The Spatial Dynamics of Amazon Lockers

INUF 2019 – Local/Last Mile Pickup and Delivery

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Outline

1 Introduction

2 Literature

3 Research Framework

4 Data Collection

5 Data Analysis Methods

6 Results and Findings

7 Conclusions

1 INTRODUCTION

- *Background*
- *Research Questions*

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Background

- Increasing Truck Activities – Online shopping
- Social impacts: safety, congestion, parking
- Environmental impacts: pollutant, emissions
- Strategy: Pick-up Points (PP) + Automated Parcel (AP) Networks
  - Replace truck trips with walking/biking
  - Reduce negative social and environmental impacts ?
  - Low costs ? + higher efficiency ?

Research Questions – GHG (+)/(-)?

(1) What is the spatial distribution of Amazon Lockers in Los Angeles?

- Clustering?
- Autocorrelation?

(2) Why are those lockers located there?

- Variables that affect the distribution
    - Demographics
    - Built Environment

(3) How do people pick up their orders?

- Travel behaviors

2 LITERATURE

- *Summary*
- *Research Gaps*

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Literature Review – Location Matters

- The Environmental Benefits of PP Networks
- The Variables that Affect the Design of PP Networks
- Developing Sustainable Networked Delivery System

Authors	Place	Findings
Weltevreden (2008)	Netherlands	Both shoppers and pick-up points benefit from vicinity.
Morganti, Dablanc, & Fortin (2014)	France	Population density and internet penetration
Iwan, Kijewska, & Lemke (2016)	Szczecin	Proper location of the machines used for deliveries → efficiency
Deutsch & Golany (2017)	Canada	Optimize the locker network based on location, size and demographics.
Lachapelle, Burke, Brotherton, & Leung (2018)	Australia	Proximity to highways, to public transport, population density, a balance of jobs and population, and higher rates of households Internet access

Research Gaps

- Few studies describe the spatial distribution patterns of pick-up point locations
- No studies have investigated the spatial distribution of Amazon Lockers in US cities
- LA – a mix of walkable and non-walkable places ≠ European cities

- Try to fill this gap by
  - Describing the spatial pattern using spatial analysis tools
  - Analyzing the socio-economic and built environment variables
  - Estimating the potential GHG emission reduction
  - Starting from LA and expand the studies to other major cities in the US.

3 Research Framework

- *Describe*
- *Explain*
- *Estimate*

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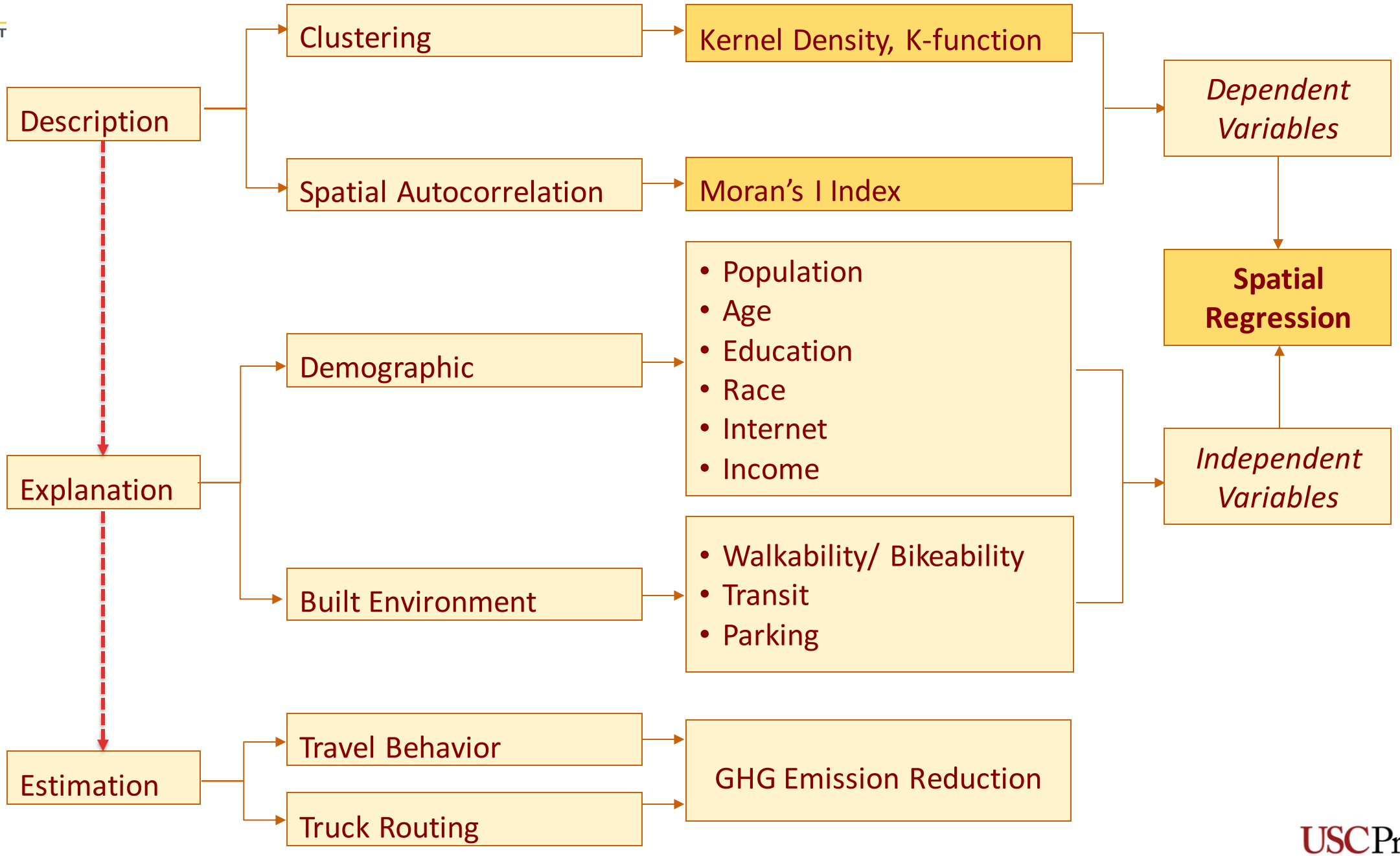
Description
Clustering
Kernel Density, K-function
Spatial Autocorrelation
Moran's I Index
Dependent Variables
Spatial Regression
Explanation
Demographic
• Population
• Age
• Education
• Race
• Internet
• Income
Built Environment
• Walkability/ Bikeability
• Transit
• Parking
Independent Variables
Estimation
Travel Behavior
Truck Routing
GHG Emission Reduction

4 Data Collection

- *Amazon Locker*
- *Built Environment*
- *Demographics*

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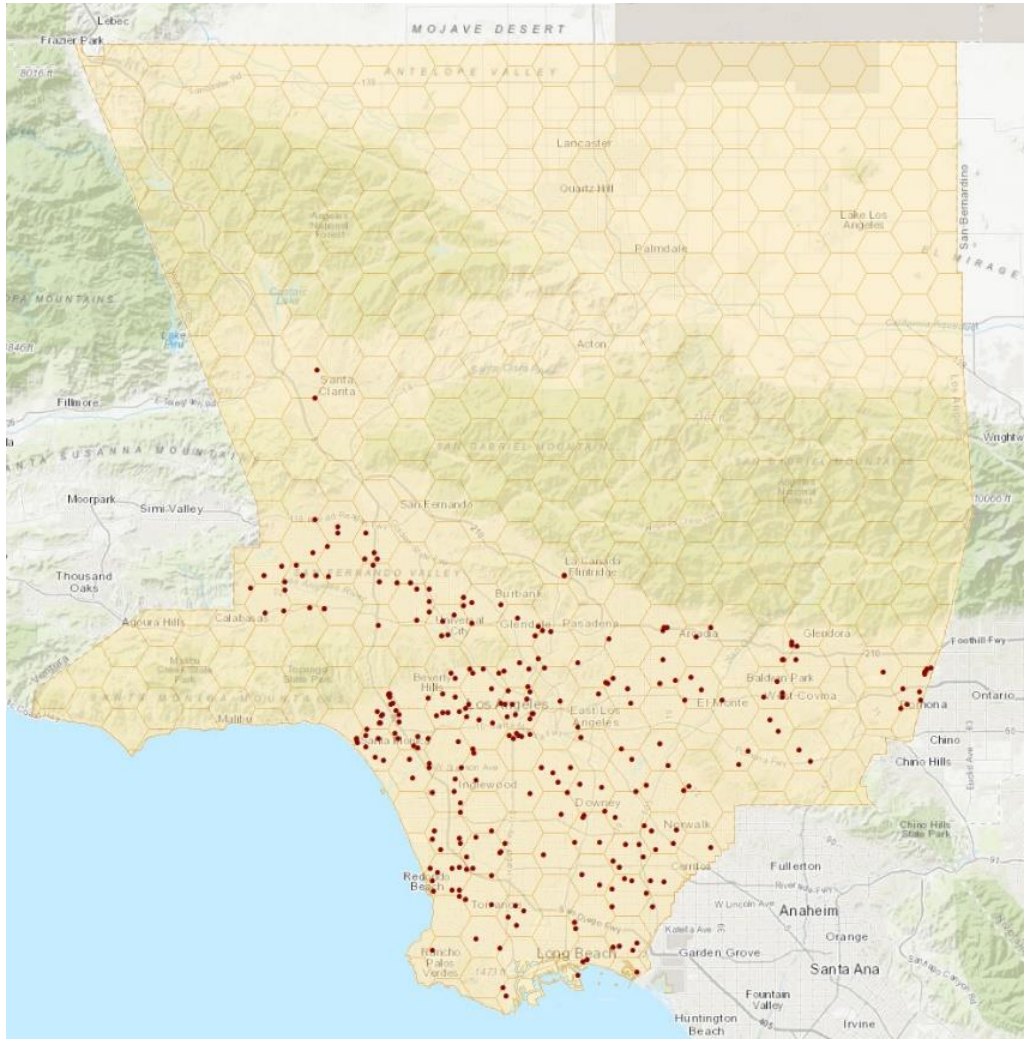
Amazon Locker Locations

- Google Map API - “Text Search”
  - Circle search
  - Radius limit
- Python
- Hexagon fishnet
  - r=2miles
  - N=502
- 273 Lockers in total.



Built Environment Data

- API + Python
- The same fishnet grid as Amazon Locker search
- Walkability/Bikeability
  - Walkscore.com API
- Parking Density
  - Google Map API – Nearby Search
  - "type" parameter = "parking"
- Transit density
  - LA Metro Bus and Rail GIS Data

Variable	Data	How to use it in research
Walkability	Walk/Bike score at the centroid of each census tract	Walkscore at the centroid of each census tract
Bikeability	Bike score at the centroid of each census tract	Bike score at the centroid of each census tract
Transit	The number of transit stops	The number of transit stops / Tract Area
Parking	The number of parking lots	The number of parking lots/ Tract Area

Demographics Data

- Source: US Census Bureau, 2017, ACS 5 year estimates
- Variables (unit of analysis – census tract)

Variable	Data (unit of analysis – census tract)	How to use it in research
Population	The number of people	The number of people / Tract Area
Age 15-39	The number of persons aged 15-39	The number of persons aged 15-39 / Tract Area
Education	The number of people with bachelor's degree or higher	The number of people with bachelor's degree or higher / Tract Area
White	The number of white people	The number of white people / Tract Area
Internet	The number of household with internet use	The number of household with internet subscriptions / Tract Area
Income	The median household income ($)	The median household income ($)

5 Methods

- *Clustering*
- *Autocorrelation*
- *Regression*

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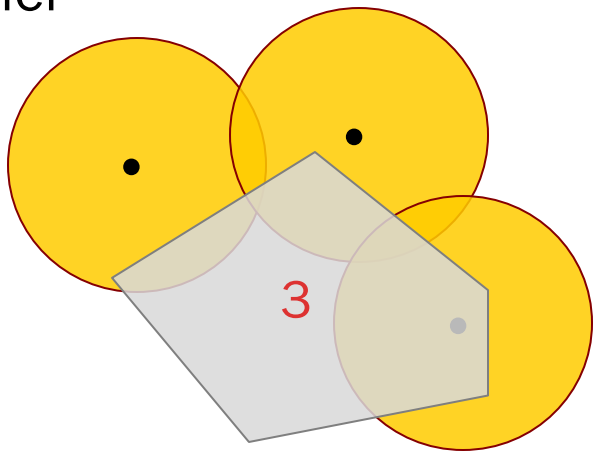
Spatial Analysis Tools

- **Spatial Point Pattern Analysis** → Original Locker Location Data (Point Data)
  - Kernel density – when the points are distributed independently
  - Ripley's K-function – when the points are distributed dependently
- **Spatial Autocorrelation** → Locker Service Availability in Each Census Tract (Polygon Data)
  - Availability – the # of **1-mile locker buffers** intersecting each census tract
  - Moran's I statistics – check tracts are affecting each other
- **Spatial Regression**
  - Ordinary Least Squares (OLS) Regression – Global
  - Geographically Weighted Regression (GWR) – Local



6 Findings

- *Clustering √*
- *Spatial autocorrelation √*
- *Spatial Regression ?*
- *Spillover effects !*

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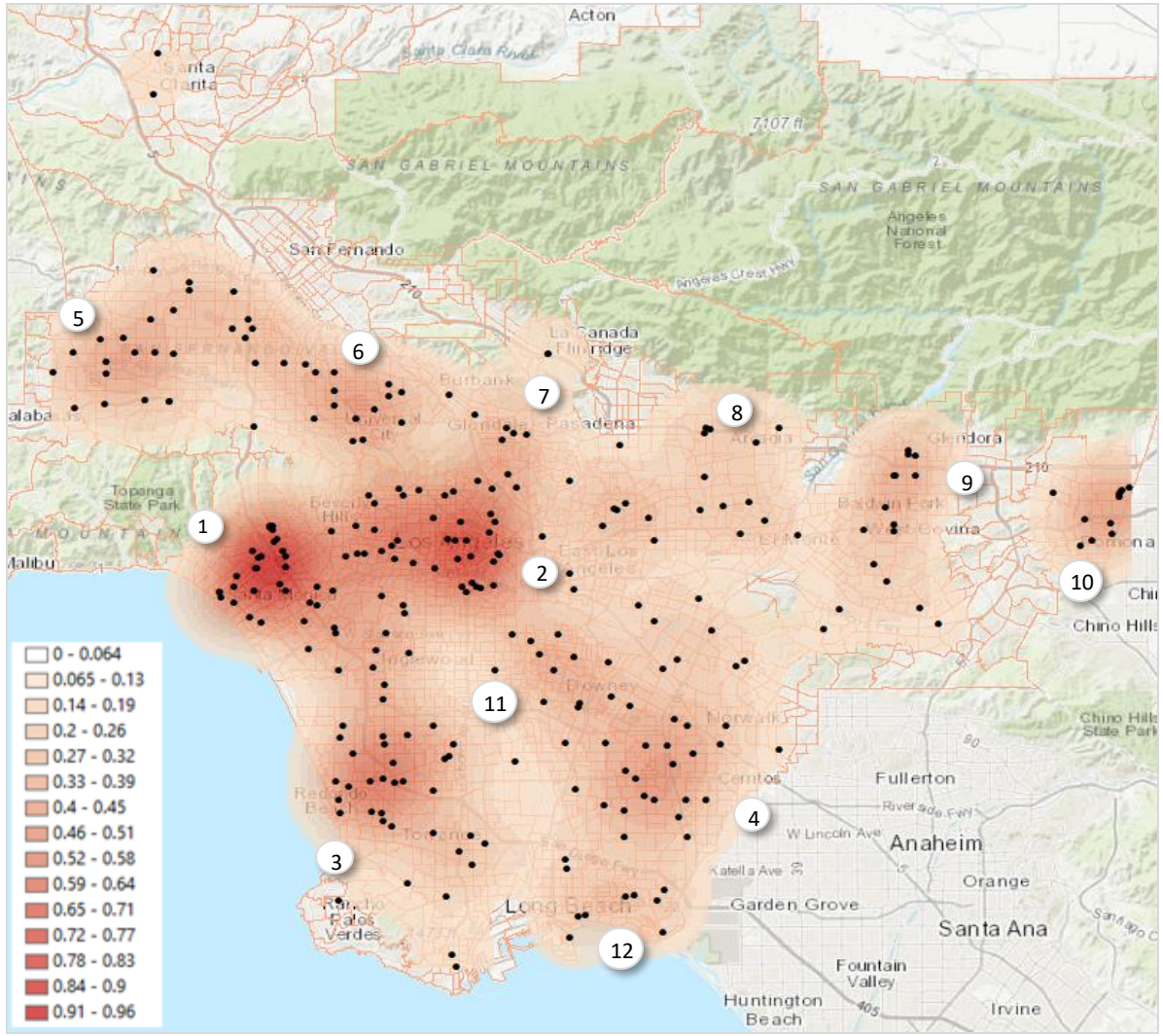
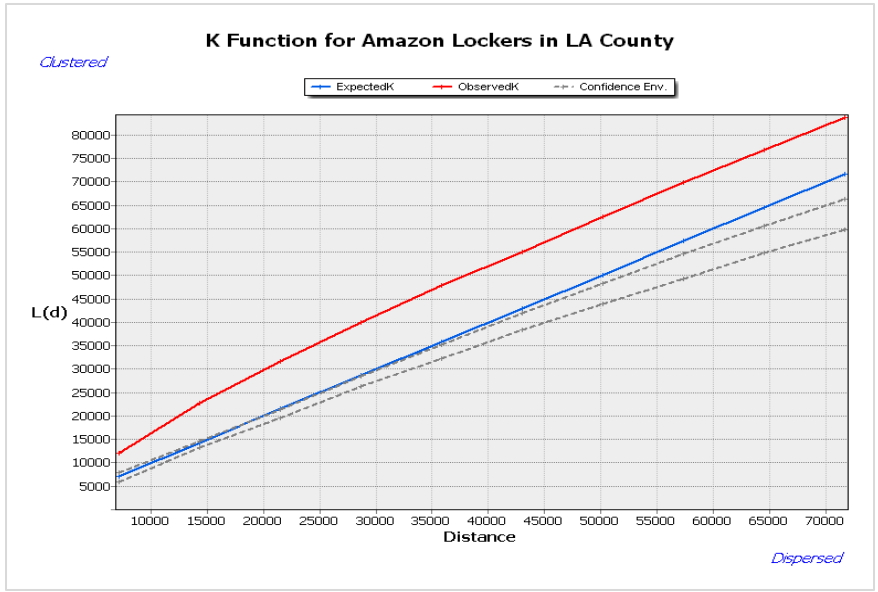
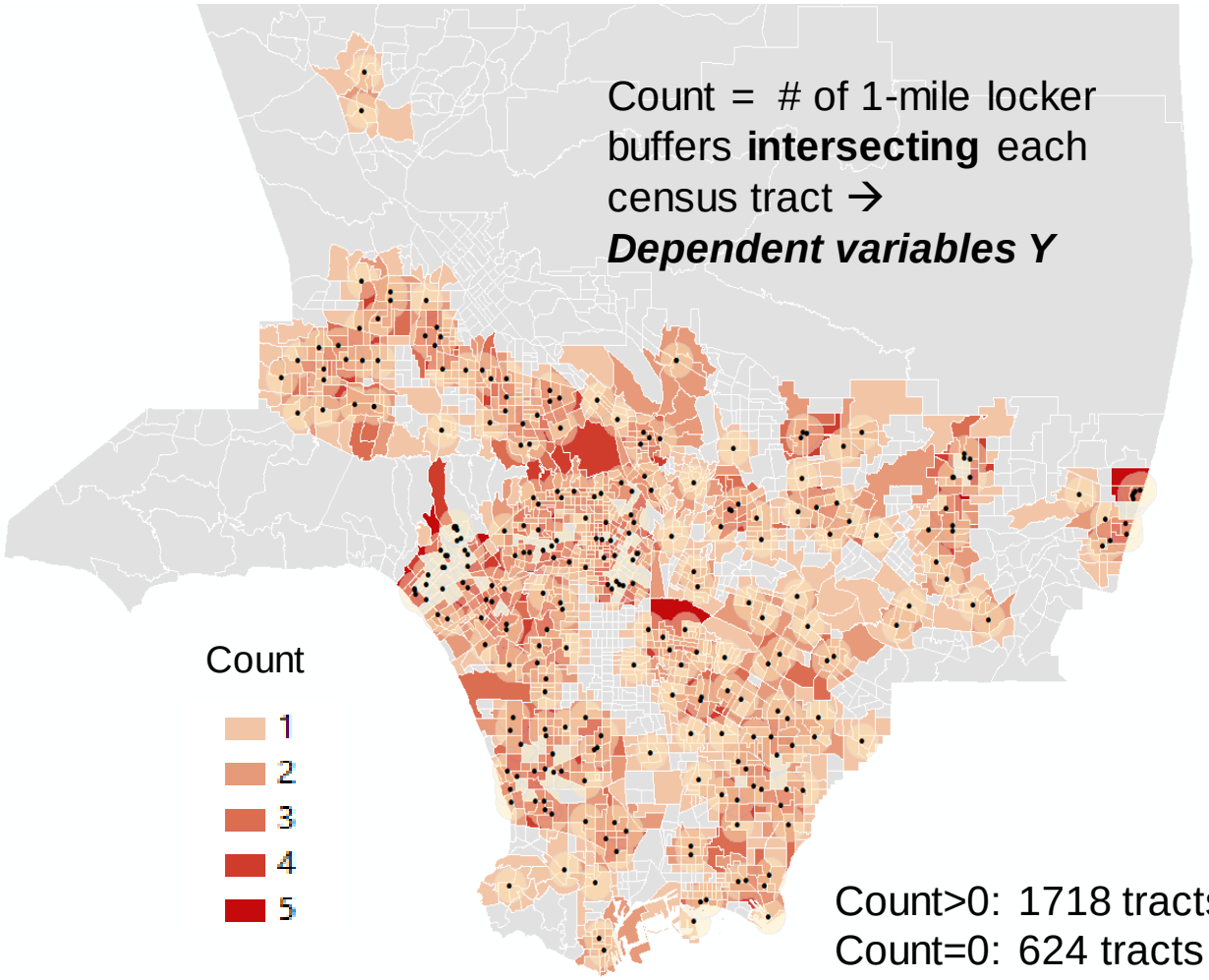
Clustering



- Kernel Density Test → Three-tier-clustering
  - Tier 1 (d=0.9): 1, 2
  - Tier 2 (d=0.6): 3, 4
  - Tier 3 (d=0.3): 5-12
- K-Function Test
  - Significant Clustered at 99% conf. level

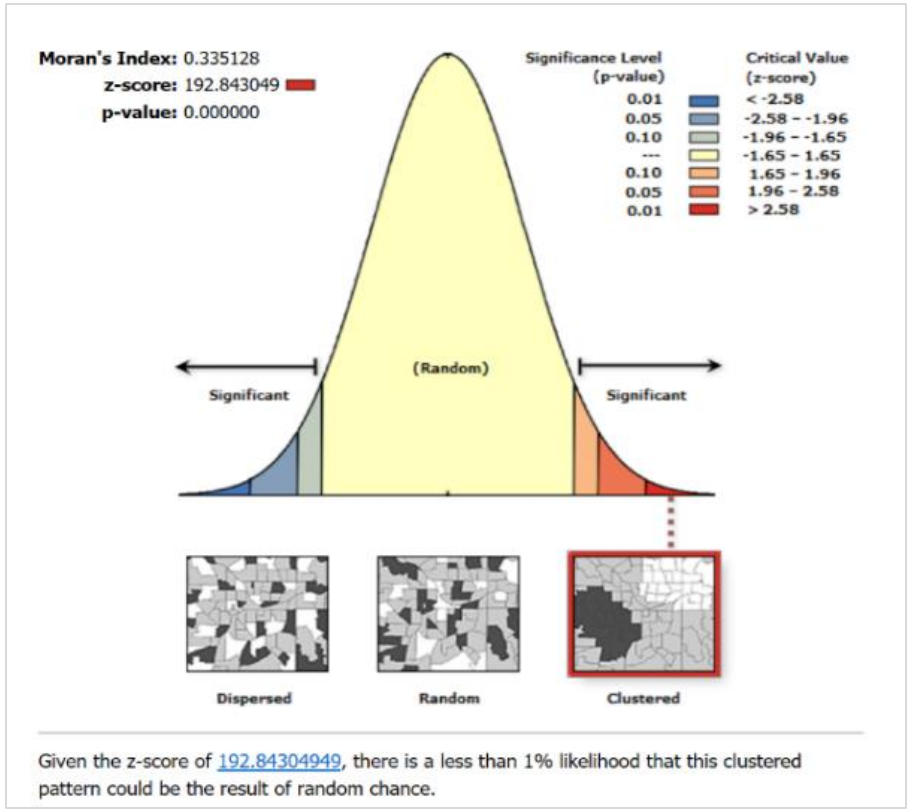


Spatial Autocorrelation

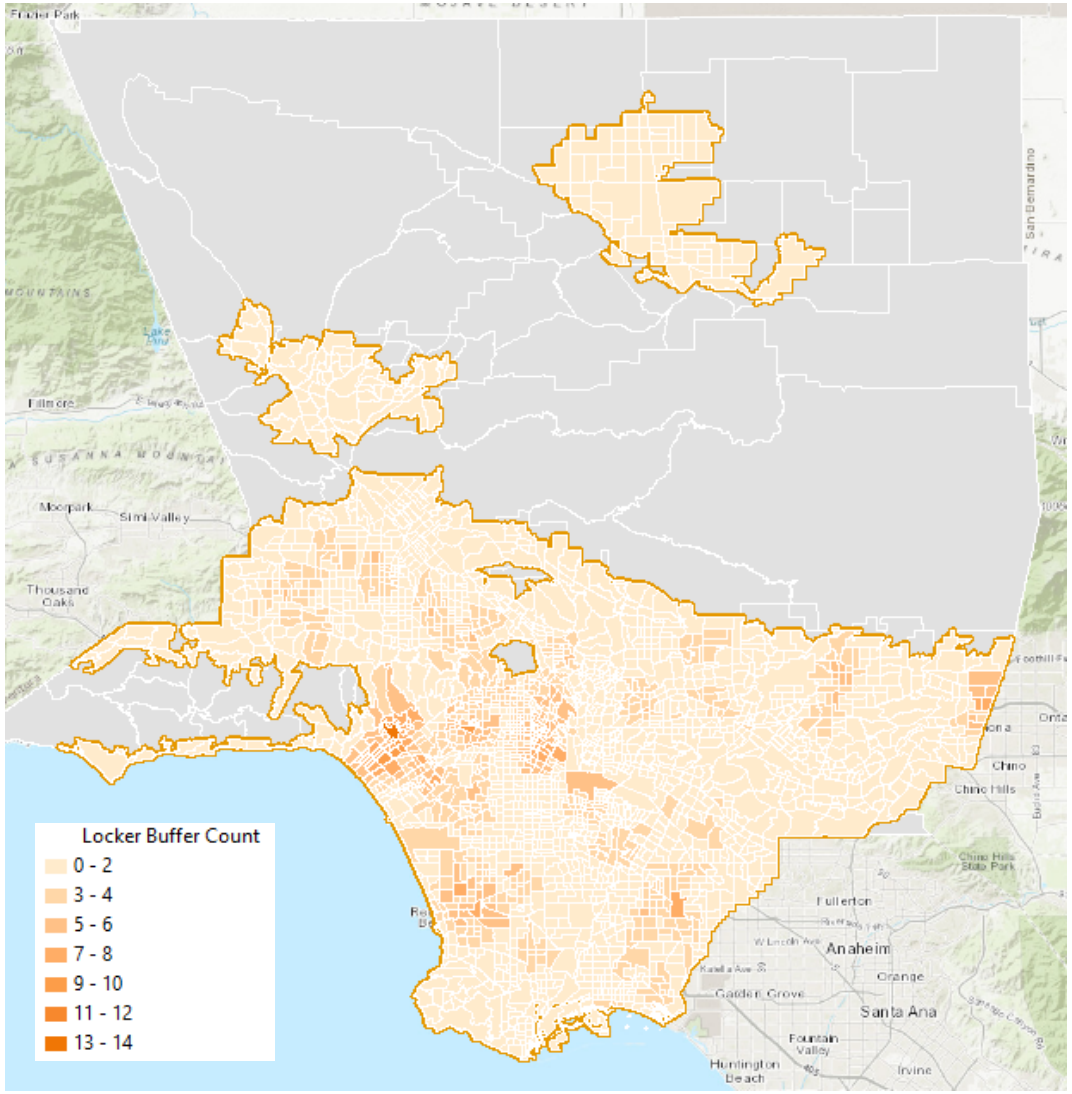


Step 1 Point data → Polygon data (Spatial Join)

Step 2 Moran I' s statistics – Significant + Positive



Spatial Regression – OLS



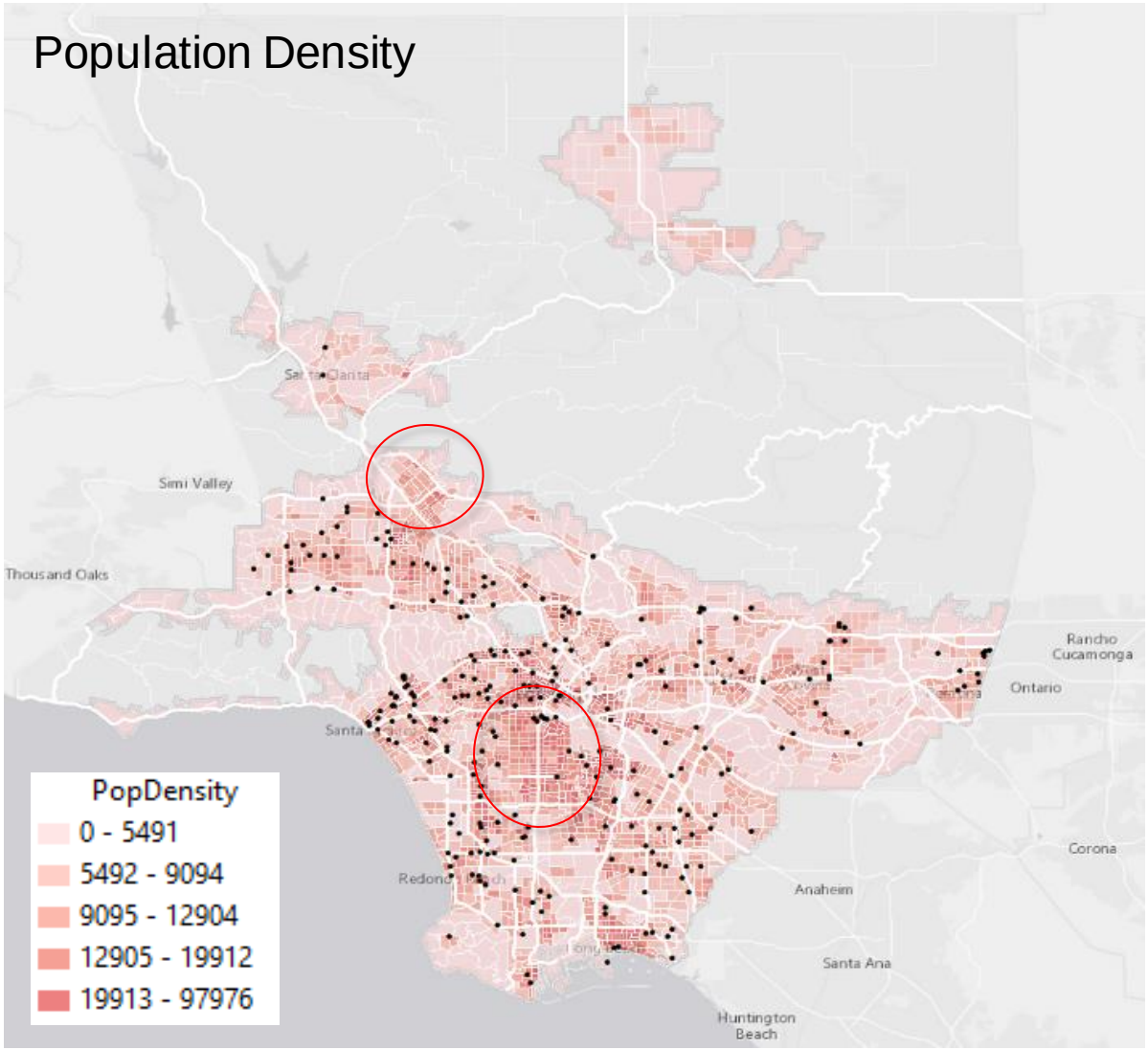
- Narrow the geographic boundary to Urbanized Area
  - 13 census tracts removed (Non-urbanized)
  - 1718 tracts with lockers
  - 611 tracts with no lockers
- Unit of analysis: census tracts
- Correlation test and Variable Filtering before OLS
  - The correlation coefficients with Y >3.0;
  - The correlation coefficients with other selected independent variables ($\boldsymbol{Xn}$) ≤ 0.7;
- Selected Independent Variables (2 sets):
  - *Walk, parking, transit, income, education, internet*
  - *Walk, parking, transit, income, education, population*

Spatial Regression – OLS

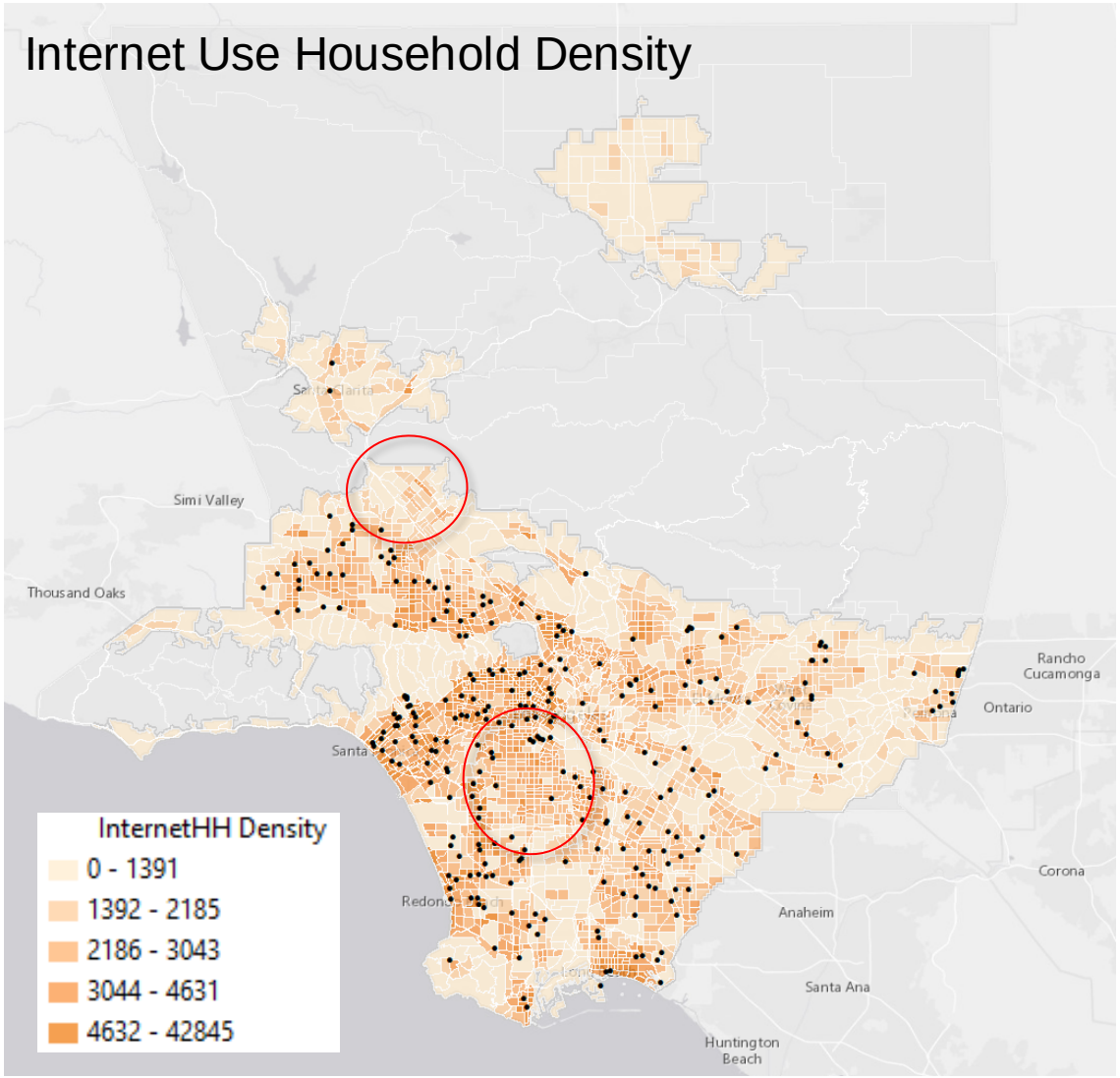
	Model (1)	Model (2)
Walk	0.293***	0.292***
Parking	0.120***	0.115***
Transit	0.110***	0.112***
Income	0.042	0.070**
Education	0.545***	0.256***
Internet	-0.426***	
Population		-0.163***
N	2329	2329
Adjusted R-squared	0.2493	0.2376
Standardized beta coefficients	* p<0.05, ** p<0.01, *** p<0.001	

Negative Effects?

Population Density

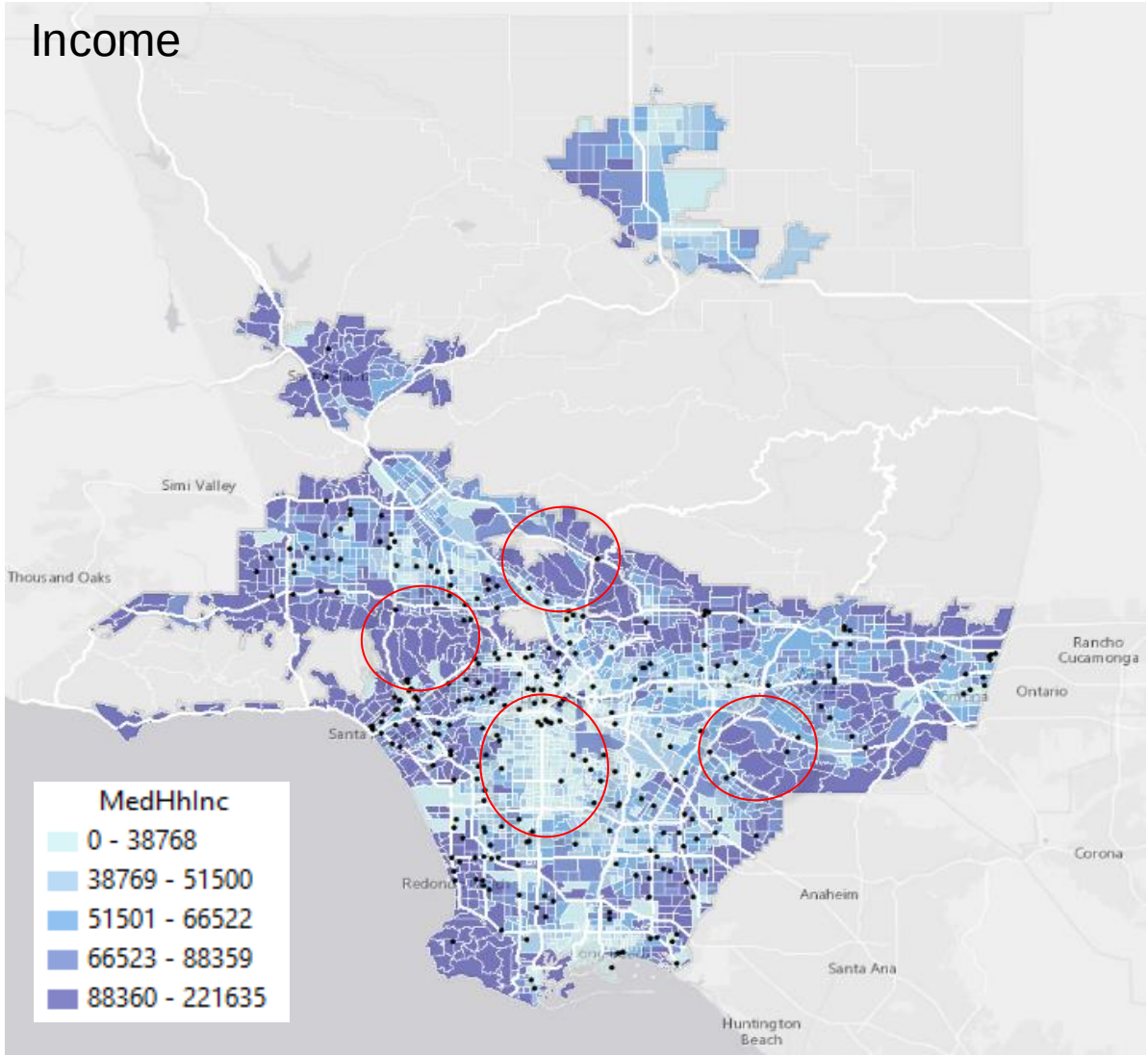


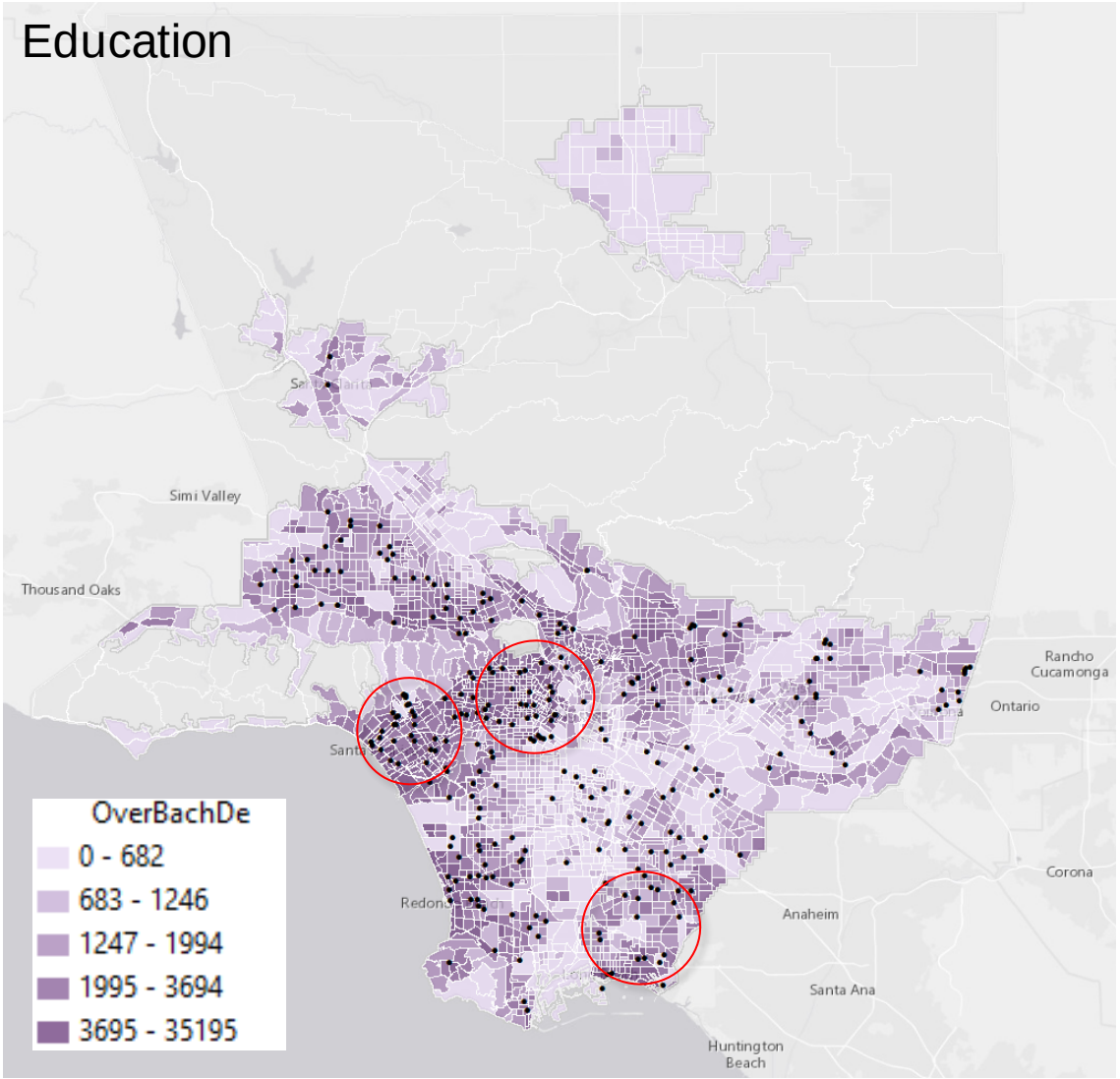
Internet Use Household Density



Not Significant?

Significant and Strong

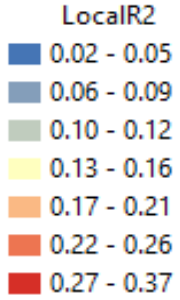


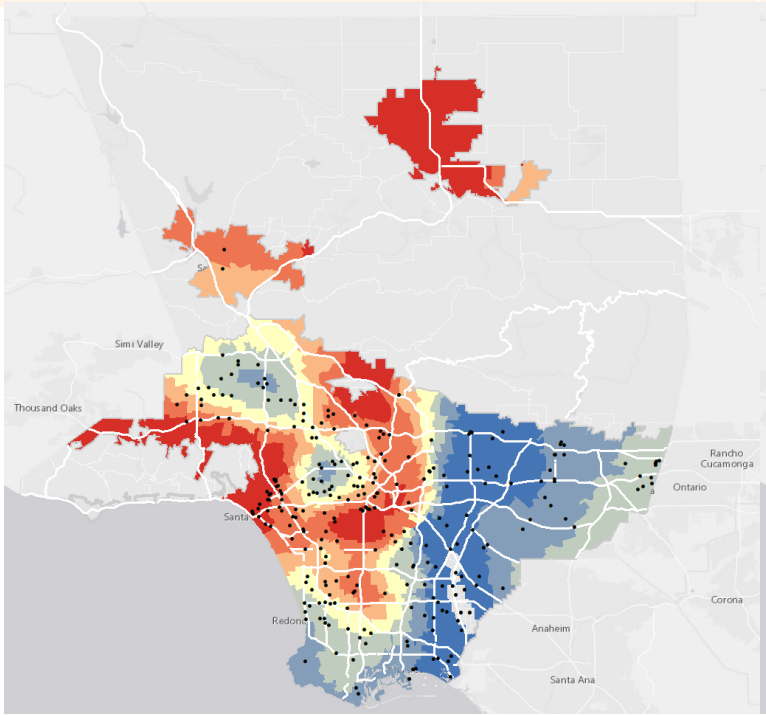


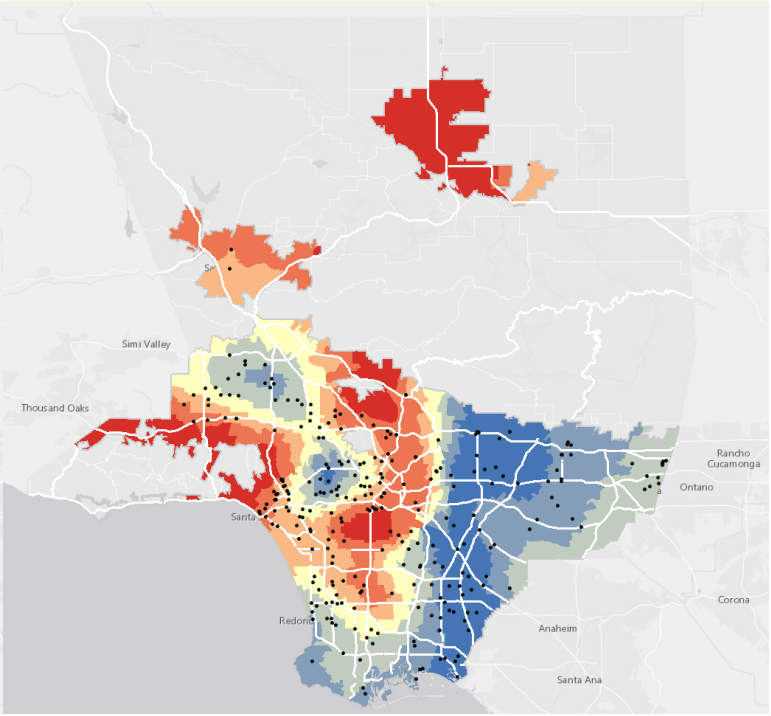
Spatial Regression – GWR

	Model (1)	Model (2)
Adjusted R-squared	0.4123	0.4010
AIC * (Aiaike Information Criterion) * Model performance for GWR	8085.22 (better)	8133.50

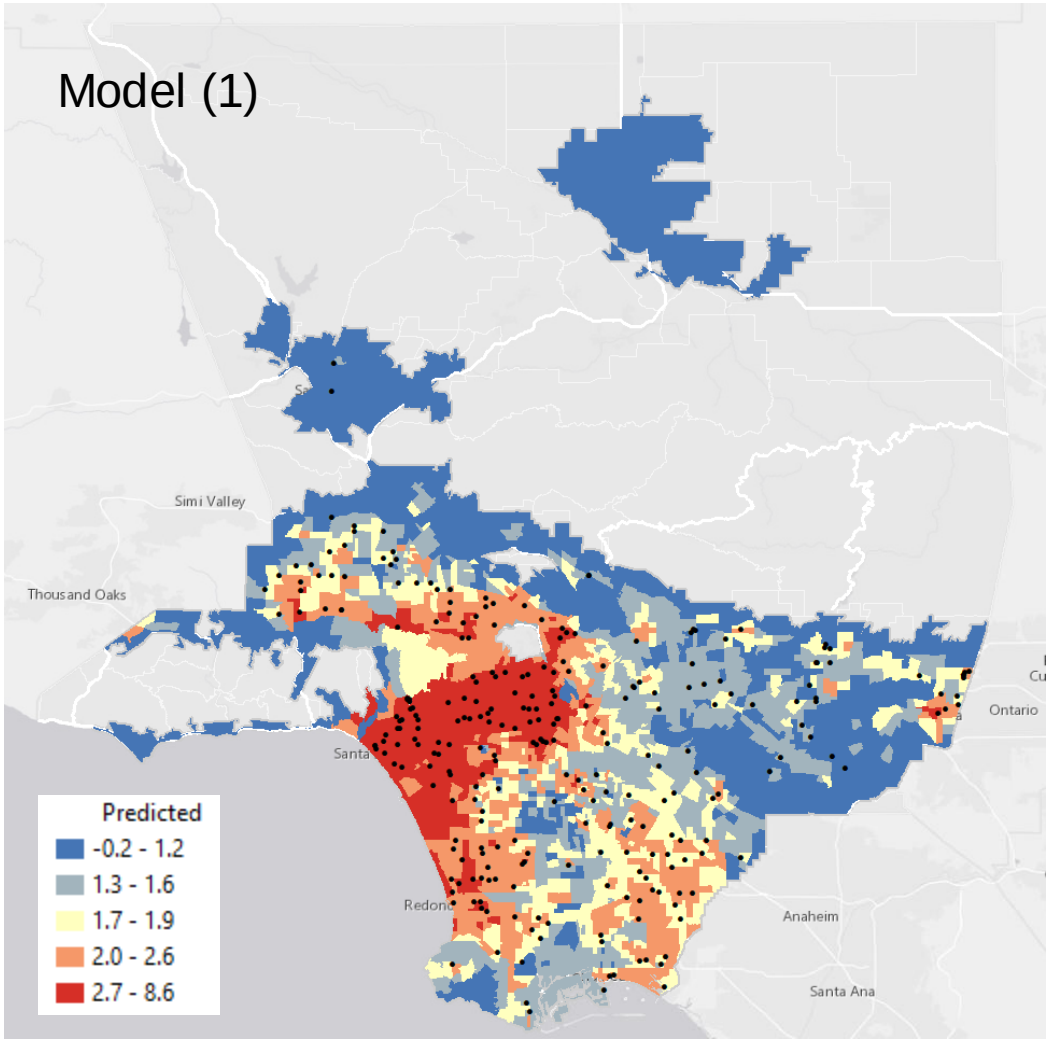
- GWR better than OLS (Adj.R^2)
- Very little difference between Model 1 and Model 2
- Places in red are better explained by the GWR model.

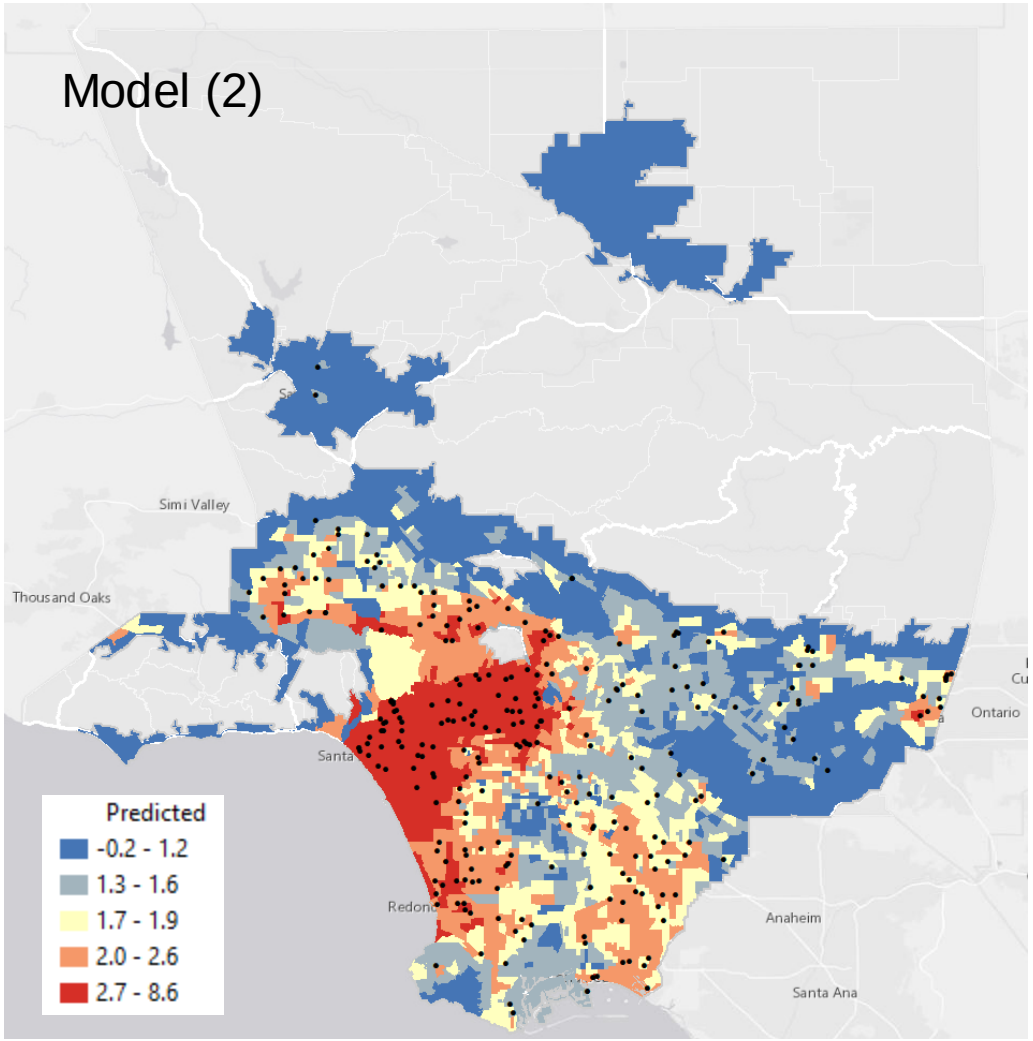




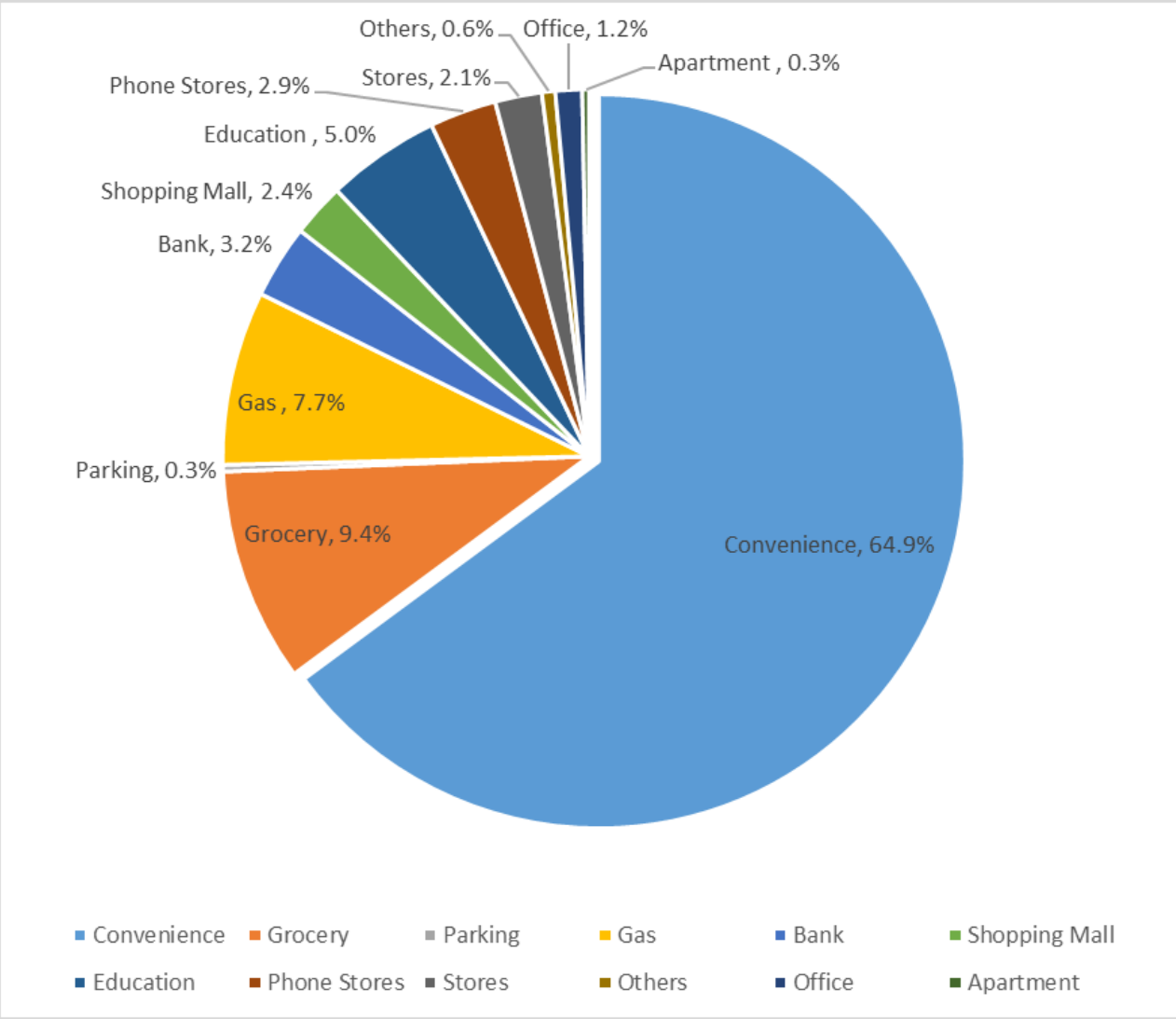


Spatial Regression – GWR – Predicted Results





Other variables – Spillover Effects



- Small business: bring foot traffic that may transfer to sales (711)
  - Little overlapping products
  - Few stipends
- Business cooperation with Amazon
  - WF, Chase, Sprint
  - Double foot traffic to Amazon.

7 Conclusions

- *Conclusions*
- *Limitations and future studies*

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Conclusions

- Kernel Density tool identified a "three-tier-clustering" pattern based on the level of density.
- Global Moran's I Index detected a significant positive spatial autocorrelation at 99% confidence level.
- GWR model can explain 41% of the variation in dependent variables, while OLS model can only explain 24% of the variation in dependent variables.
  - Three demographic variables – population/internet use, income, education - **
  - Three built environment variables – walkability, transit, parking - ***
- Beyond the spatial model, potential spillover effects and business cooperation are also important factors that affect the distribution of lockers.

Limitations and Future Studies

- Model specification – still over half of the variations cannot be explained
  - Internet Use Household Density
    - Smart phone use may be a better indicator than internet use
    - Household density also includes the influence of population density
  - How to quantify business cooperation and spillover effects and include them into the regression model.
- Estimating GHG savings needs real travel behavior data from customers and couriers.
  - Survey to be implemented

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