Prepared for SCAG Meeting of the Modeling Task Force

Using a System Dynamics Approach to Understand the Long-term Effects of External Disruptions on Travel and Housing Decisions

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Jan. 26, 2022

Project funded by ITS Joint Program Office, USDOT

Motivations

- **Underlying factors driving change:**
  - As broadband has expanded, more companies have been adopting work-from-home (WFH) policies and flexible schedules.
  - Exogenous factors (e.g., pandemic, automated vehicles) can have long-term impacts on transportation and housing decisions

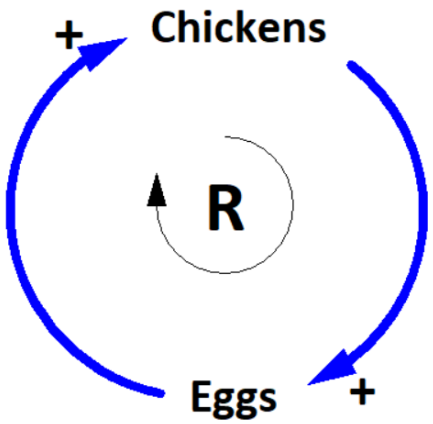
Problem: Existing modeling tools have limited capabilities to represent the multifaced impacts of disruptive changes on transportation and land use

Our Proposal

- Use ***system dynamics*** to develop an initial modeling framework to capture the systemic impacts of major disruptions to transportation and land use
  - System dynamics applies ideas from control systems theory to complex technological, social and economic problems.

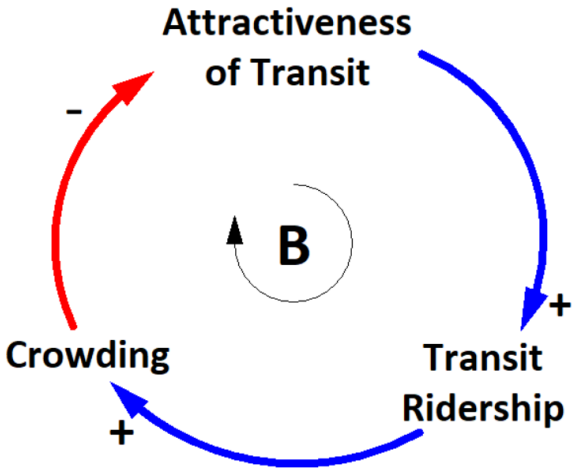
Introduction to causal loop diagrams in system dynamics

Introduction to Causal-loop Diagrams



Reinforcing Loop

- Exponential growth or decline
- "Going viral"
  - New product taking over a market as more people learn about it
  - Epidemic

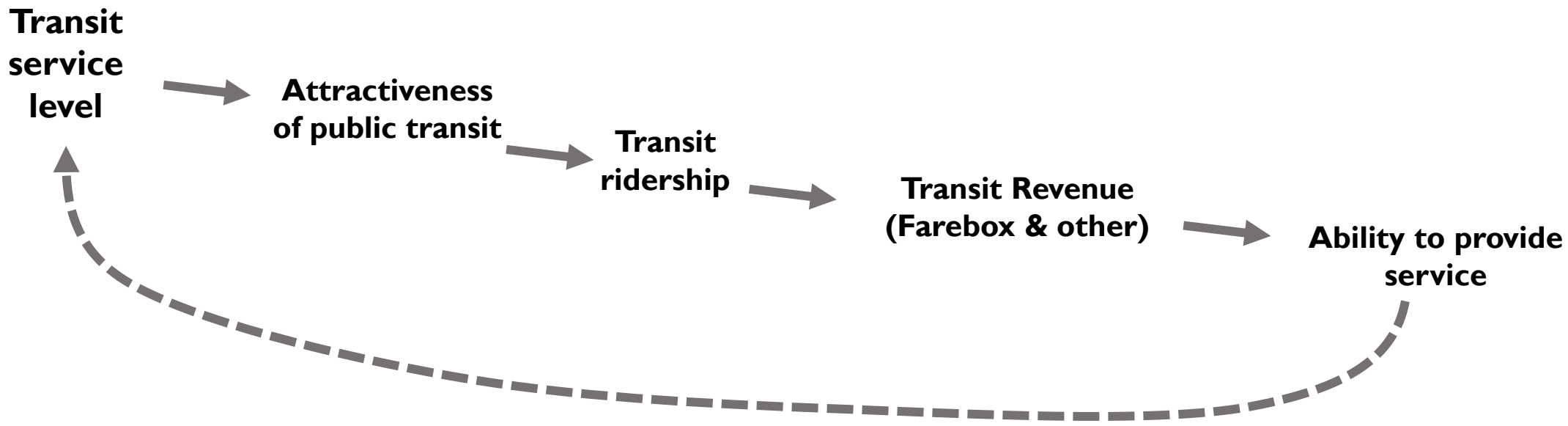


Balancing Loop

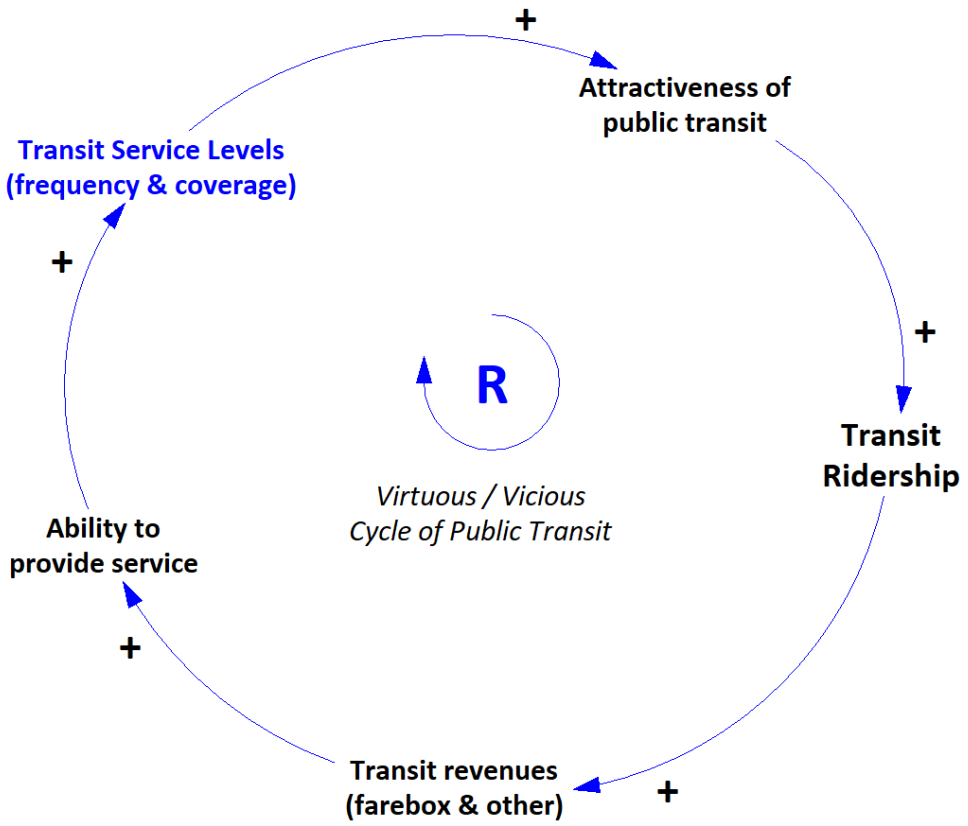
- Reaches an equilibrium, perhaps with oscillation
- Examples
  - Congestion on a road
  - Limits on food in an ecosystem

Connecting Public Transit System Supply and Demand:
What happens when we reduce service?

Begin by breaking down and connecting the outcomes from reductions in service.

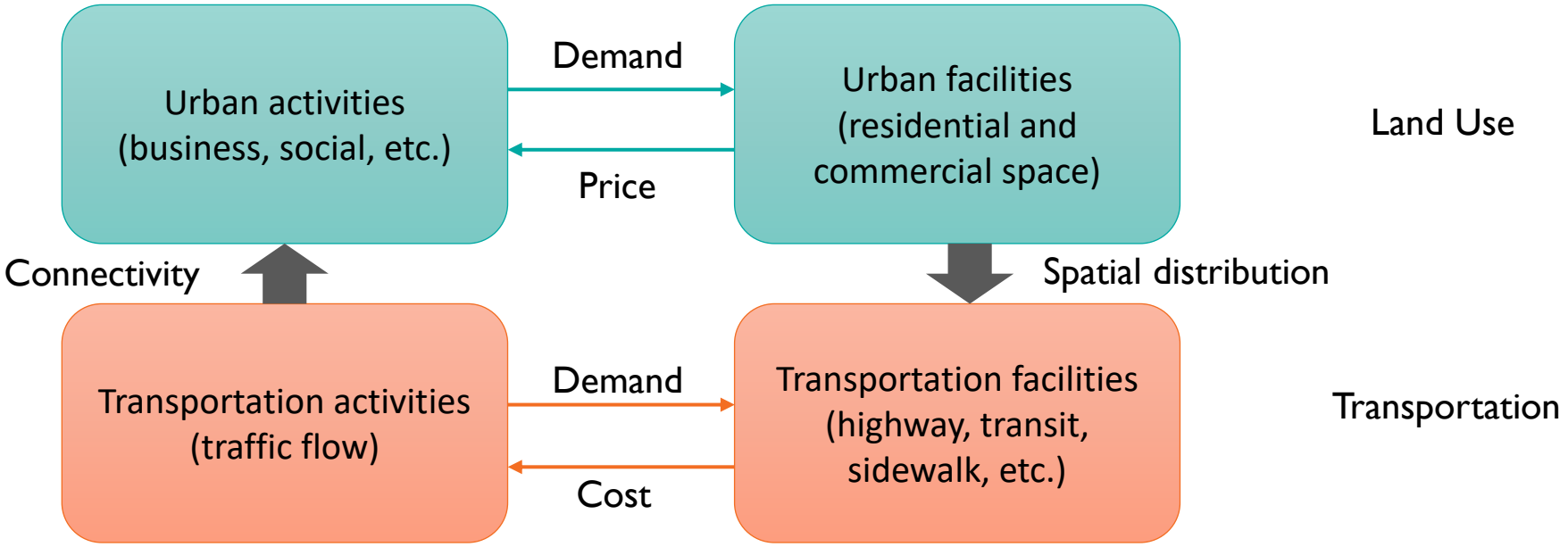


The system dynamics version of these relationships



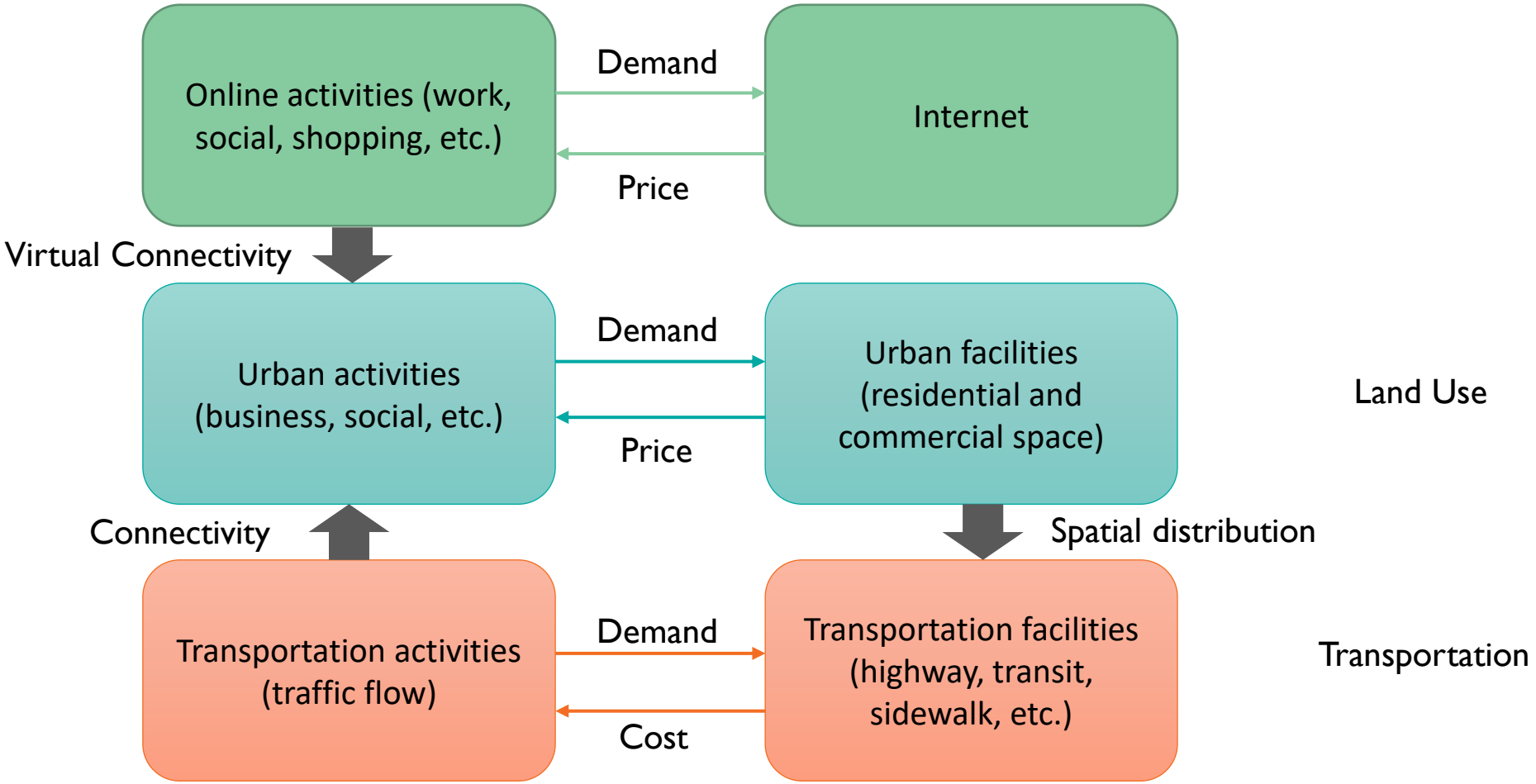
Land use and transportation

Mental model for Land Use and Transportation



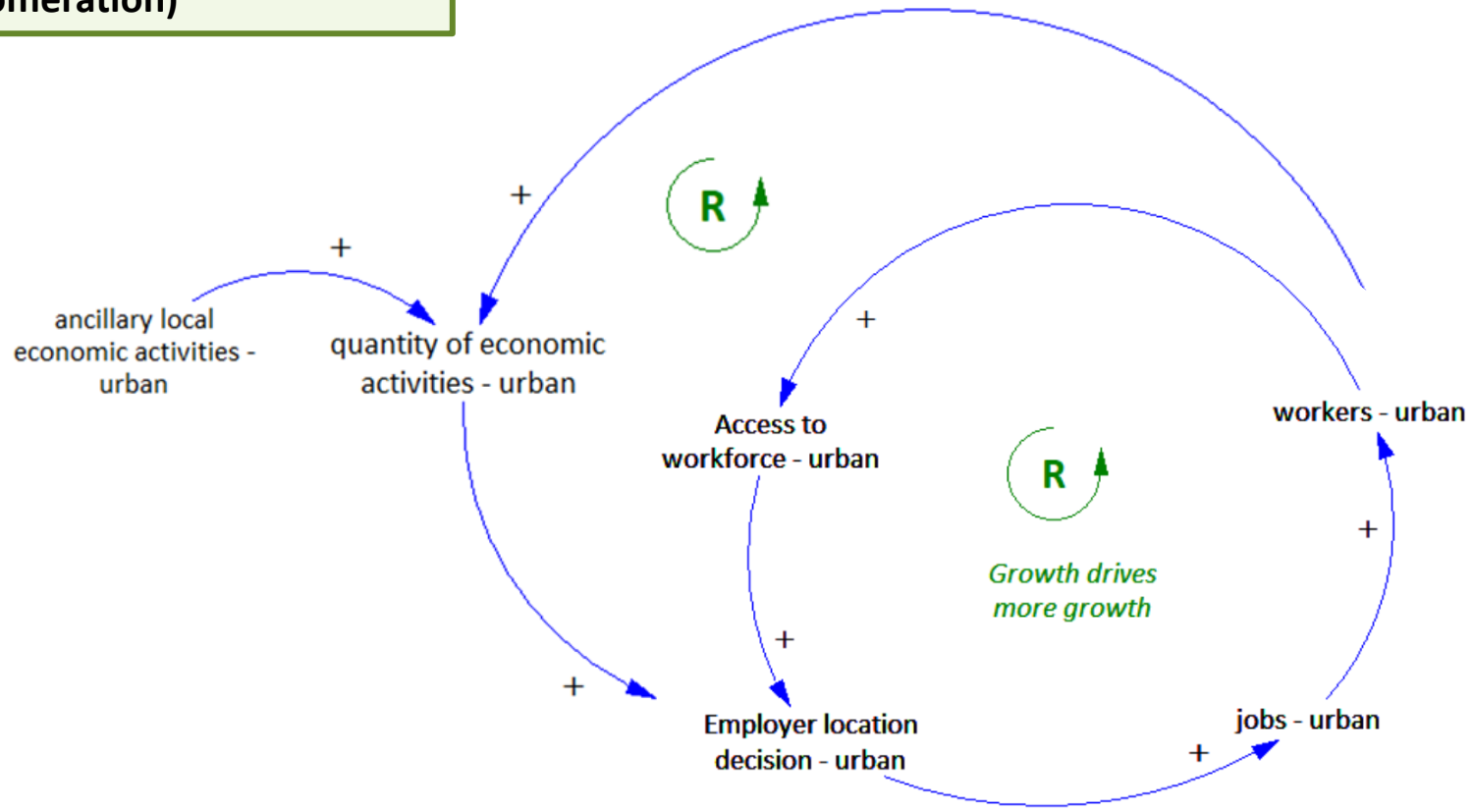
Source: MIT Webinar: Land Use-Transport Interactions: Evidence from and Implications for Urban Public Transportation Systems

How could telework change the interactions of urban and transportation activities?



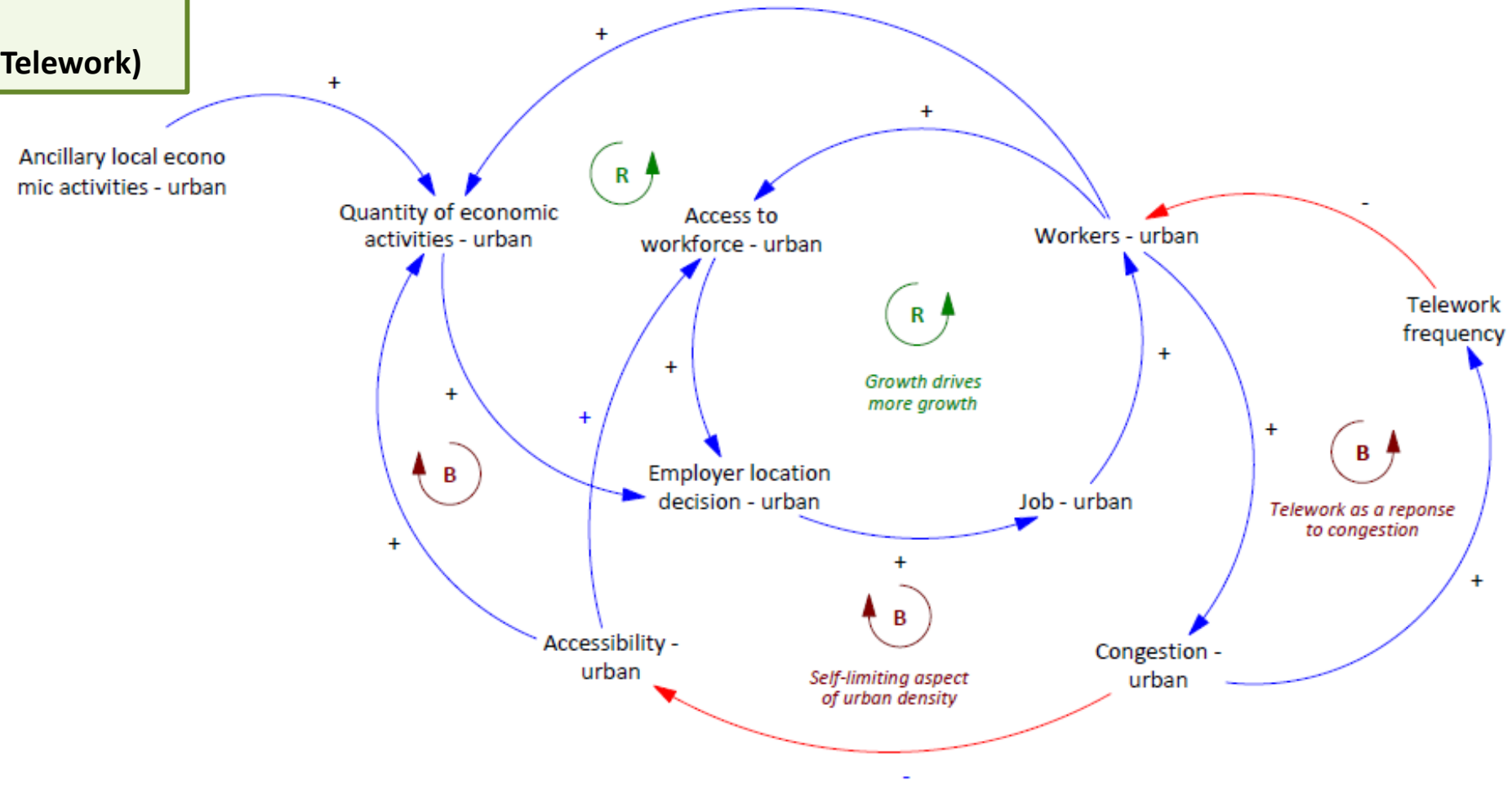
Next Level: Identify specific, detailed causal factors

JOBS & EMPLOYMENT
(Basic Agglomeration)

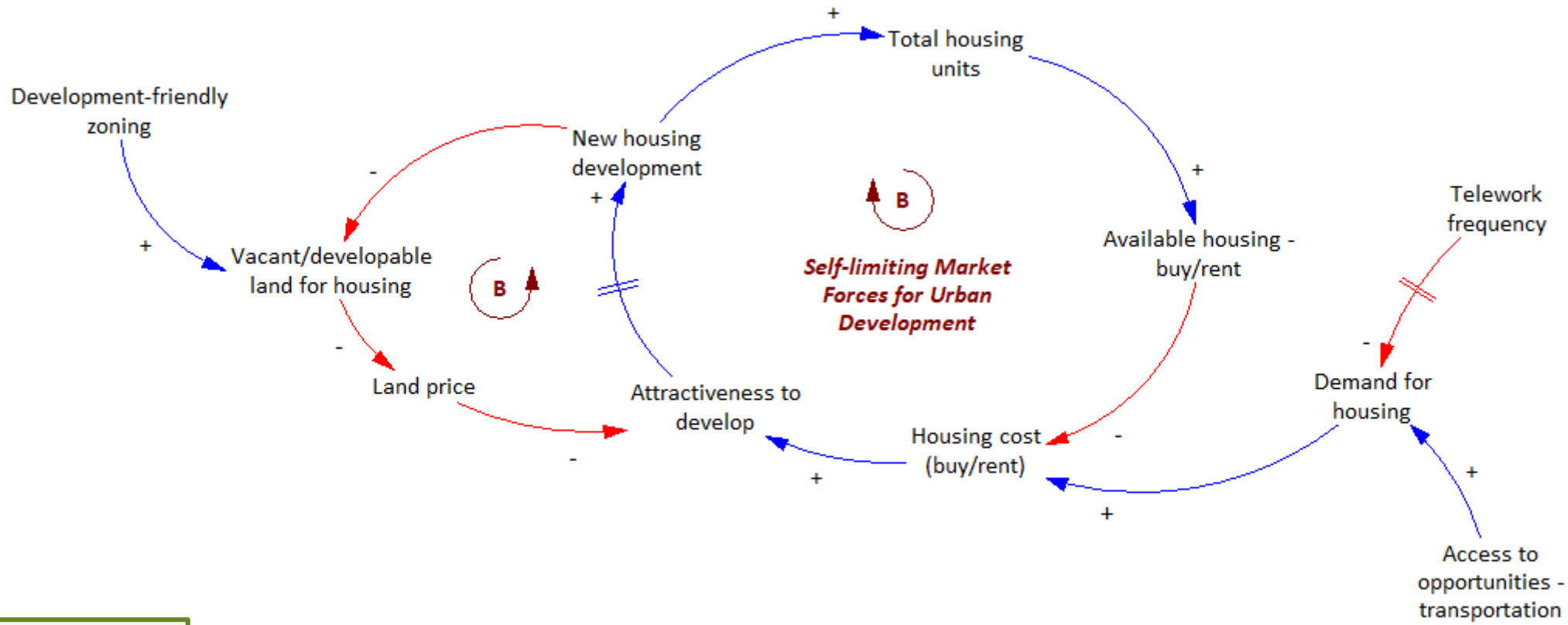


Adding balancing loops

JOBS & EMPLOYMENT
(Basic Agglomeration,
With Limiting Factors & Telework)



Self-limiting Market Forces for Urban Housing Market



Housing market

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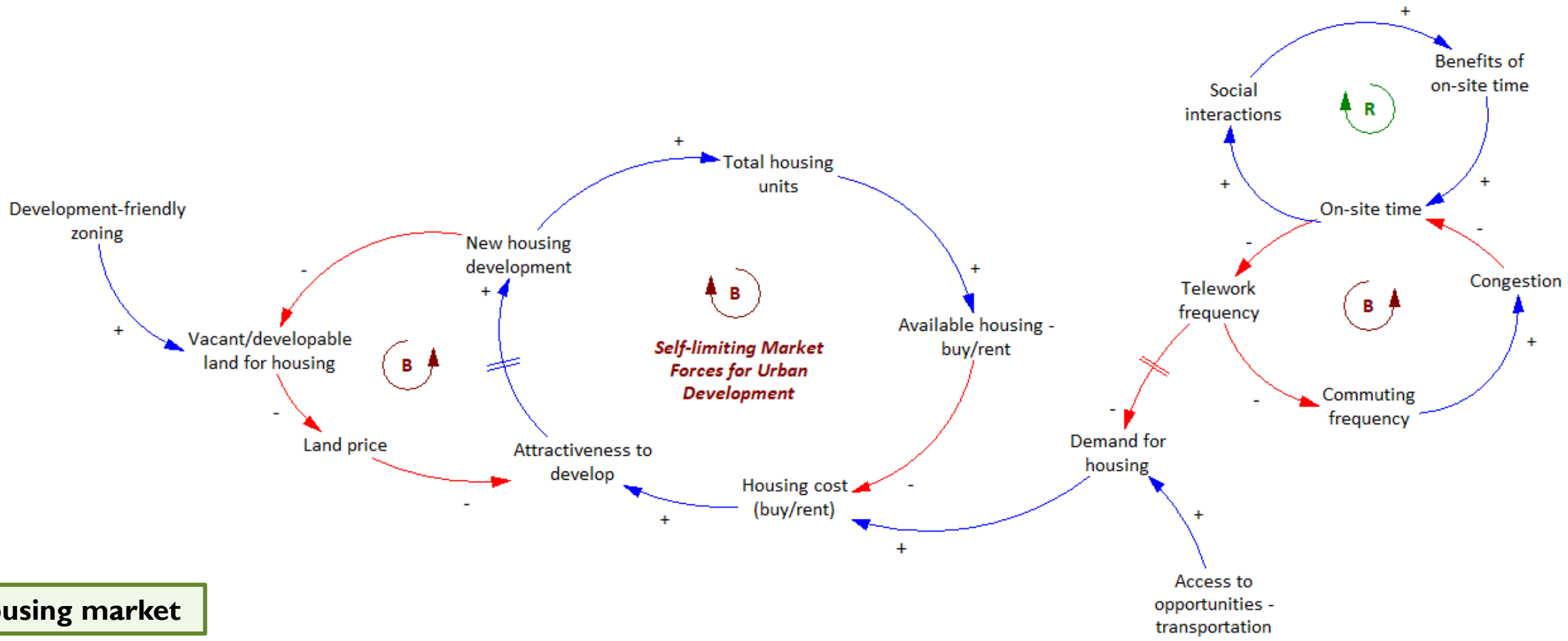
Transportation plays a key role in influencing the long-term impact of teleworking on housing demand in urban area



Housing market

SD deals with time lag and accumulation

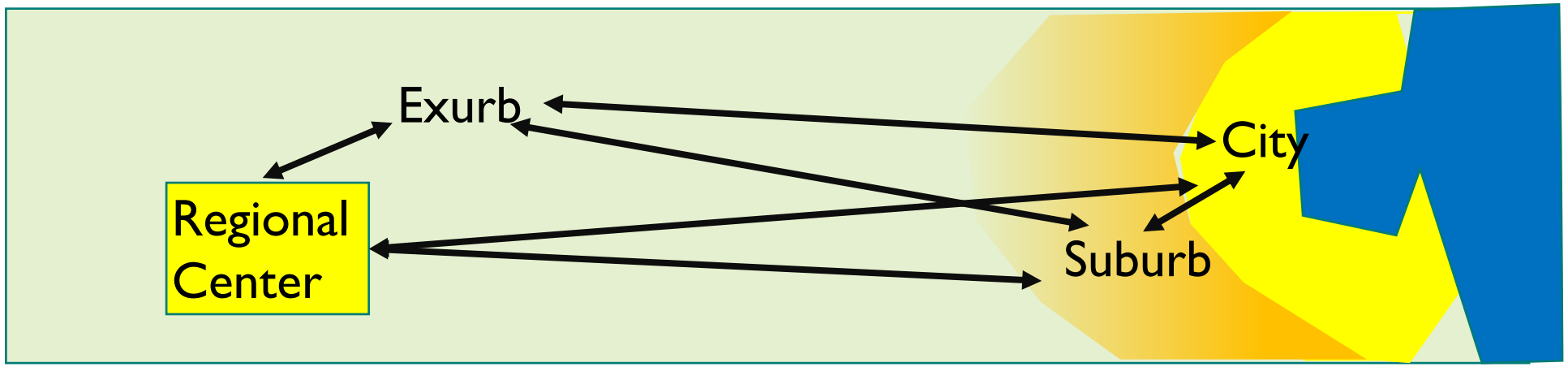
Stock and Flow

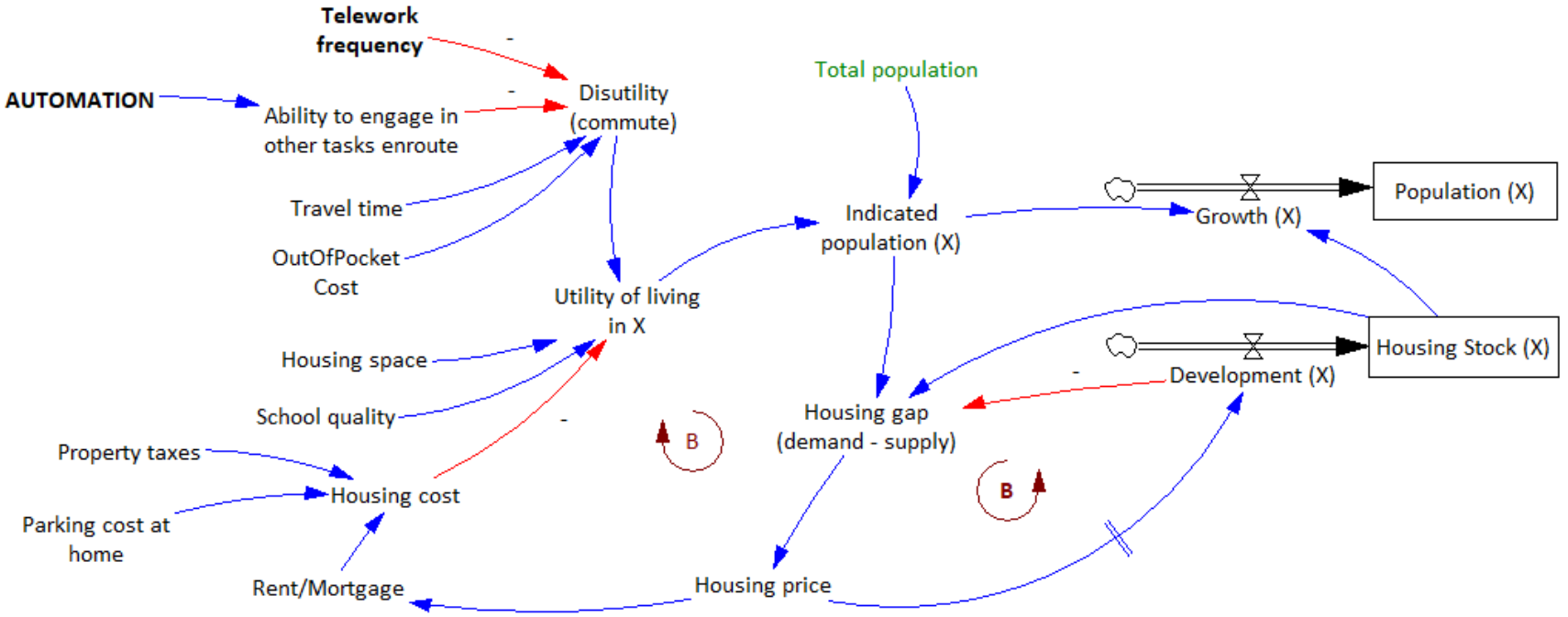
- Stock = accumulation of something
- Flow = change in the accumulation

Examples of stock

- Firm's cash on hand
- Fleet size
- Qualified bus operators
- Refueling infrastructure
- Population in a region
- Housing inventory in a region
- Persons familiar with automated vehicles
- Automakers' technical knowledge

SD molecules: Long-term dynamics in land use





Telework and automation may have a similar effect: both make long commutes less onerous

Household characteristics influence the causal relationships

X = type of region

Key takeaways from developing an SD model for understanding long-term impacts of remote work

An SD model can provide value by:

- ***Making complex systems approachable***
- ***Developing shared mental models and a common language for all stakeholders***
- ***Revealing key insights—including priorities and critical factors***
- ***Facilitating modeling AND policy-making***
- ***Identifying new directions to explore***

Discussion Questions

- What data do you think would be useful to develop a quantitative model to examine the effect of telework on traveling?
- What are the opportunities for new modeling tools, like SD, as a complement to current models in handling large behavioral changes?
  - How can SD help you identify gaps in existing models and data collection?
  - Where might a system view help?
  - Can SD help you think differently about modeling in a broad way?

Team & Acknowledgement

- VIA Team
  - Jingsi Shaw
  - Scott Smith
  - Joseph Stanford
  - Kendall Mahavier
  - Hannah Rakoff

  - Alan Rao
  - Adrian Hellman
  - Olivia Gillham
  - Scott Lian
- Advisors
  - Matt Cuddy
  - Luisa Paiewonsky
  - Gregg Fleming

Questions?

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References

- A System Dynamics Perspective for Transportation Planning under Uncertainty. (2020) Zephyr Webinar. https://zephyrtransport.org/events/2020-05-27-learning-system-dynamics/
- System Dynamics for Strategic Planning under Technological Uncertainty. (2021) Zephyr Webinar. https://zephyrtransport.org/events/2021-04-21-system-dynamics-applications/
- Rakoff, H., Shaw, J. (2021) Pandemic-triggered telework as a living lab for assessing future impacts of automated vehicles on urban form and employment. Industry Studies Conference.
- Testing a System Dynamics Approach for Modeling Mode Shift and Equity under Uncertainty. (2021) 18th TRB Conference on Transportation Planning Applications.
- Smith, S., Berg, I., Eilbert, A., Rakoff, H., Shaw, J., & Stanford, J. M. (2021). Automated Vehicle Impacts on the Transportation System: Using system dynamics to assess regional impacts (FHWA-JPO-21-849). https://rosap.ntl.bts.gov/view/dot/55247