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

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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

Urban activities (business, social, etc.)

Demand

Price

Connectivity

Transportation activities (traffic flow)

Demand

Cost

Urban facilities (residential and commercial space)

Spatial distribution

Transportation facilities (highway, transit, sidewalk, etc.)

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?

- Online activities (work, social, shopping, etc.)
  - Internet
    - Virtual Connectivity
      - Urban activities (business, social, etc.)
        - Transportation activities (traffic flow)
          - Demand
            - Connectivity
              - Transportation facilities (highway, transit, sidewalk, etc.)
                - Spatial distribution
                  - Land Use
                    - Transportation
                      - Cost
                        - Demand
                          - Price
                            - Cost
                              - Price
                                - Demand
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
Transportation plays a key role in influencing the long-term impact of teleworking on housing demand in urban areas.
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?
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Questions?

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References


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