast data: https://www.unacast.com/covid19/social-distancing-scoreboard
  - Apple: https://covid19.apple.com/mobility
  - StreetLight COVID-19 Data: https://www.streetlightdata.com/covid-transportation-metrics/
- Other data sets from government agencies
  - Bureau of Labor Statistics
  - Bureau of Transportations Statistics
  - U.S. Census Bureau
  - U.S. National Transit Database

Free data: SafeGraph COVID-19 Data Consortium

- Free SafeGraph access under the SafeGraph COVID-19 Data Consortium
- License agreement
  - usage: COVID-19 responses
  - period: min. of 1 year or until COVID-19 global response has subsided
  - publishing: must credit SafeGraph if data is used
- Data coverage
  - Data range: Jan 2019 – present
  - Content: aggregated and anonymized datasets on social distancing and foot traffic to businesses



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