The Economics of Spatial Mobility: Theory and Evidence Using Smartphone Data

Yuhei Miyauchi, Boston University
Kentaro Nakajima, Hitotsubashi University
Stephen J. Redding, Princeton University & NBER
Motivation

• Smartphone data have the potential to revolutionize our understanding of spatial mobility
  o Track mobility with high spatial and temporal resolution

• Travel itineraries (trip chains) are a key feature of this spatial mobility
  o Travel from home to work, meet a friend for dinner elsewhere after work, and then travel back home

• Trip chains matter because create consumption externalities
  o As one location becomes more attractive, that increases the attractiveness of other locations that are nearby or along the way
  o Impact of place-based interventions (e.g., transport infrastructure)
  o Collapse in demand for non-traded services with the shift to working from home (WFH) in the aftermath of Covid-19 pandemic
Smartphone GPS Data from Japan

• Tracks anonymised GPS location every 5 minutes (min) when phone on
  o Most popular map app in Japan (*Docomo Chizu NAVI, My Daiz*)
  o Each month ≈ 545,000 users and ≈ 1,497,000,000 GPS points

• NTT Docomo Inc. pre-processes original GPS data points
  o **Baseline sample:** April 2019 (pre Covid-19)
  o **Stay:** no movement ≤ 100 meters for ≥ 15 minutes
  o **Home:** most frequent location (geographically contiguous stays)
  o **Work:** second most frequent location, ≥ 600 meters from home

• Focus on user-days whose:
  o First and last stays of the day is at home (to avoid overnight travelers)
  o Home and work is within Tokyo metropolitan area
Example of Stays (around Meiji Shrine)

- Track the movement of users through the park to the shrine
Stays Frequently Occur as Trip Chains

- Implications for consumption externalities
  - Opening a new shopping center will attract people to nearby coffee shops and restaurants and draw them away from coffee shops and restaurants elsewhere
Localized Consumption Spillovers

- Event study estimates for the impact of the closure of **large retail stores** (>5,000m²) on log non-work stays
Collapse in Downtown Foot Traffic post-Pandemic

• As people stopped commuting downtown to work, this led to a collapse in local demand for non-traded services (e.g., coffee shops and restaurants)
Model

• Consider a city consisting of many locations (city blocks)
• Each agent chooses a residence and a workplace
• Given her residence and workplace, she chooses a travel itinerary
  o How many other locations to visit to consume non-traded services
  o The sequence in which to visit those locations
• Each agent experiences idiosyncratic preference shocks for travel itineraries and faces travel costs that reduce utility
• Non-traded services in each location are supplied by horizontally-differentiated firms with free entry
• Consumption externalities
  o As more agents are attracted to one location, this raises the number of agents that visit nearby locations that are along the way
• We overcome the high-dimensional state space using importance sampling
Work from Home Counterfactual

• Calibrate the baseline model using April 2019 data

• Re-estimate two parameters using April 2020 data
  o Sensitivity of travel costs to travel time
  o Probability of going to work

• Two counterfactuals
  o Short-run: fix general equilibrium variables (e.g., land prices)
  o Long-run: endogenize general equilibrium variables

• Compare against “no trip chain” model (visit consumption locations from home)
Short-Run Collapse in Foot Traffic

• Model with trip chains captures the short-run decline in downtown consumer foot traffic
Long-Run Implications

- Reduction of residential/employment, rents, wages, firm entry in downtown
Conclusions

• Smartphone data have the potential to revolutionize our understanding of spatial mobility
  o Track movement of individuals with high spatial and temporal resolution

• We develop a tractable model of spatial mobility using these smartphone data

• Travel itineraries (trip chains) give rise to consumption externalities
  o As more agents are attracted to one location, this raises the number of agents that visit nearby locations that are along the way

• Travel itineraries are central to understanding
  o Collapse in demand for non-traded services with the shift to working from home (WFH) in the aftermath of Covid-19 pandemic
  o Impact of place-based interventions (e.g., transport infrastructure improvement, opening of new shopping center)
Thank You