Post-Pandemic Urban Transportation: Some Propositions

Presentation to:
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Webinar Series
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UNIVERSITY OF TORONTO
FACULTY OF APPLIED SCIENCE & ENGINEERING
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Presentation Outline

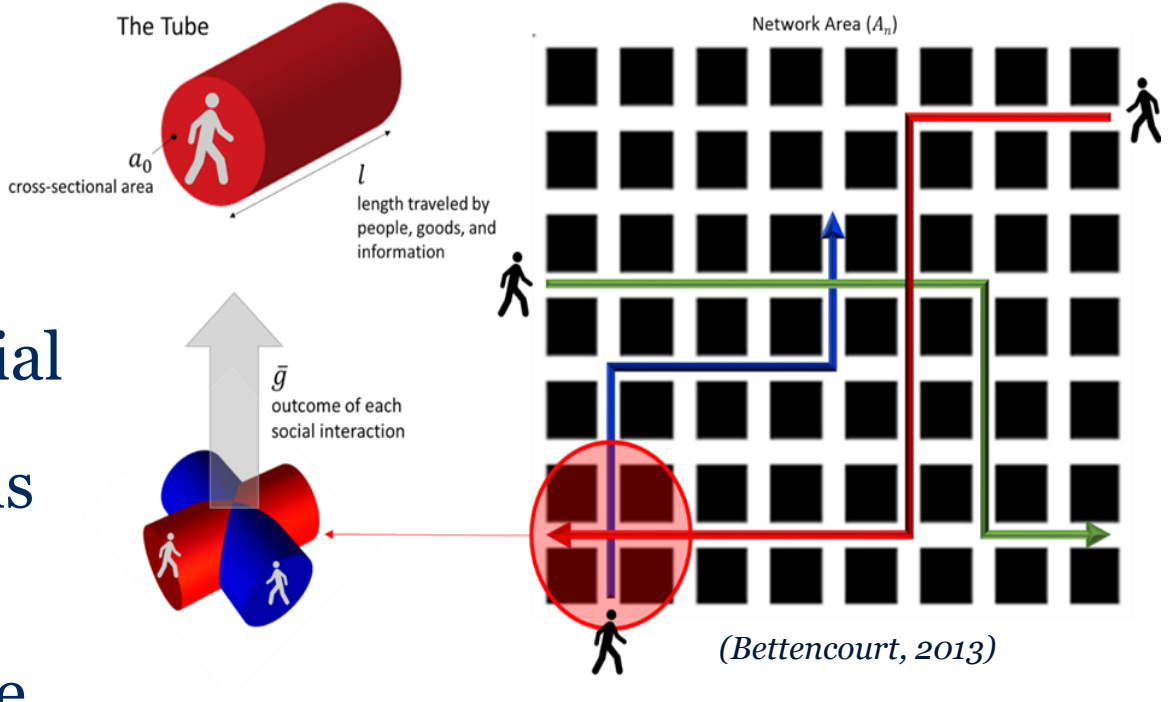
1. The “Science of Cities”.
2. COVID-19 Impacts.
    a. Short Run.
    b. Longer Run.
3. More Disruptions.
4. Final Words: Investing in the Future.

COVID-19 & Cities

- COVID-19 is a "direct attack" on the whole *raison d'etre* of cities:
  - To bring people together to interact.
  - To create massive positive feedback loops generating both economies of scale and agglomeration.
  - To be "the containers of civilization" (Mumford, 1961).

Cities as Social Networks

- Cities are massive social networks, generating myriads of interactions (economic, social, cultural, political, …).
- The bigger the city, the more potential interactions there can be.
- These grow non-linearly with city size & generate agglomeration economies (scaling).



(Bettencourt, 2013)

(Bettencourt, et al. 2007)

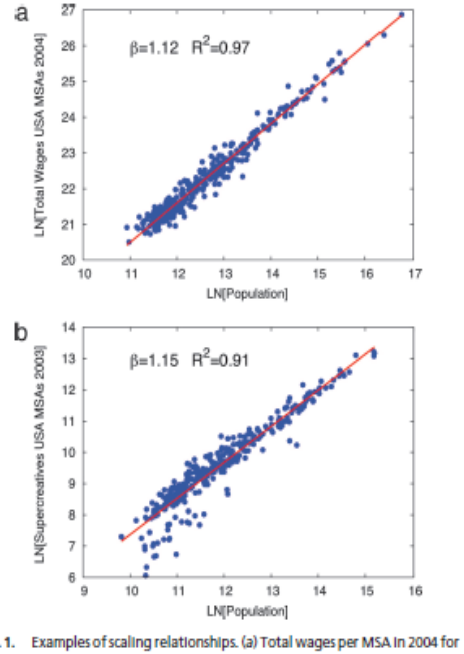


Fig. 1. Examples of scaling relationships. (a) Total wages per MSA in 2004 for the U.S. (blue points) vs. metropolitan population. (b) Supercreative employment per MSA in 2003, for the U.S. (blue points) vs. metropolitan population. Best-fit scaling relations are shown as solid lines.

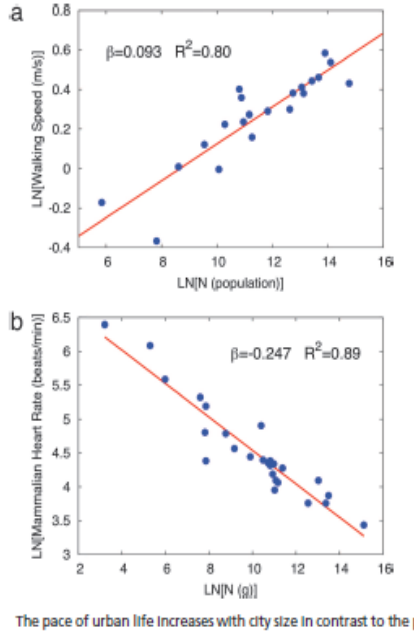
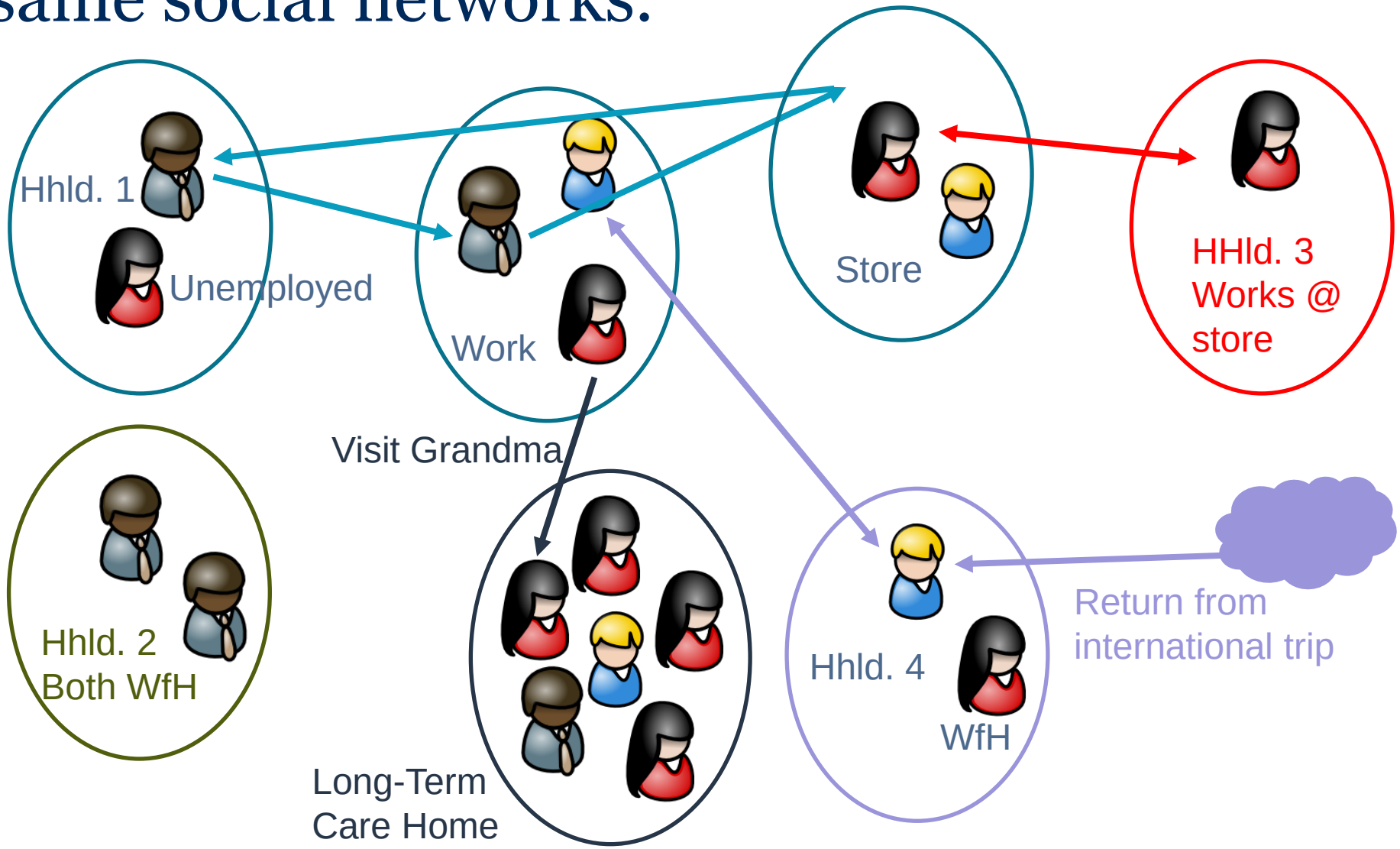


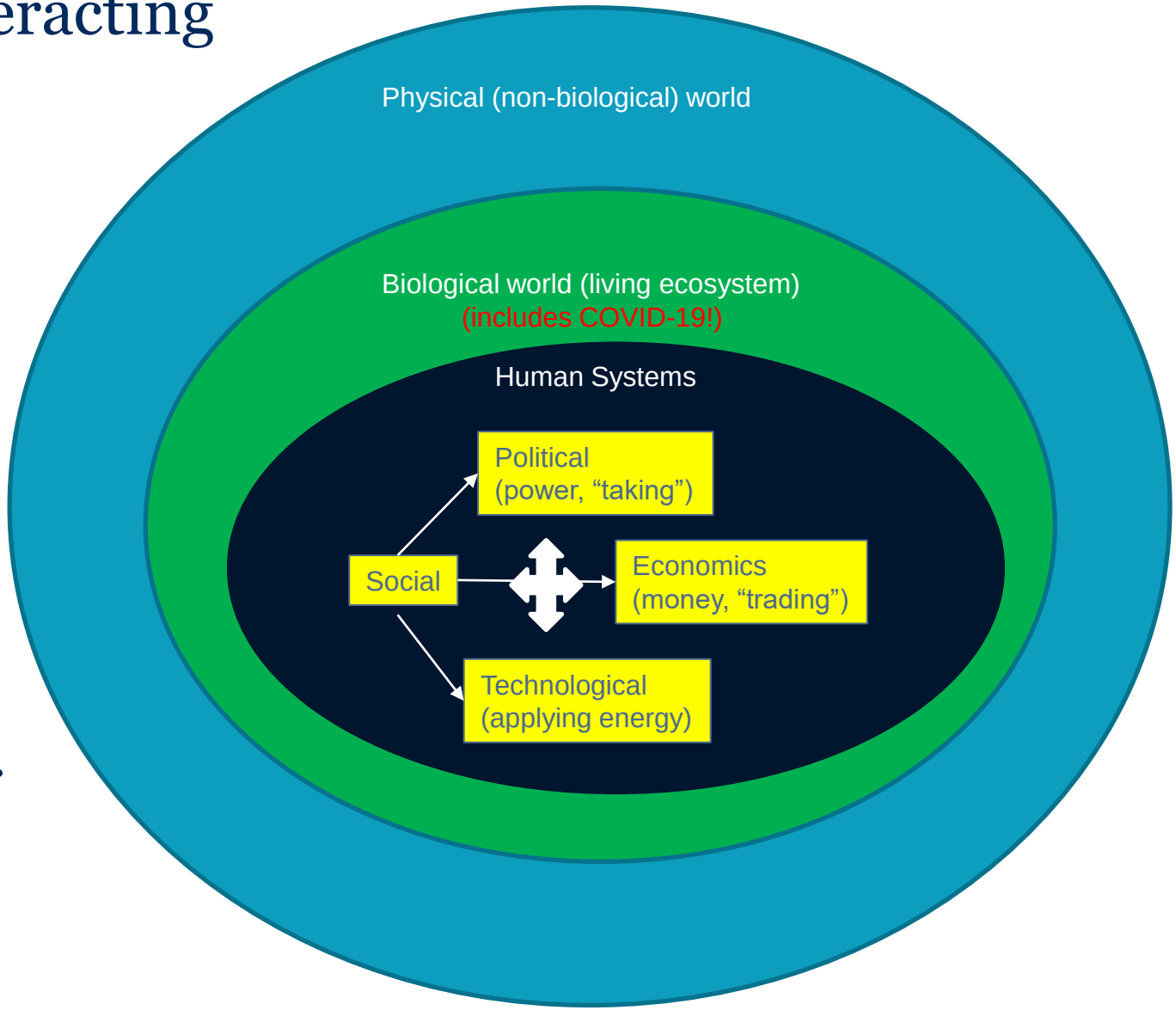
Fig. 2. The pace of urban life increases with city size in contrast to the pace of biological life, which decreases with organism size. (a) Scaling of walking speed vs. population for cities around the world. (b) Heart rate vs. the size (mass) of organisms.

But the virus spreads precisely through these same social networks.



Cities are also Systems of Systems

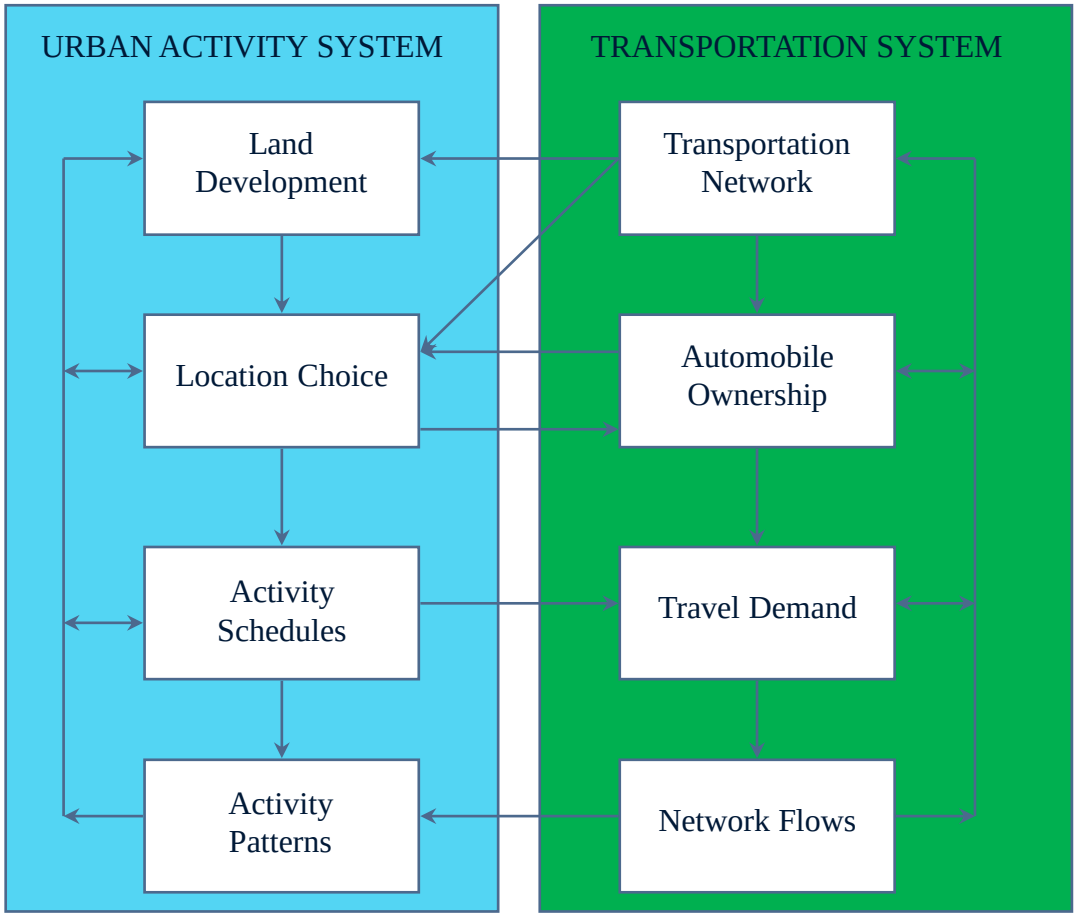
- Cities are complicated systems of interacting systems:
  - Economic.
  - Social.
  - Political.
  - Health.
  - Technical:
    - Transport.
    - Energy.
    - …
  - Information.
  - …



System of Systems (1): The Urban Activity and Transportation Systems

- In particular, the transportation system "mediates" between all activities in space, influencing land development, the location choices of households, firms & other activities.
- The distribution of people, businesses & activities, in turn, drives the demand for transportation.
- "Transportation 101"

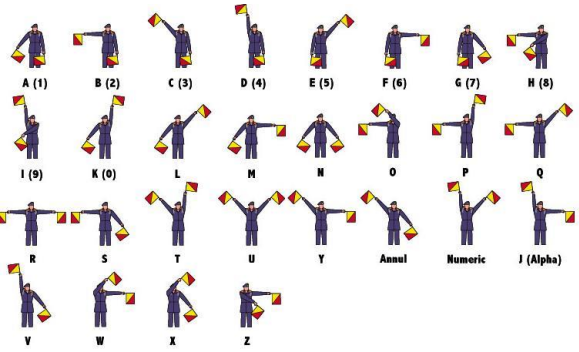
Manheim, M.L. (1978) *Fundamentals of Transportation Systems Analysis Volume 1: Basic Concepts*, MIT Press

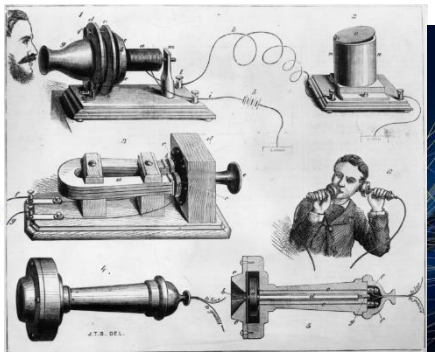


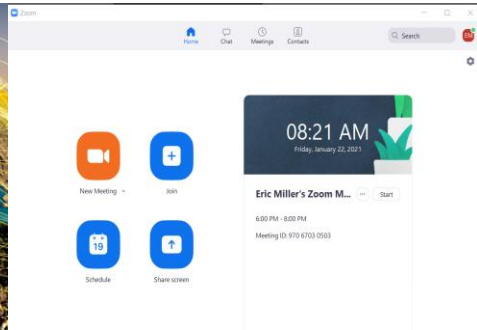
(Meyer & Miller, 2013)

System of Systems (2): Urban Activity & ICT

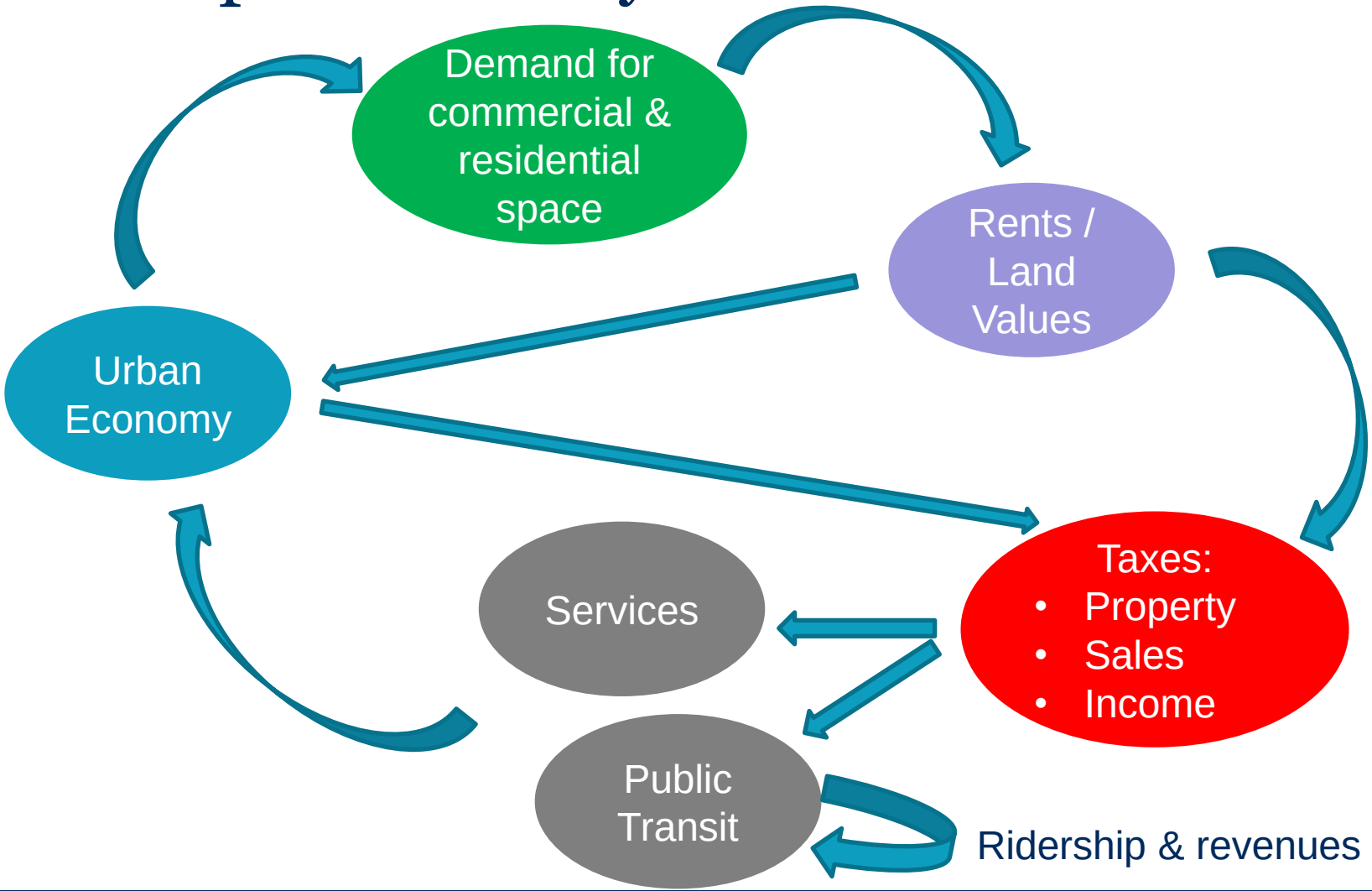
- But telecommunications also network people & activities together.
- There has always been a complex complementary/competitive (but, overall, synergistic) interaction between travel & communications.
- COVID-19 is disrupting this interaction.





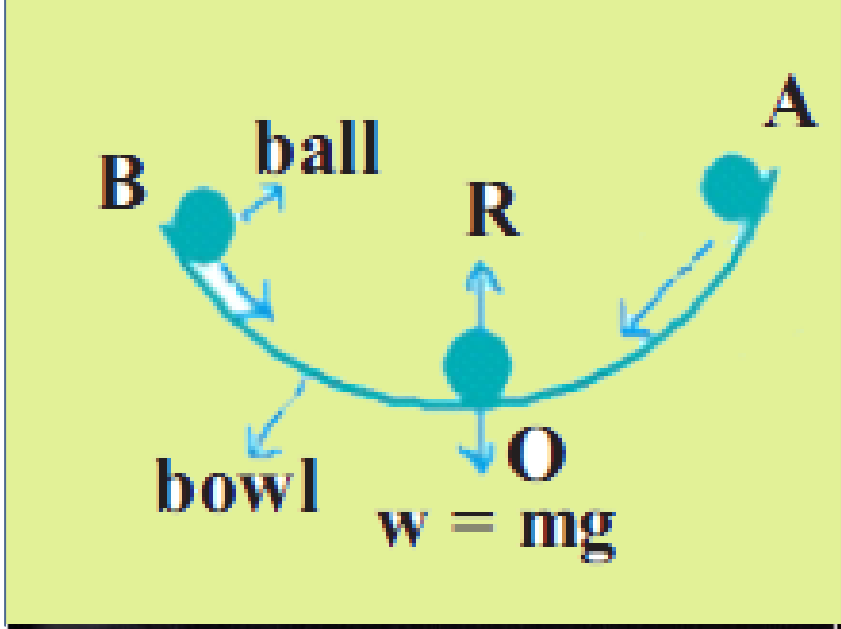


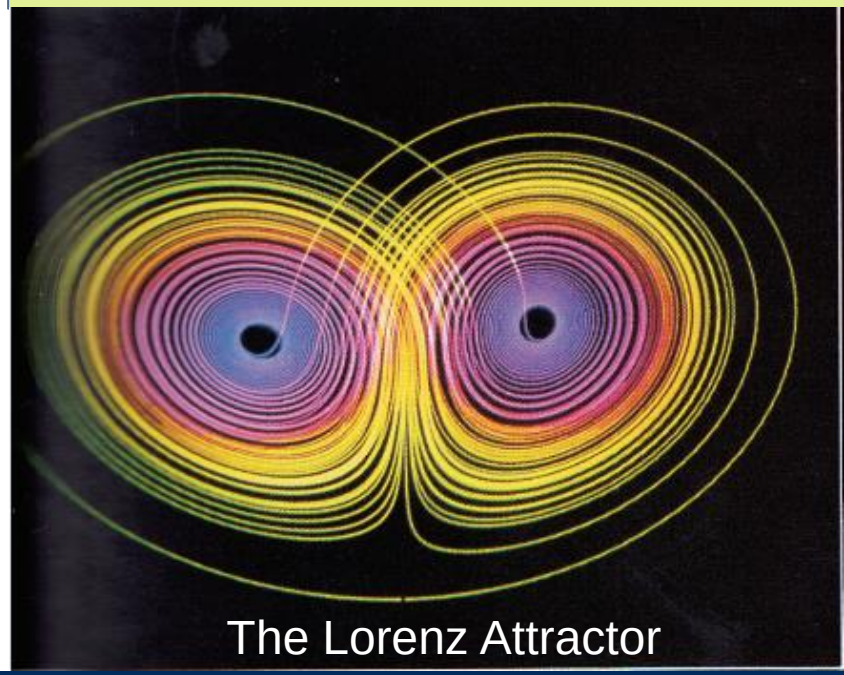
System of Systems (3): Urban Form & the Municipal Economy



Attractors

- Every system has one or more attractors, to which the system state will tend to converge (if left undisturbed).
- Attractors are an emergent characteristic of the system.
- The number & location of the attractor(s) depends largely on the *parameters* of the system, given the system structure.



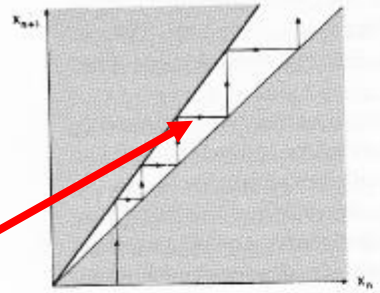

The Lorenz Attractor

Changing the Attractor

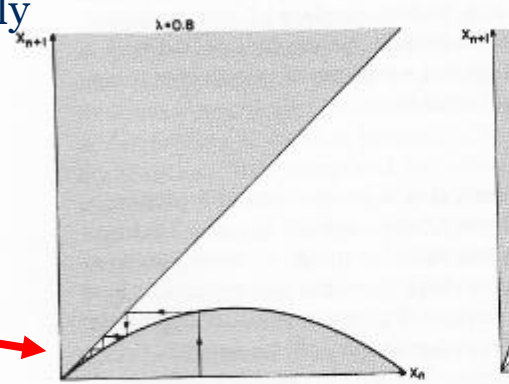
- Disease spread is a classic problem in population dynamics (births & deaths of the population – in this case the populations of viruses & infected individuals).
- The "control parameter" α determines the behaviour of the system.

X(t) = population at time t

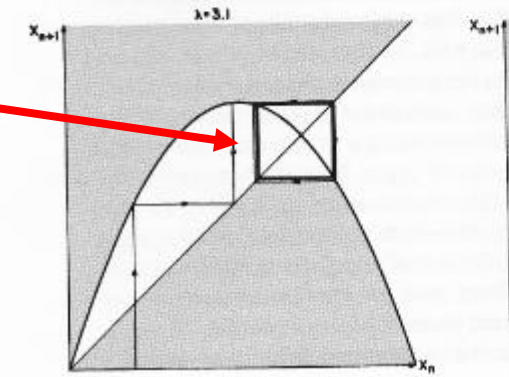
$X(t+1) = \alpha X(t)$
No balancing control
Population grows indefinitely



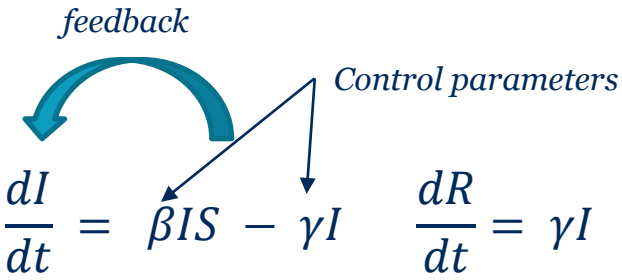
$X(t+1) = \alpha X(t)[1-X(t)]$
Balancing control.
We want to find an α that drives the virus/infected population to zero.



Not one that causes recurring outbreaks.



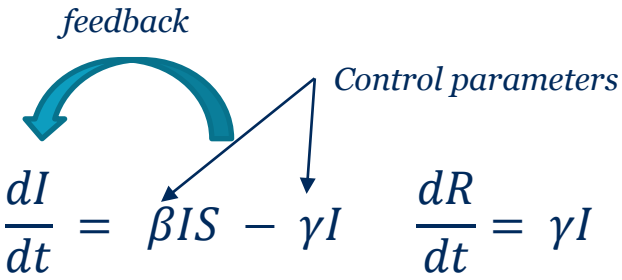
Controlling COVID-19 Spread



S = "Susceptible"
I = "Infectives"
R = "Removed"

- Control strategies should be designed to affect the control parameters (reduce β & increase γ):
  - Timing & extent of shut-downs & re-openings.
  - Testing & tracking.
  - Social distancing.
  - Wearing masks.
  - VACCINES!
  - ….

Controlling COVID-19 Spread



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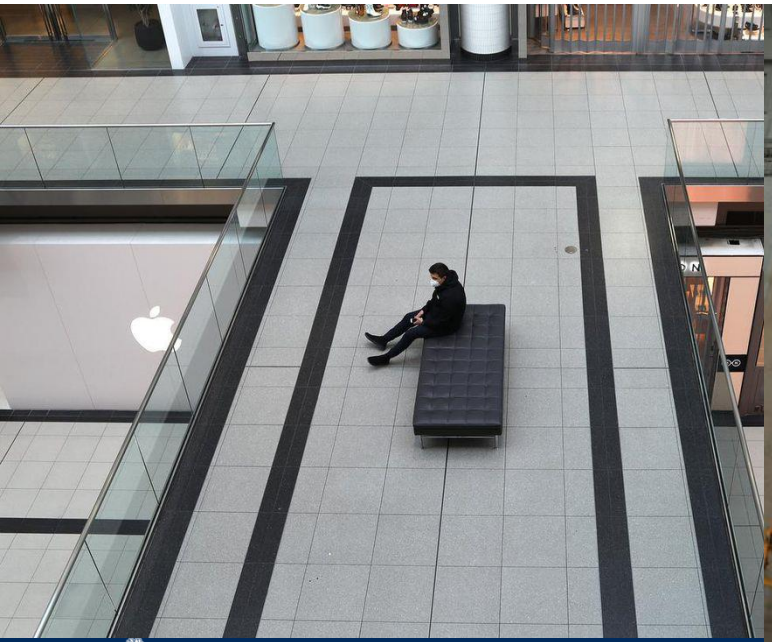
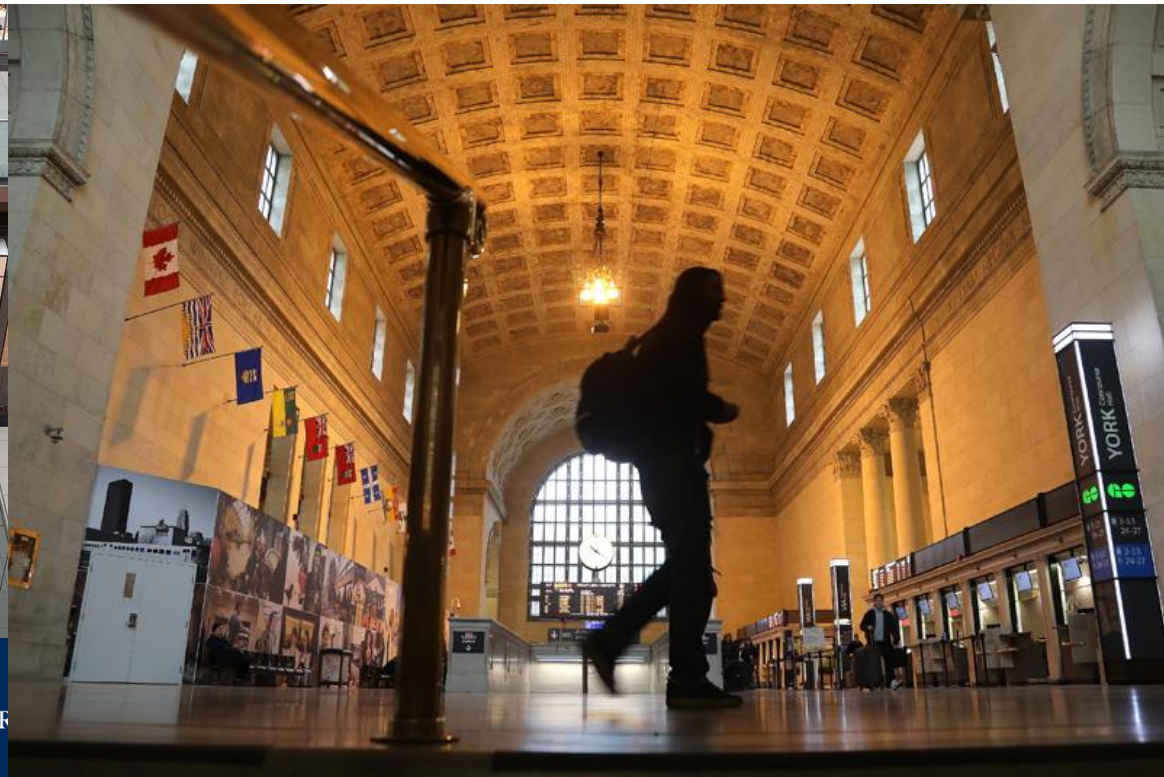
  - VACCINES
  - ….

Involve breaking social & economic networks & interactions.

Short-run Impacts

- The short-run impacts of pandemic lockdowns, etc. on the urban system have been profound and deeply damaging.





Small Business Closures

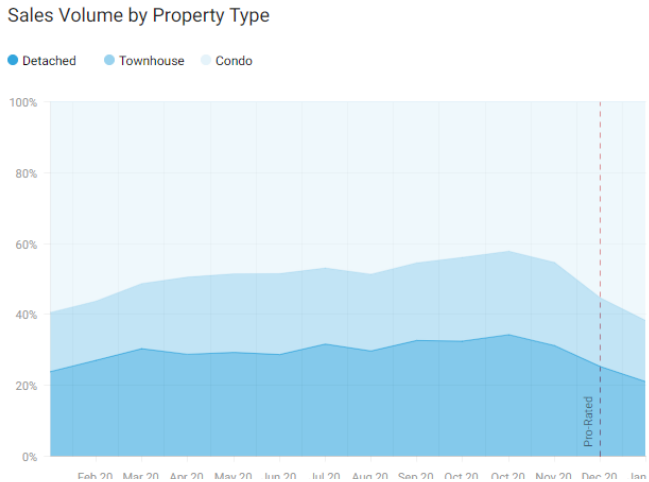
- 239,000 Canadian small businesses closed by end of 2021 (> 1 in 6).
- 2.42M jobs lost (13% of total employment).

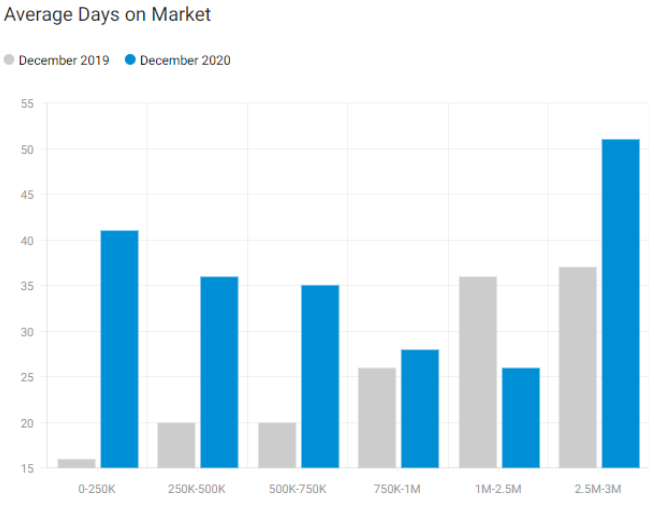
(Canadian Federation of Independent Business, 2021)

Housing Market Impacts

- Housing market impacts have been mixed.
- Some increased demand for larger houses in more suburban (or ex-urban locations).
- Reduced demand for condos.
- Upper income households actually have more money to spend on housing.
- Lower income households in danger of losing their dwellings.

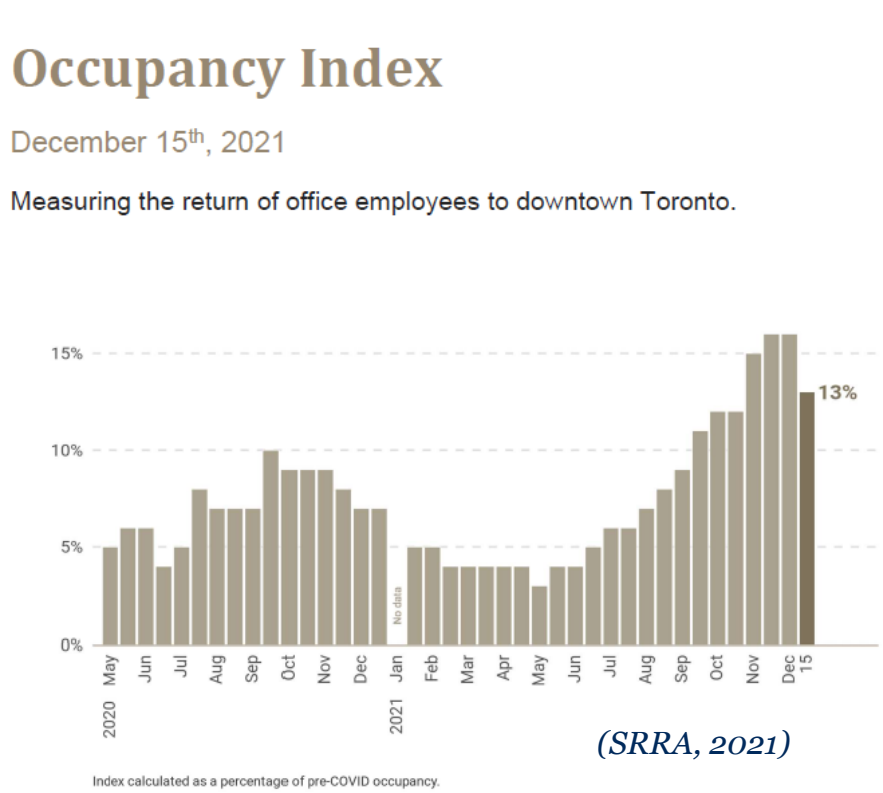
(Source: Zolo, 2021; https://www.zolo.ca/toronto-real-estate/trends)





Central Area Ghost Towns

- CBD dominated by “white collar” office-based workers.
- Most shifted to working from home (WfH).
- Only very slowly returning.
- This has a huge impact on:
  - Subway ridership.
  - “Secondary” employment (stores, restaurants, etc.).



(SRRA, 2021)

Municipal Finances

- Municipal revenues have declined precipitously due to reduced property taxes, transit revenues, etc.
- At the same time, the cost of social services has increased dramatically.

Vehicle Boardings - Week ending January 8, 2021

Mode	Percentage compared to pre-COVID levels	Customer Boarding
	40%	552,000
	26%	91,000
	22%	326,000
	Total System-wide Boardings:	969,000

TORONTO | News

Toronto will face opening shortfall of $1.5 billion in preparation of 2021 budget, city report says

Chris Fox Web Content Writer, CP24
Contact

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Long-Run Impacts ("the new normal")?

- Systems differ dramatically in terms of their resiliency and their ability to "bounce back".
- For some, the "long-term attractor" is so strong, that the system "returns to normal", often surprisingly quickly.
- For others, a "new attractor" emerges that differs significantly from the old one.

So what about cities?

- While cities have certainly come and gone over the course of human civilization, generally, cities have historically been very resilient.
- London, Chicago, San Francisco all recovered after major fires destroyed much of the city and "built back better".
- Most European cities suffered enormous damage in WWII and were subsequently completely rebuilt.
- The great influenza pandemic of 1918-19 did not substantively change the course of urban development.
- ....

Berlin, 1945

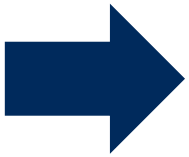
Berlin, today

What about cities, cont'd

- The long-term urbanization trend will continue – there are too many economic, cultural & social drivers still at play.
- The "logic" of the urban economy (& human socialization) is unchanged.
- Unlike the impacts of massive fires & world wars, the physical city is untouched by the pandemic and is ready to be "re-occupied" at a moment's notice.

What about cities, cont'd

- So too with the economy, but with some major uncertainties:
  - "Office work" – WfH, virtual offices.
    - & hence commercial office space.
  - Retail/shopping.
  - Restaurants, entertainment.
  - Shifts in residential locations.

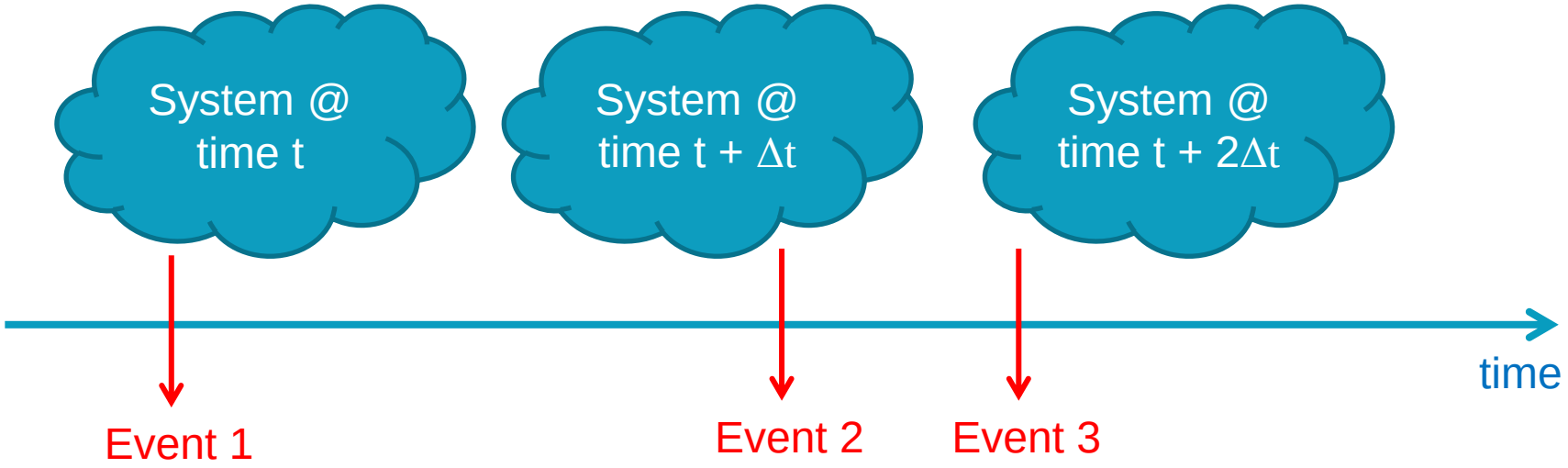


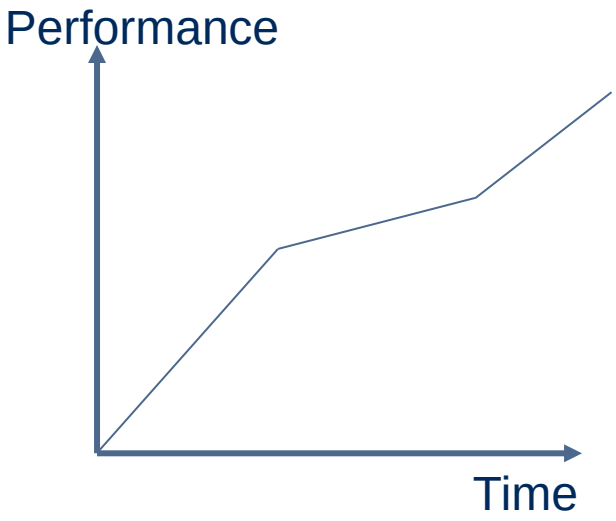
Transportation Impacts

Transportation

- As with every other aspect of our society, COVID-19 has seriously disrupted our urban transportation system:
  - Disastrous declines in transit ridership & revenues.
  - Shifts to auto usage.
  - Massive growth in online shopping.
  - Exacerbated inequities.
  - On the positive side:
    - Increased walking & biking.
    - Experimentation with:
      - Alternative street usage.
      - "Re-inventing transit":
        - » Demand-responsive transit.

Events vs. Trends/Behaviour

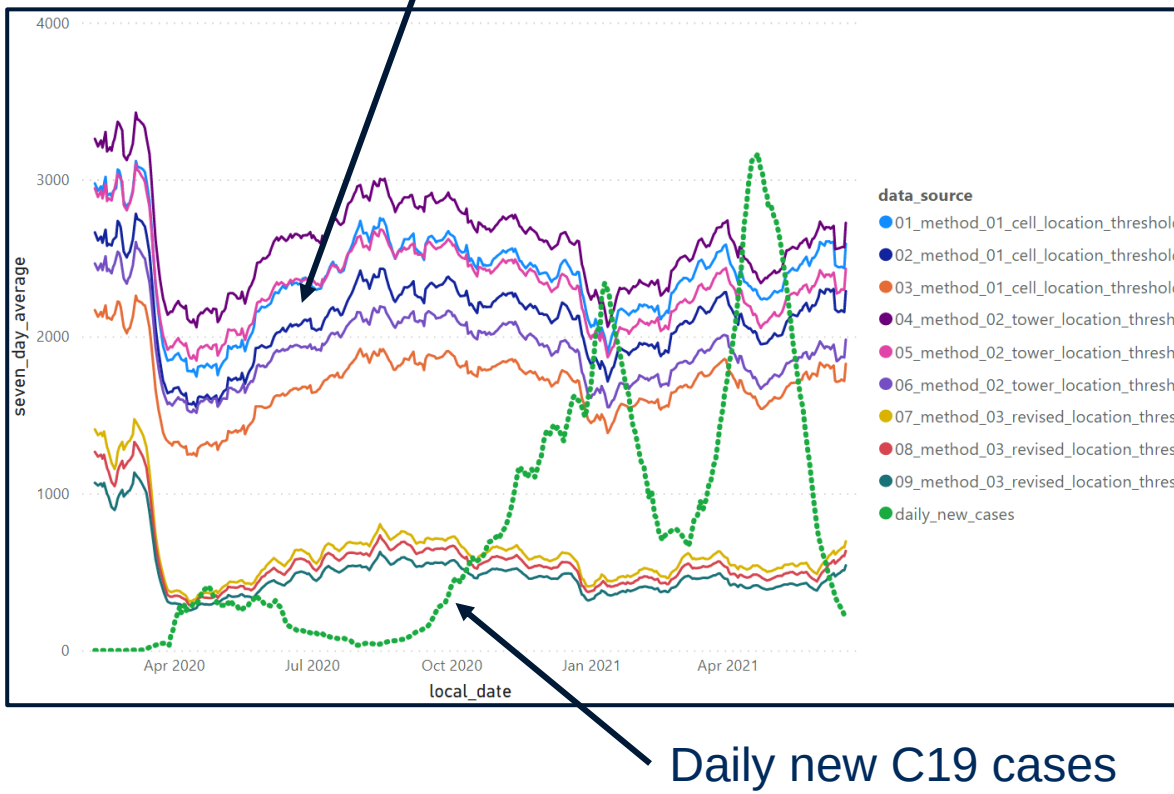




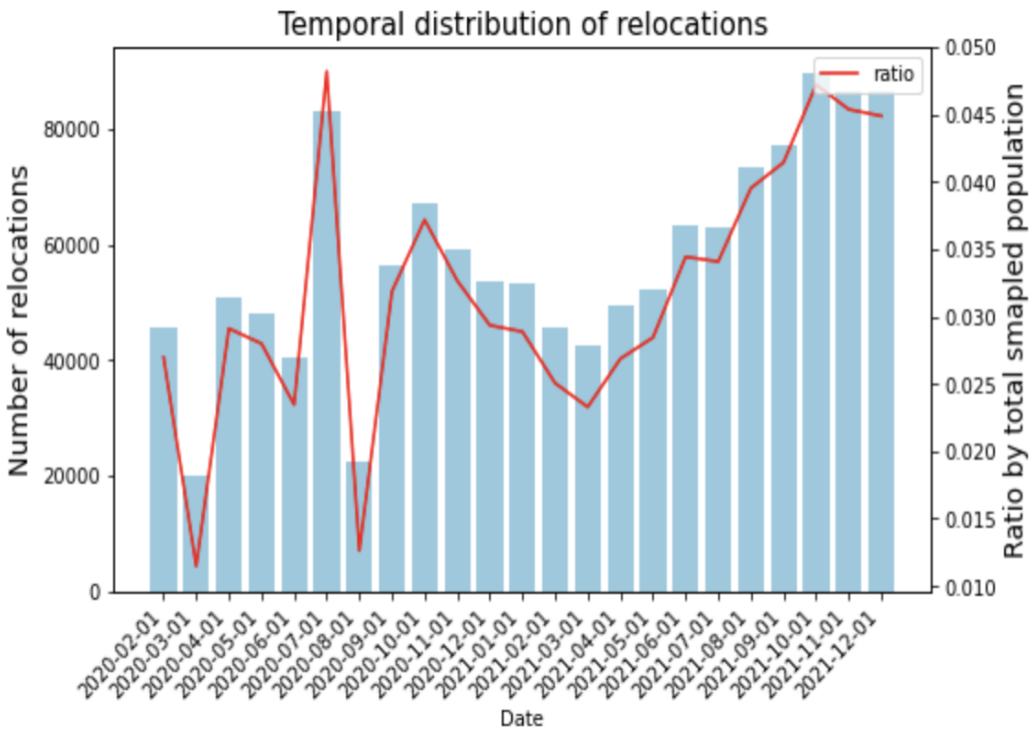
- We are captivated by the anecdote and by day-to-day events/news:
  - *"No-one is returning to the office (ever)."*
  - *"Everyone is moving out of the city."*
  - *"Transit is dead."*
  - …
- We are often too quick to extrapolate short-run events into the longer term.
- But the overall story is often quite different.
- Great inertias (& rationales for this inertia) exist.
- (But, not to say that permanent disruptions cannot occur.)

Tracking GTA Trip-Making with Cellphone Data

- Cellphone trace data can be used to track out-of-home movements.
- Spatial-temporal imprecision makes precise trip identification difficult.
  - Each line represent a different set of pattern recognition parameters.
- But overall trend is clear.

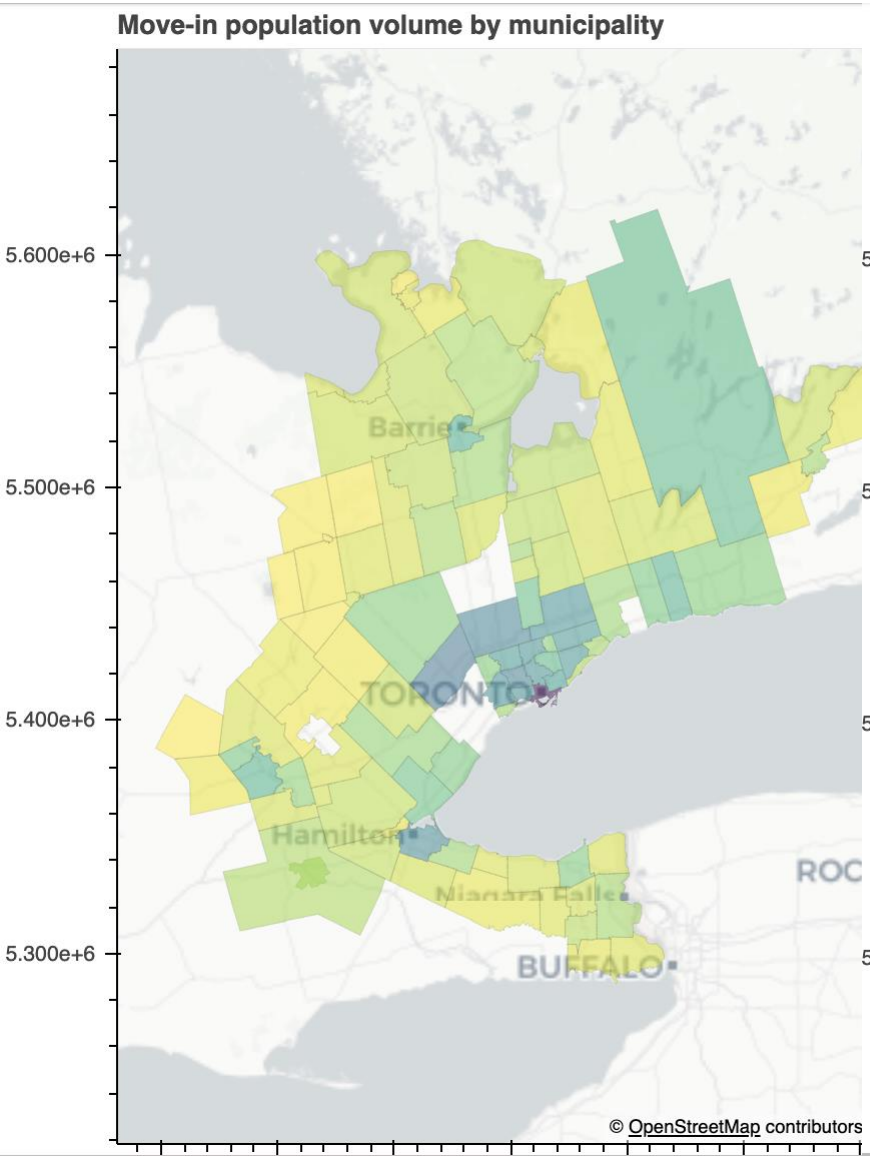


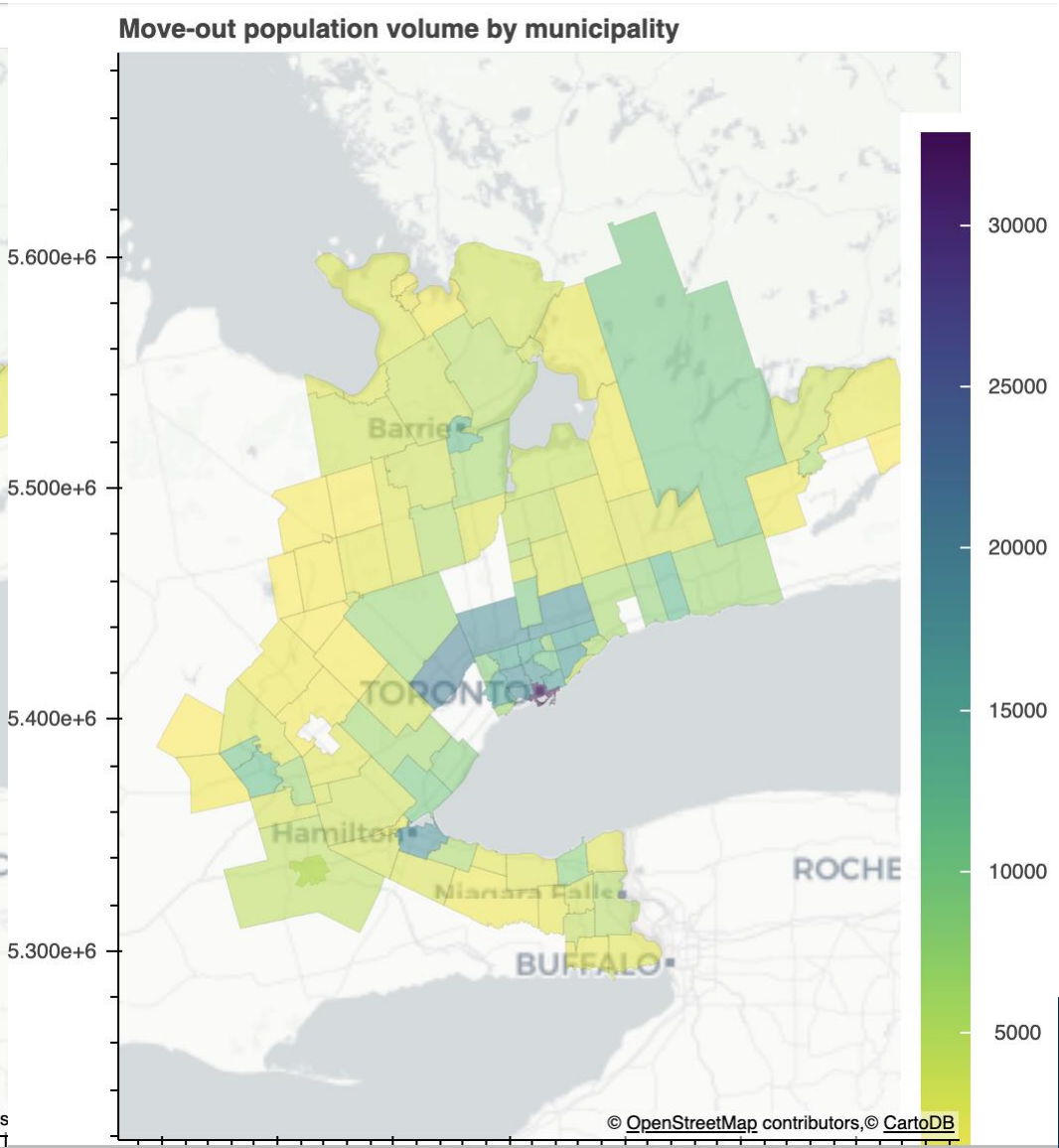
Tracking Residential Relocations with Cellphone Data



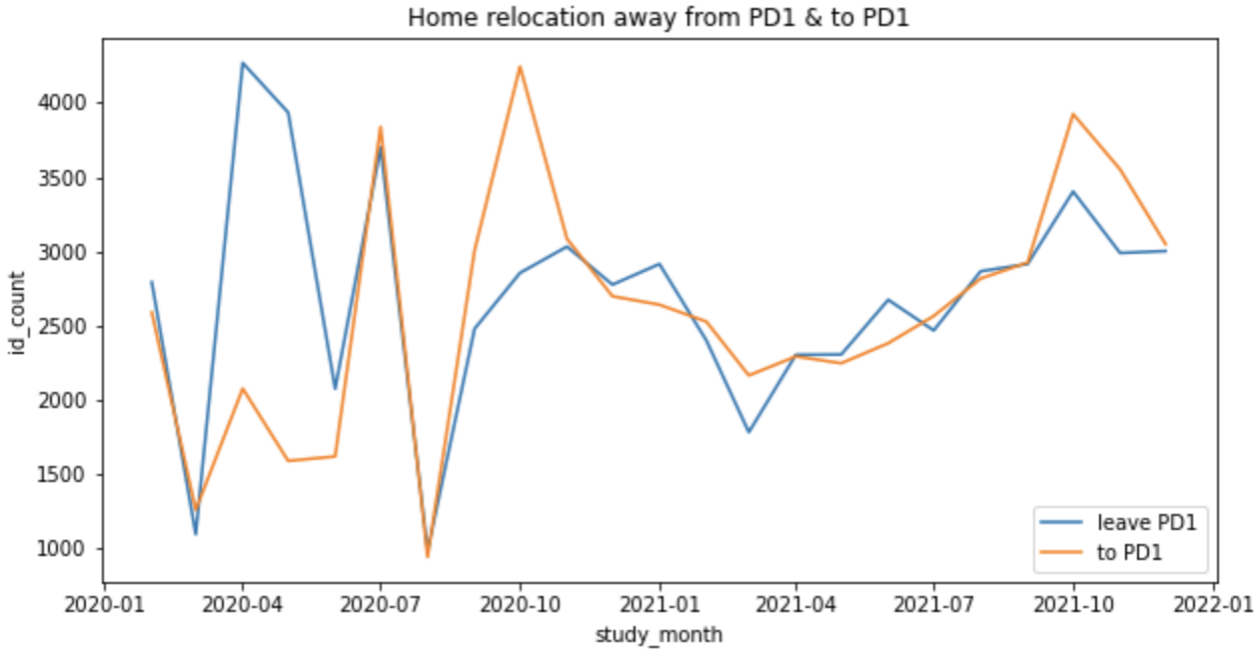
- Home locations are readily detectable in cellphone data.
- Changes in residence can therefore be tracked.
- Overall upward trend in housing market activity very clear.

Where are households relocating to/from?

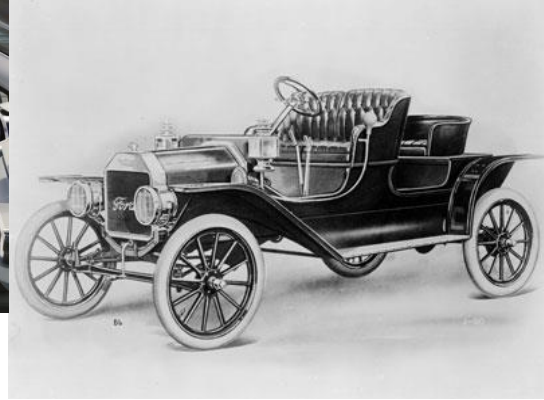




Housing Relocations from/to the Toronto Downtown

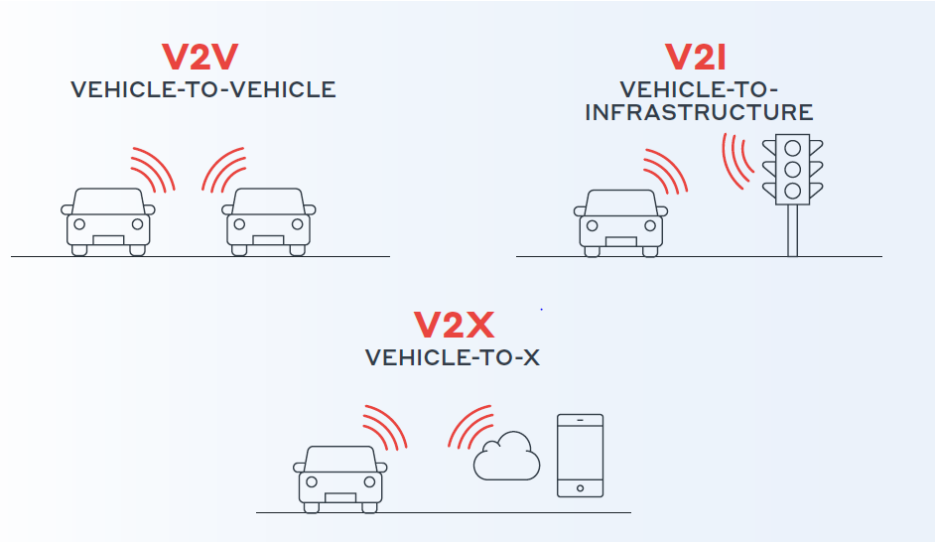


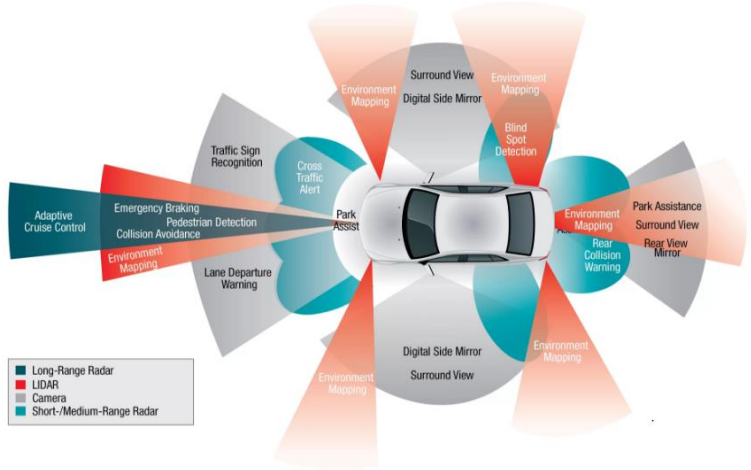
More Disruptions



- The transportation system was undergoing significant & numerous disruptions pre-COVID and will continue to be shaped by these post-COVID.
- Just as COVID is the biggest public health crisis in a century, we are in the midst of the biggest change in transportation & mobility over this same century.

Disruptions (1): New technologies & services





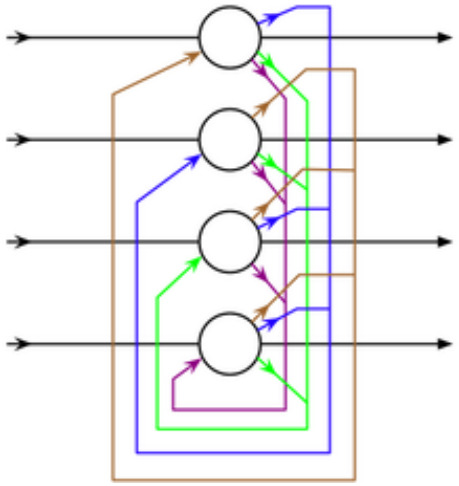
- Connected
- Autonomous
- Electric

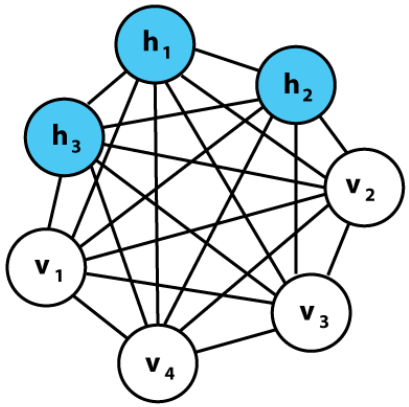
Traditional public transportation services, such as buses and trains

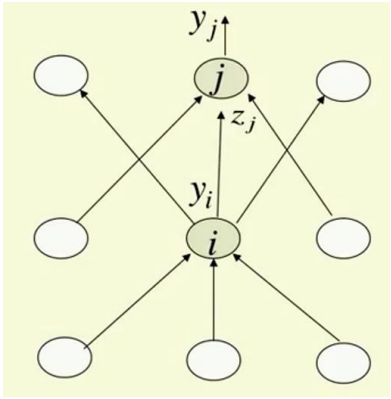
Vanpools, carpools, shuttles, transport network companies (TNCs) and rideshare pools

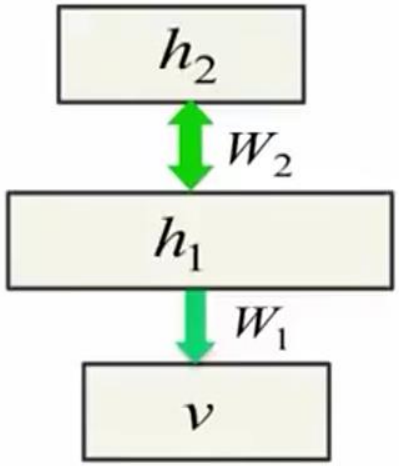
Carsharing, bikesharing, scooter sharing in all its forms

Disruptions (2): ICT, IoT, AI & Big Data

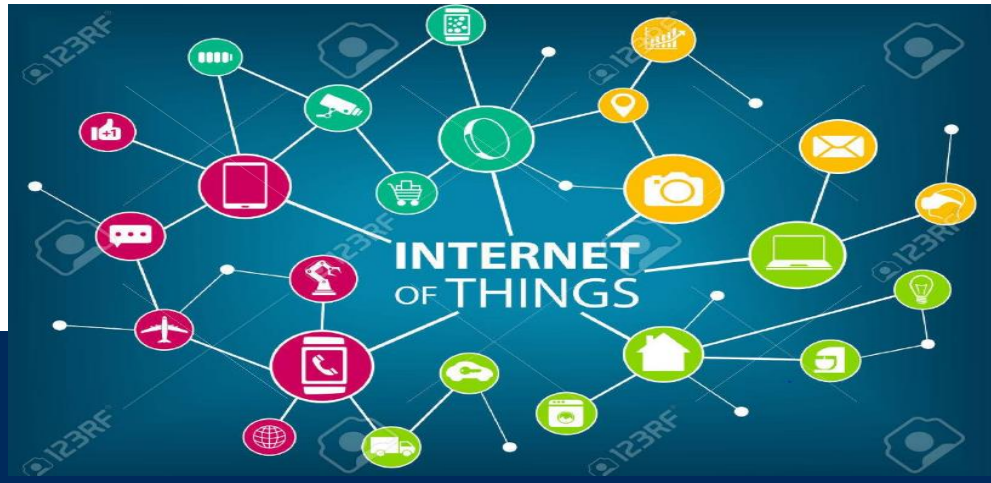




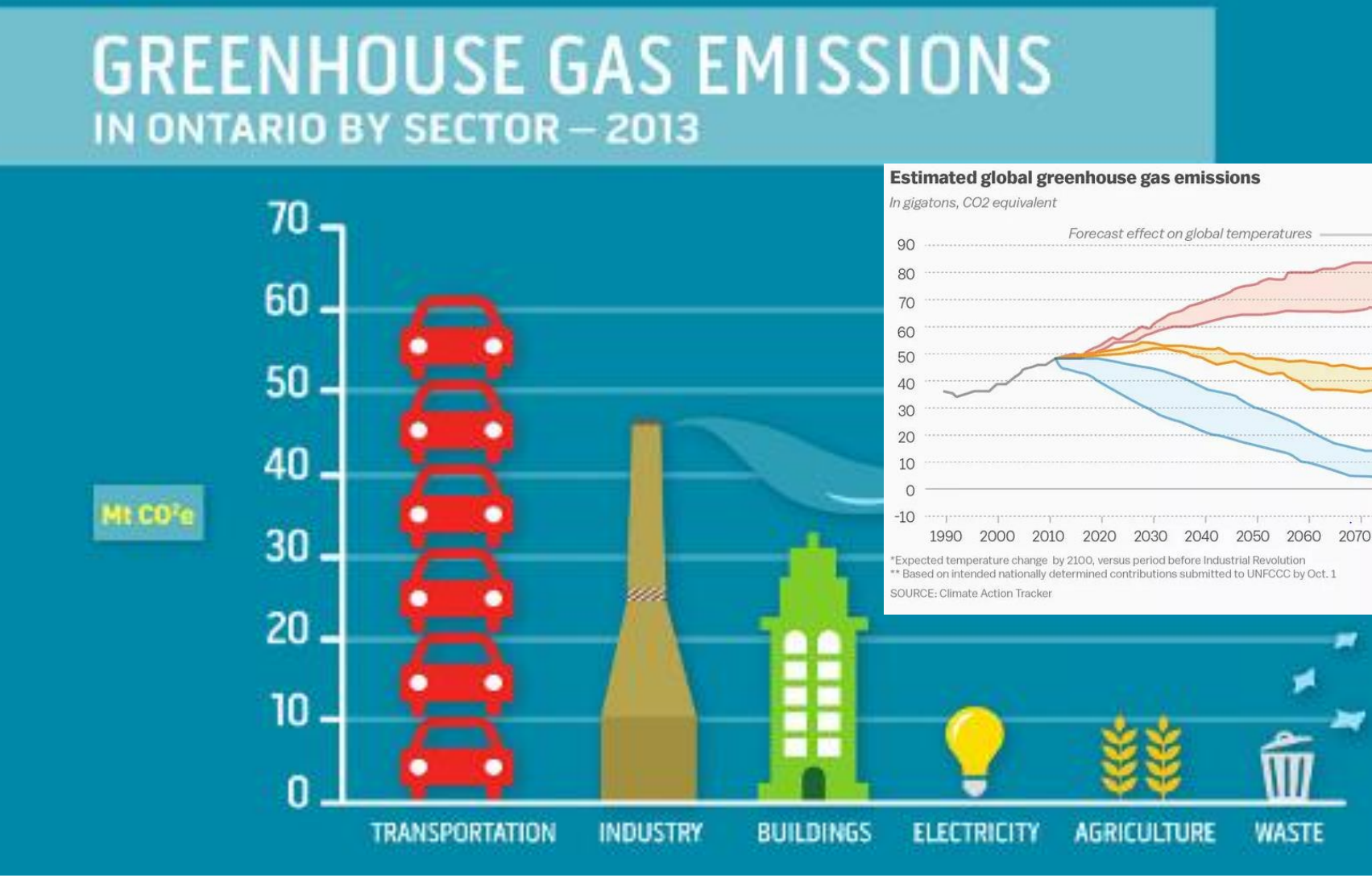


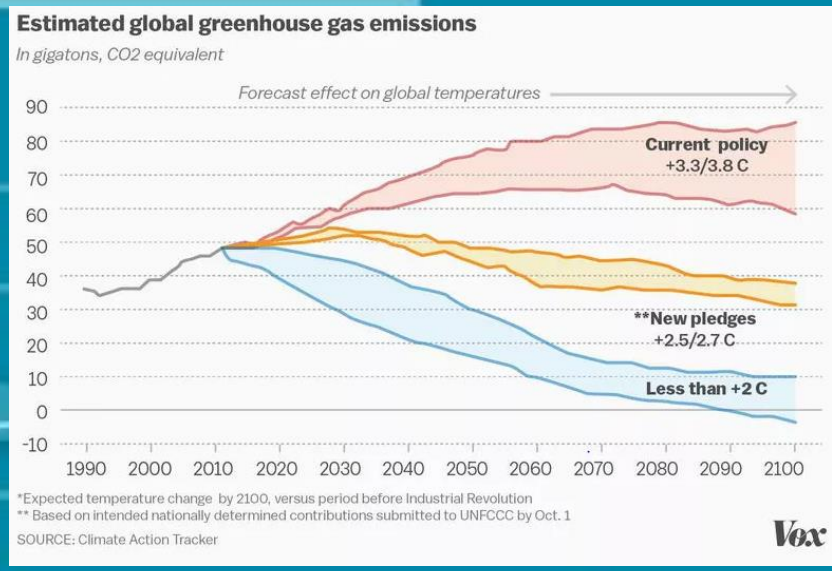


- At the same time, the technology that is so disrupting transportation services is also generating massive amounts of new data about travel behaviour that potentially will allow us to view travel in new ways:
  - Very large samples.
  - Dynamic, time-series.
  - But (usually) lacking socio-economics.
- New analysis and computing methods are enabling the analysis of these huge new datasets (machine learning, etc.) that will provide exciting new insights into how to design & operate our systems.



Disruptions (3): Climate Change

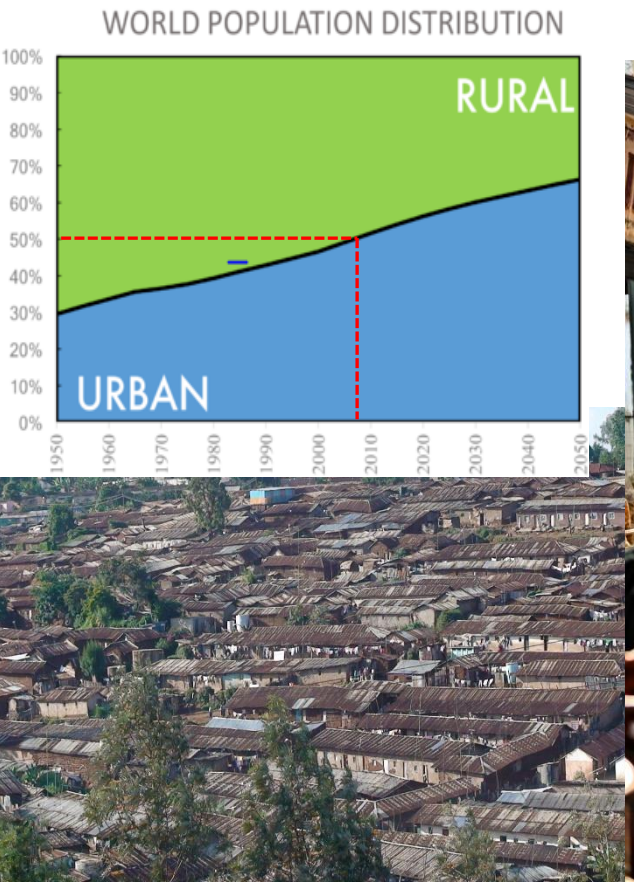


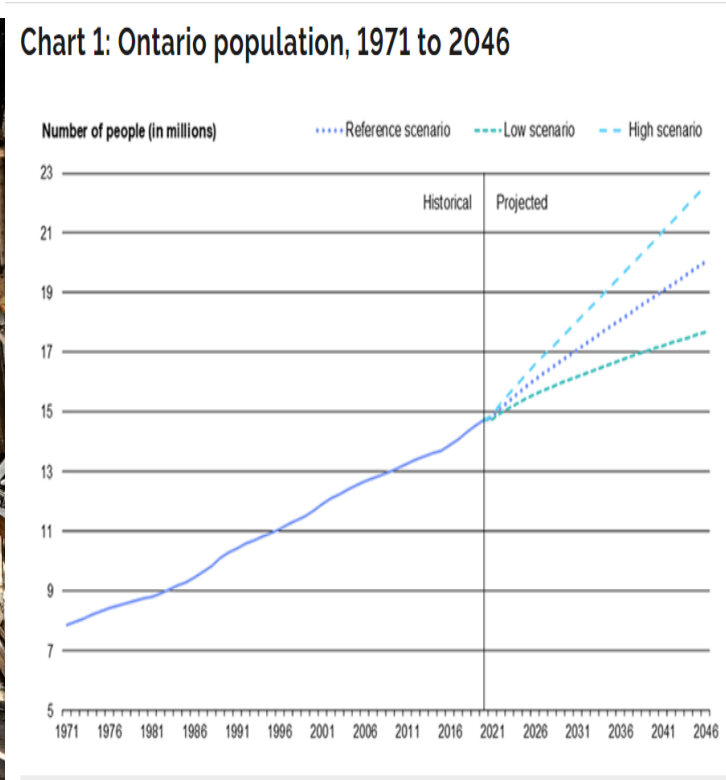


Disruptions (4): The quest for social & economic equity

Disruptions (5): Global Urbanization

- The challenge of planning/building the world's emerging cities & mega-cities is enormous, but world stability, etc., etc. depends on getting the 21st century urban world "right".
- A "first-order" world-wide problem that is not being adequately addressed in most cases.
- Canadian cities will continue to see significant growth & resulting stresses on transportation, housing, services, …





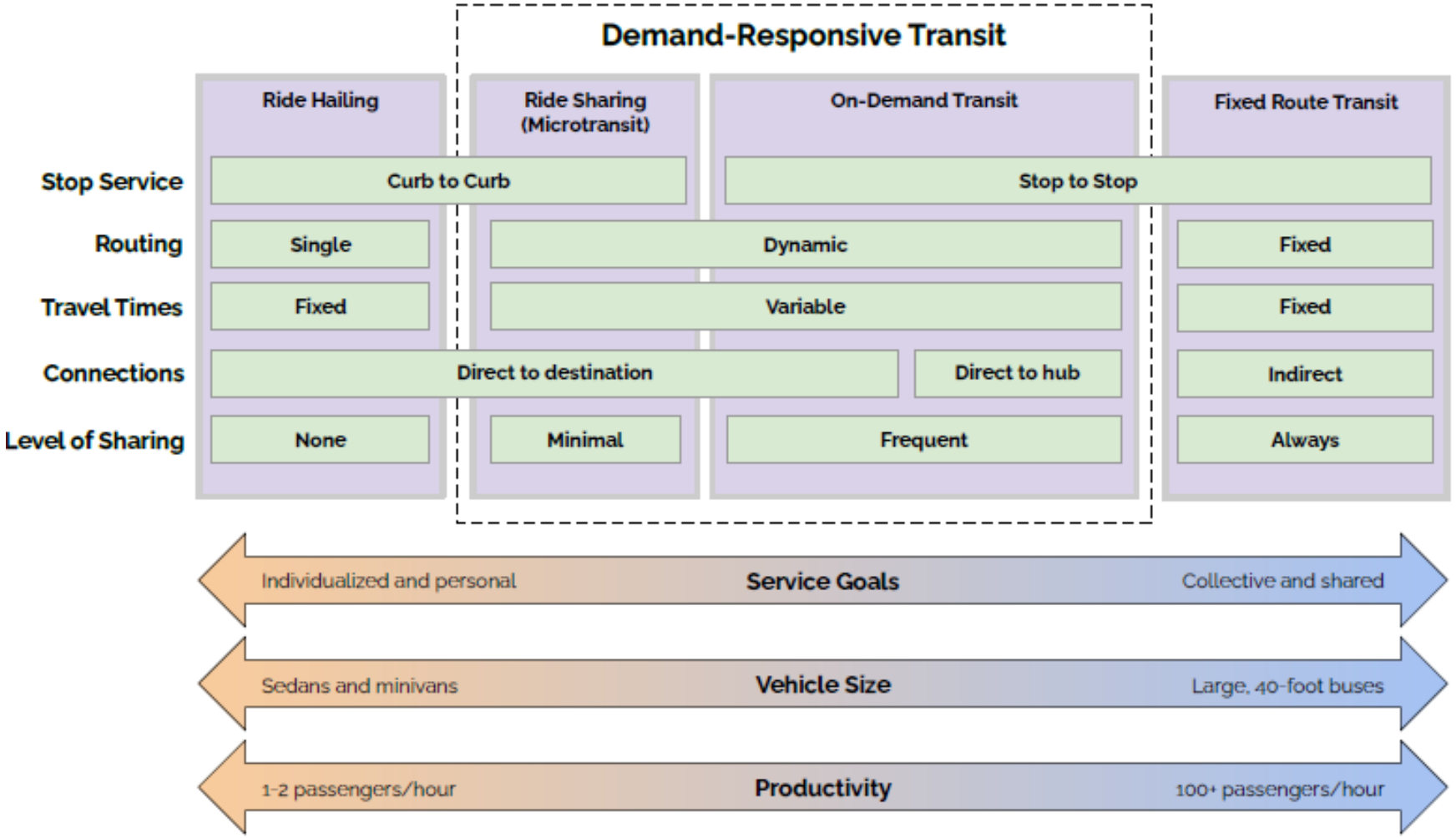
Sources: Statistics Canada for 1971–2020, and Ontario Ministry of Finance projections.

Transit Investment

- We will continue to need “smart” investment in transit.
- In the Toronto case:
  - Much improved “surface” transit (this applies across the country):
    - Bus Rapid Transit (BRT).
    - High-frequency, prioritized bus routes.
    - Demand-responsive transit.
  - Much more aggressive use/prioritization of streetcars & LRT.
  - Subways: add “real” capacity where needed:
    - SmartTrack (a much mis-understood “orphan”)
    - Ontario Line (yes, but …)
    - Real RER.
    - Current extensions underway of existing lines are largely a waste of money & effort & will not solve any problems.
      - At least, if not tied to other major investments that really do add capacity & redundancy to the system.



Demand-Responsive Transit (DRT)



UTTRI
Research Report

The State of Demand-Responsive Transit in Canada

Willem Klumpenhouwer
July 2020

https://uttri.utoronto.ca/files/2020/09/UTTRI-Report-State-Demand-Responsive-Transit-Canada-Klumpenhouwer-2020.pdf

Municipality	Province	Project Timeline
Belleville	Ontario	2018 to Present
Bowen Island	British Columbia	2019
Calgary	Alberta	2019 to Present
Cochrane	Alberta	2019 to Present
Edmonton	Alberta	Planned (2021)
Okotoks	Alberta	2019 to Present
St. Albert*	Alberta	Planned (2020)
Waterloo	Ontario	2018 to 2019
Winnipeg*	Manitoba	Planned (Unknown)
Chatham-Kent	Ontario	Planned (2020)[10]
Milton	Ontario	2015 to 2016[11]
Niagara Region	Ontario	Planned (2020)[12]
Oakville	Ontario	2015 to Present[13]
Regina	Saskatchewan	Planned (2020)[14]
Sault Ste. Marie	Ontario	2019 to Present
Saskatoon	Saskatchewan	Planned (2020)[15]

* Currently operating dial-a-ride service

Municipal DRT Experiments

- **Belleville**

  https://www.belleville.ca/en/walk-ride-and-drive/using-belleville-transit.aspx

- **Durham Region**

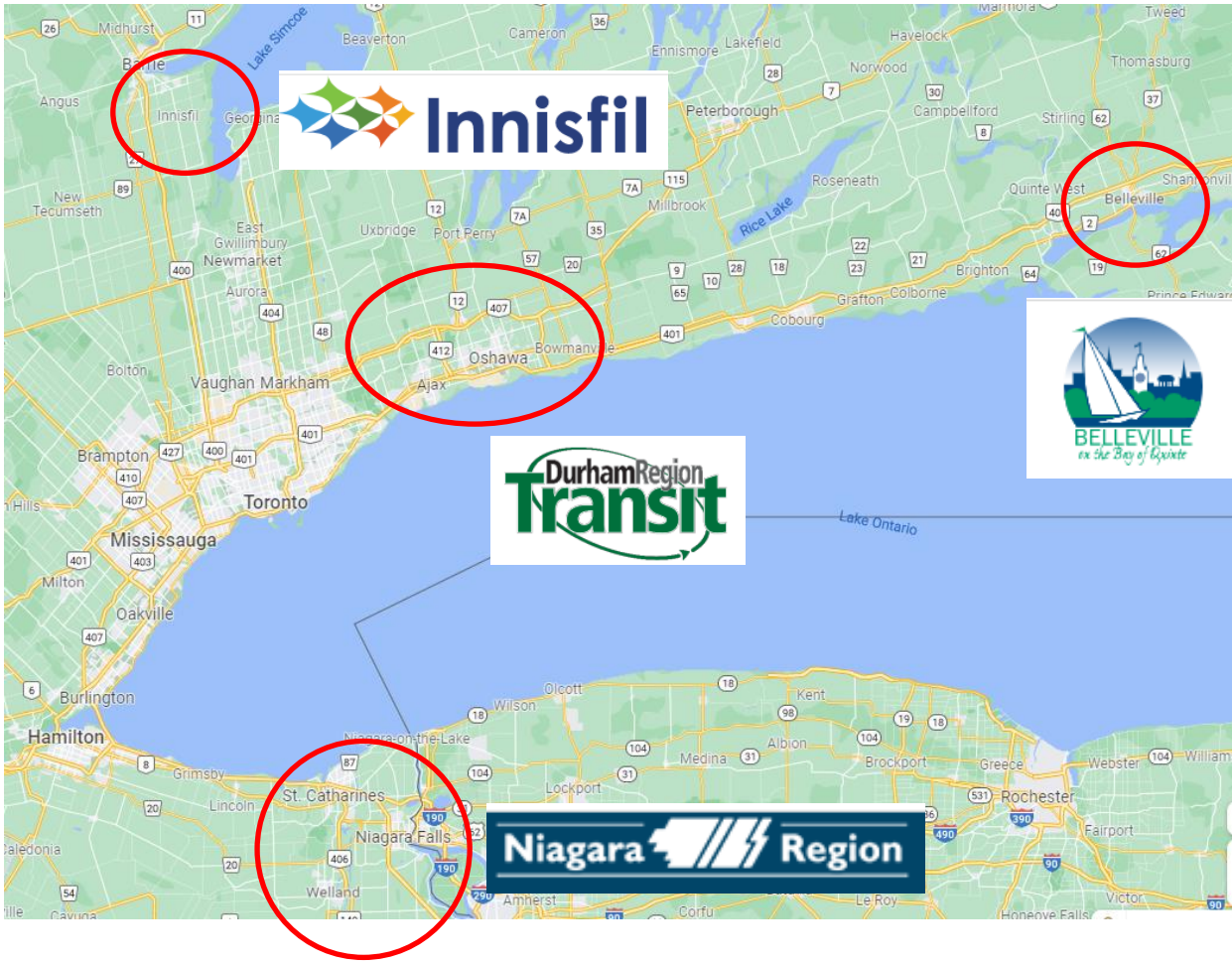
  https://www.durhamregiontransit.com/en/travelling-with-us/planning-your-travel.aspx

- **Innisfil**

  https://innisfil.ca/transit/
  https://www.uber.com/ca/en/u/innisfil/

- **Niagara Region**

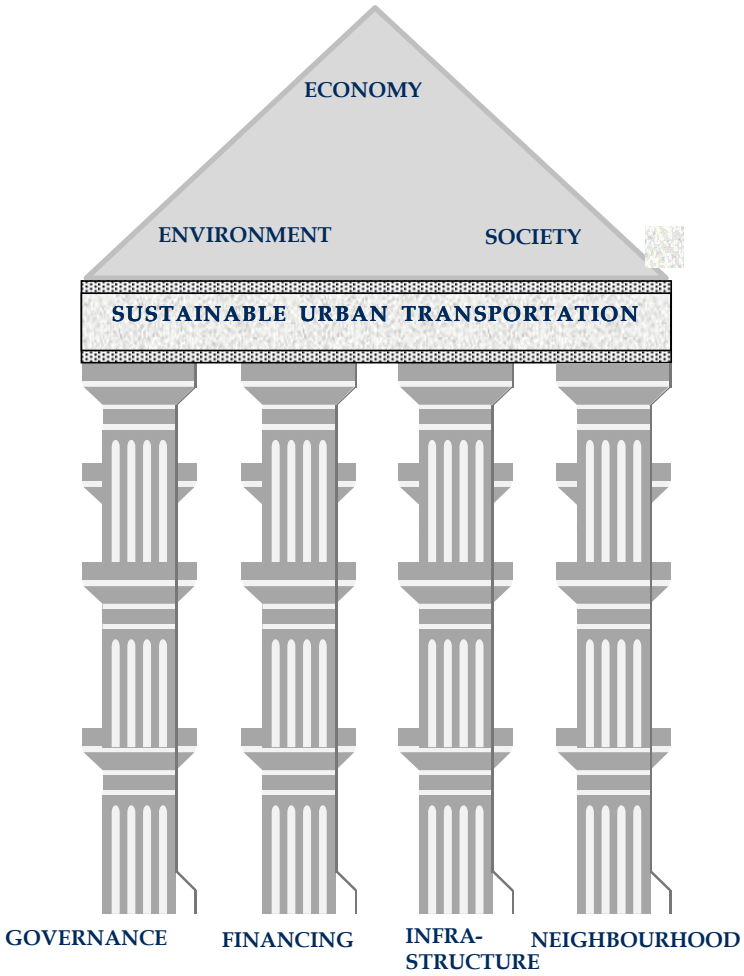
  https://niagararegion.ca/transit/on-demand/



Highway Investment

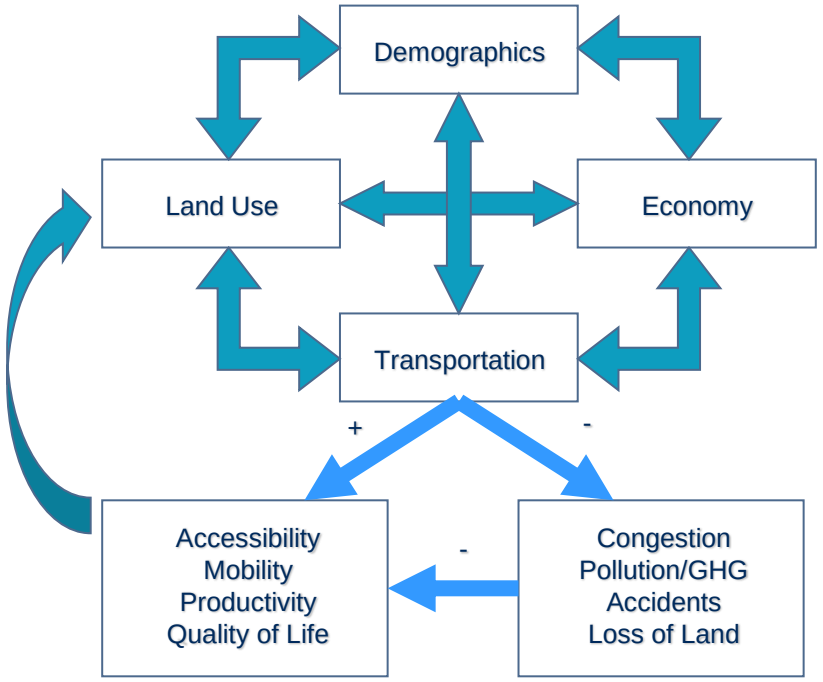
- The myth that building new urban highways will "solve congestion" unfortunately seems to be alive & well, at least in Ontario.
- Yes, we need to accommodate growth, but, as with transit, we need to be much more thoughtful about where capacity increases are truly needed:
  - No alternatives (transit, etc.) exist.
  - Meet regional development needs (e.g., Northern Ontario).
  - Careful, thoughtful consideration of land use implications:
    - Start with where growth "should go" & then work out the transportation needed to sustainably support this.
    - How do we de-couple transportation investment & sprawl?

Looking ahead …



Kennedy, C.A., E.J. Miller, A.S. Shalaby, H. MacLean and J. Coleman (2005). "The Four Pillars of Sustainable Urban Transportation", Transport Reviews, 25:4, 393-414.

- I am both optimistic & pessimistic about the future.
- I do think that we will "bounce back".
- But will we "build back better"?



Thank you. Questions?