Mobility in Post-Pandemic Economic Reopening under Social Distancing Guidelines: Congestion, Emissions, and Contact Exposure in Public Transit

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June 23, 2021

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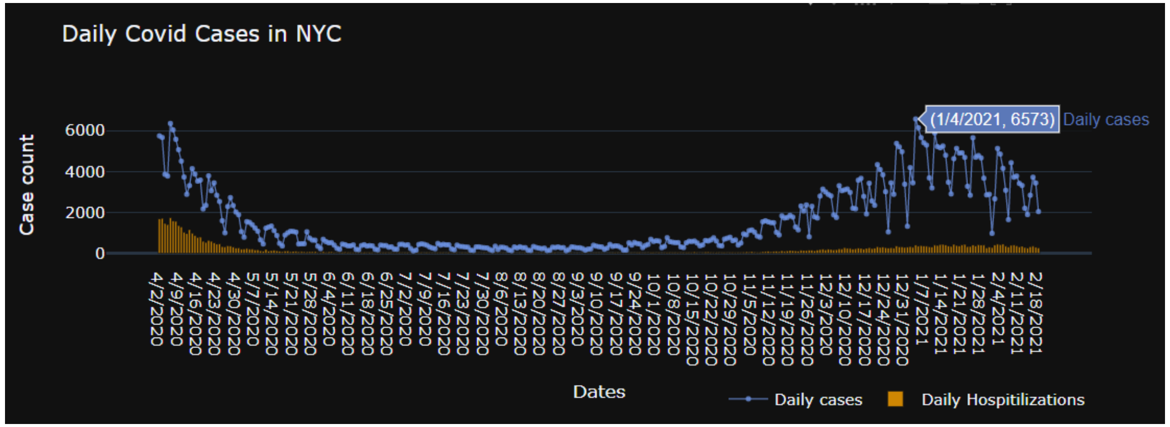
Introduction

Motivation

- Early on in COVID-19 pandemic, NYC became the national epicenter
- New York shut down with "stay-at-home" orders to maintain social distancing and "flatten the curve" in March 2020.
- Even with reopening in the last few months, transit ridership remains low despite studies indicating no evidence of transit being a super spreader.

Research questions

- What is the effect of COVID-19 on mode choice travel behavior?
- How much would "behavioral inertia" from COVID impact reopening? i.e., how much worse can traffic congestion get under reopening due to this change in behavior?
- Under transit operating guidelines to incorporate social distancing, how would the combined effects with behavioral inertia affect travel?



Develop a simulation tool to estimate and evaluate the impact of COVID-19 on transport system.

MATSim
Multi-Agent Transport Simulation

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C2SMART COVID-19 Data Dashboard:
https://c2smart.engineering.nyu.edu/covid-19-dashboard/
Data source: Department of Health and Mental Hygiene

Existing pre-COVID Multi-agent Based Model: MATSim-NYC

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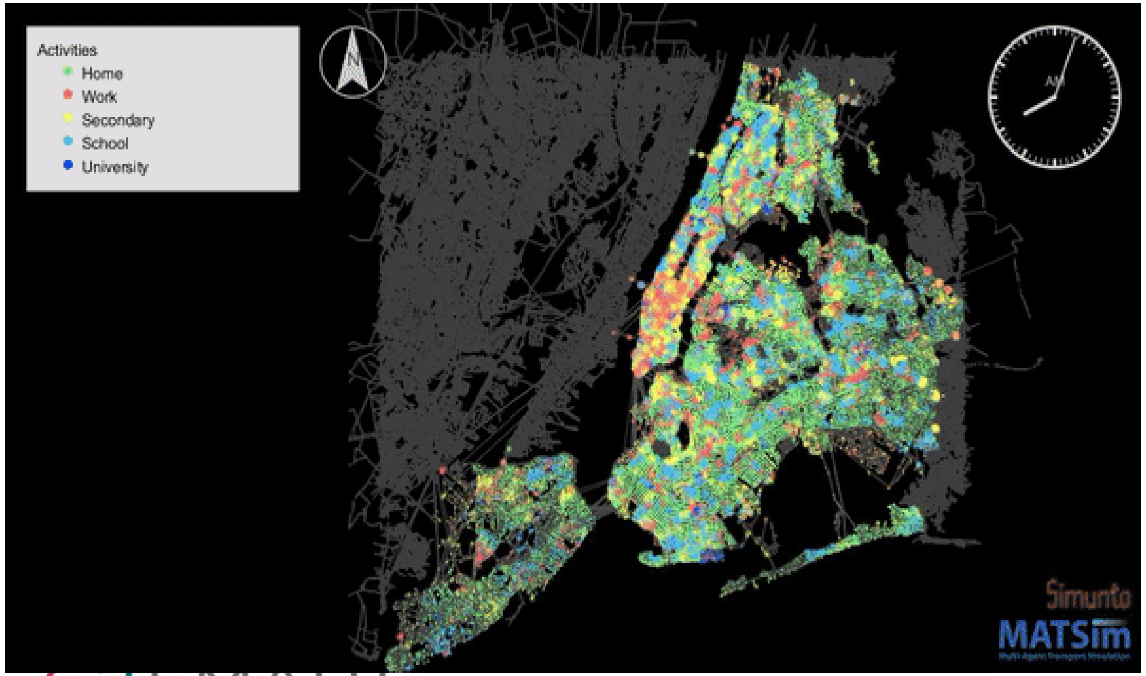
MATSim-NYC

- MATSim-NYC consists of a calibrated synthetic population and a calibrated day-to-day simulator (He et al., 2021)
- Base year 2016 (for COVID we updated transit schedule to January 2020 GTFS)
- Population of 8.3+M, separated to Manhattan and non-Manhattan segments with gateways for nonresident trips



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Recalibrated COVID model: MATSim-NYC-COVID

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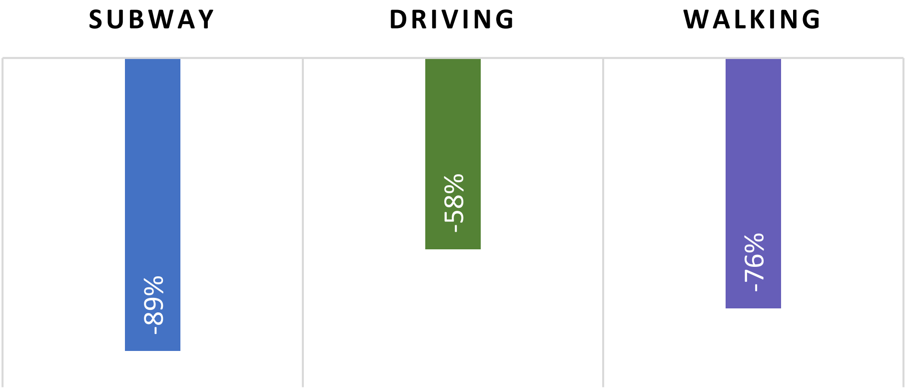
❶ Mode choice during COVID-19

- Work-From-Home (WFH) population based on NAICS
- Model recalibrated based on MTA transit ridership and trip reduction from Apple Mobility Report

TRIP REDUCTION (BASED ON AVERAGE NUMBERS FROM MAR 23 TO APR 19)



Reference: 1. Dingel, J. I., & Neiman, B. (2020). How many jobs can be done at home? (No. w26948). National Bureau of Economic Research.
2. Priority Industries for Re-opening in NYS: https://www.governor.ny.gov/new-york-forward/regional-guidelines-re-opening-new-york

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❷ Simulated scenarios based on research on work from home by industry combined with NY State Phased Reopening plan.

- Mode preference is assumed to be the same as in the COVID period in all reopen phases
- Transit schedules adjusted based on recovery phases

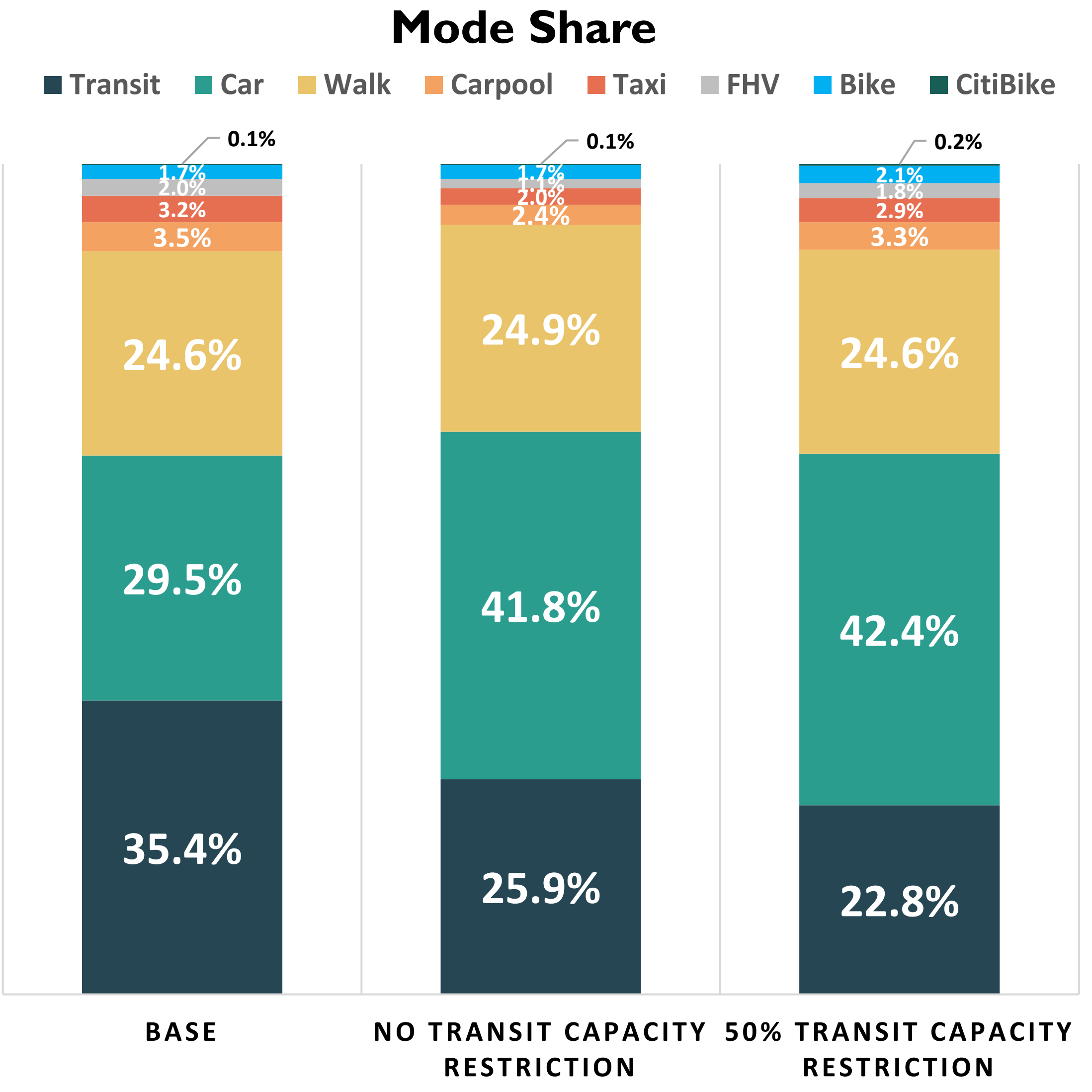
	Industry	COVID	Phase1	Phase2	Phase3	Phase4
1	not working	0	0	0	0	1
2	Agriculture, forestry, fishing and hunting, and mining	0.92	0.92	0.92	1	1
3	Construction	0.81	1	1	1	1
4	Manufacturing	0.78	1	1	1	1
5	Wholesale trade	0.48	1	1	1	1
6	Retail trade	0.86	0.93	1	1	1
7	Transportation and warehousing, and utilities	0.72	0.72	0.72	1	1
8	Information	0.28	0.28	0.28	0.28	1
9	Finance and insurance, and real estate and rental and leasing	0.41	0.41	1	1	1
11	Professional, Scientific, and Technical Services	0.2	0.2	1	1	1
12	Management of Companies and Enterprises	0.21	0.21	0.605	1	1
13	Administrative and Support and Waste Management and Remediation Services	0.69	0.69	0.69	1	1
14	Educational services, and health care and social assistance	0.46	0.46	0.46	0.73	1
15	Arts, entertainment, and recreation, and accommodation and food services	0.83	0.83	0.83	0.915	1
16	Other services, except public administration	0.69	0.69	1	1	1
17	Public administration	0.59	0.59	1	1	1

Case study 1: NYC reopening scenarios

- **Worst Case Scenarios: Assume people maintain mode preferences held during the crisis**
- **Scenario1: No transit capacity restriction:** no limitations on the number of riders per subway car/bus
- **Scenario 2: 50% transit capacity restriction:** limiting subway cars and buses to half of its full capacity.

After Phase 4 reopening* vs Base Model		
Scenario	**No transit capacity restriction**	**50% transit capacity restriction**
# of Transit Trips Restored	73%	64%
Transit Mode Share	-10%	-13%
Car Mode Share	+12%	+13%
#Car Trips	142%	143% (bike/citibike trips ↑ Carpool, Taxi, FHV trips are also higher than scenario 1)

*assuming near-normal recovery



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Case study 2: Mobility in Post-Pandemic under Social Distancing Guidelines

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What policies can be implemented in post-COVID to help **relieve traffic congestion and emission as well as maintaining the social distance** in transit systems?

Factors that may impact future transport

- Behavior change
- Social distancing guideline
- Telework
- Flexible work schedules

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Scenario Analysis

Travel mode preference: 1) Pre-COVID model; 2)COVID model

Transit operations: 1)100% capacity; 2)50% capacity.

Commuting pattern: 1) no change (100% commuting without telework and Staggered work hours (SWHs); 2) partial commuting with telework, and 3) 100% commuting with SWHs.

Telework: assume 59% of people continue to WFH based on findings from the survey by *Fluentpulse*.

SWHs: assume 50% of people change their departure times to one hour earlier and the remaining 50% of people change their departure time to one hour later.

https://fluentpulse.com/covid-19-future-of-travel/

Transit schedule updated to Aug 2020

Scenarios to investigate the changes in the transportation system after Covid-19

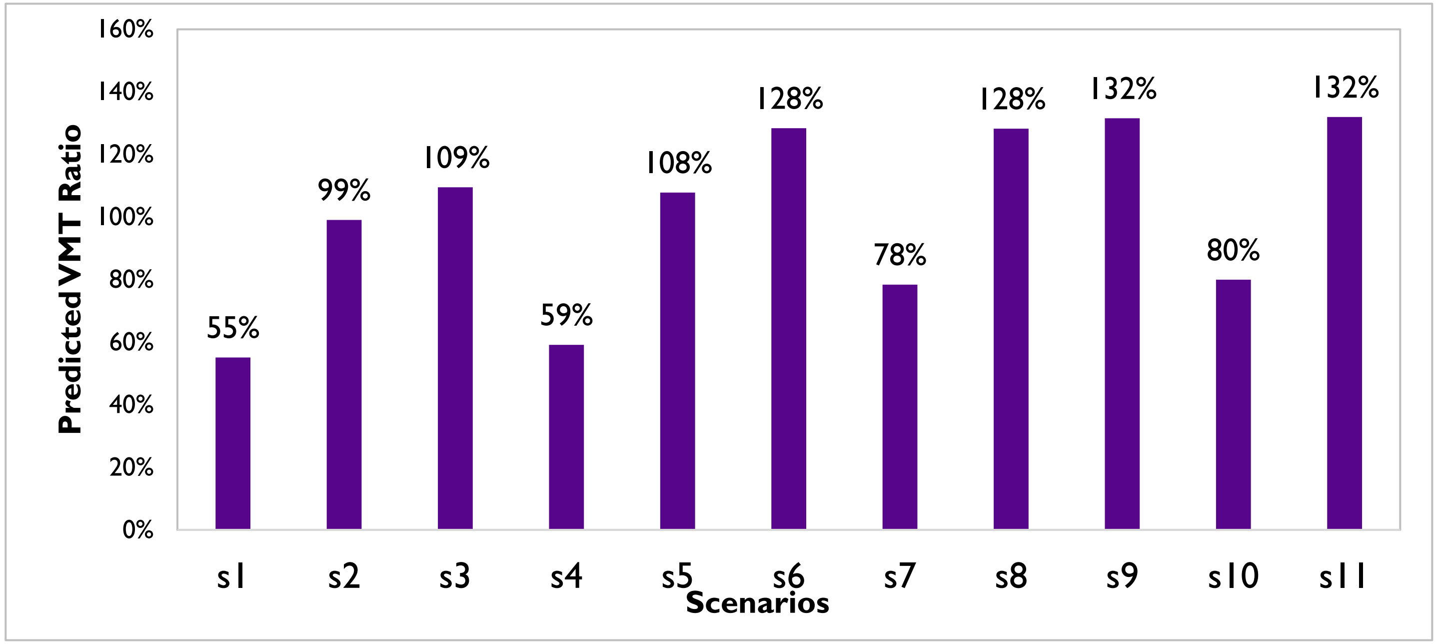
Scenarios	Mode preference	Transit Capacity	Commuting
S0 (Base scenario)	Pre-Covid level	100% capacity	No
s1 (PreCovid-100-Telework)	Pre-Covid level	100% capacity	Telework
s2 (PreCovid-100-SWHs)	Pre-Covid level	100% capacity	Staggered work hours
s3 (PreCovid-50-No)	Pre-Covid level	50% capacity	No
s4 (PreCovid-50-Telework)	Pre-Covid level	50% capacity	Telework
s5 (PreCovid-50-SWHs)	Pre-Covid level	50% capacity	Staggered work hours
s6 (Covid-100-No)	Covid level	100% capacity	No
s7 (Covid-100-Telework)	Covid level	100% capacity	Telework
s8 (Covid-100-SWHs)	Covid level	100% capacity	Staggered work hours
s9 (Covid-50-No)	Covid level	50% capacity	No
s10 (Covid-50-Telework)	Covid level	50% capacity	Telework
s11 (Covid-50-SWHs)	Covid level	50% capacity	Staggered work hours

Predicted trip ratio and VMT

May 2021 data shows that **transit ridership** in NYC was resumed to about **50%** compared to pre-COVID time. The observed data shows some mixture between Scenarios 10 – 11, indicating

1) COVID-19 mode preferences remain in effect during reopening,
2) commuters' self-enforced social distancing is effectively imposing a transit capacity reduction, and
3) telework is reducing the number of trips.

Mode preference: behavior inertia from COVID time				
Scenario	Mode preference change (s6)	50% capacity restriction (s9)	50%+Telework (s10)	50%+Staggered work hours (s11)
Transit Trips Restored	77%	68%	44%	68%
Car Trips Restored	132%	133%	77%	133%



Contact Exposure on Transit

We define the measure of number of contacts with duration longer than 15min as ***individual contact exposure*** to COVID-19, computed using a contact network approach from Bóta et al. (2017).

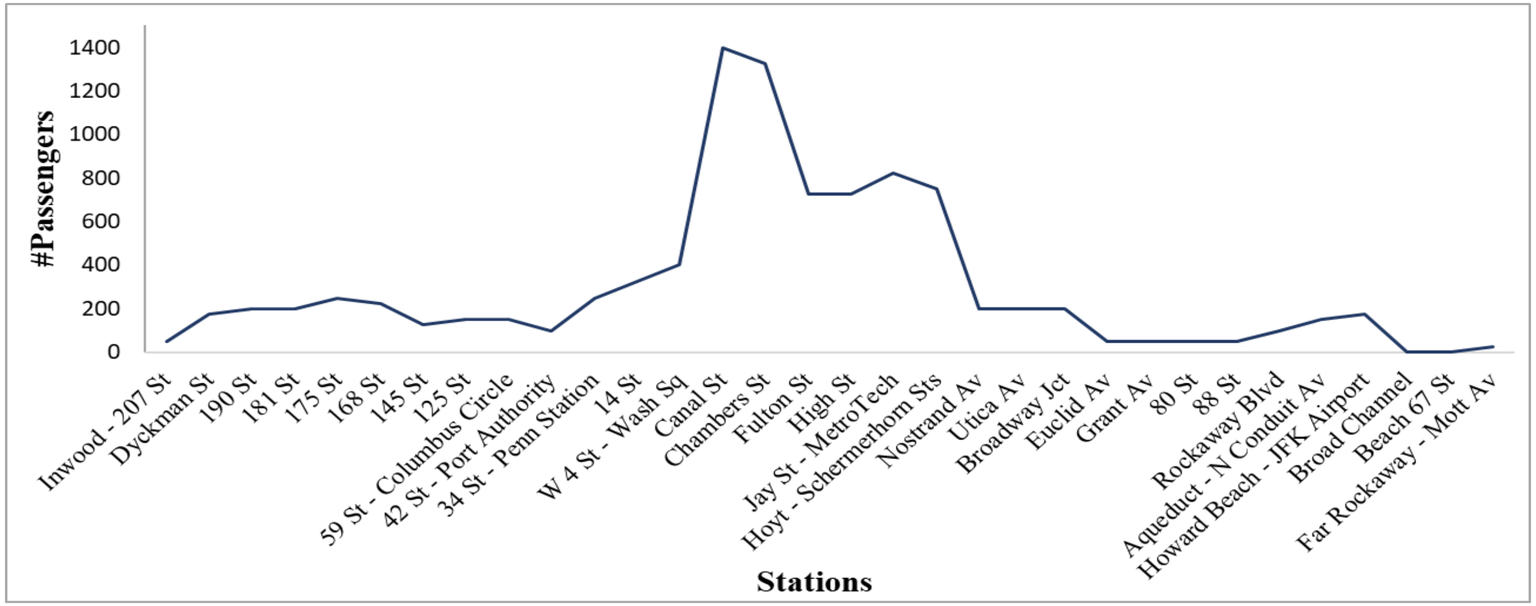
KEY TAKEAWAYS

- The percentage of contact exposure on subway is around 3%, without consider the presence of masks, PPE, etc.
- Subway lines 2, 5, and A running at peak hours are found to have the highest contact exposure in different scenarios.
- Telework and SWHs can reduces contact exposure to 36.19% and 69.8% compared to pre-COVID model.
- Passenger flow/density varied significantly on both spatial and temporal scales.
- Route-based or station-based transit strategies can be implemented to ensure social distancing at busy sites.

Bóta A, Gardner LM, Khani A. Identifying critical components of a public transit system for outbreak control. Networks and Spatial Economics. 2017 Dec;17(4):1137-59.

Estimated contact exposure in the subway network

Scenarios	Number of contact exposures compared to pre-COVID model	% of contact exposures (divided by ridership)	Subway trips with the highest contact exposures (line, direction, departure time)
Pre-COVID behavior (base scenario)	100.00%	3.14%	A, South, 6:13AM
COVID behavior	83.90%	3.20%	A, South, 6:13AM
COVID behavior + Transit capacity restriction	72.54%	3.08%	5, North, 08:05AM
COVID behavior + Transit capacity restriction + Telework	36.19%	2.37%	A, South, 6:18AM
COVID model + Transit capacity restriction + SWHs	69.80%	3.00%	2, South, 7:22AM



Number of passengers on a southbound A line trip with the highest contact exposure among all subway trips in the base scenario

Trade-offs between traffic congestion, emissions, and subway contact exposure

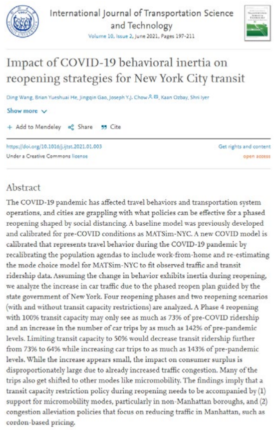
Scenarios	Performance measures increase/decrease				
	Total travel time costs (million $ per day)		GHG emissions (million tons per day)		Subway contact exposure (% change)
	Citywide	Manhattan	Citywide	Manhattan	
Mode preference change (s0 -> s6)	+96.58	+18.08	+26.54	+1.31	-40%
With transit capacity reduction (s6 -> s9)	+10.06	+6.89	+2.37	+0.76	-16%
Implementing telework (s9 -> s10)	-93.20	-10.65	-15.23	-1.23	-75%
Implementing SWHs (s9 -> s11)	-19.97	-1.63	-0.33	0.00	-3%

Takeaways

- Transit capacity reduction has minor impact on auto mode share on top of behavioral inertia; this suggests the road is already highly saturated and diverted trips would move to other modes.
- Contact risk on subways is relatively low. For transit to return and auto traffic to reduce back the city needs to introduce a campaign to raise awareness to shift behavior back.
- The already very popular telework strategy is found to be an effective way to reduce contact exposure in transit.

Conclusion and future work

- A **low-cost simulation tool** is developed that can be used to evaluate traffic congestion and emissions for different scenarios and policies.
- This tool, which can also evaluate school reopening and industry-oriented policies, are available to NYC, NY State, and MTA to use.
- The team is continuing to collect data to update/refine the model.
- We are collaborating with Cornell team to look at other policies and strategies considering COVID exposure and emissions, such as electric vehicles, social equity issues in traffic emissions, etc.



International Journal of Transportation Science and Technology
Volume 10, Issue 2, June 2021, Pages 197-211

Impact of COVID-19 behavioral inertia on reopening strategies for New York City transit

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https://doi.org/10.1016/j.ijtst.2021.01.003

Abstract

The COVID-19 pandemic has affected travel behaviors and transportation system operations, and cities are grappling with what policies can be effective for a phased reopening shaped by social distancing. A baseline model was previously developed and calibrated for pre-COVID conditions as MATSim-NYC. A new COVID model is calibrated that represents travel behavior during the COVID-19 pandemic by recalibrating the population agendas to include work-from-home and re-estimating the mode choice model for MATSim-NYC to fit observed traffic and transit ridership data. Assuming the change in behavior exhibits inertia during reopening, we analyze the increase in car traffic due to the phased reopen plan guided by the state government of New York. Four reopening phases and two reopening scenarios (with and without transit capacity restrictions) are analyzed. A Phase 4 reopening with 100% transit capacity may only see as much as 73% of pre-COVID ridership and an increase in the number of car trips by as much as 142% of pre-pandemic levels. Limiting transit capacity to 50% would decrease transit ridership further from 73% to 64% while increasing car trips to as much as 143% of pre-pandemic levels. While the increase appears small, the impact on consumer surplus is disproportionately large due to already increased traffic congestion. Many of the trips also get shifted to other modes like micromobility. The findings imply that a transit capacity restriction policy during reopening needs to be accompanied by (1) support for micromobility modes, particularly in non-Manhattan boroughs, and (2) congestion alleviation policies that focus on reducing traffic in Manhattan, such as cordon-based pricing.

Wang, D., He, B. Y., Gao, J., Chow, J. Y., Ozbay, K., & Iyer, S. (2021). Impact of COVID-19 behavioral inertia on reopening strategies for New York City transit. International Journal of Transportation Science and Technology. https://www.sciencedirect.com/science/article/pii/S2046043021000046

Ding Wang, Mohammad Tayarani, Brian Yueshuai He, Jingqin Gao, Joseph Y. J. Chow, H. Oliver Gao, and Kaan Ozbay. Mobility in Post-Pandemic Economic Reopening under Social Distancing Guidelines: Congestion, Emissions, and Contact Exposure in Public Transit. Under Review.

C2SMART COVID-19 dashboard:
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