Bike Share Station Rebalancing: A Preliminary Comparative Study

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Intro

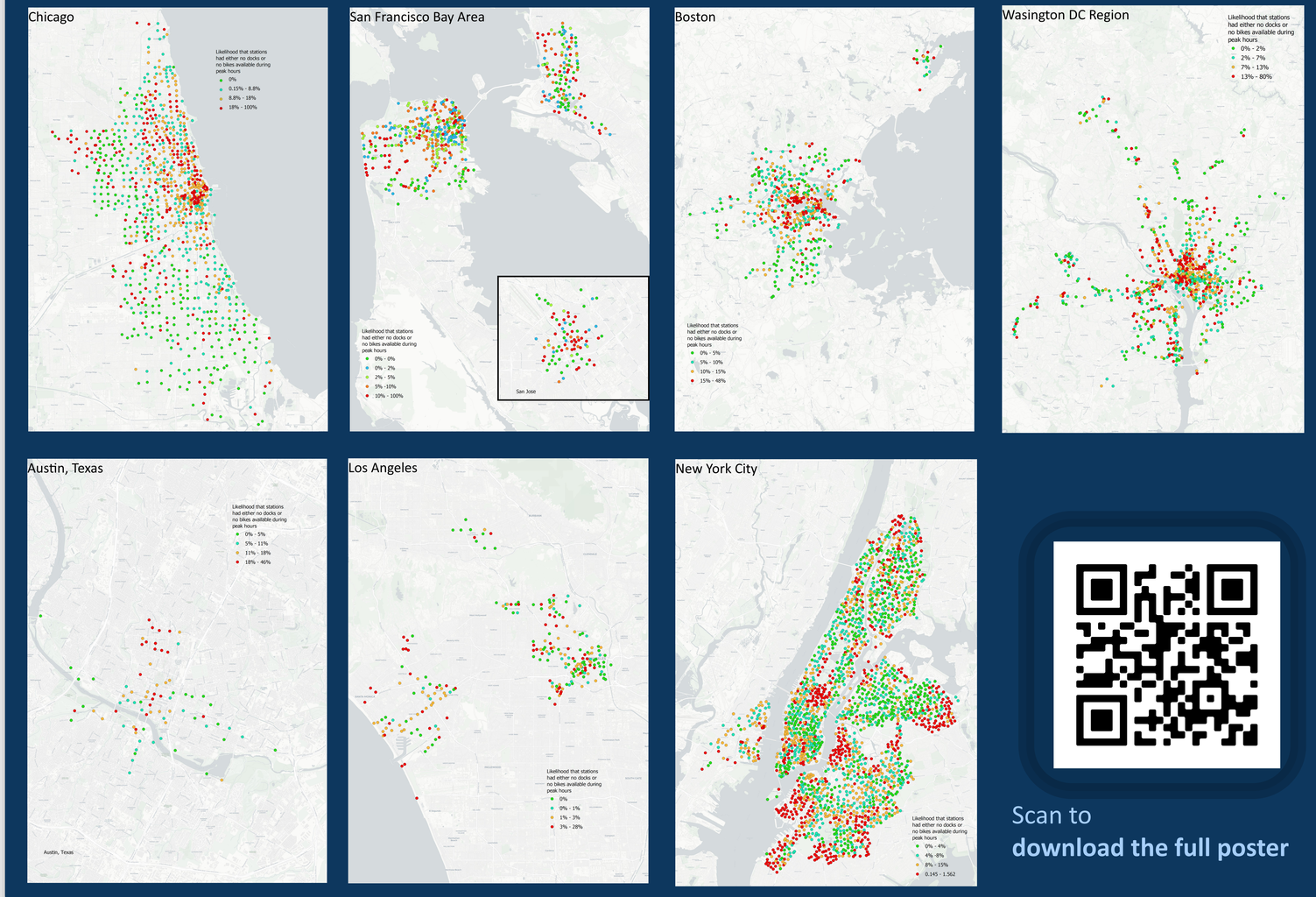
Bike share station availability is an under-studied phenomenon in the literature on micromobility. An important component of bike share systems is ensuring availability of bikes at bike kiosks and having open docks available for users seeking to return bikes following a ride. This process of bike rebalancing is a key service of bike share operators and requires shuffling bikes throughout service areas to meet the varying demand for ride origins and bike deposits at different locations. From the perspective of bike share users, not being able to access a bike when needed or not being able to return it at a destination dock can be frustrating and could impact bike share system usage.

This study is a preliminary attempt to look at the factors that may influence the likelihood that a bike share station may be inaccessible for users. We assembled a unique data set using automated collection of dock and bike availability from seven different bike share systems in the United States and deploy existing data relating to demographics, job and residential mixture, transit density, and street intersection density as predictors of dock inaccessibility.

Methods

1. An automated R script downloaded station availability data at 15-minute increments in May and June of 2024 from bike share systems in Chicago, Austin, San Francisco, Boston, Los Angeles, Washington DC, and New York City.
2. Data downloaded includes the number of bikes available, the number of docks available, and reporting time for each station in each city.
3. A count was made for any time a station was either: a) filled to capacity thus inhibiting the station's ability to accommodate a bike return or b) had no bikes available for a user to check out. Trips occurring during peak use periods between 7:00am-11:00am and 4:00pm and 11:00pm were filtered for analysis.
4. Independent variables were obtained from the American Community Survey 5-year estimates (2022) and the EPA Smart Location Database at the block group level and included the % African American residents, the % of population over 25 with a Bachelor's degree, median household income, % households without access to a car, pedestrian-oriented street intersection density, distance to transit, housing & employment diversity mix, % of residents who are low wage workers.
5. After testing for multicollinearity, negative binomial regression models were used with the count of station inaccessibility used as a response variable.

The reliability of bike share kiosk availability varies across cities and neighborhoods.
The local context matters.



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Results

- The maps and regression show a wide variability in terms of station performance within and across cities.
- The mean likelihood that one encounters a station that has either no bikes or no docks available varies from 2% in Washington DC to 14% in Chicago.
- The negative binomial regression did not find common variables of significance throughout all the cities chosen for the study.
- The coefficients for the percentage of African Americans in the stations' block groups showed a significant negative relationship to the count variable in Chicago, Austin, Washington, and the Bay Area. This suggests that an increase in the percentage of African Americans in a station's block group will see a lower log of expected counts.
- The significance of the percentage of the population with bachelor's degrees on unavailability counts differs amongst cities with Chicago experiencing a negative relationship and Boston and Washington DC seeing a higher expected log dock unavailability counts.
- One advantage of bike share systems is that they give another mobility option to households that have no access to automobiles. We find that in Washington, DC, block groups with higher percentages of zero-car households are more likely to see station unavailability while in New York City and the Bay Area the relationship is reversed.
- The street network density variable was included because it is a commonly used measure of walkability and multi-modal comfort. People may be more likely to use bike share in environments that are less accommodating to automobiles. We find that only in Boston does the higher level of street network density predict higher levels of dock unavailability.
- We find that the other variables related to infrastructure (distance to transit) and location diversity (housing and employment mix) are rather poor predictors of dock unavailability.
- Finally, the percentage of low wage workers residing in a block group holding bike share stations showed a significant negative relationship to bike dock unavailability in Chicago while it was positive in New York City.

Table 1: Summary of Negative Binomial Models for Select Cities

	Dependent variable: Count of bike share station inaccessibility						
	Chicago	Austin	Boston	Wash. DC	Los Angeles	NYC	Bay Area
%AfAm	−0.818***	−8.905*	−0.303	−0.590*	−3.210	−0.105	−2.059***
	(0.226)	(4.999)	(0.394)	(0.323)	(2.497)	(0.125)	(0.783)
%Bachelors	−1.169**	−0.024	1.757***	1.585**	−0.952	0.142	1.023
	(0.535)	(2.319)	(0.597)	(0.708)	(1.276)	(0.245)	(0.905)
log(median income)	0.018	0.723	−0.329**	−0.017	1.045**	0.113*	−0.266
	(0.151)	(0.882)	(0.161)	(0.196)	(0.520)	(0.064)	(0.227)
%No access to car	0.688	4.071	0.065	1.071**	1.812	−0.453***	−1.836***
	(0.421)	(3.712)	(0.398)	(0.423)	(1.543)	(0.158)	(0.633)
Street intersection density	−0.0003	0.004	0.002***	0.0002	−0.0001	0.0001	−0.0001
	(0.0005)	(0.003)	(0.001)	(0.001)	(0.002)	(0.0002)	(0.001)
Distance from transit	0.0005	−0.0003	0.0004	0.0001*	0.001	−0.0004*	0.00000
	(0.0005)	(0.003)	(0.0005)	(0.00005)	(0.001)	(0.0002)	(0.00002)
Housing & employment mix	−0.231	−0.115	0.110	−0.087	0.082	−0.146	0.387
	(0.295)	(1.794)	(0.294)	(0.316)	(0.903)	(0.131)	(0.532)
%Low wage worker residing	−3.775***	−1.962	−1.833	1.300	−0.888	1.244*	3.396
	(1.373)	(9.908)	(1.520)	(2.163)	(3.737)	(0.685)	(2.599)
Constant	5.731***	−3.921	7.491***	3.934	−8.878	3.031***	7.196**
	(1.827)	(10.340)	(2.017)	(2.489)	(5.931)	(0.801)	(2.924)
Observations	823	26	251	431	127	1,499	314
Log Likelihood	−4,465.374	−130.347	−1,383.835	−2,310.455	−467.300	−8,353.412	−1,257.771
θ	0.371*** (0.018)	1.408*** (0.427)	1.070*** (0.095)	0.543*** (0.036)	0.341*** (0.045)	0.097*** (0.034)	0.410*** (0.092)
Akaike Inf. Crit.	8,948.748	278.694	2,785.669	4,638.910	952.599	17,324.830	3,133.541

Note: *p<0.1; **p<0.05; ***p<0.01

Discussion

This study is an initial foray into understanding factors that influence bike share station performance. Using data gleaned from seven bike share systems across the United States we find that the significant factors vary in each city.

For the researcher this suggests that variables not captured in these data could be significant such as operator rebalancing capabilities and activities or other factors such as spatial clustering.

For the practitioner, this research suggests that individual bike share operators could benefit from developing similar predictive models to better understand the phenomenon of bike station unavailability in their localized context.