Scooter Share Equity Report: Providence, RI

Nolan Flynn, Marion Madanguit,
Hyunkyung Rho, Maeve Stites, and Alice Paul

September 7, 2020

1 Introduction

In late 2018, the City of Providence began allowing scooter share companies to operate within their city and to provide alternative forms of transportation to their population. These scooter share companies are required to uphold certain distribution requirements within the five geographical regions of the city: downtown, east side, south side, north west, and west.

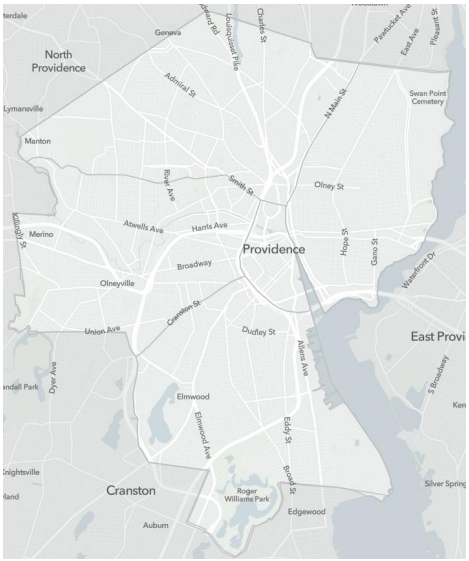


Figure 1: Regulatory zones for Providence scooter share - marked with gray lines

The system has definitely changed over time. From August 2018 to October 2019, Bird and Lime were the primary scooter providers to the city. They were later replaced by Spin and Veoride. In general, all providers increased their scooter deployments over time and saw an increase ridership as a result. It is clear, however, that each provider expanded their services

to meet the needs of each region quite differently. This is evident in how fleet size differs across each region over time.

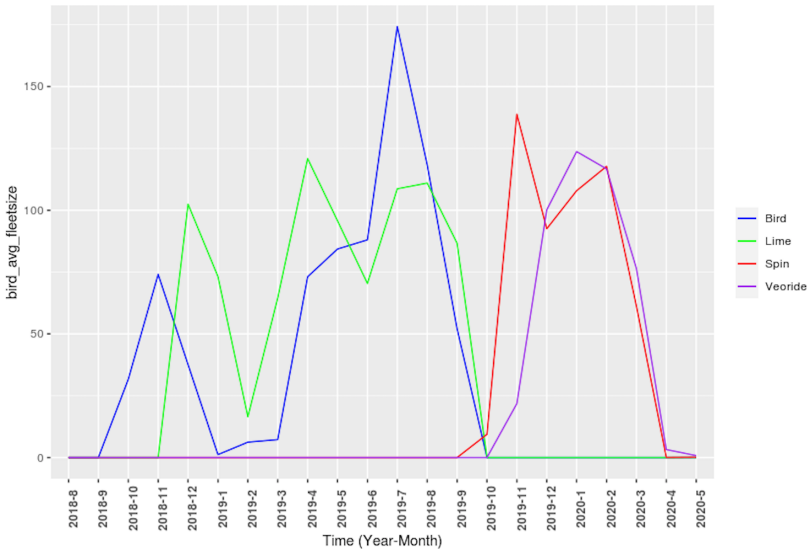


Figure 2: Average daily fleet size by month and provider

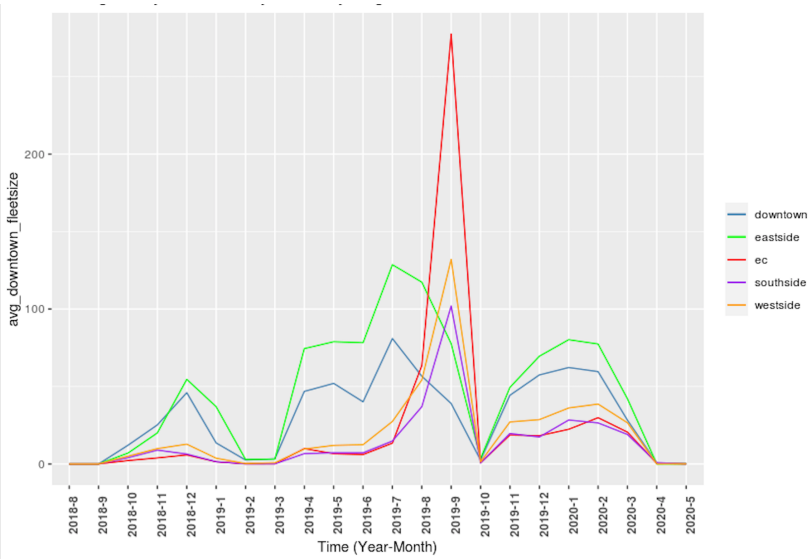


Figure 3: Average daily fleet size by month and region

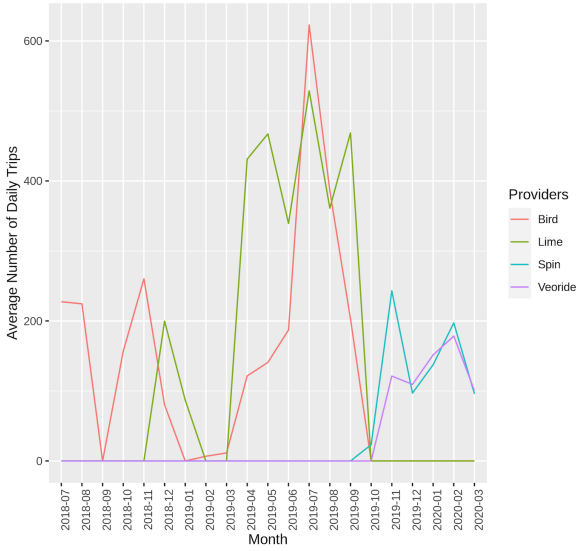


Figure 4: Average daily trips by month and provider

In this paper, we discuss our study of the equity of access to scooter share services in Providence. We work with the City to investigate how ridership, coverage, and service vary across the region to identify underserved communities. Further, we analyze socio-demographic factors 2018 census data to put these patterns into context.

2 Data

2.1 Census Data

We pull the following census data variables from the 2018 ACS 5-year survey, each variable was recorded by census tract:

- Population (count): population per tract
- Sex (percentage): male/female breakdown
- Race/ethnicity (percentage): White (non Hispanic), Black (non Hispanic), Hispanic, and other races (Native, Asian, Hawaiian and Pacific Islanders, other races alone, two or more races)
- Median family income (count)
- Per capita income (count)
- Poverty (percentage): population in poverty
- Internet access (percentage): anyone with an internet subscription or access to internet without subscribing

- Language (percentage): English only, Spanish speaker, Spanish weak English, Spanish strong English
- Commuting method (percentage): population that commutes via car, public transportation, walking, or other methods
- College (percentage): college student or a grad/professional school student

2.2 Scooter Data

The scooter share companies provide the vehicle event and vehicle location information to the City. We will use this data from 2019 for our study, focusing on May through Sep 20, when the data is most complete.

The events data set contains a list of events for each scooter (e.g. pickup, maintenance, reserved) and the time of the event. We use this data set to generate the number of pickups per area.

The locations data set contains information on the parked locations of individual scooters. It contains the following variables:

- location over time
- interval of time at location
- reason for location (user drop off, maintenance, provider drop off)
- scooter status (available, unavailable, maintenance)

3 Methodology

3.1 Calculating Estimated Demand

The pickups data represent ridership, but not demand (potential ridership with more coverage). Within regions, there are times when zero scooters are available and no trips can be taken. To properly estimate demand, we need to fill in the data for these times.

The demand estimate approximates the number of pickups that would have occurred if at least one scooter was always available.

3.1.1 Availability Intervals and Pickups

The demand estimate relies on two pieces of information: (1) the amount of time that scooters are available and (2) the number of pickups that occur per region per day between the operating time: 6am to 10pm.

3.1.2 Final Estimate

Using the availability intervals and pickups data, we calculate a demand estimate. The final number is based on three separate computations:

1. Non-time dependent demand estimate:

$$estimated\,pickups = \frac{actual\,pickups}{portion\,of\,day\,with\,available\,scooters} \tag{1}$$

   We scale the number of recorded pickups by a factor proportional to the amount of time that scooters are available. For example, a 50% availability time results in a demand estimate double the pickup count. This calculation treats all intervals equally, regardless of the time they occur.

2. Time dependent demand estimate:

$$estimated\,pickups = \frac{actual\,pickups}{\begin{array}{r}average\,portion\,of\,pickups\,that\,occur\,while\\ scooters\,are\,available\end{array}} \tag{2}$$

   This estimate mirrors the first estimate, but takes into account the fluctuation of demand throughout the day (see Figure 2).

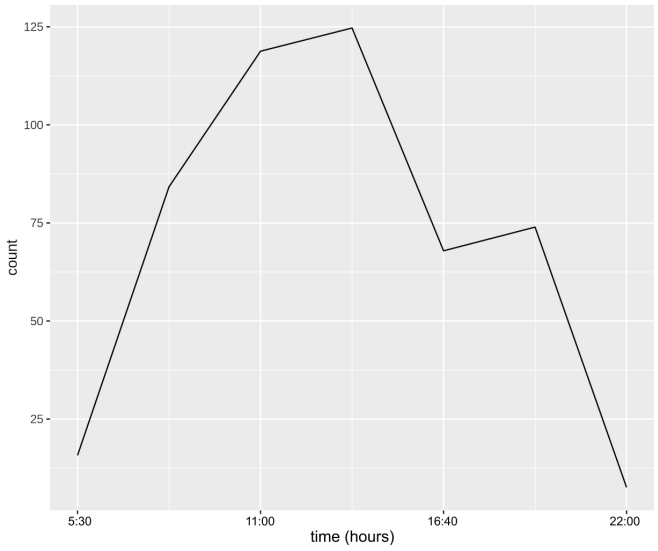


Figure 5: Hourly average scooter usage across the entire city of Providence over the course of one year

3. Demand estimate cap:

$$estimated\,pickups = 5 * actual\,pickups \tag{3}$$

We cap demand estimates at five times the pickup count for any regions with less than 20% availability. This number impacts only a small fraction of demand estimates, but ensures that our estimates do not overcompensate for short availability intervals.

The final demand estimate equals the minimum of these three values. We take all three calculations into account to handle each model's shortcomings and to ensure our estimates do not overcompensate for short availability intervals.

Each model fails under certain circumstances. The time dependent and non-time dependent demand estimates fail with short availability intervals. Short availability intervals lead to unreasonably high demand estimates. The demand estimate cap limits the effect of low availability time.

We create an overly pessimistic model by taking the minimum of the three calculations. This leads to conservative findings, resulting in likely underestimated inequalities.

3.2 Evaluating Service

To evaluate the service within a region, we analyze two metrics:

$$\%\, demand\, unmet = \frac{estimated\, pickups - actual\, pickups}{estimated\, pickups} \tag{4}$$

$$scooter\, availability = \%\, of\, day\, with\, zero\, available\, scooters \tag{5}$$

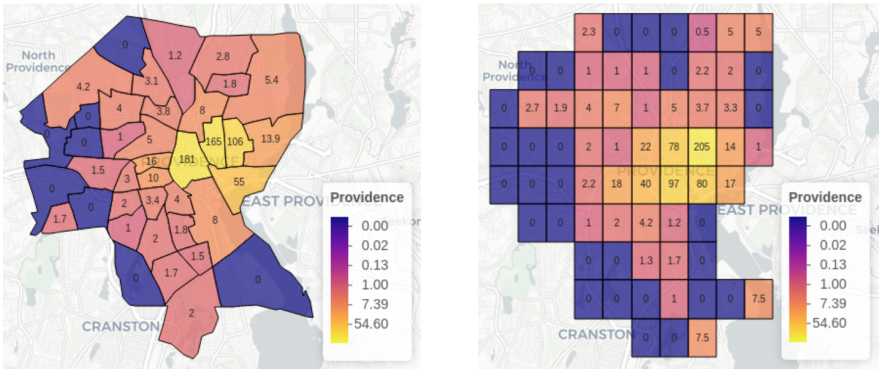
To understand how service changes over time, we track these metrics over three periods in 2019:

1. April through May
2. June through August 20
3. August 20 through September 20

We chose these three intervals because of their alignment with the seasons, the school year, and to minimize drastic fluctuations. We sampled a number of different periods before settling on these. The September 20 cutoff is due to inconsistent data the rest of the month.

3.3 Geographical Mapping

We map demand by tract and by lat long area. Tract mapping allows for easy comparison with the census data. Lat/lng mapping provides finer detail and consistently sized geographic regions.



(a) Map by tract

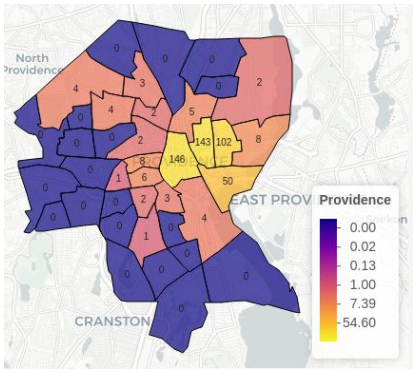
(b) Map by lat long area

Figure 6: Our two geographical mappings

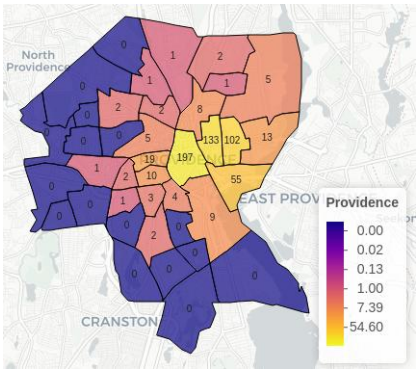
4 Results

4.1 General Trends

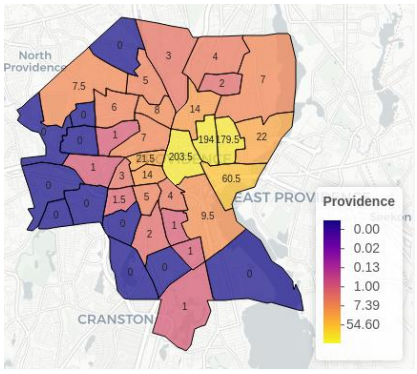
4.1.1 Ridership



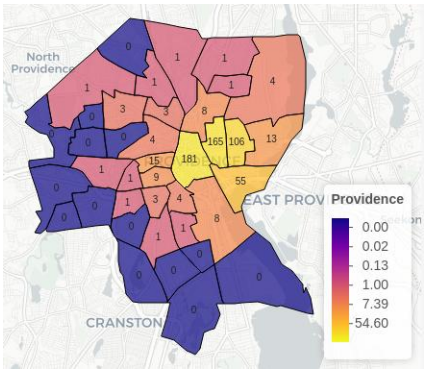
(a) Apr to May



(b) Jun to Aug 20



(c) Aug 20 to Sep 20



(d) Whole Period

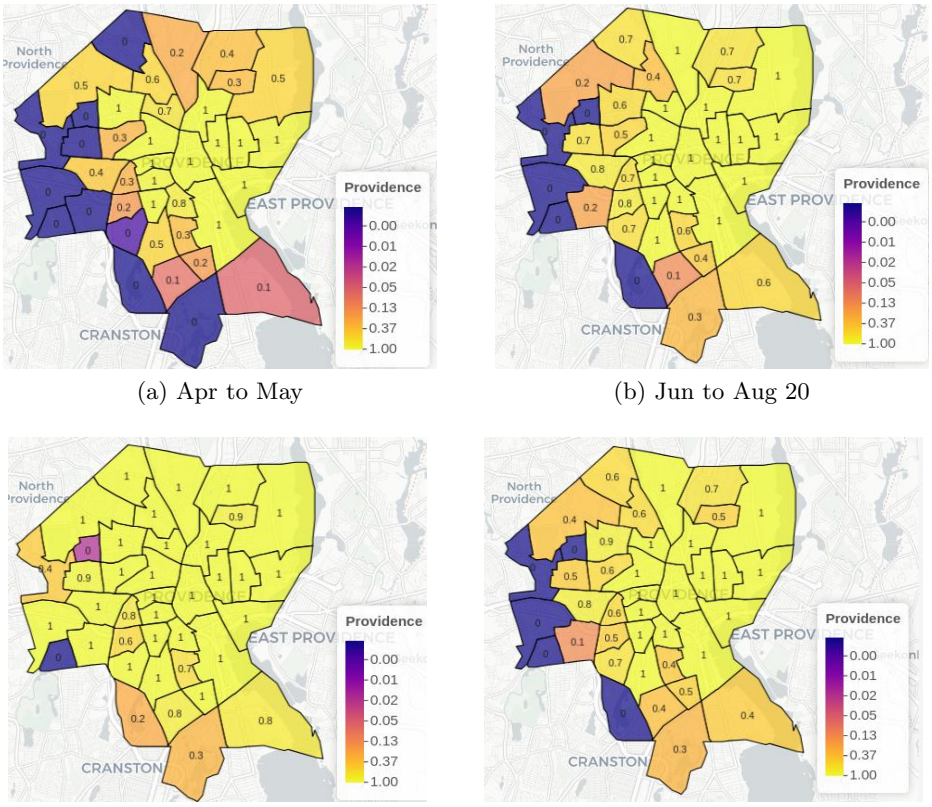
Figure 7: Median trips per day

Generally, tracts closer to the downtown region saw more pickups than tracts further from the downtown region.

The majority of pickups consistently occur in and around the downtown region and Brown University. The most significant increases in ridership also occur in this area.

The outer eastern region and north west tracts 23 through 27 notably increase in number of trips over time. Tracts near the southern downtown area sees a small increase in number of trips. In the outer southern and western regions, pickups remain consistently low.

4.1.2 Coverage



(a) Apr to May

(b) Jun to Aug 20

(c) Aug 20 to Sep 20

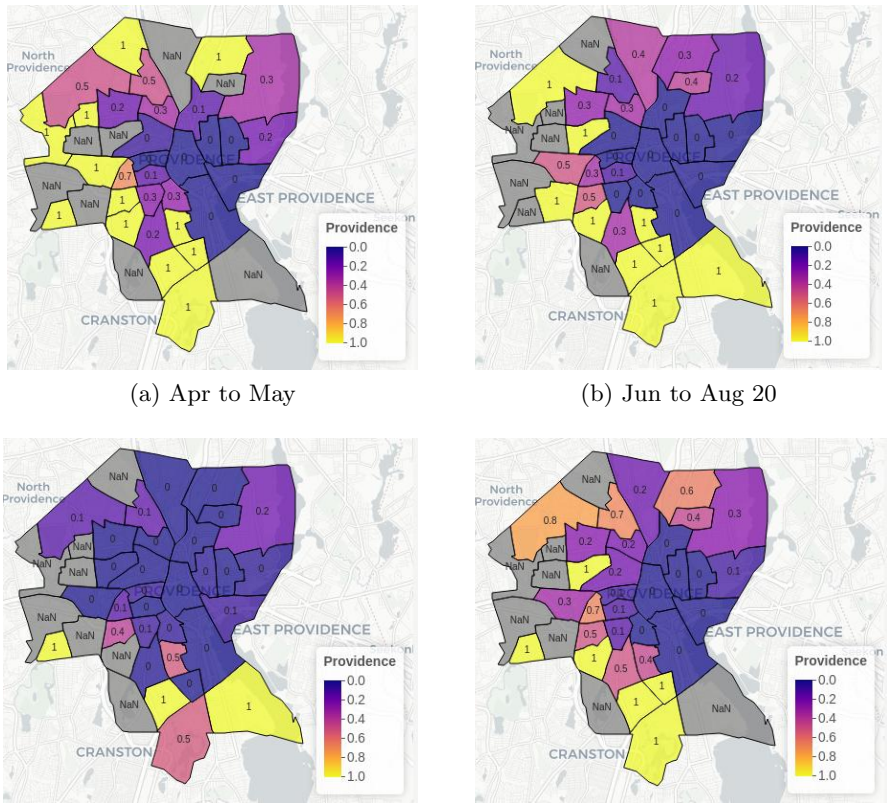
(d) Whole Period

Figure 8: Median portion of the day with an available scooter

Similar to ridership, scooters are consistently available in and around the downtown region and Brown University. Generally, tracts closer to the downtown region saw more significant increases in availability than tracts further from the downtown region.

In eastern and western tracts, an increased availability corresponds to an increased ridership. The same occurs in tracts near southern downtown to a lesser degree.

4.1.3 Unmet Demand



(a) Apr to May

(b) Jun to Aug 20

(c) Aug 20 to Sep 20

(d) Whole Period

Figure 9: Median portion of unmet demand

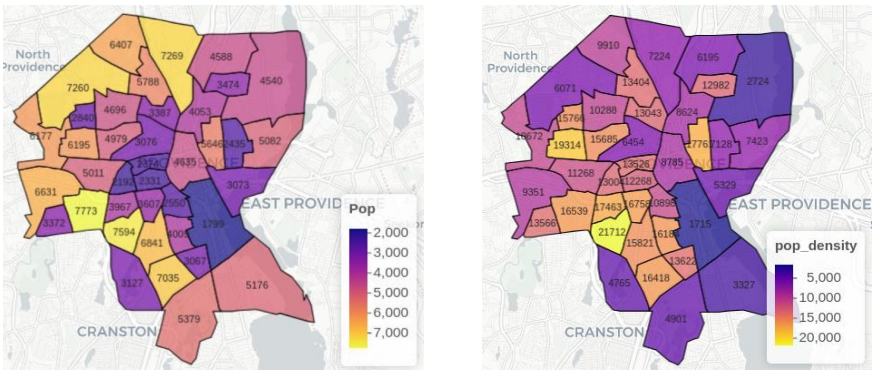
Scooter shares consistently meet demand in and around the downtown region and Brown University. Service expands to meet demand across the entire eastern region, in western tracts 23 through 27, and in upper southern tracts. Service fails to meet demand in the outer southern and western tracts.

The greyed out tracts indicate no demand estimate could be made. Zero trip in the region or too short of availability intervals cause the no demand issues.

4.2 Comparing to Census Data

We look at census information to get a better understanding of our demand data. We use the census variables to determine any distinct characteristics about the under-served areas.

4.2.1 Population

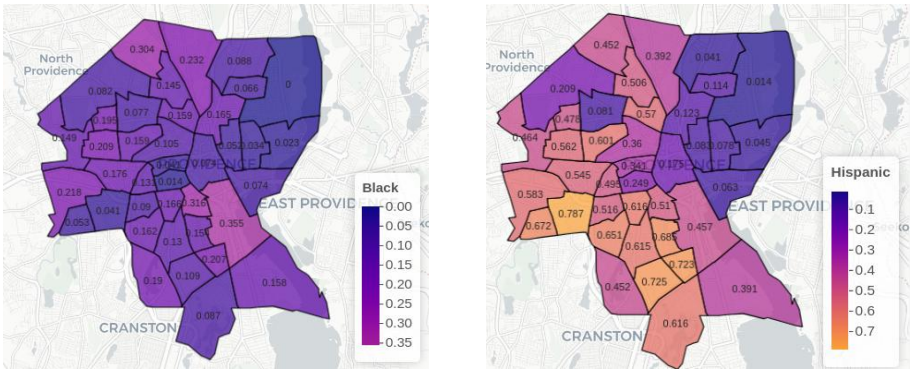


(a) Population (b) Population density

Figure 10: Population and population density by census tract

We find no strong relationship between population / population density and ridership, coverage, or service, suggesting that differences in services are correlated to other geographical differences (e.g. race/ethnicity, income).

4.2.2 Race / Ethnicity



(a) Black (non Hispanic) (b) Hispanic

Figure 11: Proportion of population by race / ethnicity by census tract

Most majority White neighborhoods have almost complete availability coverage, with the exception of census tract 24 in the northwest. These White neighborhoods are also the first areas to get consistent scooter availability.

Some areas with high Black populations have decent availability, notably tracts 6 and 7 near the city. Outside of the center of Providence, tracts with higher Black populations are under-served.

Predominantly Hispanic populations are the most under-served tracts. This is especially true in the outskirts to the south and the west.

4.2.3 Median Family Income

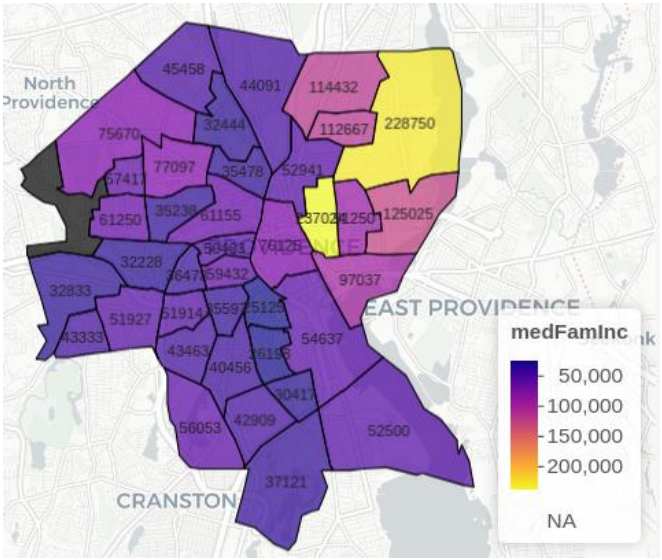
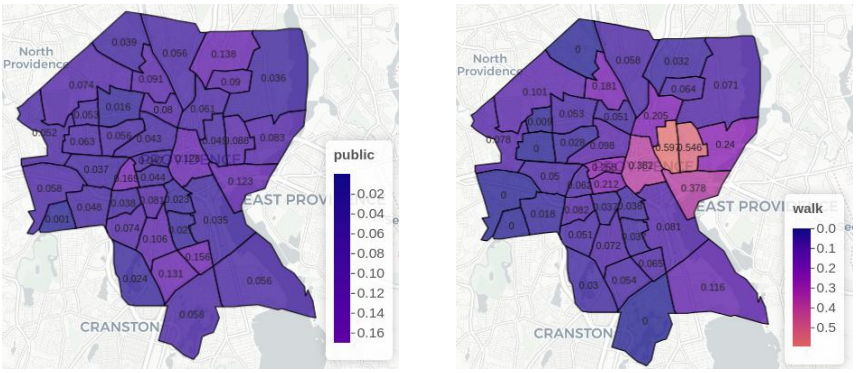


Figure 12: Median family income by census tract

Income correlates with high scooter availability. Wealthy tracts in the north-east and west have consistent and almost complete coverage. Lower income regions (specifically the south and west), have notably lower availability when compared to high income regions.

4.2.4 Commuting



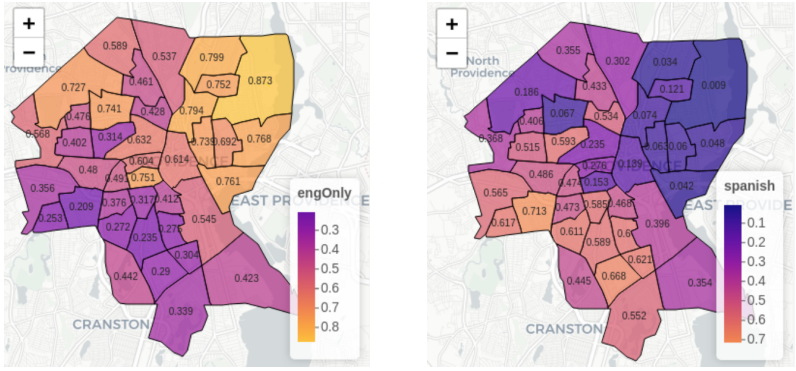
(a) Via public transportation (b) Via walking

Figure 13: Proportion of population by commute to work by tract

Most of the city commutes by car. However, there are key tracts with high percentages of public transportation and/or walking.

Multiple tracts outside of the city center have a high portion of walking commuters (>10%) and a high amount of zero availability days. We see the same trend in areas that have a high portion of public transportation commuters.

4.2.5 Language



(a) English-speaking only (b) Spanish-speaking

Figure 14: Proportion of population by language by tract

The majority of the populations in the north are English-speaking only. The downtown region has a slightly lower percentage of English-speaking only

people, that being 61.4%. Outside of these regions, there is a significant population of Spanish-speaking people. Spanish-speaking is correlated with lower ridership and scooter availability.

5 Conclusion

From these results, we find that there are clear inequalities in terms of the populations being served by scooter share companies in Providence. Although there has been a large improvement since first launching the program, there are still many areas that are under-served: predominantly Black, Hispanic, and/or low-income regions. These results are true even in our model's pessimistic lens; the inequalities are likely much larger than we found. We believe our findings show that scooter share companies in Providence should be pushed by the City to have higher scooter availability in areas with high percentages of marginalized populations.

To get a better understanding of Providence's ridership potential, it is important that data is collected on regions where scooters are typically not available. Until then, their potential is largely unknown. We would like to see more research into scooter share pricing structures and how this affects equity. We would also like to see more analysis into community attitudes towards the scooter share services, as our study takes a mostly human-removed approach.

6 Acknowledgement

Thank you to the Clare Booth Luce Program for partial funding for the project.

7 Resources

- Shiny App: a tool built as part of our research to analyze scooter data
- GitHub Repository: code repository