Tracking parcels: Understanding delivery paths and their impacts

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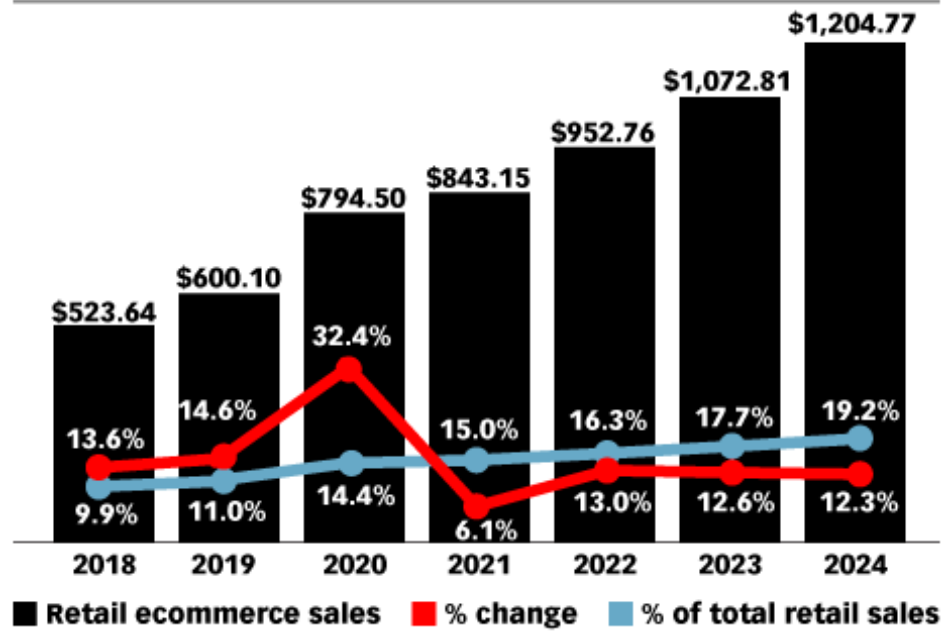Yaxin Zhang, Ph.D.

May 26th, 2022

Study Purpose

US Retail Ecommerce Sales, 2018-2024
billions, % change, and % of total retail sales

Year	Retail ecommerce sales	% change	% of total retail sales
2018	$523.64	13.6%	9.9%
2019	$600.10	14.6%	11.0%
2020	$794.50	32.4%	14.4%
2021	$843.15	6.1%	15.0%
2022	$952.76	13.0%	16.3%
2023	$1,072.81	12.6%	17.7%
2024	$1,204.77	12.3%	19.2%

Note: includes products or services ordered using the internet, regardless of the method of payment or fulfillment; excludes travel and event tickets, payments such as bill pay, taxes or money transfers, food services and drinking place sales, gambling and other vice goods sales
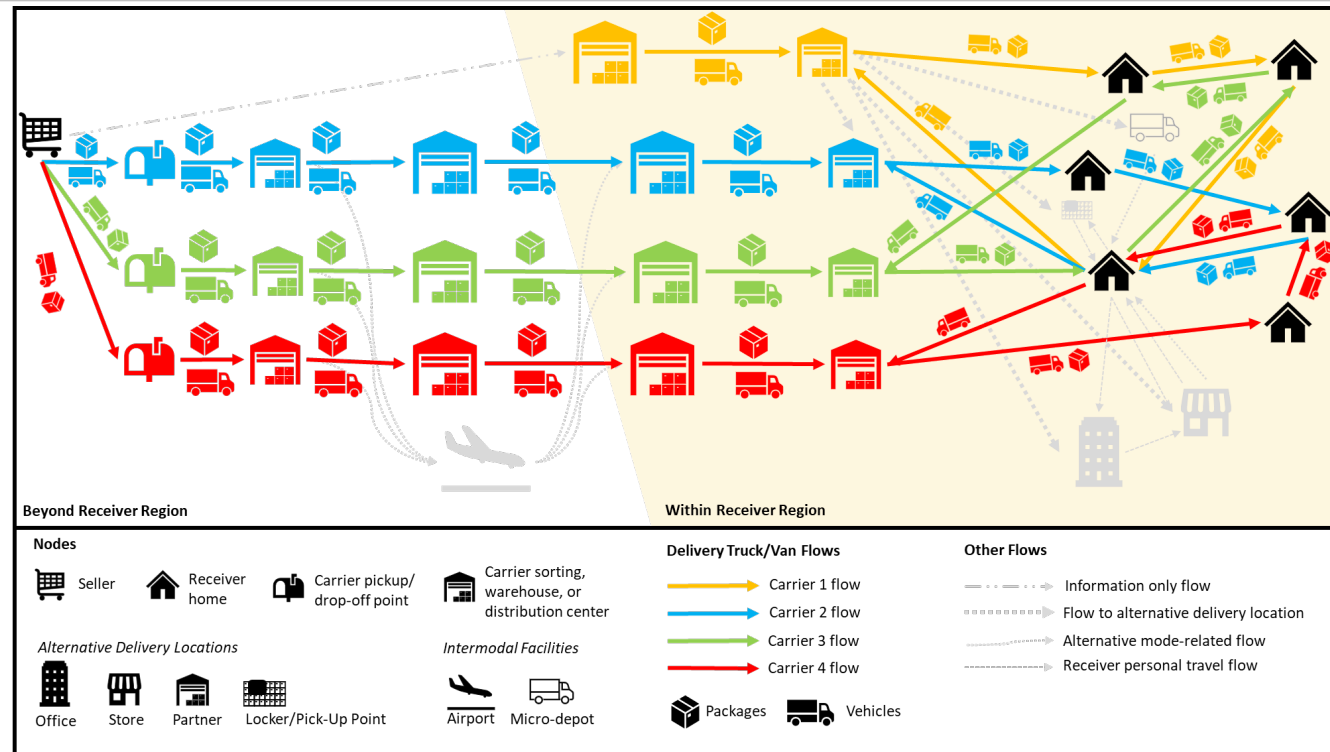Source: eMarketer, Oct 2020
259467
www.eMarketer.com

Chrisman, 2019

The growth of e-commerce and the rise of urban population, are two factors resulting in **more frequent deliveries** of **smaller shipments** to an **increasing number of urban locations**.
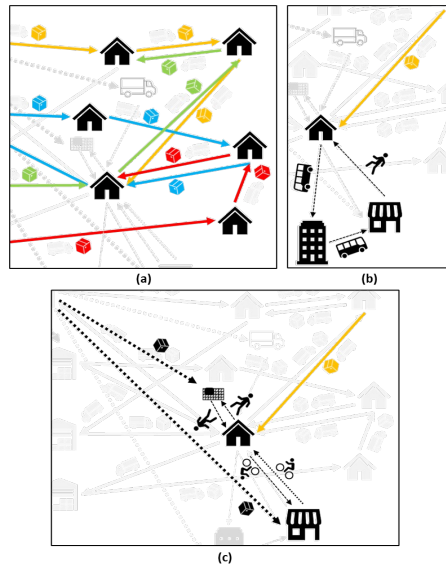
5/26/22

Study Purpose

1. What data is available to **measure** e-commerce activity? Can this data **inform** transportation system planners about logistics operations **beyond the last-mile**?

2. Is this new data useful to **address existing data gaps**?
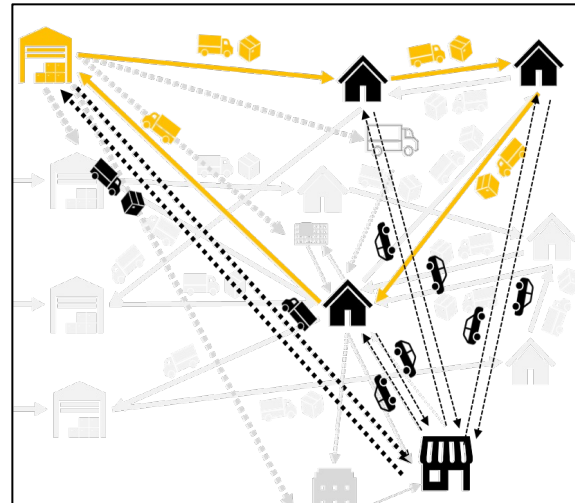
Measuring e-commerce activity

Regional and last mile movements

a. Consumer shopping behavior and associated demand
b. Passenger and travel demand trade-offs
c. Demand of specific city logistics services

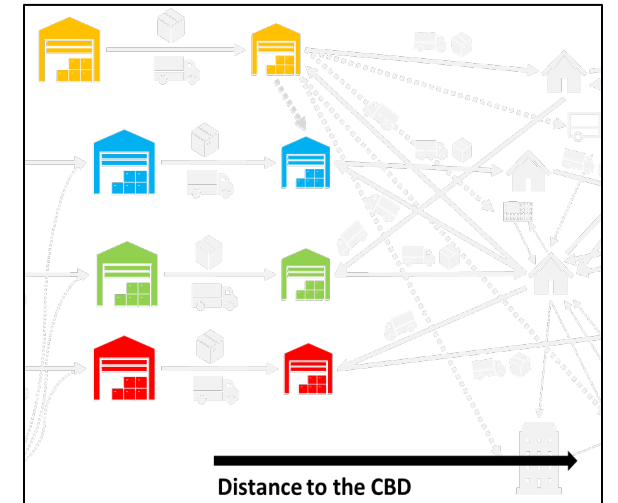## Expected traffic and cost trade-offs

Studies inform the organization of urban streets, curbsides, and neighborhoods.
Usually rely on delivery records and/or simulations.

Changing geography of e-commerce

Distance to the CBD

Investigates changes in spatial distribution of logistics facilities and their effect on land-use policies and regional traffic impact.

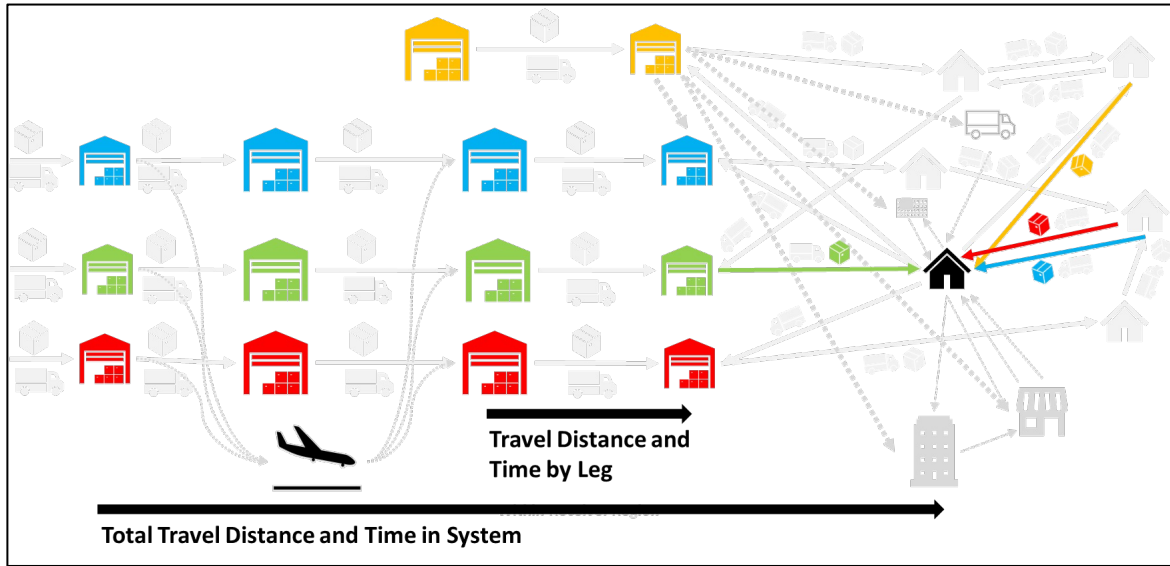# Measuring e-commerce activity
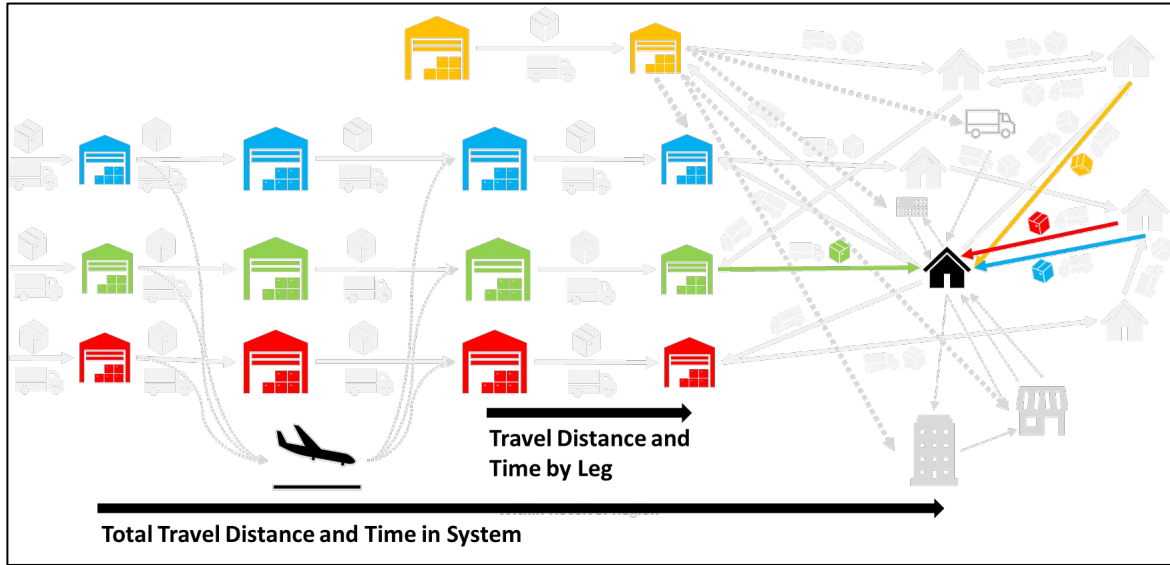
This study uses receiver package tracking information to:

- Focus on E-commerce travel activity related to the **upstream logistics**.
- Compares **end-to-end performance** across multiple carriers.
- Analyze relevant insights for **freight transportation planning**.

| Delivery by Carrier #		
Tracking ID: ###########		
Date of movements 1		
	Order Placed	
Time 1	Package Picked up by Carrier	
Time 2	Arrived Facility	Address 1
Date of movements 2		
Time 3	Departed Facility	Address 1
Time 4	Arrived Facility	Address 2
Time 5	Departed Facility	Address 2
Date of movements 3		
Time 6	Arrived Facility	Address 3
Time 7	Out for delivery	Address 3
Time 8	Package delivered	Final Address

Measuring e-commerce activity

This study uses receiver package tracking information to:

- Focus on E-commerce travel activity related to the **upstream logistics**.
- Compares **end-to-end performance** across multiple carriers.
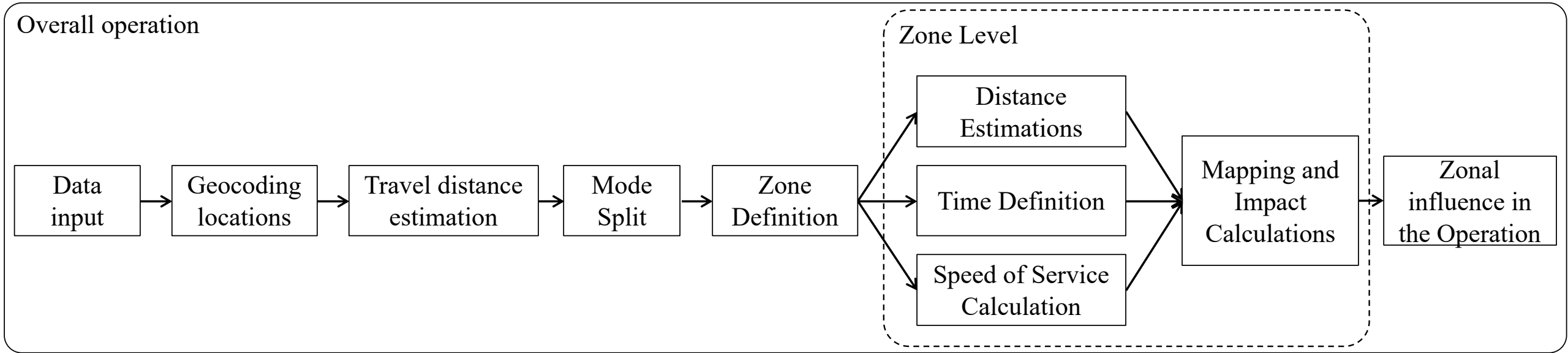- Analyze relevant insights for **freight transportation planning**.
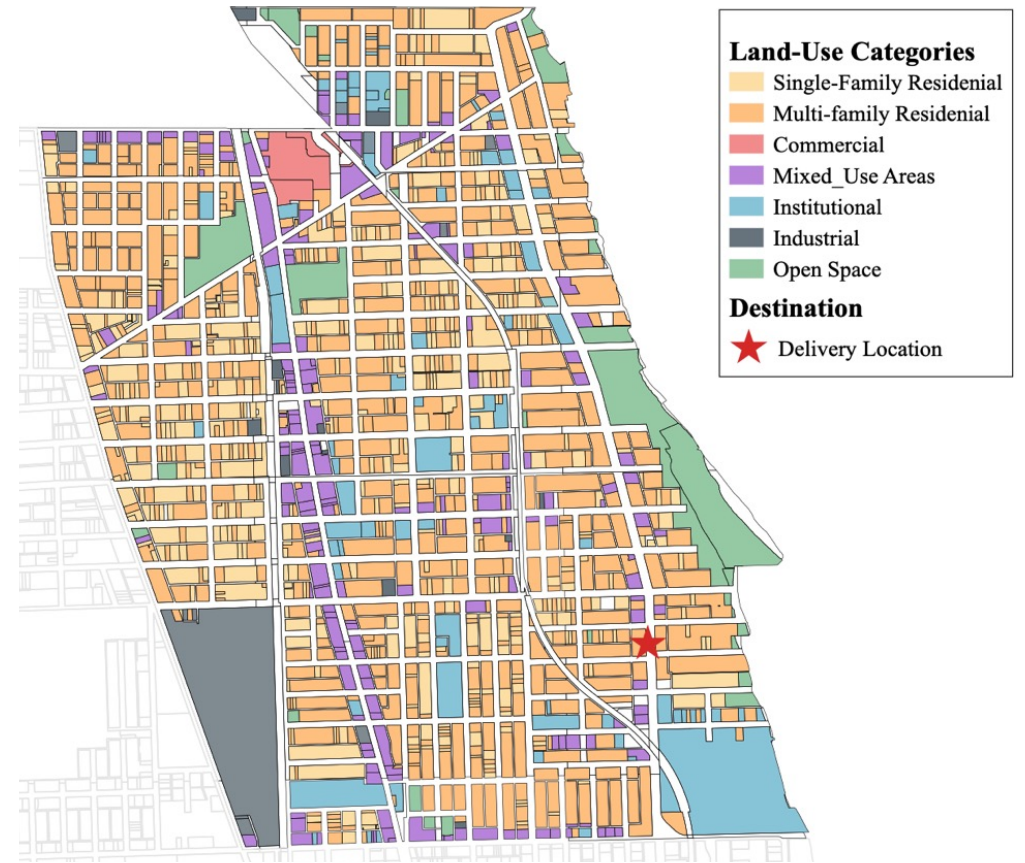
Rogers Park, Chicago, IL

1 household: 140+ observations with, at least, 4 delivery events each across 4 zones

Methods – Data processing

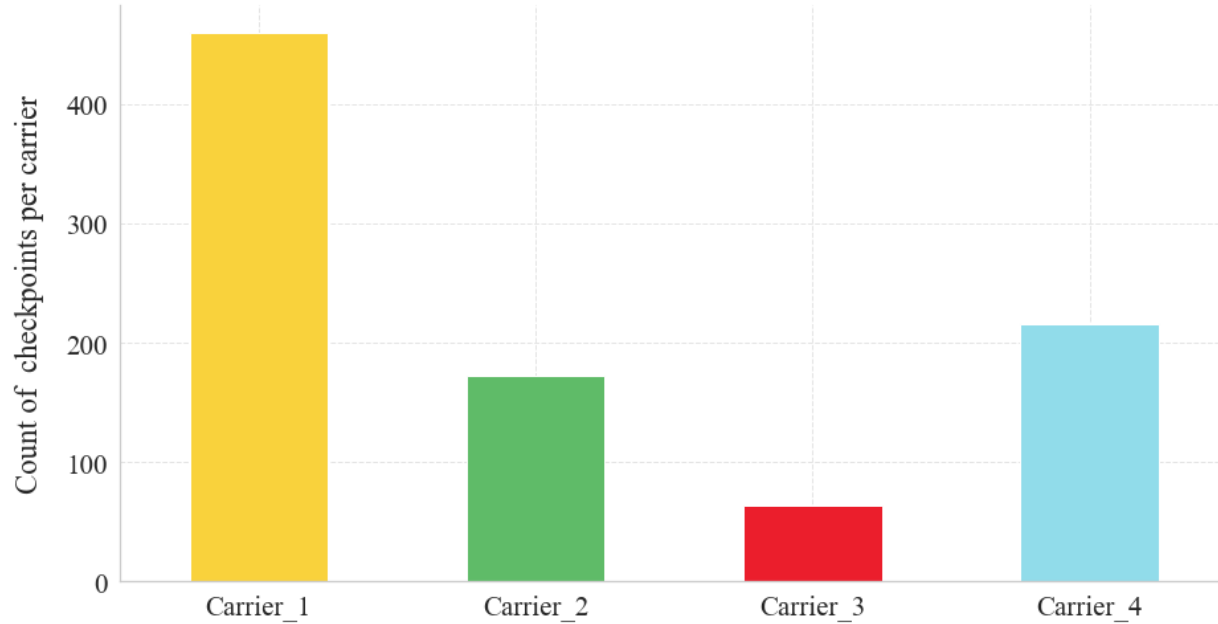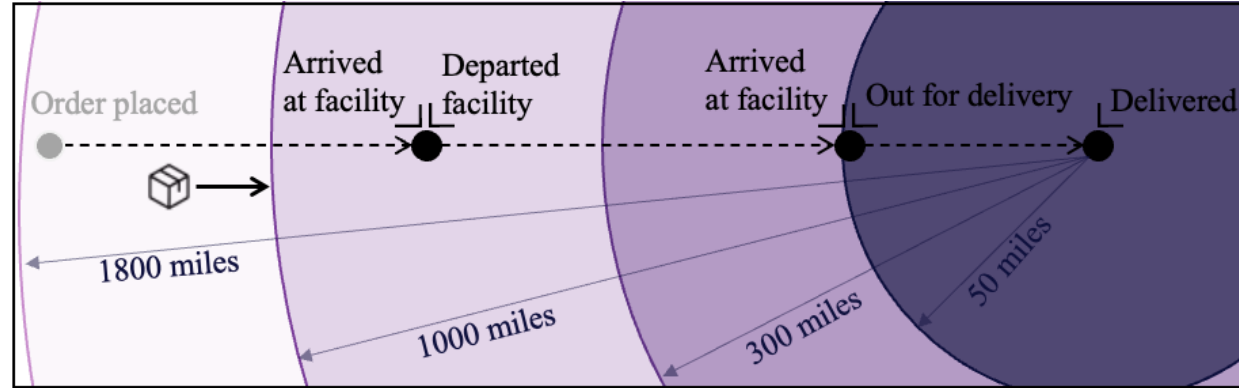To estimate travel time and distance, we used the OSRM API which shows:
- Free-flow travel time
- Optimal route (minimum mileage).

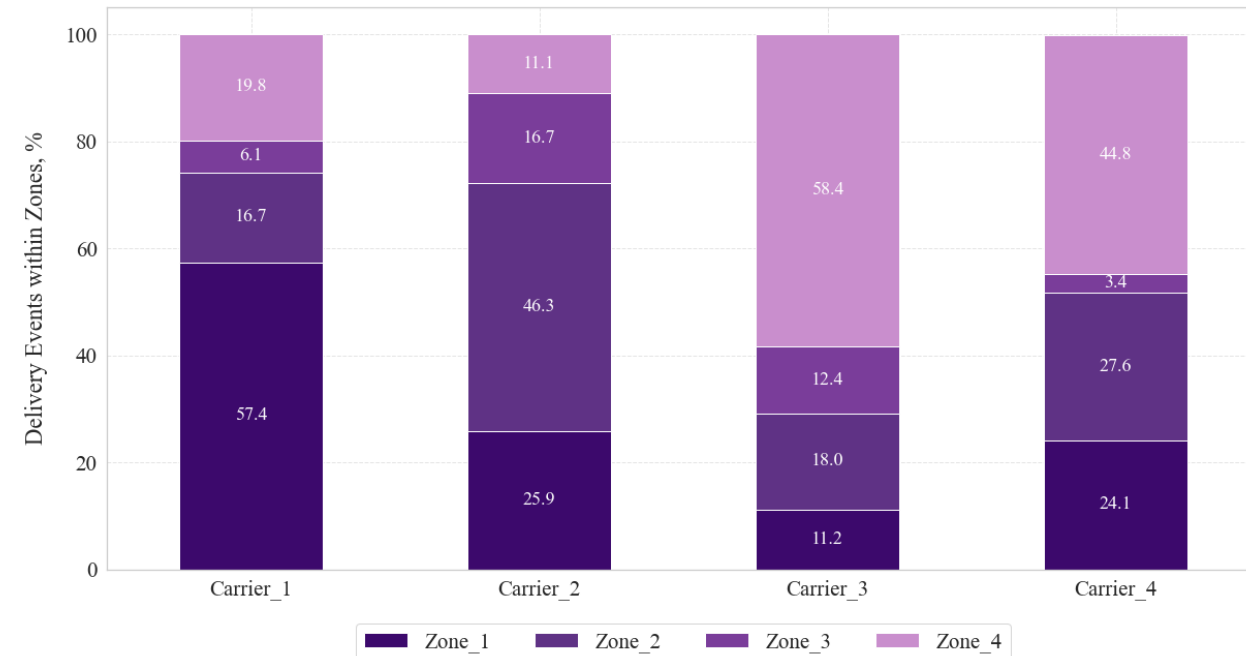$$Service\ Speed = \frac{min.\ travel\ distance\ (mi)}{service\ time\ (hrs)}$$

$$DI_{j,z} = \frac{\sum_i \frac{D_{zij}}{D_{Oij}}}{i \in j} \times 100$$

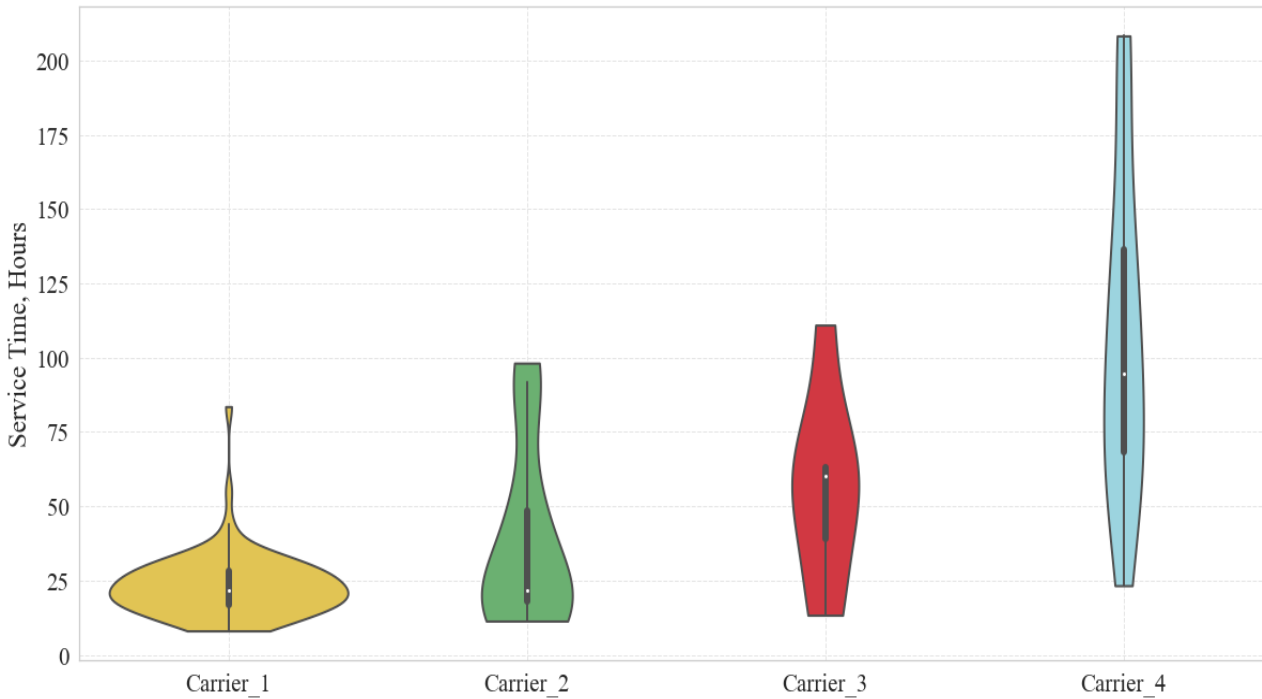$$TI_{j,z} = \frac{\sum_{ij} \frac{T_{zij}}{T_{Oij}}}{i \in j} \times 100$$
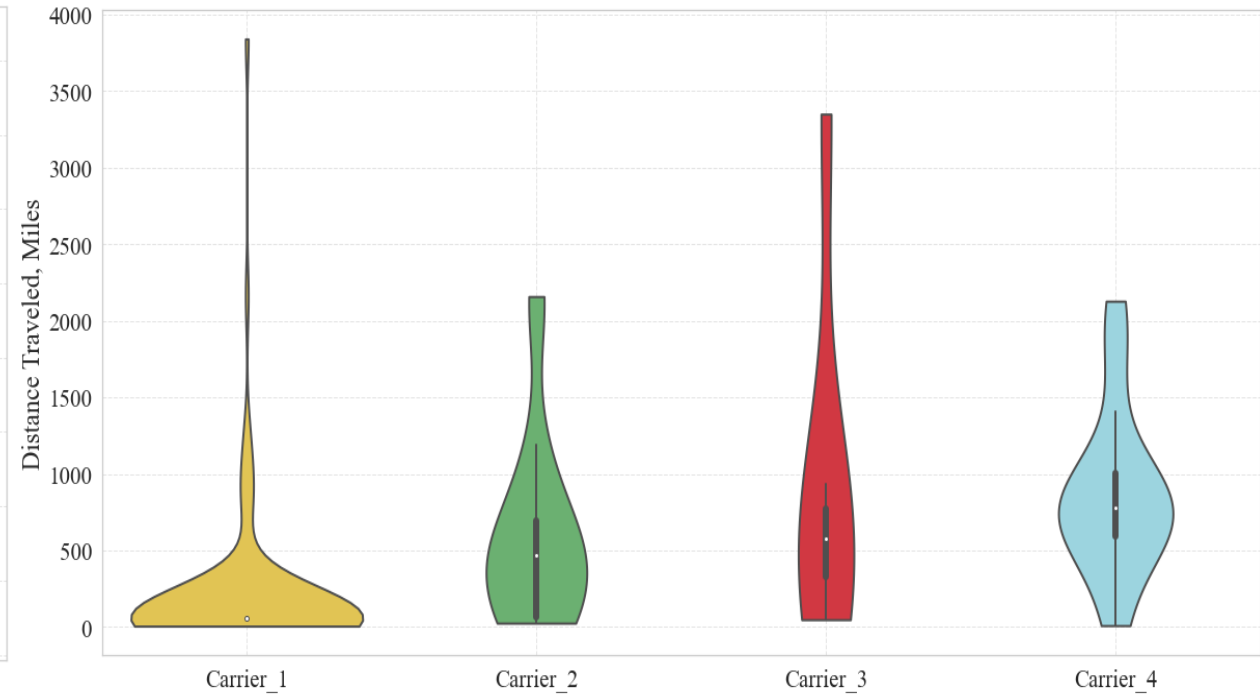
Methods – Data Inputs

Results _ Overall Operation

(a) Distributions of Operational Time per Carrier, Hours

(b) Distributions of Distance Traveled per Carrier, Miles

From the moment the package enters the network to its final delivery:

- In general **time distributions** tend to be more **controlled** (carrier 1, 2, and 3)
- **Distances** have more **variability** (carrier 1 and 3).
- Carrier 4 has its own behavior – long service time and rather controlled distances travelled.

Results _ Last Mile Operation

(a) Distributions of Time per Carrier in the Last Mile, Hours
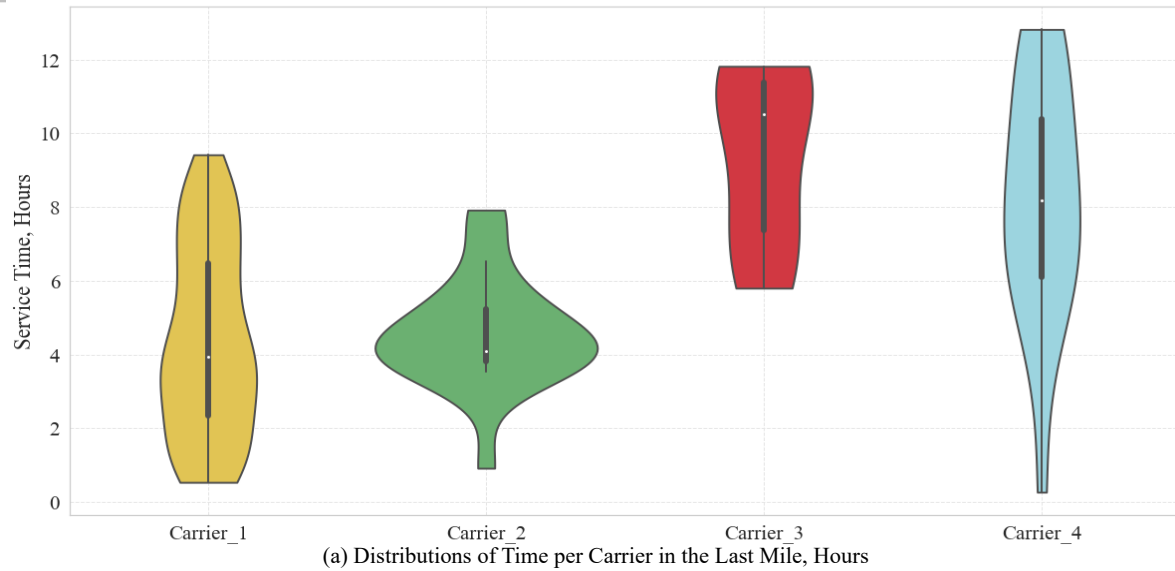
	Number of Observed Trips	Average Travel Distance (mi)	Average Service Time (hrs)	Average Service Speed (mi/hrs)
Carrier 1	89.0	6.5	4.4	2.6
Carrier 2 (Location 1)	20.0	15.0	4.5	4.0
Carrier 2 (Location 2)	1.0	26.0	5.6	4.7
Carrier 3	7.0	7.0	9.4	0.8
Carrier 4 (Location 1)	17.0	<2	8.7	0.5
Carrier 4 (Location 2)	5.0	<2	6.5	0.2
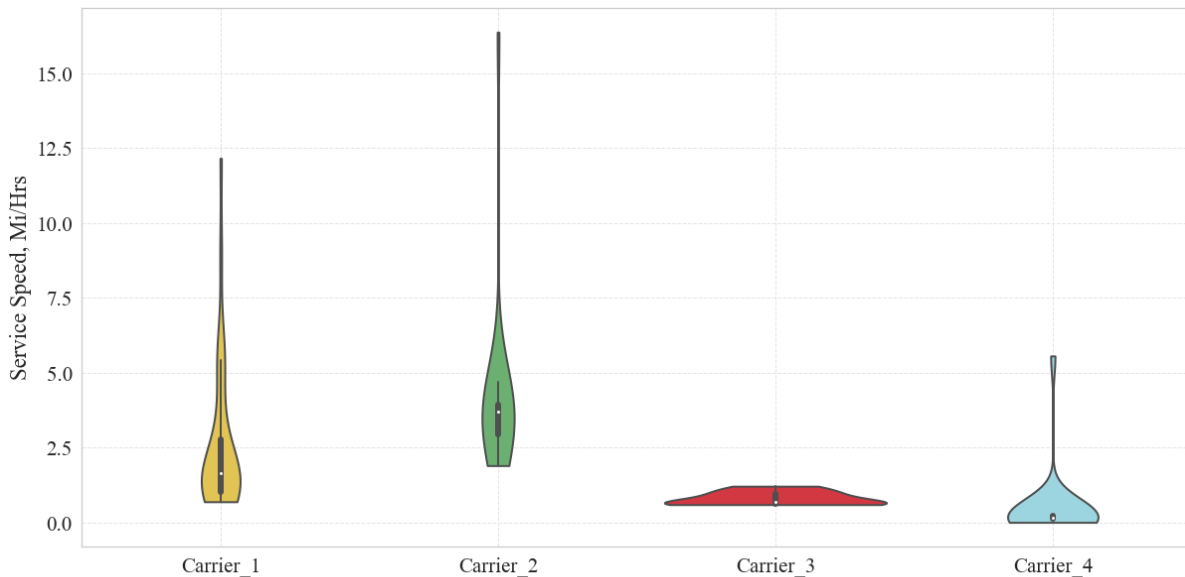
The variability linked to service time across all carriers could be attributed to factors such as:
- Traffic
- Number of stops per delivery tour
- Time spent sorting at the curbside

Results _ Last Mile Operation

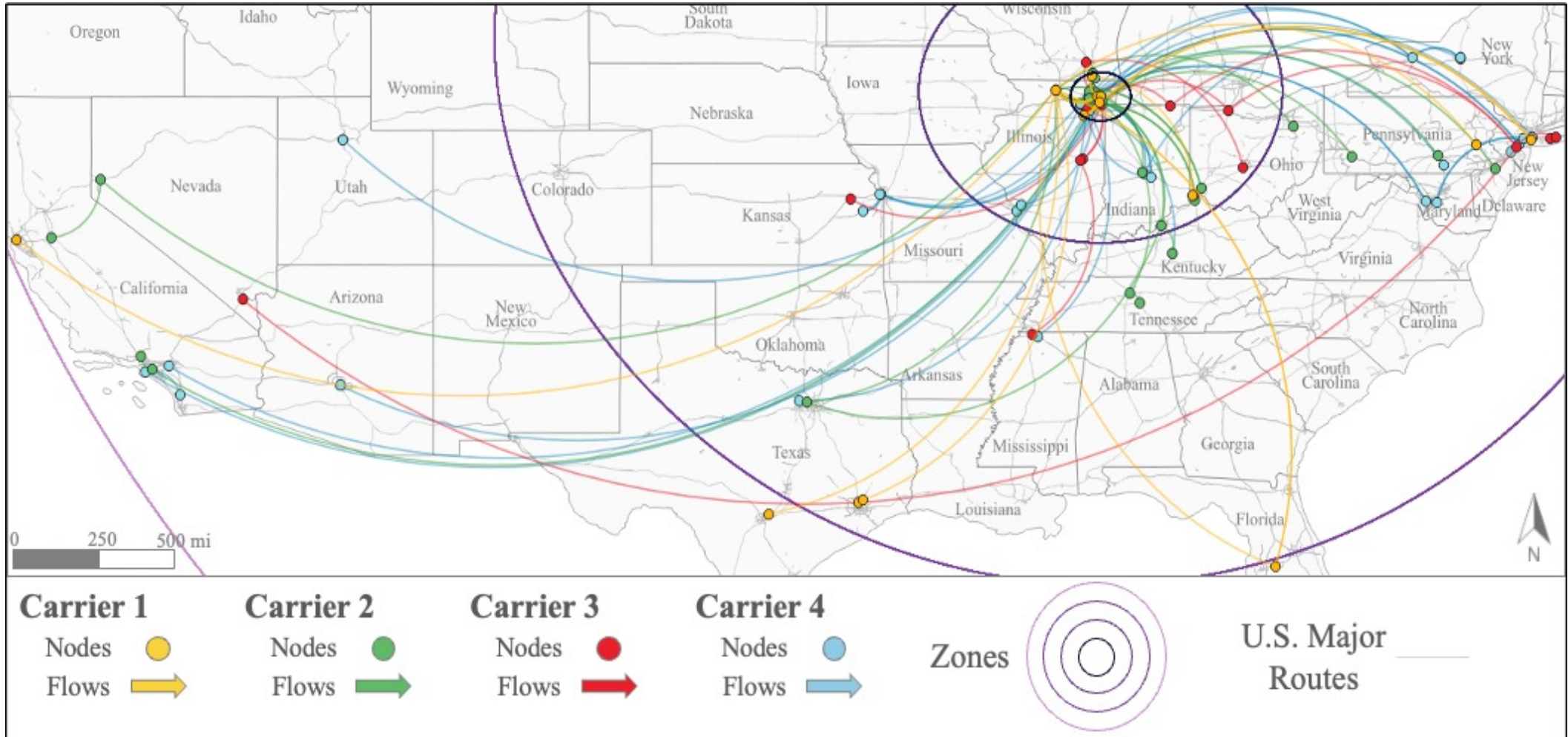(a) Distributions of Time per Carrier in the Last Mile, Hours
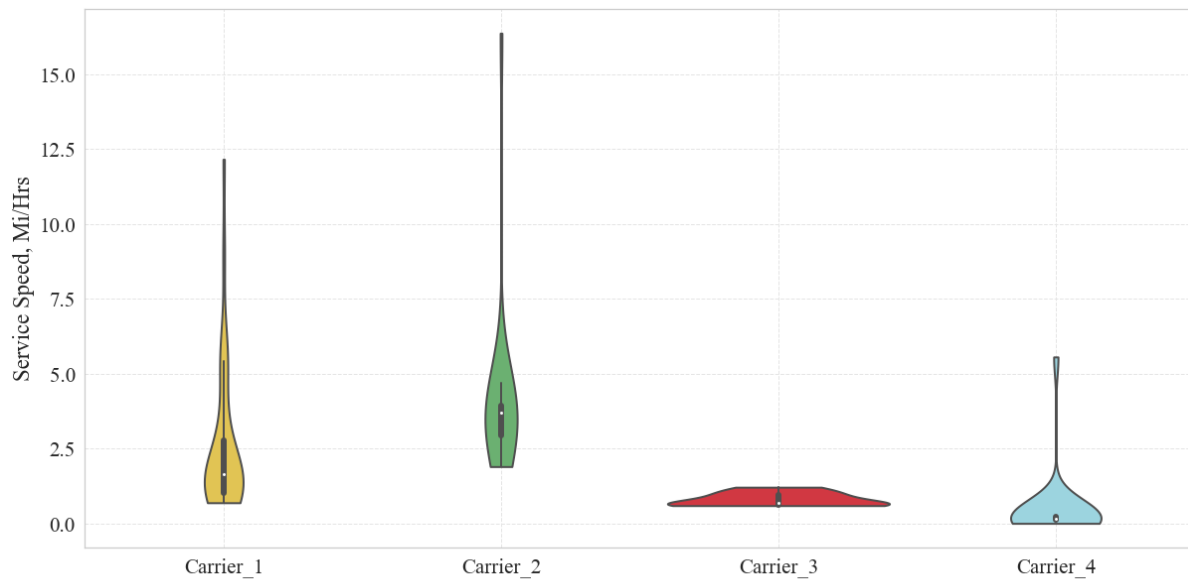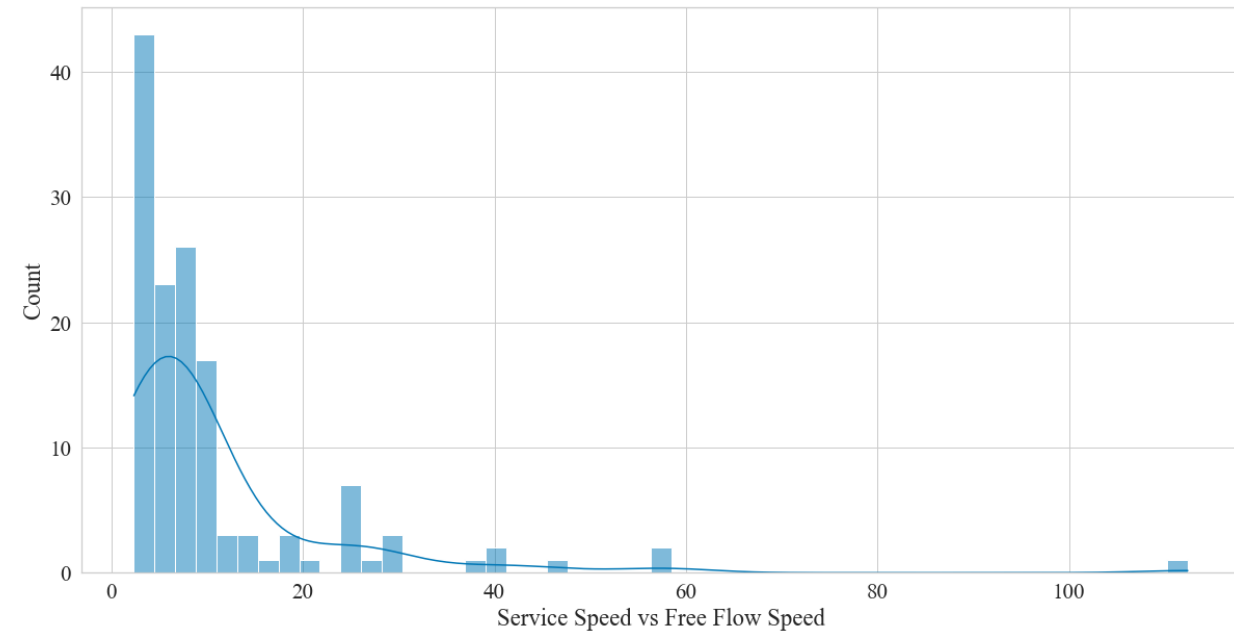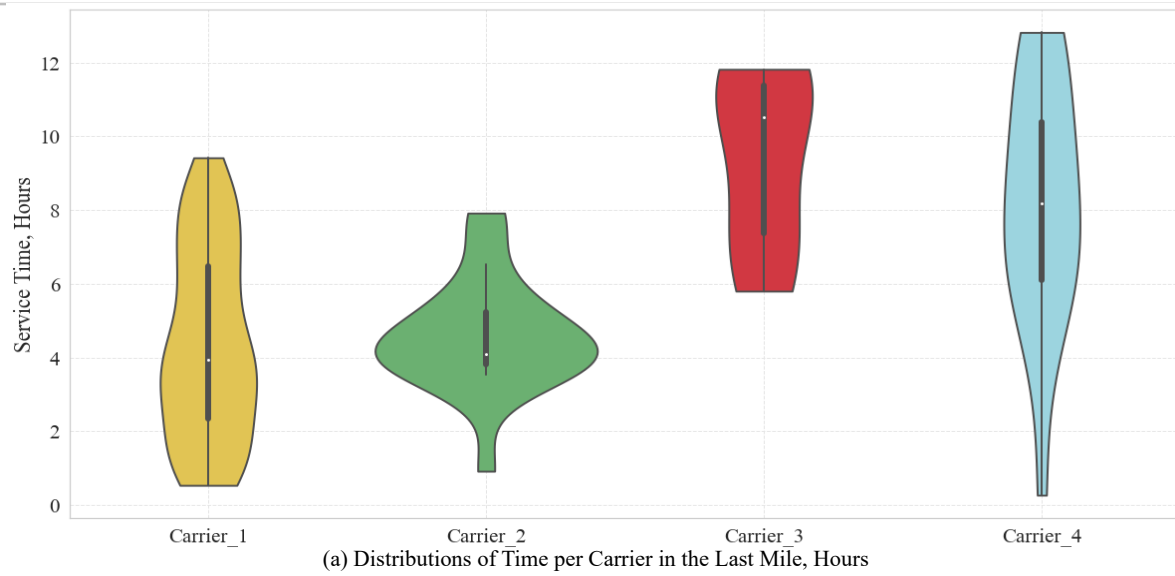
Results _ Zonal Analysis

Results _ Zonal Analysis

U.S. Urban Areas
(U.S. Census Bureau)

U.S. Major
Routes
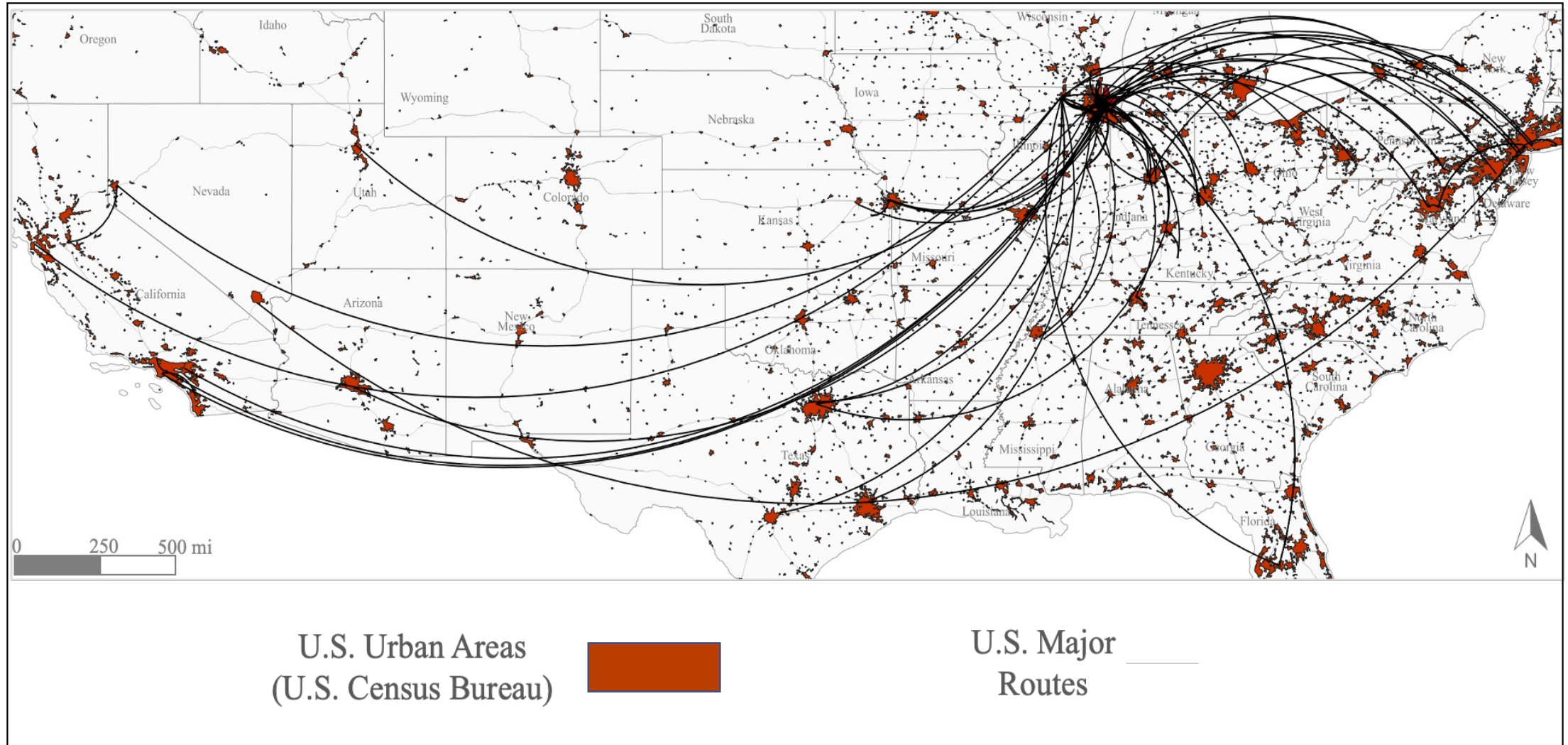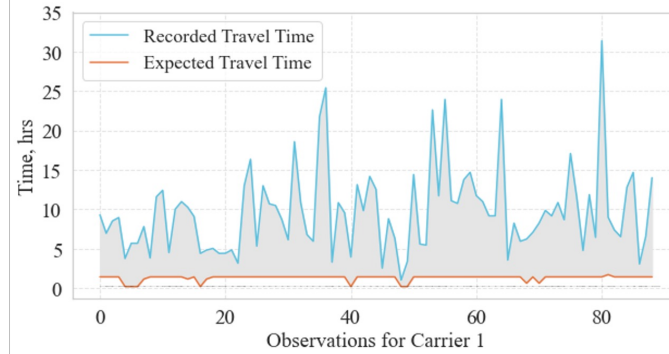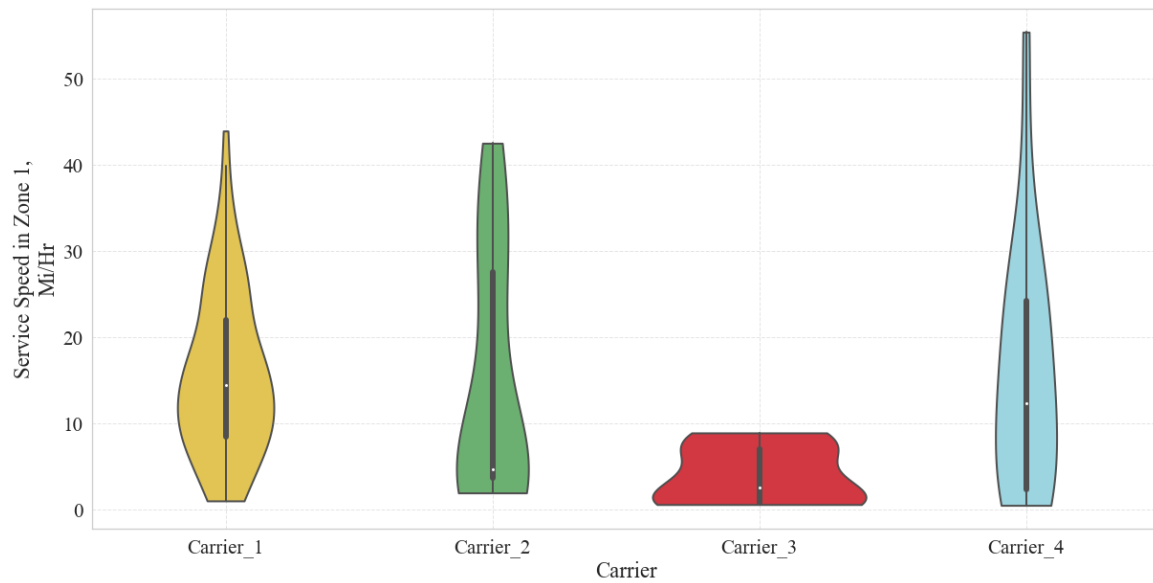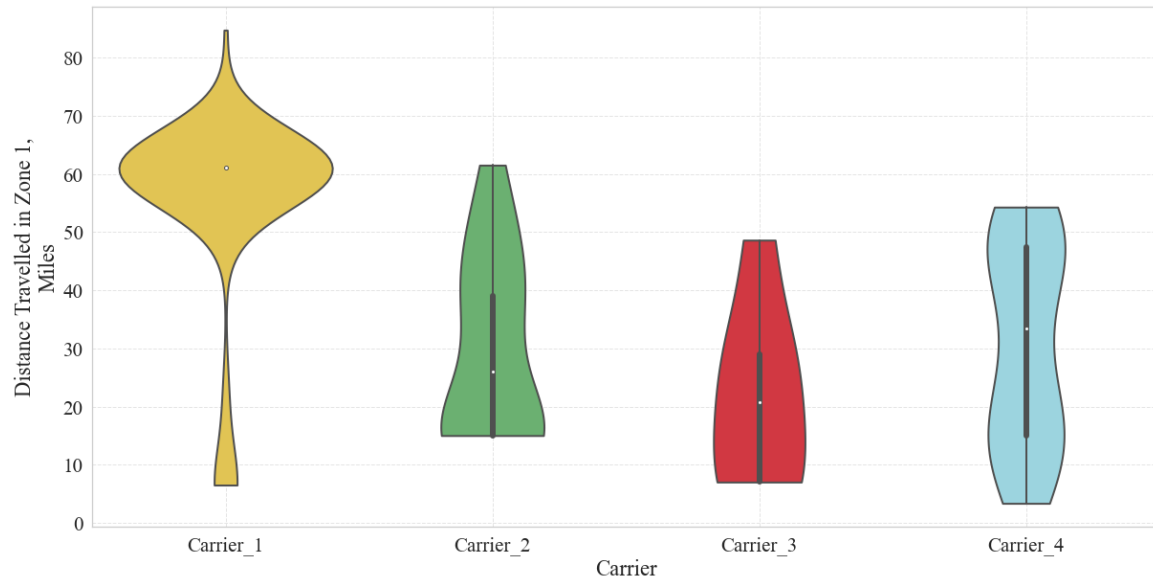
(a) Time Distribution for all Observations for Carrier 1, in hours
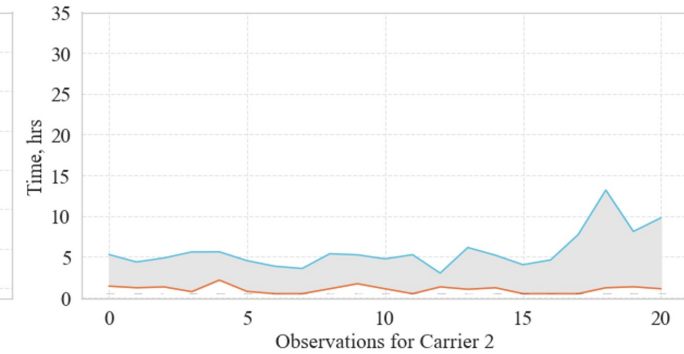
(b) Time Distribution for all Observations for Carrier 2, in hours

(c) Time Distribution for all Observations for Carrier 3, in hours

(d) Time Distribution for all Observations for Carrier 4, in hours

	Truck	Airplane
Carrier 1	177	11
Carrier 2	39	24
Carrier 3	21	3
Carrier 4	111	4

Impacts on the operation

Share of Total Distance per Zone,%

Carrier 1

		Destination Zone			
		1	2	3	4
Origin Zone	1	86.72			
	2	13.3			
	3			0.25	
	4				

Carrier 2

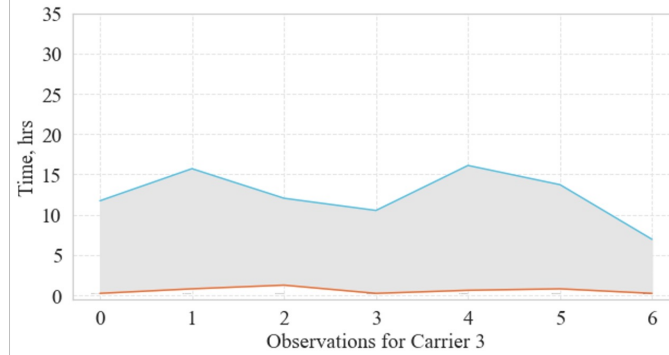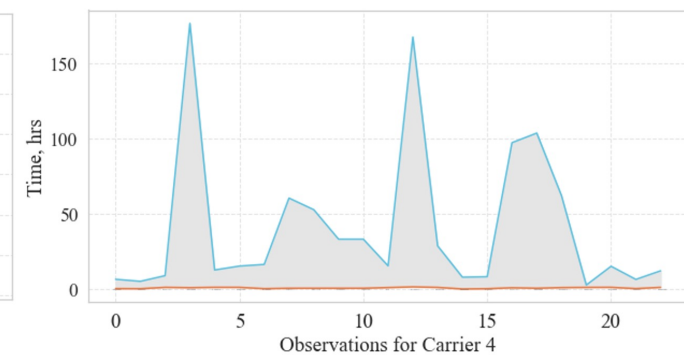|		Destination Zone			
		1	2	3	4
Origin Zone	1	14.33			
	2	4.67	0.38		
	3	26.85	1.82	0.68	
	4	46.70			4.56

Carrier 3

		Destination Zone			
		1	2	3	4
Origin Zone	1	6.12			
	2	31.83	17.06		
	3	23.76	17.23	4.00	
	4				

Carrier 4

		Destination Zone			
		1	2	3	4
Origin Zone	1	3.85			
	2	5.08	0.09		
	3	46.54		4.94	
	4	39.50			0.002

Share of Total Time per Zone,%

Carrier 1

		Destination Zone			
		1	2	3	4
Origin Zone	1	96.39			
	2	3.03			
	3			0.58	
	4				

Carrier 2

		Destination Zone			
		1	2	3	4
Origin Zone	1	46.01			
	2	6.75	0.83		
	3	21.44	1.12	1.33	
	4	21.01			1.52

Carrier 3

		Destination Zone			
		1	2	3	4
Origin Zone	1	41.06			
	2	30.10	4.47		
	3	10.18	3.77	10.42	
	4				

Carrier 4

		Destination Zone			
		1	2	3	4
Origin Zone	1	58.05			
	2	9.95	0.08		
	3	16.19		4.22	
	4	11.43			0.076

Overall trends include:

- For all carriers they spent the biggest share of the operation in terms on time in the local zone.
- Carrier 1, spent both the greatest number of miles and hours on the local zone.
- Movements within zones (2, 3, and 4) usually consist of a small number of miles but there is variability in terms of time.
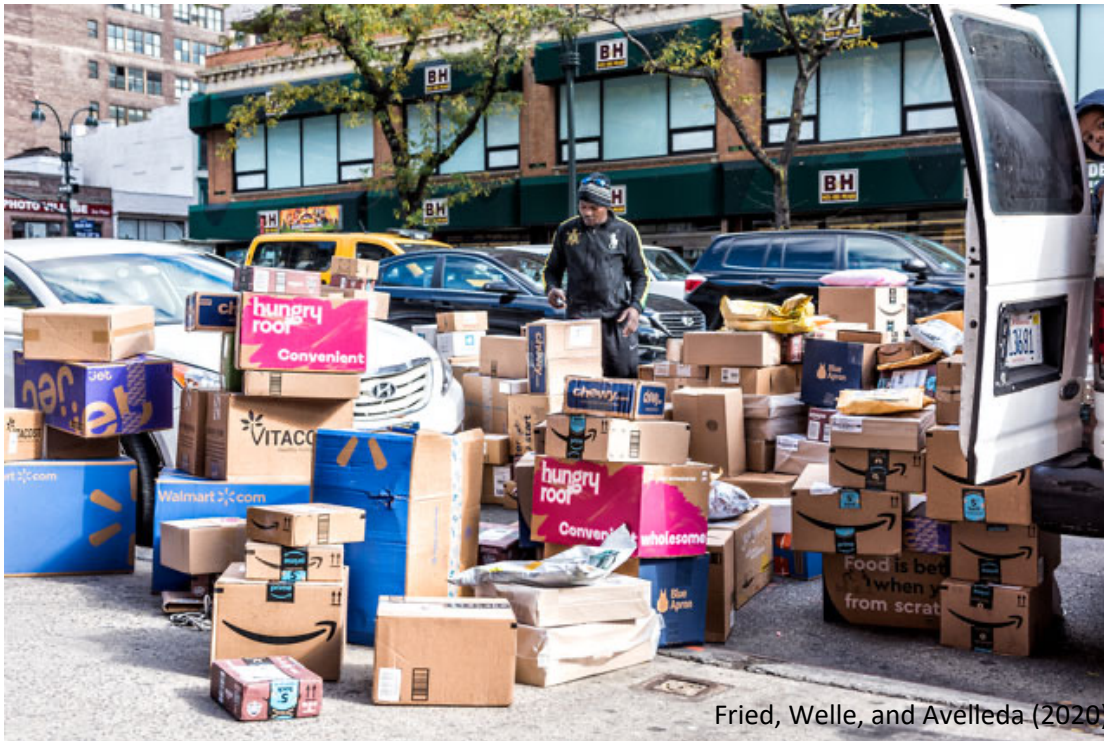
Answering the questions:

What data is available to **measure** e-commerce activity? Can this data **inform** transportation system planners about logistics operations **beyond the last-mile?**

Fried, Welle, and Avelleda (2020)

The dataset allows us to compare and understand the scope of the operations of each carrier – carrier 1 vs carrier 2 and 4.

We can see and analyze the upstream logistics and analyze distance, time, and service speed beyond the last mile. This analysis cannot be done without considering urban area development.

Expanding this analysis could help us understand the area of impact of each logistics facility.

Answer to the questions:

Is this new data useful to **address existing data gaps**?

The data does not reveal the number of packages per delivery trip.

The data does not allow to properly identify the mode used other than truck.

This study could guide planning agencies to recognize the data gaps and to guide in the discussion with carriers for further information.

Thank you,
Questions?

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