Divvy (Chicago) Bike-sharing Network Analysis

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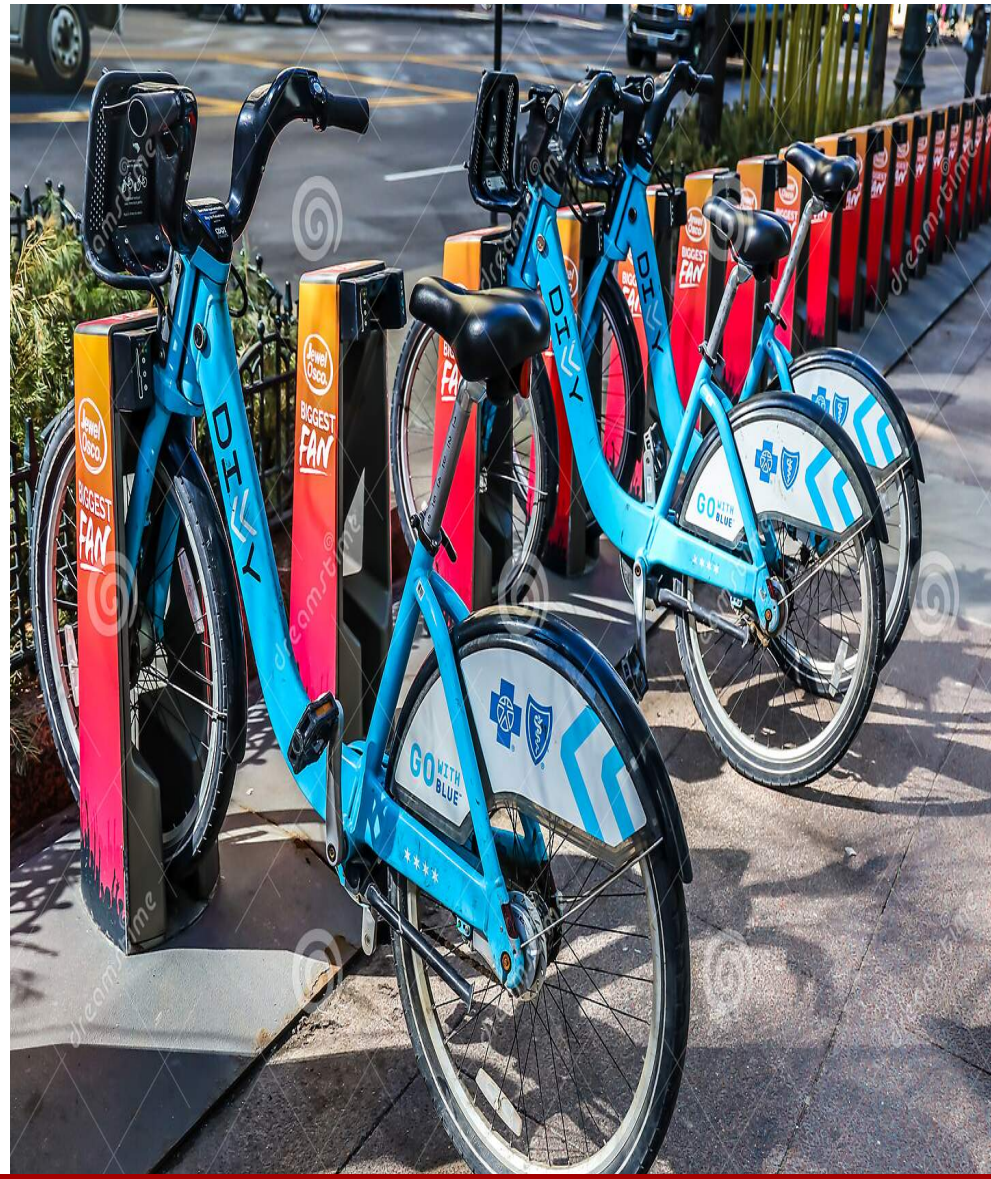
Outline



A little about DIVVY, the Chicago Bike-share System

A fun and affordable way to get around town

Single Ride

$1 to unlock

Plus $0.16 a minute for non-members.

Day Pass

$15/day

Unlimited 3-hour rides for 24-hours ($0.16 a minute after 3 hours)

Annual Membership

$10*/month

Unlimited 45-min rides.

Divvy is a playful reference to sharing ("divvy it up"). Divvy's light-blue color palette and four stars evoke the Chicago flag. The double Vs in the Divvy logo refer to the shared-lane markers painted on bike lanes throughout the city, showing how the city prioritizes bike safety.

How it works

Join

Become an Annual Member or buy a Pass from a Divvy station kiosk or the Divvy App.

Unlock

Find an available bike nearby, and scan the QR code or use your member key to unlock it.

Ride

Take as many short rides as you want while your pass or membership is active.

Return

Return your bike to any station, and wait for the green light on the dock to make sure it's locked.

Background and Motivation

- Safety, health, economic and environmental benefits
- Much focus placed on the use of network analysis methodologies.
- Yao etal. (2019) employed complex network methods to analyze the relationship between stations within theNanjing bike-sharing system in China.
- Rixey (2013) also expanded on prior studies involving the use of station-level ridership data by including the network effects of the size and spatial distribution of the bike sharing station network

Objectives of the project

The study seeks to address the following research questions:

- Do different user types (members or casual users) and bike rideable types (classic, docked, and electric bikes) influence ridership in general and in terms of network structure?
- What are the central stations within the bike-share system station network?

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- Is there some underlying community structure that can be utilized by the operators of the Chicago public bike-share system to help meet operational needs as well as the needs of bike riders?

Data Exploration

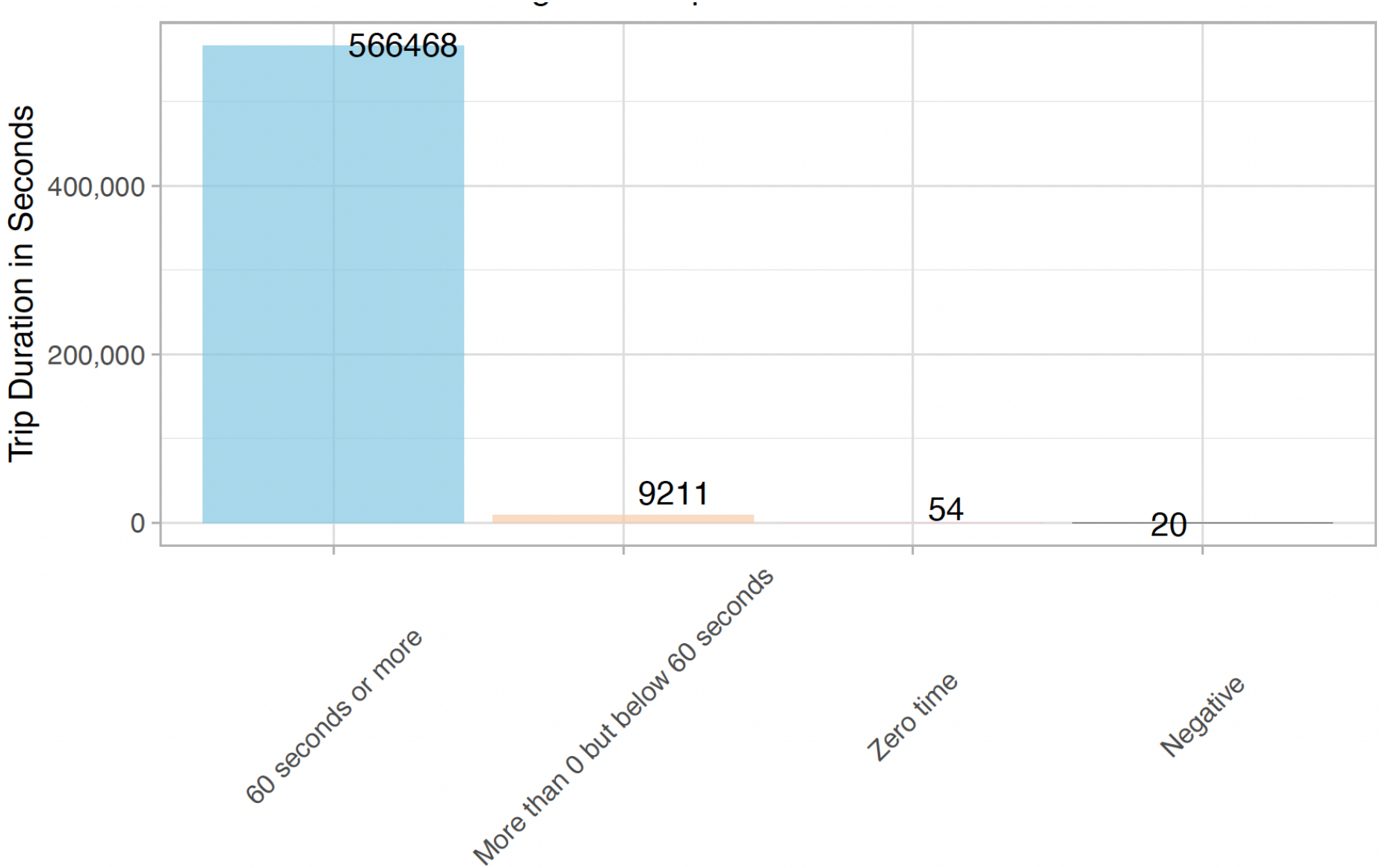
- Downloaded directly from the Divvy system data repository
- 5,757,551 observations measuring the total number of trips over a 12-month period
- 10% stratified random sample was taken
- Final study size of 455275 after treating data anomalies

Attribute	Full 12 Months Data	10% Stratified Sample
Unique Station IDs	857	854
Unique Station Names	866	862
Number of Observations	5757551	575753

Data Exploration: Variables

Variable Name	Description	Data Type
ride_id	Unique trip identification number	Alphanumeric character
rideable_type	Either a classic bike, docked bike, or an electric bike for the trip	Character/categorical
started_at, ended_at	Trip start and end day and time	Date/Time
start_station_name	Trip start station name	Character/categorical
start_station_id	Trip start station ID	Alphanumeric character/categorical
end_station_name	Trip end station name	Character/Categorical
end_station_id	Trip end station ID	Alphanumeric character/categorical
start_lat, start_lng	Pick-up station location latitude and longitude	Numeric
end_lat, end_lng	Bike return station location latitude and longitude	Numeric
member_casual	Whether the trip involved a subscribed member or a casual rider	Character/Categorical

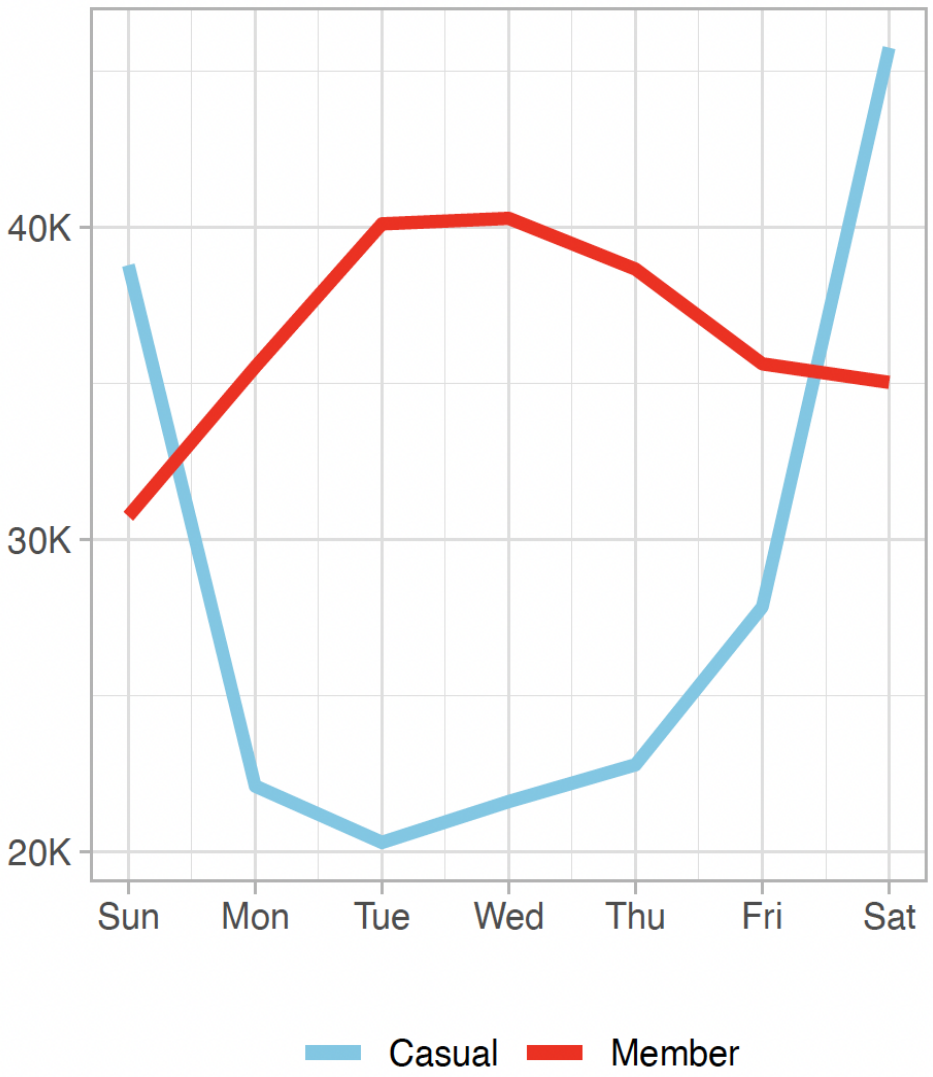
Trip Time length Anomalies

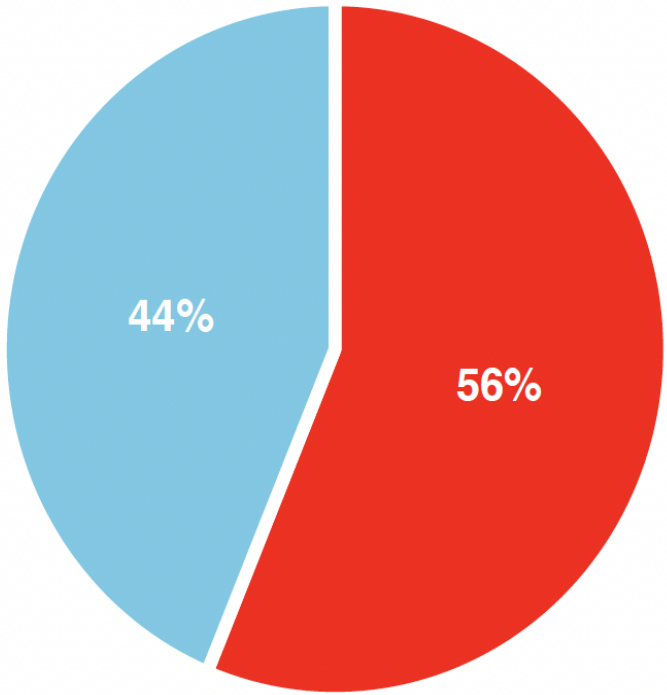


Methods Used

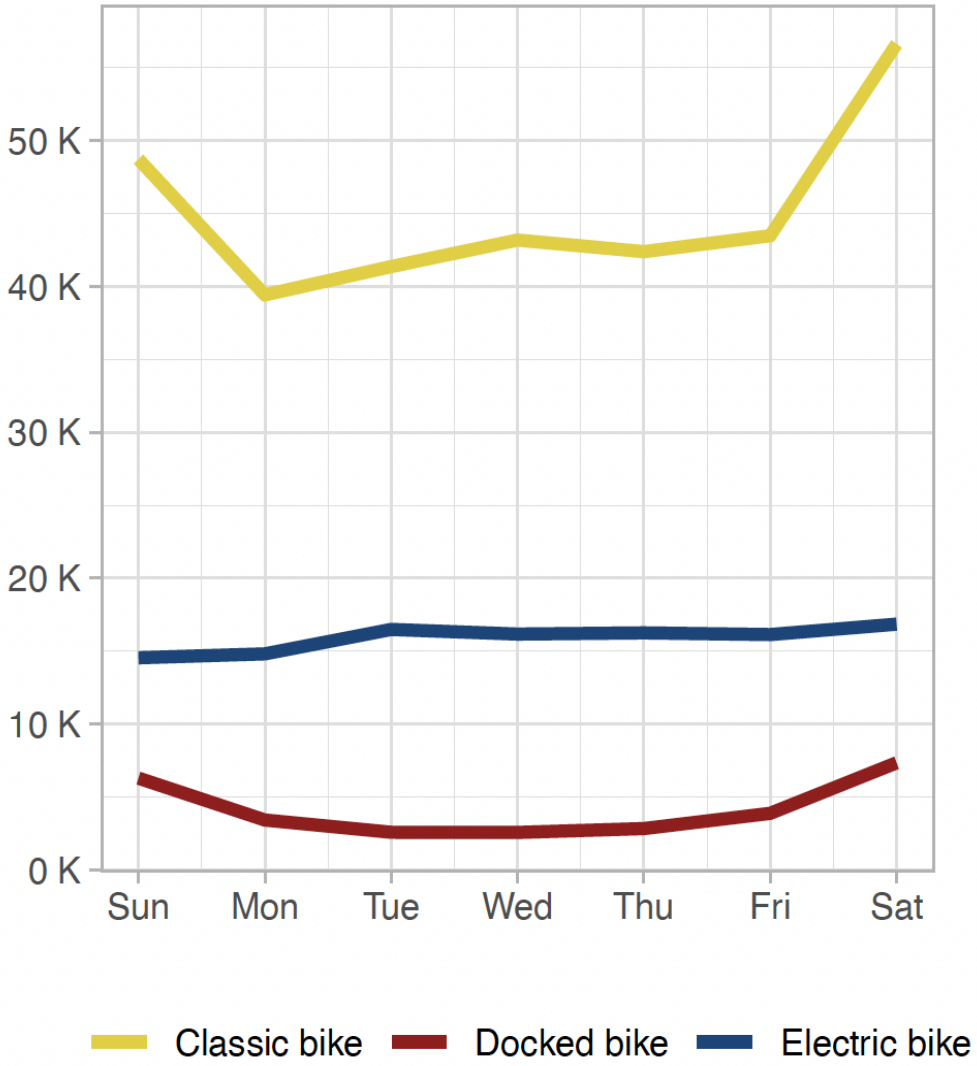
- Stratified Random Sampling
- Centrality measures: Degree and Betweenness
- Interconnectivity measures:
  - Average path length
  - Diameter
  - Density
- Community Detection Algorithms:
  - Louvain Algorithm
  - Walktrap Algorithm

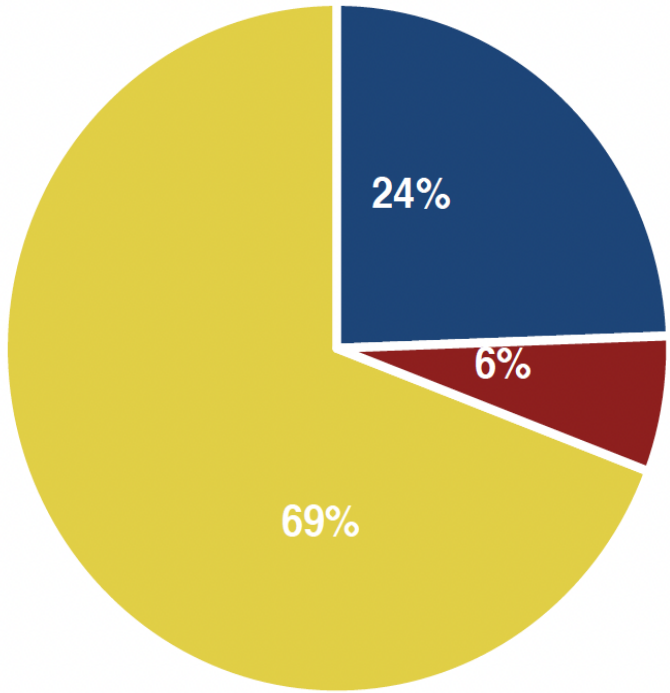
Distributions of Rides by day of week and type of bike users



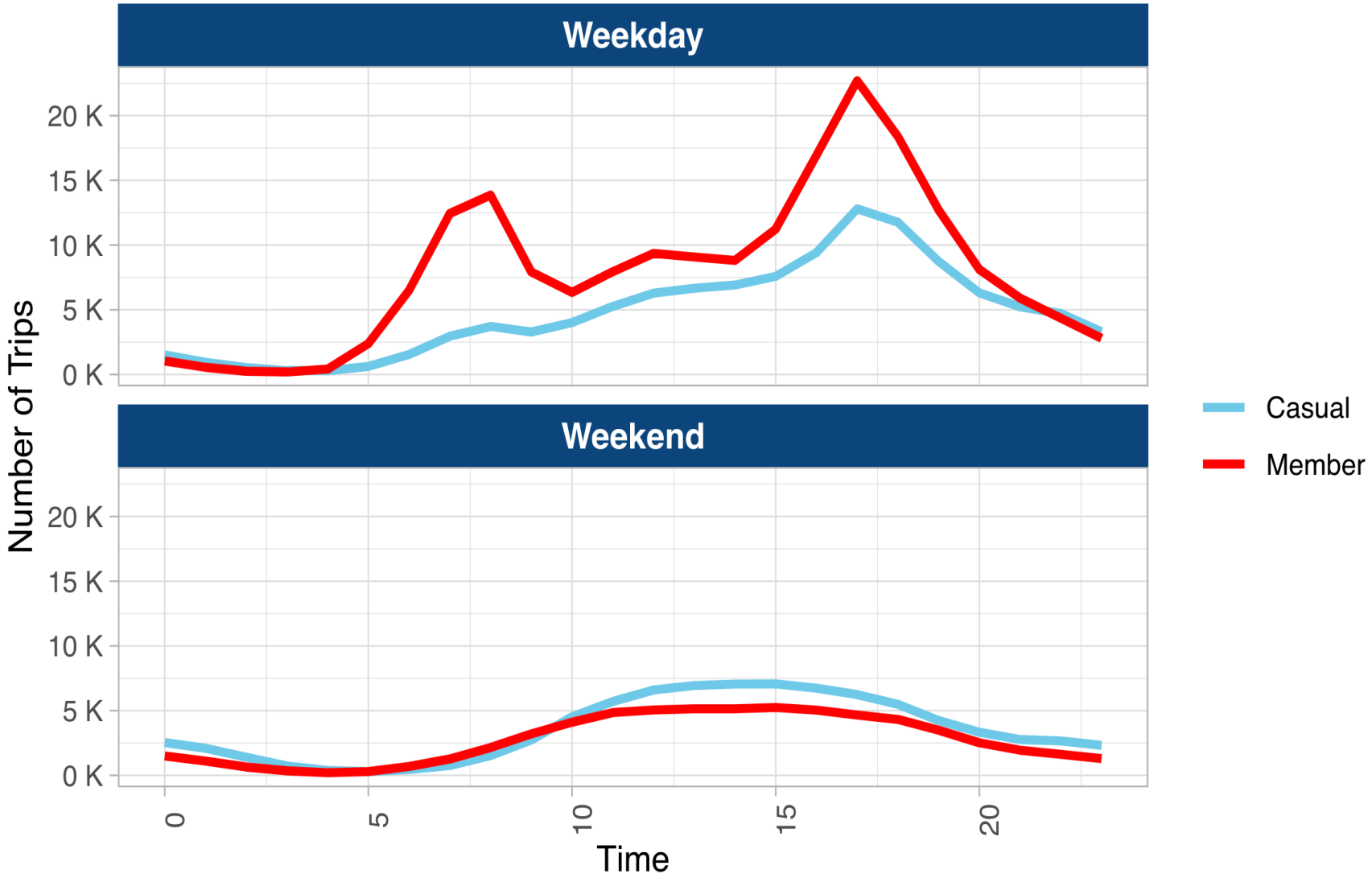


Distributions of Rides by day of week and rideable types





Weekday versus Weekend Rides



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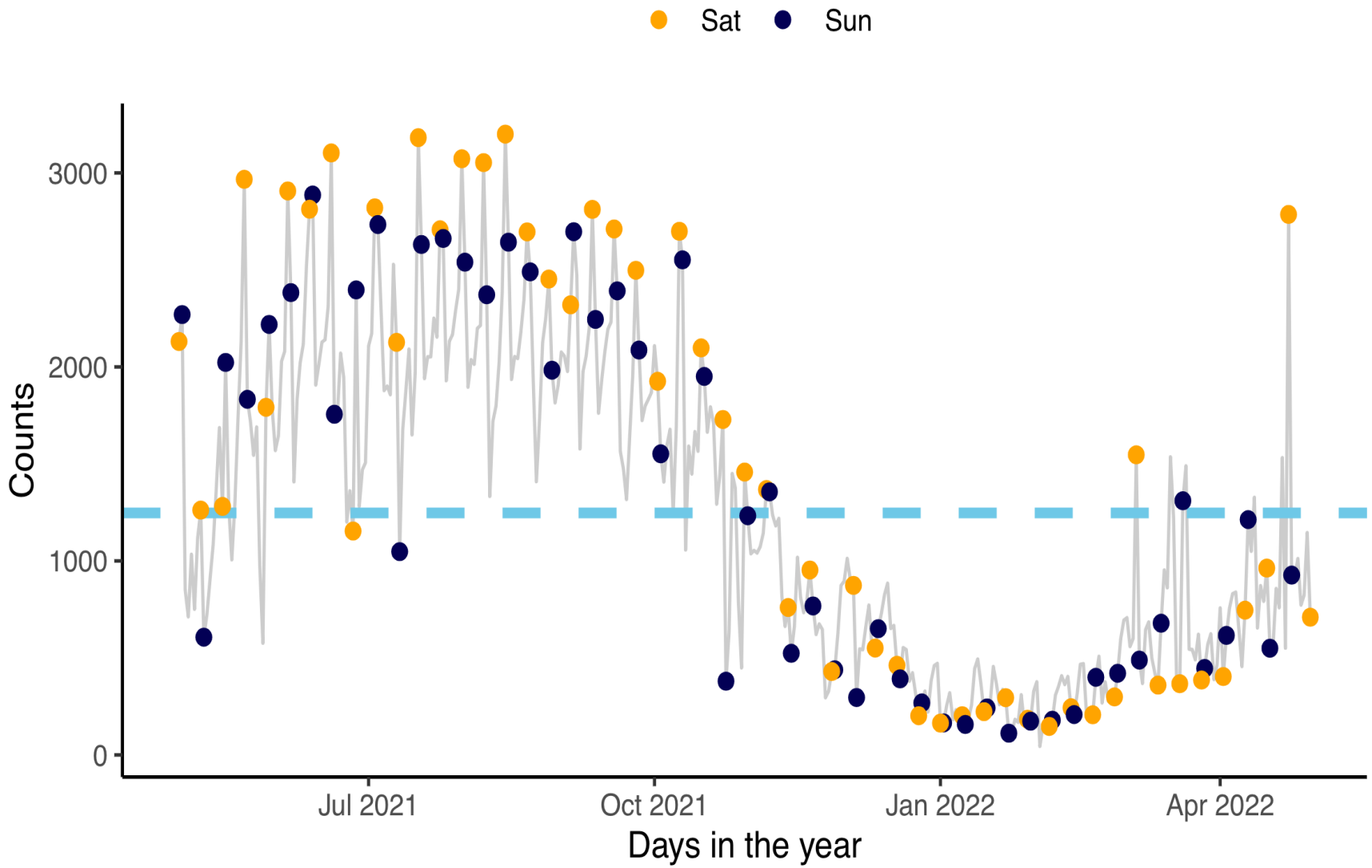
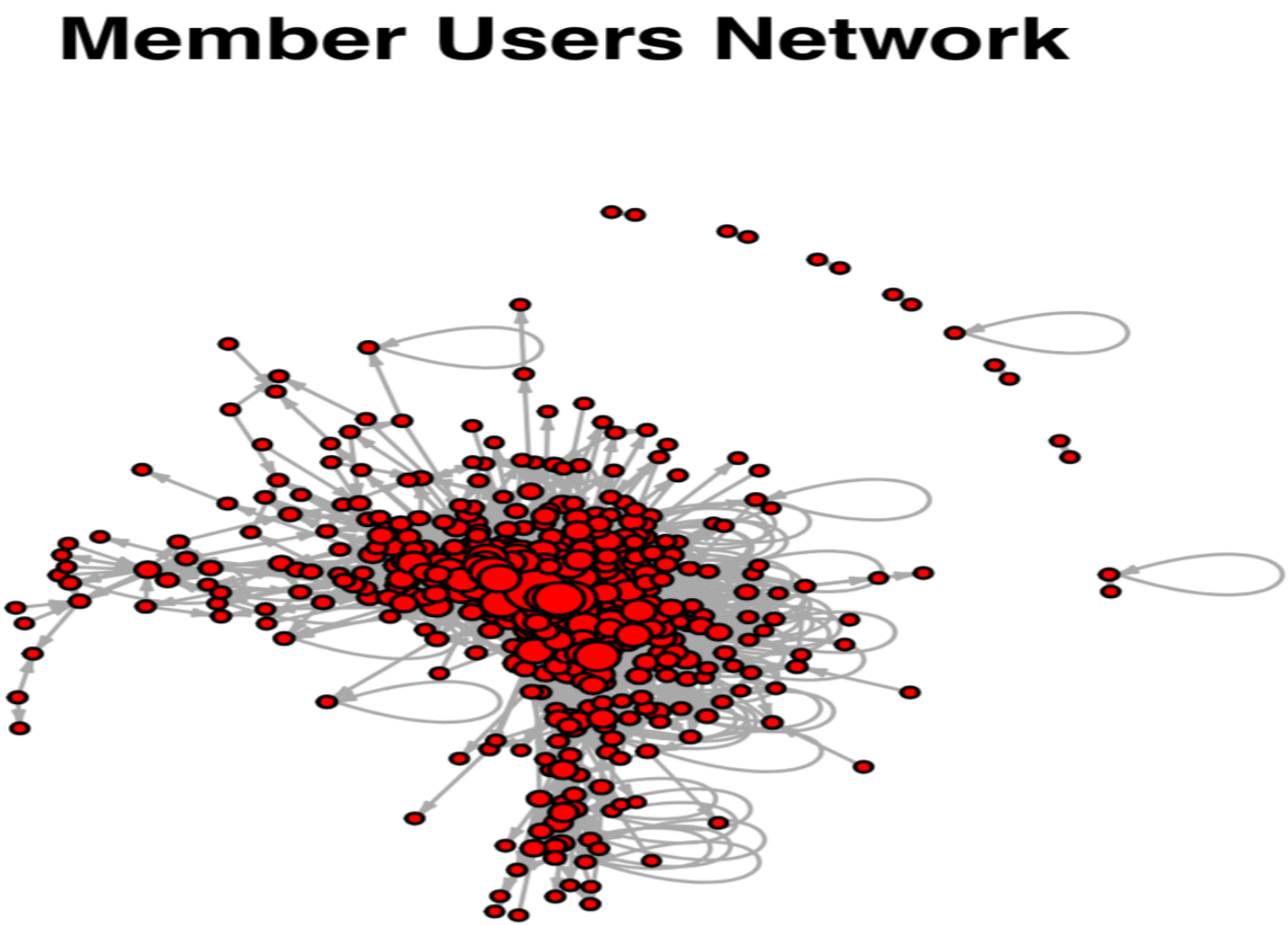


Network Construction and Characteristics

Characteristic	Full Graph	Member Graph	Casual Graph	Classic Graph	Docked Graph	Electric Graph
Number of Vertices	8.430e+02	526.0000	5.52e+02	549.0000	332.0000	506.0000
Number of Edges	7.834e+04	4491.0000	3.49e+03	5337.0000	522.0000	2128.0000
Density (edges)	1.104e-01	0.0163	1.15e-02	0.0177	0.0048	0.0083
Average path length	2.391e+00	3.1987	3.23e+00	3.1136	4.5903	3.5108
Diameter	8.000e+00	11.0000	9.00e+00	9.0000	12.0000	12.0000

User Type Graphs



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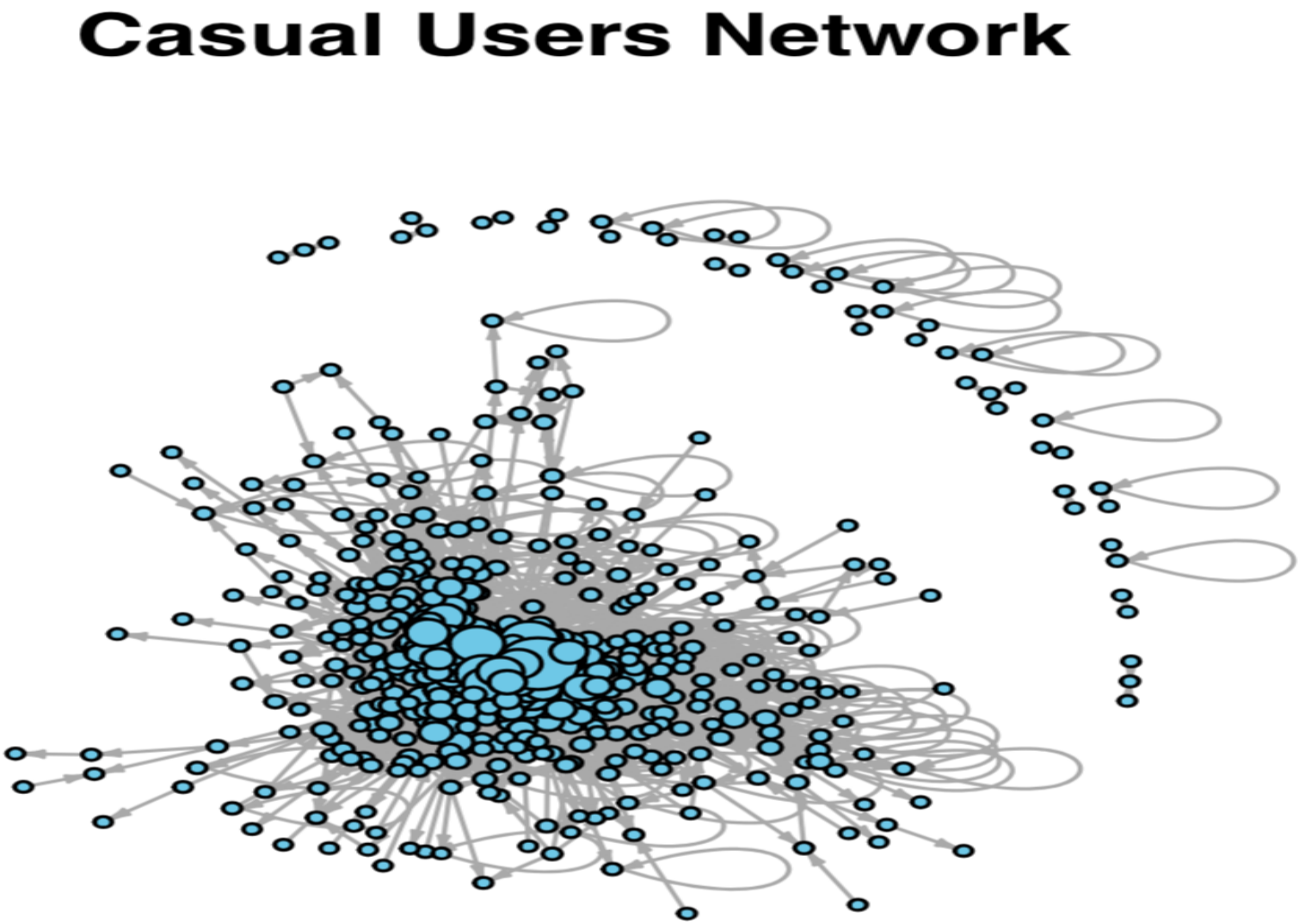
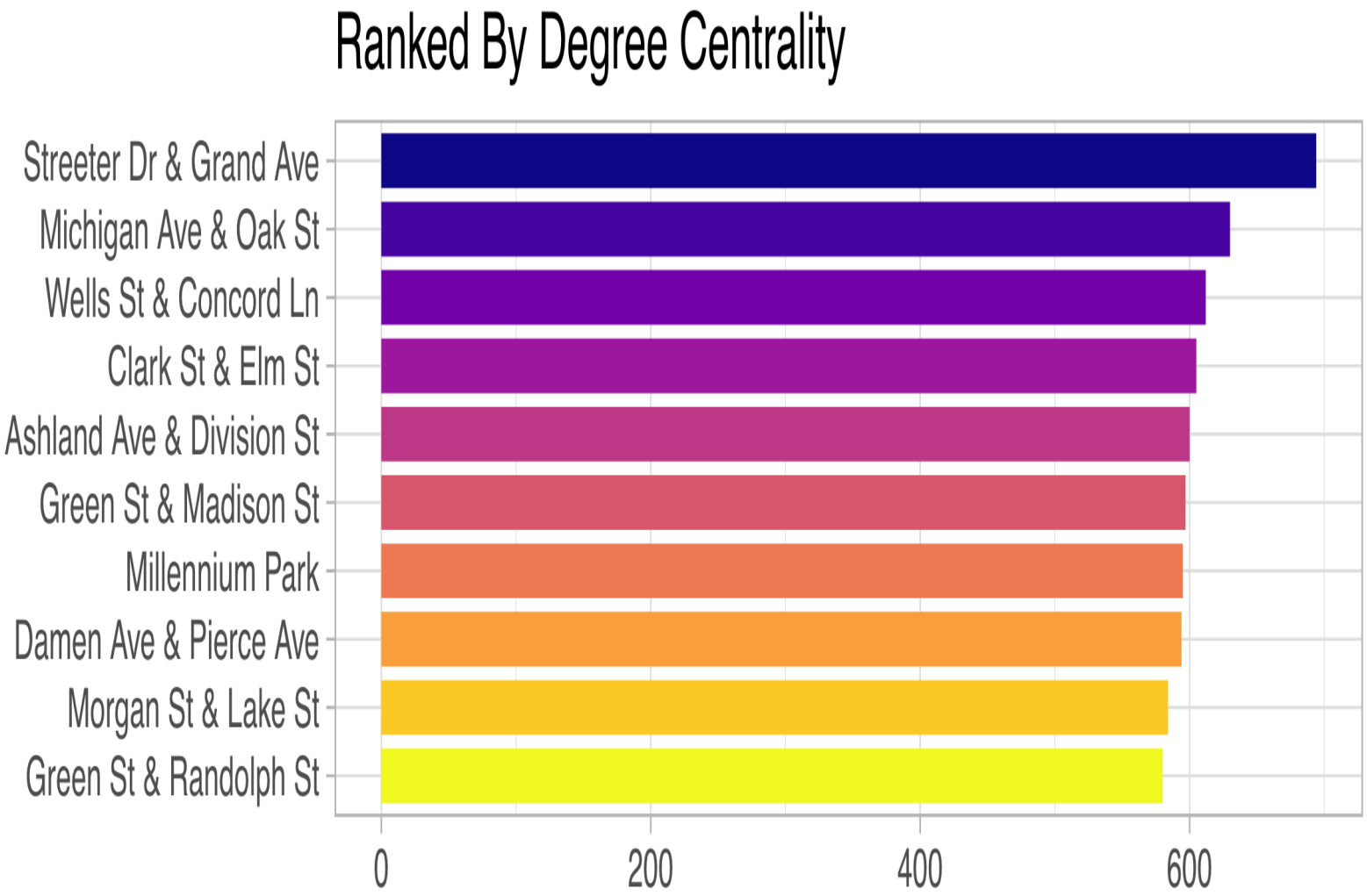


Ranking By Centrality Measures



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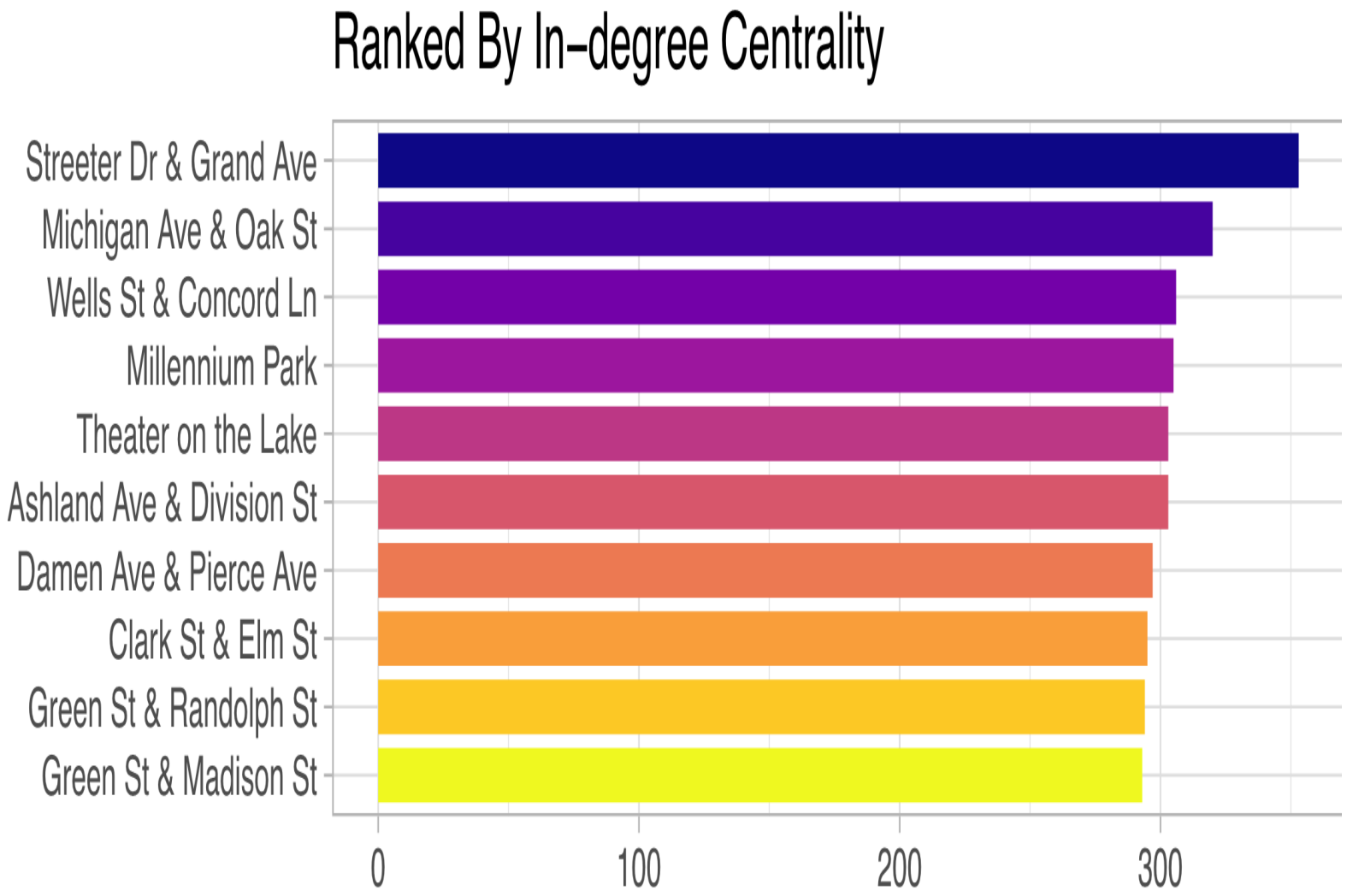

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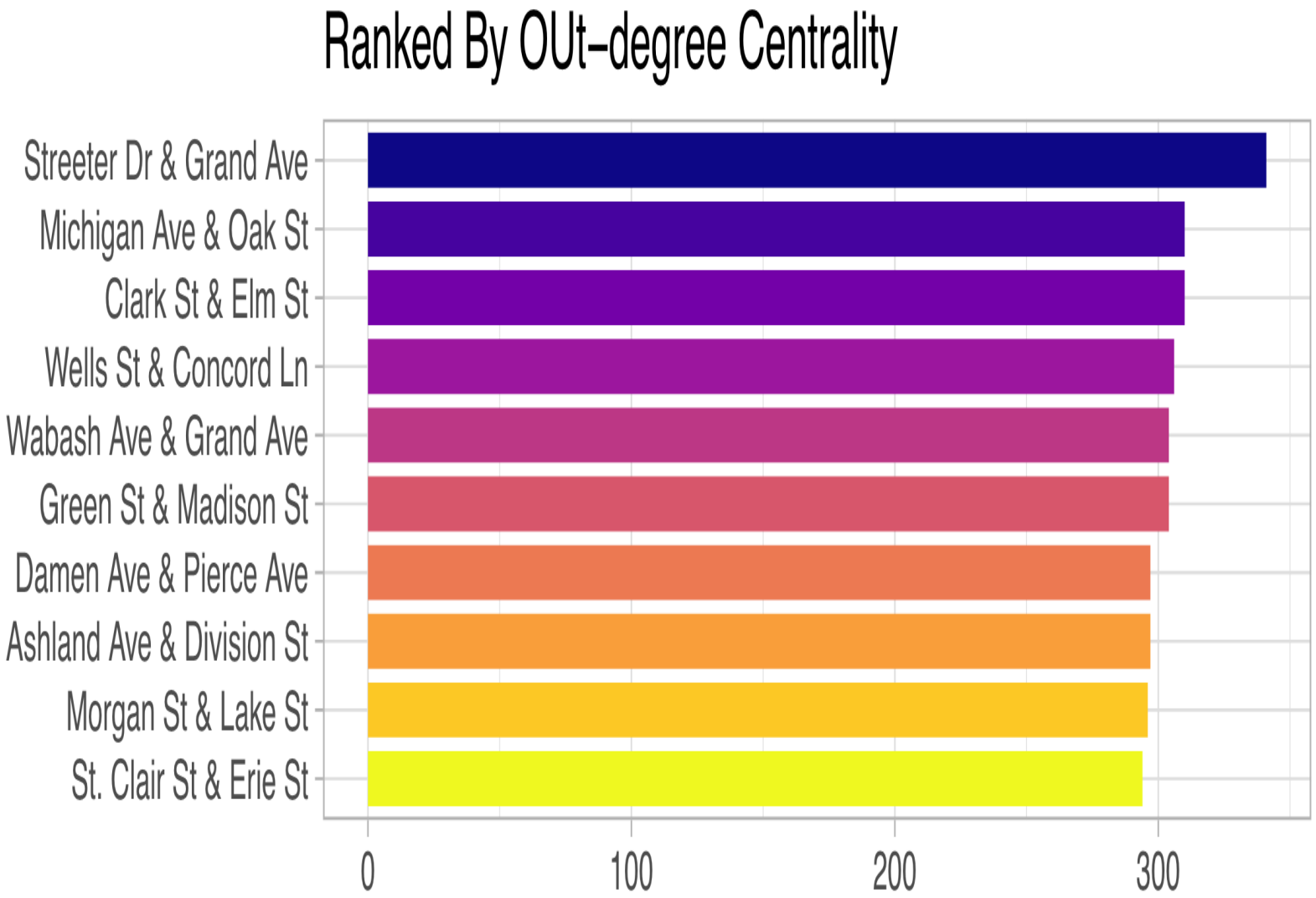

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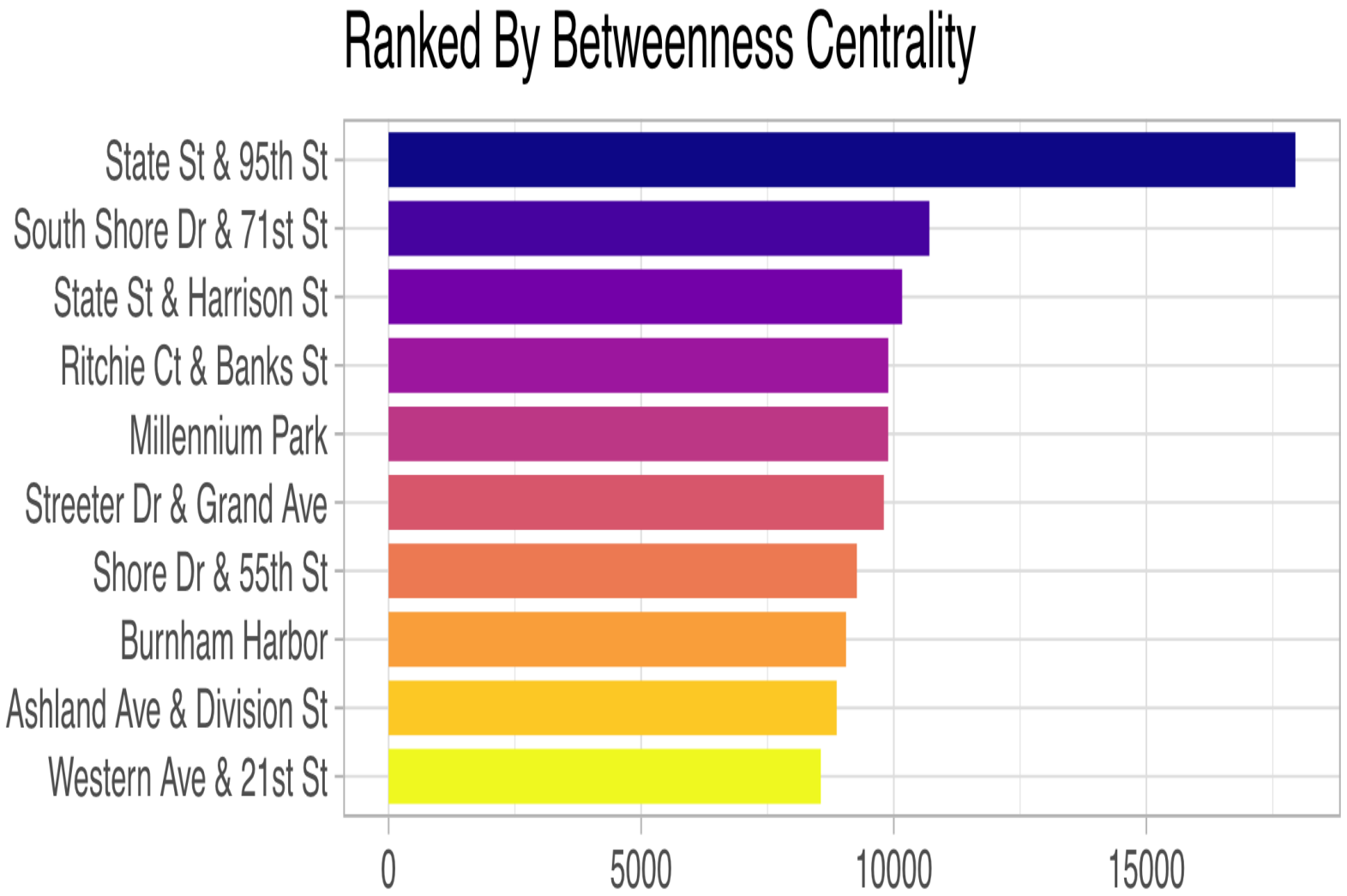
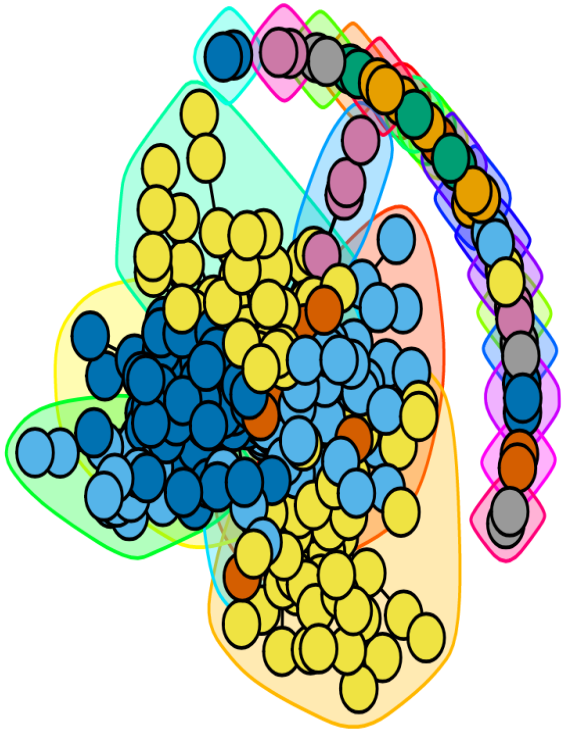
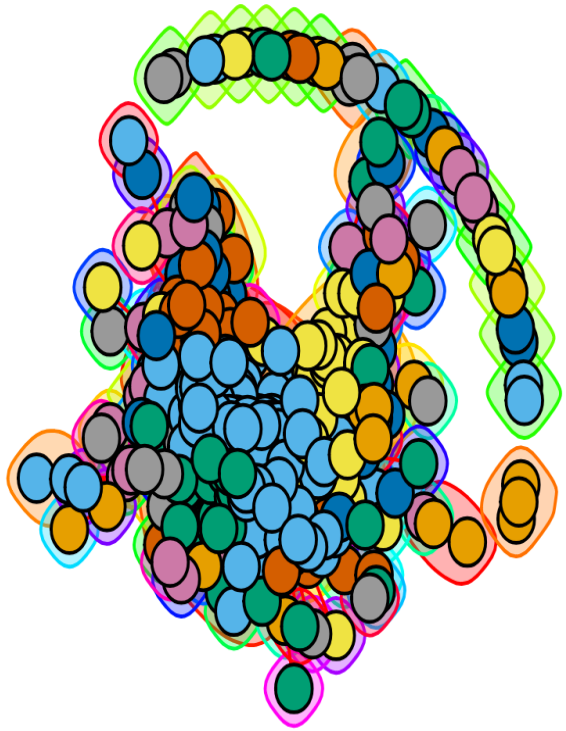


Community Detection

Community structure by the Louvain algorithm



Community structure by the Walktrap algorithm



Discussion

- Casual users make more rides on weekends than on weekdays and vice versa for members.
- The analysis revealed that the **Streeter Dr & Grand Avenue** bike station is the most central station
- while the **State St & 95th St** station appeared to be the most critical to information flow in the bike-share network.
- The bike-share network can be thought of as involving one big giant component

- The study was largely plagued by limited time constraint
- Failure to explore spatial trends
- Lack of demographic and weather information

Reference

- Rixey, R. A. (2013). Station-level forecasting of bikesharing ridership: Station network effects in three US systems. Transportation research record, 2387(1), 46-55.
- Yao, Y., Zhang, Y., Tian, L., Zhou, N., Li, Z., & Wang, M. (2019). Analysis of network structure of urban bike-sharing system: A case study based on real-time data of a public bicycle system. Sustainability, 11(19), 5425.tical model to analyze COVID-19 spread in the USA." Journal of Applied Statistics (2021): 1-20.