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

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Motivation

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

- Travel itineraries (trip chains) are a key feature of this spatial mobility
  - 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**
  - As one location becomes more attractive, that increases the attractiveness of other locations that are nearby or along the way
  - Impact of place-based interventions (e.g., transport infrastructure)
  - 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
    - Most popular map app in Japan (*Docomo Chizu NAVI, My Daiz*)
    - Each month ≈ 545,000 users and ≈ 1,497,000,000 GPS points

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

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

Example of Stays (around Meiji Shrine)
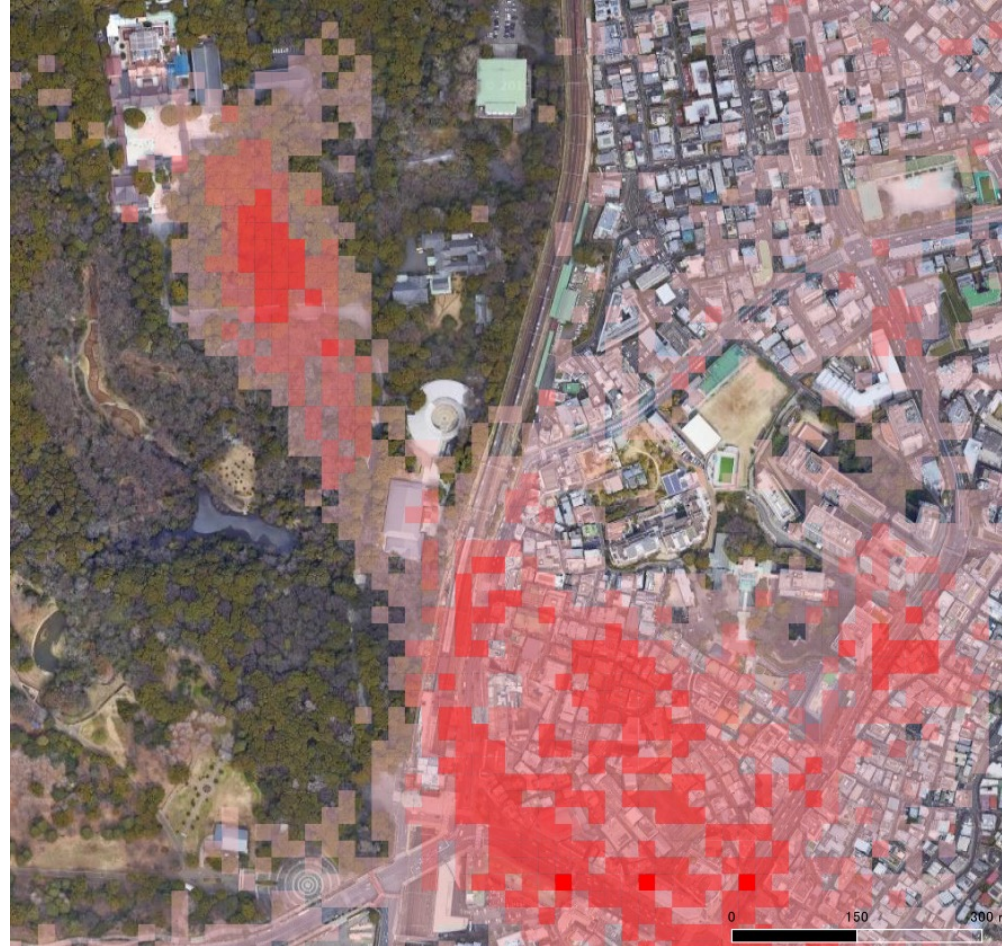
- Track the movement of users through the park to the shrine

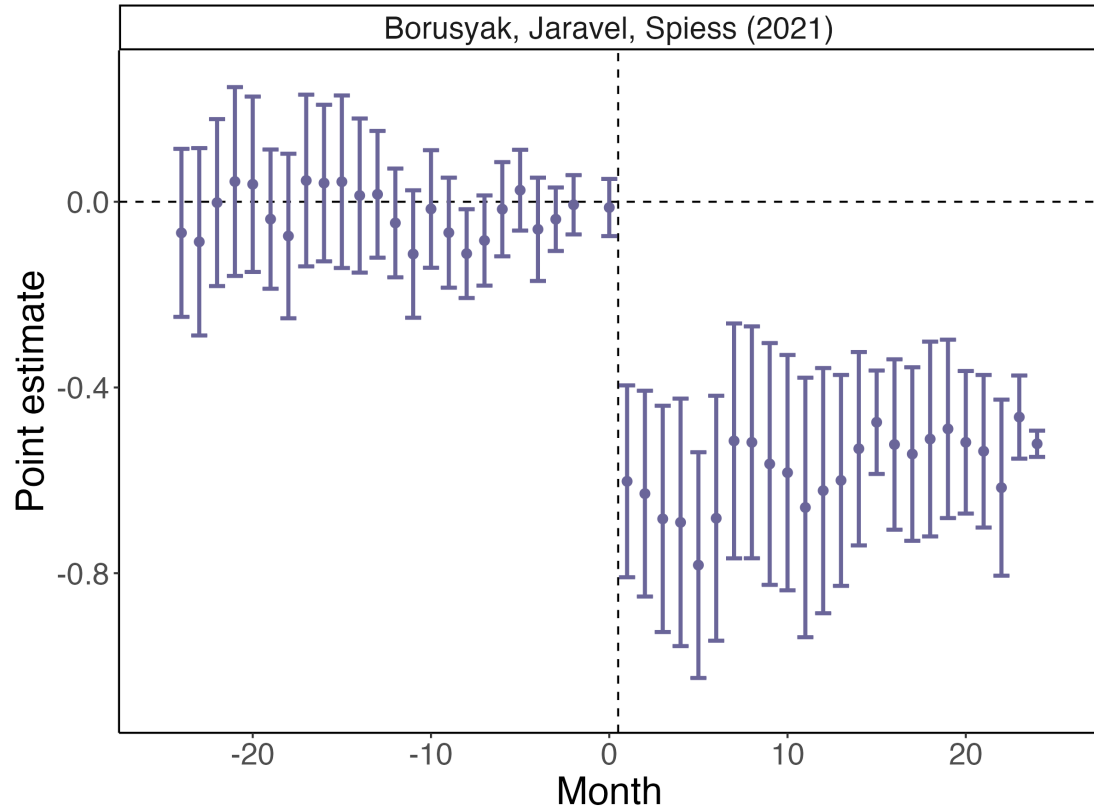# Stays Frequently Occur as Trip Chains
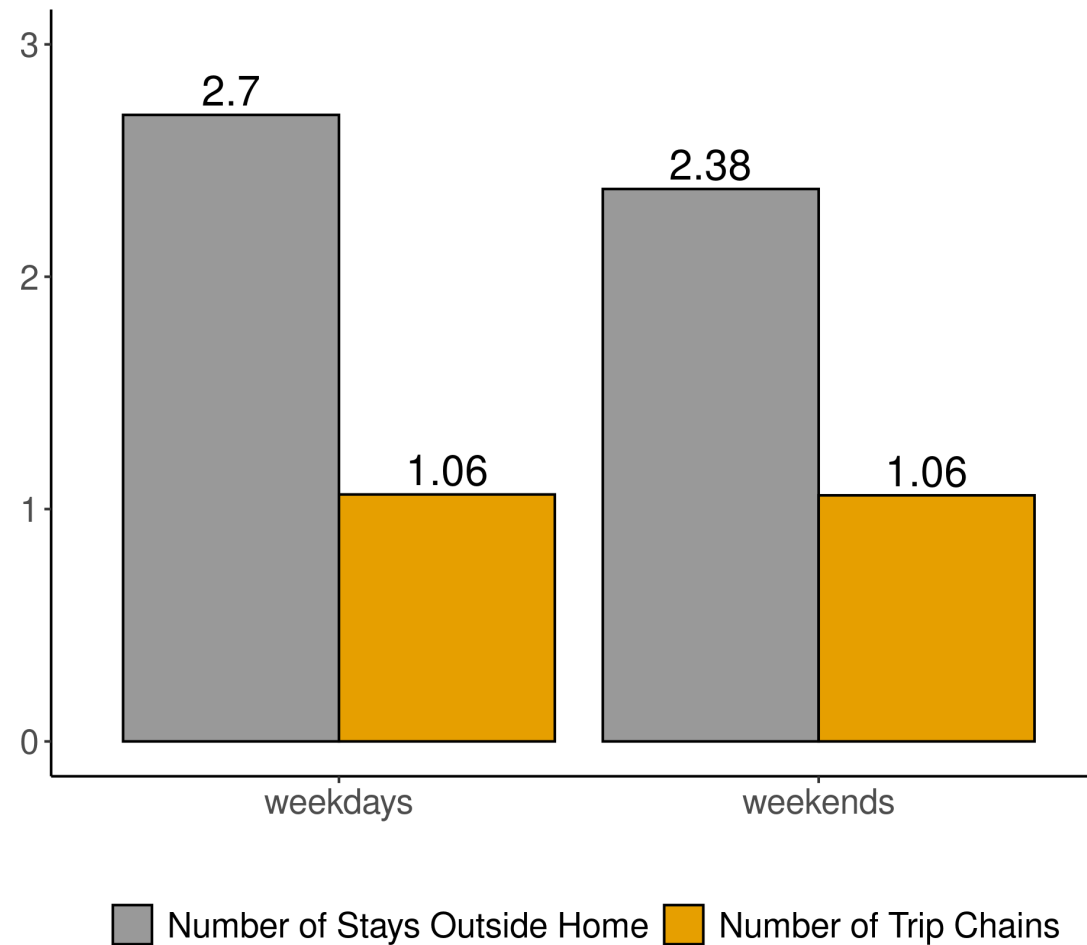
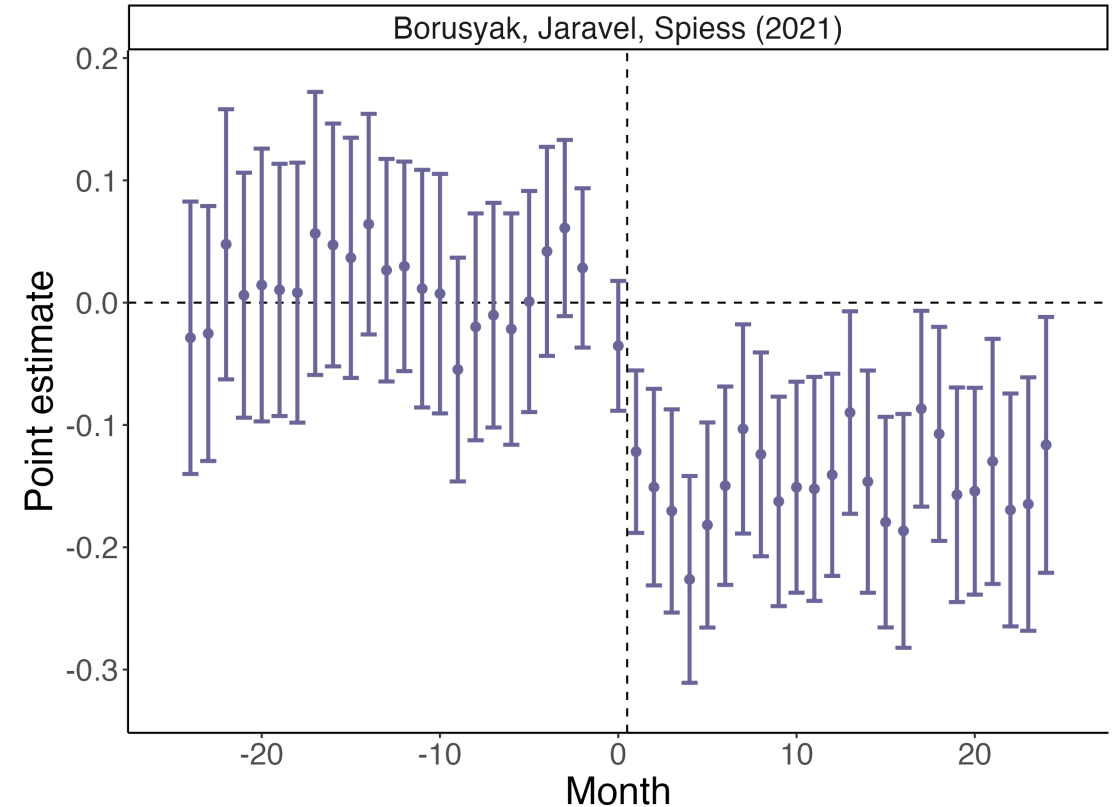- Implications for **consumption externalities**
  - Opening a new shopping center will attract people to nearby coffee shops and restaurants and draw them away from coffee shops and restaurants elsewhere

Localized Consumption Spillovers

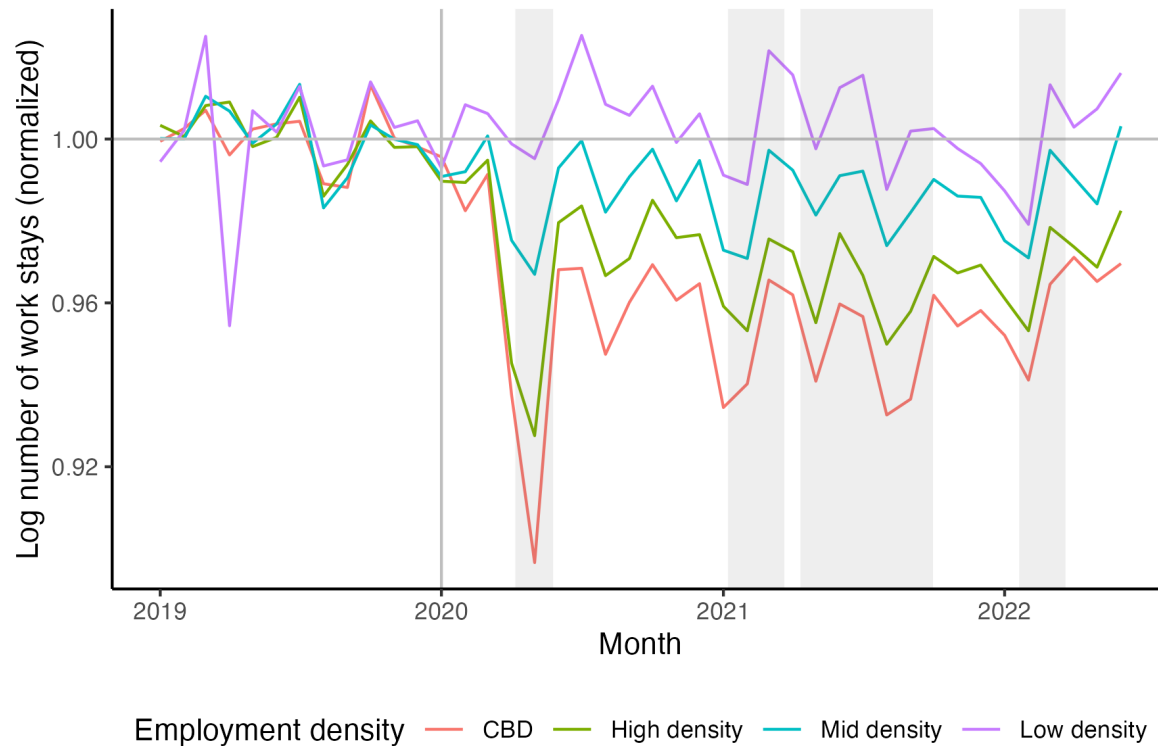## (A) Direct effect (within 250m mesh)

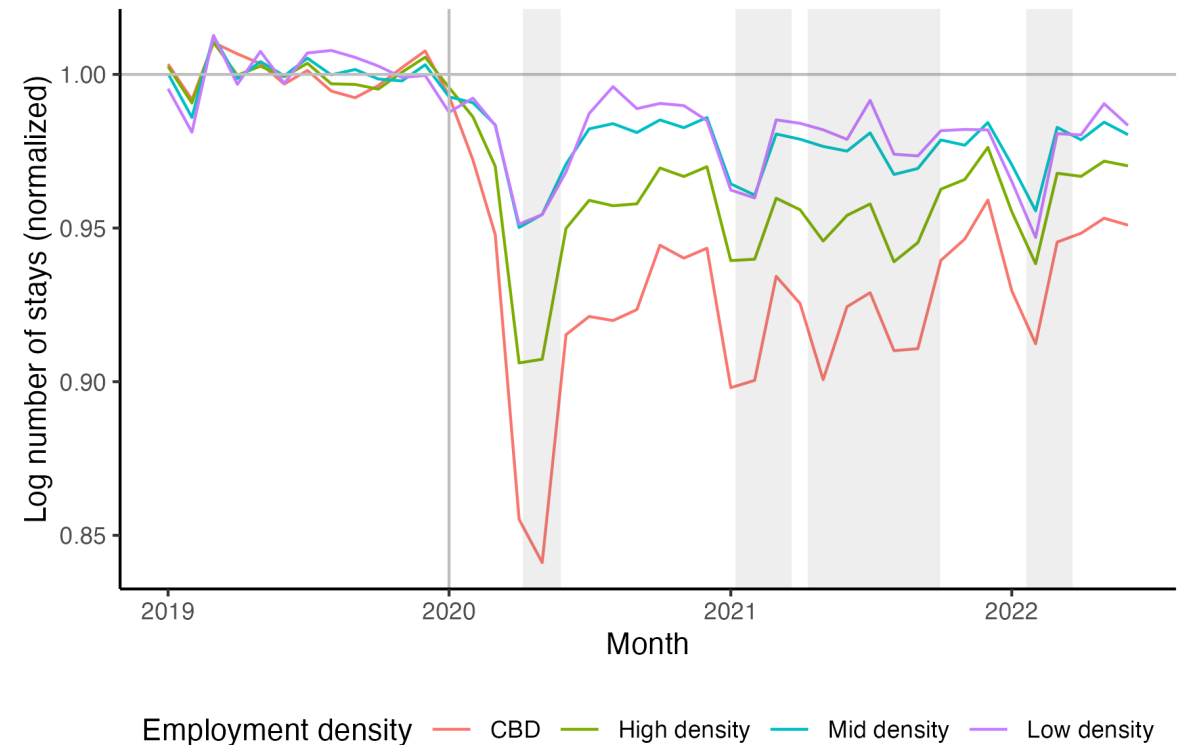## (B) Spillover effect (contiguous 250m mesh)

- 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

(A) Work Stays

(B) Non-Work Stays

- 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)
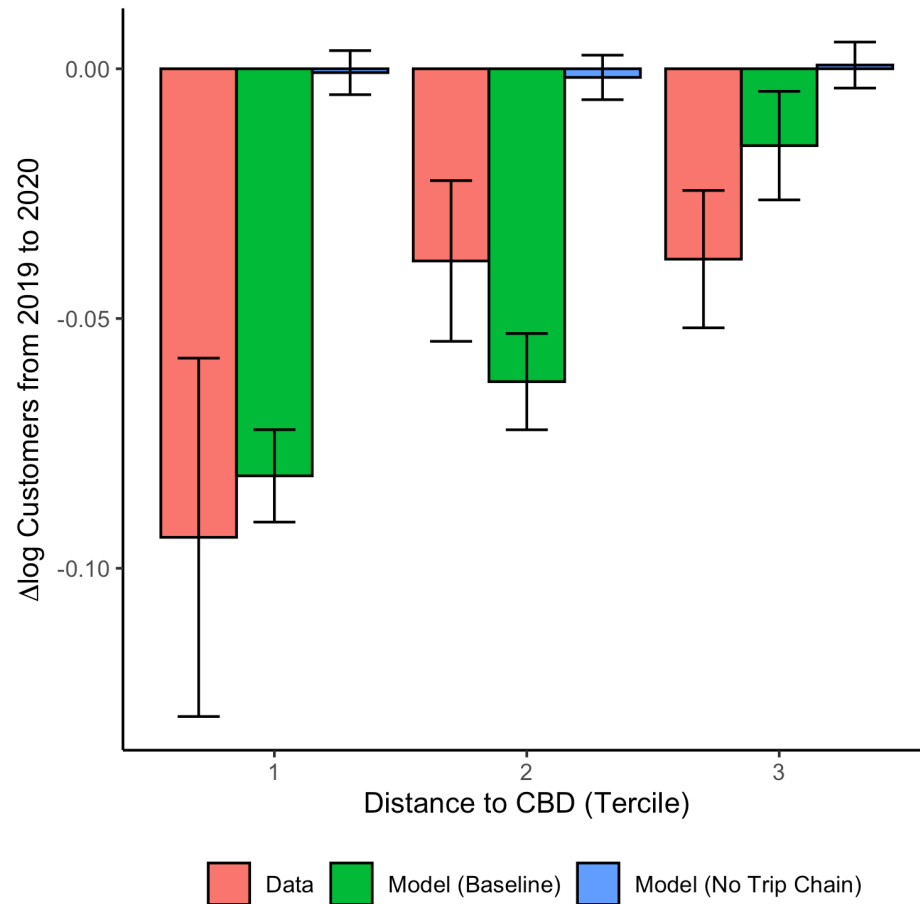
Model

- 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
  - How many other locations to visit to consume non-traded services
  - 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
  - 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
  - Sensitivity of travel costs to travel time
  - Probability of going to work

- Two counterfactuals
  - Short-run: fix general equilibrium variables (e.g., land prices)
  - 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
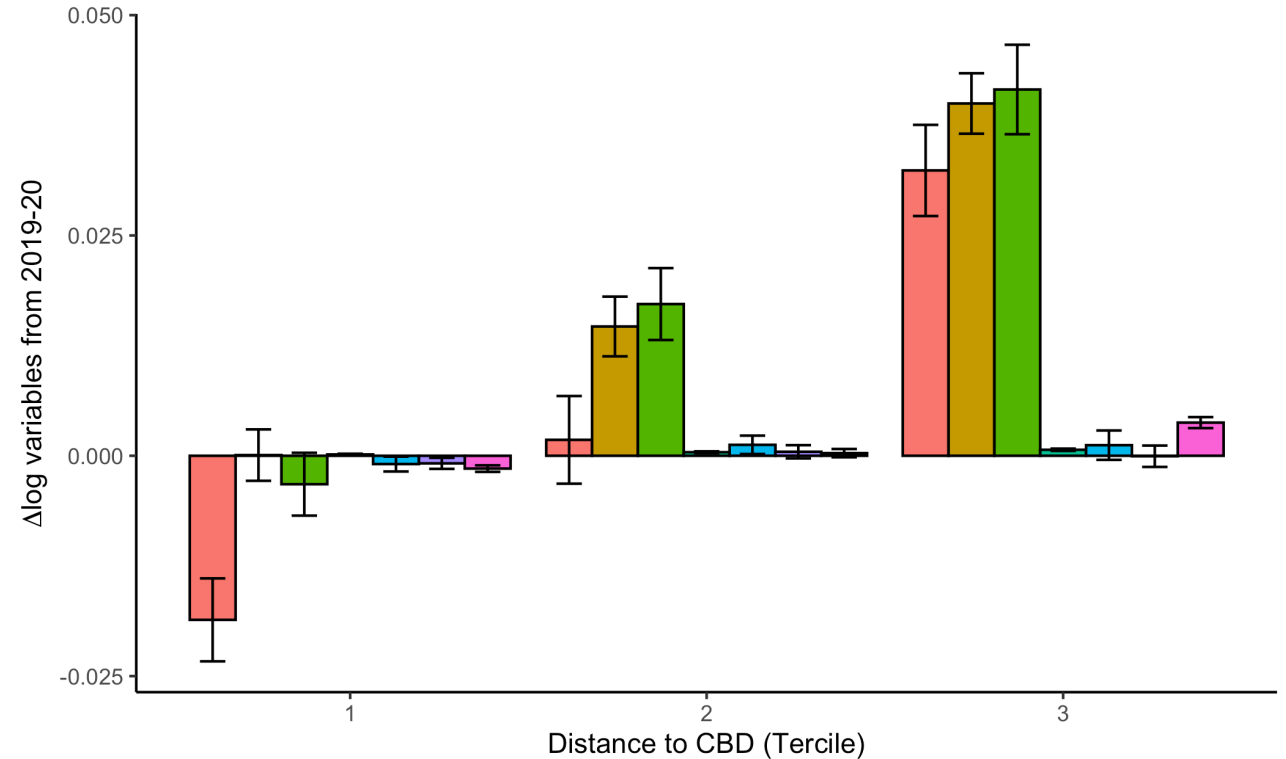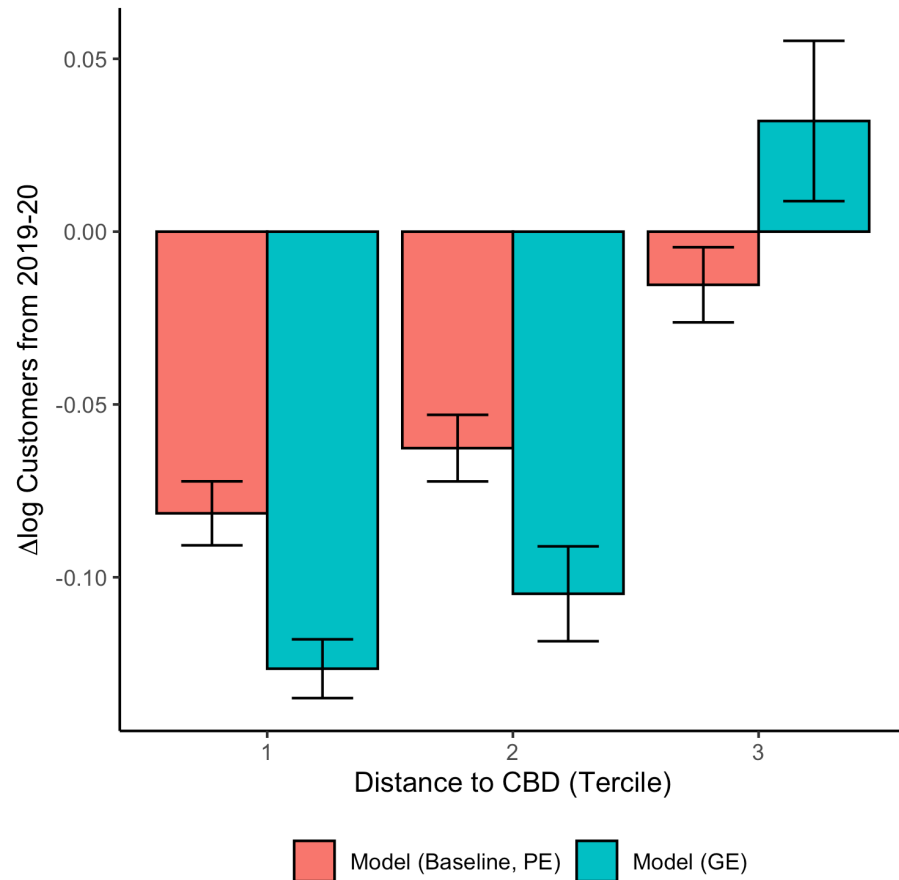
- Reduction of residential/employment, rents, wages, firm entry in downtown

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