



MOBILITY EQUITY ANALYSIS OF ELECTRIC SCOOTERS IN LINDEN, COLUMBUS

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Executive Summary

In our fast paced, highly globalized world, transportation connects individuals to opportunities and physical accessibility to resources is a determinant for many in achieving a high-quality lifestyle. Yet barriers to mobility prevent many from financial stability and educational capital. Many of our cities are constructed to prioritize the utilization of expensive personalized vehicles or for public transit. Though mass transportation excels in environmental sustainability and affordability, many citizens must navigate long distances to reach stops and must coordinate around routes that are out of their control. Electric scooters, as a form of micro-transportation, present one solution for overcoming the mobility barrier, with advantages including cheap fares, easy parking options, and limited waits for rides. Linden is one of the “opportunity zones” of Columbus, where mobility is a significantly high barrier that impedes a

higher quality of life for its residents. Scooters present a unique opportunity to address this need in the community.

The overall research goal of this project was to provide the City of Columbus with mobility information regarding the feasibility of electric scooter transportation in the neighborhood of Linden. To do so, our team outlined six objectives to achieve this goal.

Our first research objective for the project was to determine the patterns and relationships of scooter usage data for the Linden area by analyzing geospatial data provided to us by Smart Columbus. Our second objective was to ground-truth the Linden neighborhood by analyzing the area for scooter-supporting infrastructure, such as the physical characteristics of sidewalks and roads. The process of ground-truthing requires direct observation of a physical study area, so that remotely collected data can be interpreted within the context of the physical environment. Our third objective was to understand whether scooters are adequately provided within this region of the city through analyzing the number of scooter drop zones within the neighborhood. Our fourth objective was to determine whether the scooters are a viable first-mile, last-mile solution, in the context of transporting residents to and from the new Smart Mobility Hubs that will be built along major transportation corridors in Linden. These city planned mobility hubs will serve as central locations for residents to access multiple forms of transportation, such as buses, taxis, bike racks and bike and car sharing services. Our fifth objective was to compare trends in scooter usage in Linden to a neighborhood of similar geographic size. For this reason, the team chose to compare North and South Linden to the Clintonville neighborhood. Our sixth and final objective was to identify existing barriers to adoption for the Linden neighborhood residents.

The results of our research revealed that though trends in scooter usage are similar within both the Linden and Clintonville neighborhoods, the volume of scooter usage is significantly

greater in Clintonville than in Linden. Our research reveals that adoption in Linden is limited. Within both Clintonville and Linden, our research suggests that scooters were used more to enter the neighborhoods than to exit them. A particularly busy area of scooter activity in Linden was found along Cleveland Avenue – one of the proposed locations of the Smart Mobility Hubs that would be implemented by the City of Columbus. Ground-truthing and observing differences in socioeconomic data both confirm that Linden residents face significant barriers to scooter adoption.

Moving forward, we believe that Smart Columbus should implement studies such as ours in all neighborhoods deemed as “Opportunity Zones” by Columbus. These 44 city approved Opportunity Zones in Franklin County are categorized as such due to their low-income, high-poverty status. We recommend that the City implement a Smart Mobility Hub along Cleveland Avenue, particularly to mitigate the “last-mile” problem for residents when getting on and off the COTA bus along this corridor. Finally, we recommend that the City require Bird and Lime to market their government assisted programs more publicly as part of their contract with the city. For the next semester of capstone projects, we recommend that a group build upon the ground work we have conducted this past semester. Next steps should include surveying scooter riders in Linden to more conclusively determine the barriers hindering adoption of electric scooters in the Linden neighborhood. In these surveys, we recommend that the group enlist the assistance of Bird and Lime to provide scooter incentives to participants participating in the study. In return, the group can share the findings of their research with the two companies.

Introduction

Since their introduction to Columbus in July of 2018, dock-less electric Lime scooters have revolutionized individual mobility. Their adoption in the Linden Community has been limited compared to the neighboring Clintonville Community. Further research is needed to understand the limits to scooter adoption in Linden, and the value of scooters in addressing the limitations of mobility in Columbus. Our project research objectives are as follows:

- Analyze Geographic Information System (GIS) data of scooter usage in Columbus, specifically in Linden and Clintonville
- Ground-truth the Linden community for physical barriers and assets of scooter usage
- Examine scooter availability within the city of Columbus
- Analyze scooters applicability to the first-mile, last-mile issue in relation to Smart Mobility Hubs in Linden
- Compare scooter usage trends within Clintonville and Linden
- Identify existing barriers to scooter adoption, and research company programs that alleviate the impact of these barriers

This project addresses the City of Columbus' sustainability goals, which are outlined in MORPC's Sustainable 2050 plan. Specifically, Goal 3, Economic Activity, and Goal 4, Sustainable Neighborhoods, are addressed through this project. As a potential tool to overcoming the first-mile, last-mile barrier, scooters can be key in linking community members to potential jobs that were previously inaccessible. Thus, they are an important tool in the toolbox for building economic opportunity for the region - which addresses Goal 3. Scooters demand investment in local transportation infrastructure, as they cannot be ridden on sidewalks in Columbus, and roads are often unfit for scooter usage. This need for investment can help

propel the development of other transportation infrastructure, such as bike lanes, which addresses goal 4, Sustainable Neighborhoods. A potential goal to be addressed in the future continuation of the project is Goal 1, a reduction of energy consumption. The energy consumption of our mobility systems is impacted by scooter usage. This could mean replacing fossil-fuel powered, single occupancy vehicles with cleaner electric scooters. Alternatively, it could mean replacing walking – a carbon neutral mode of transportation – with electric scooters that are cleaner but still usually powered by fossil fuels.

Methods

The team was provided with Lime scooter ride data through contacts provided by Smart Columbus. This data ranged from summer of 2018, when scooters were first dropped into Columbus, to late January of 2019, when the data was received by the project group. This dataset contained start and stop coordinates, a time stamp, and ride distance of Lime scooter ridership. Through contacts at Bird, we discussed the potential of obtaining similar usage data from Bird scooters. However, this request did not result in the delivery of usage data in time for the project to be completed, so the only usage data used in the project was from Lime.

The initial start/stop coordinate data was input into ArcGIS and used to generate a heatmap, specifically focusing on the Linden Area. Next, we identified the number of rides starting and ending in Linden using the geolocations associated with each data point from our scooter usage database. This process was conducted through analysis using the ArcGIS tool. We mapped out these start and end points of rides to identify higher traffic areas or “hot spots” that couldn’t otherwise be seen in the heatmap. This information was used to formulate statistical analysis from the ride data and examine the differences between start and end points of usage.

To contextualize this data, we compared scooter usage in Linden to scooter usage in Clintonville, an area of similar size and proximity to the university but with a different demographic makeup. We compared ride statistics and heatmaps from both neighborhoods. Next, we completed demographics research to better compare the populations of Linden and Clintonville.

With data from the Mid-Ohio Regional Planning Commission (MORPC), we mapped the bus routes, bus stops, and bikeways, to identify the optimal routes for scooter travel and to better understand the viability of scooters in Linden. Using this map and the ride point maps, we highlighted a few areas in Linden with higher scooter activity. We then completed a ground-truthing assessment of these high activity areas, as well as other key travel routes in the neighborhood. This allowed our group to observe the physical barriers to scooter usage, as well as ensure we were seeing the neighborhood of assessment for ourselves beyond merely reading its statistics and quantitative analysis. Finally, using GIS, we identified the number of Linden rides starting or ending within 50 feet of a COTA bus stop. The frequency of rides ending and starting within such a close distance of a bus stop guided the team in understanding the role of scooters as a first-mile, last-mile solution for mobility.

Key Findings

1. Clintonville has 76% fewer residents than Linden, but has 3.6 times as many start rides

Throughout our research, our team chose to compare the Linden neighborhood with the Clintonville neighborhood in hopes of examining scooter usage in both areas. Both neighborhoods are similar in size: Linden has a total land area of 5.79 square miles and Clintonville has a total of 5.42 square miles (City Data, 2019). Figure 1 shows that Clintonville

has a population of 8,897 people, while North and South Linden have a combined population of 35,702 people. Thus, Clintonville has 76% fewer residents than the Linden neighborhood, and yet our analysis of ride data shows that Clintonville has 3.6 times as many start rides as Linden. Population is important to consider when finding scooter usage in a certain area since the scooters are provided in areas due to change in demand. The more scooters that are used in an area, the more scooters will be dropped off in that area in the morning. The process of scooter placement is carried out by contracted chargers, who are instructed by the company exactly where to pick up and drop off scooters. This shows that population is not driving demand. The location of the neighborhoods in respect to other attractive areas matters as well when determining demand.

Columbus Neighborhood	North Linden	South Linden	Clintonville	Columbus Total
Median Household Income	\$37.3K	\$22.3K	\$70.6K	\$47.2K
Population	26,617	9,085	8,897	837,038
Employment Status	58.30%	47.50%	73.30%	65.20%
Number of Households on Government Assisted Programs	3,466	1,651	92	59,168

Figure 1: Household Income Data for Linden and Clintonville

Another important aspect of Figure 1 below is the drastic difference in household income in both neighborhoods. Average household income in Clintonville is more than twice the average household income of Linden. This demographic data is important to mention when looking at the barriers to adoption. All data from the chart below was obtained from the Statistical Atlas of the United States. Even though Clintonville has a significantly lower population, their scooter usage

surpasses that of Linden. There are many further potential implications of these numbers, but two main assumptions can be made from these data:

- Household income is a barrier to adoption
- Greater population in numbers and intensity do not necessarily create a higher demand

2. 18.4% of Linden rides started within 50 feet of a bus stop, and only 5.4% ended within that buffer

By data analysis, our team found that 18.4% of Linden scooter rides started within 50 feet from a bus stop and 5.4% ended within the same 50 foot buffer. The number of rides and the average distance of rides can be seen in Figure 2 below. This information may suggest that scooters are being used as a last-mile solution, rather than a first-mile solution. If the scooters were being used as a first-mile solution for transportation, such as using the scooters from home to get to a bus stop, then more scooter rides would have ended within the 50 foot buffer from a bus stop. Since more scooter rides are starting within 50 feet of a bus stop, it shows that people are most likely using these scooters after using a public transportation service to go elsewhere after being dropped off.

	Number of Rides	% of Total Linden Rides	Average Distance of Ride (meters)
Rides starting within 50 ft of a bus stop in Linden	312	18.39%	4,623.2
Rides ending within 50 ft of a bus stop in Linden	123	5.40%	3,110.7

Figure 2: Number of Rides Within a 50 ft. Radius of a Bus stop

The map of the bus routes can be overlain on the Smart Mobility Hubs locations, and the start-stop heat maps for Linden. There are many bus stops along Cleveland Avenue. Seeing both the heat map in Figure 6, as well as the map of the bus routes in Figure 3, shows the direct correlation between bus stops and location of scooter usage.

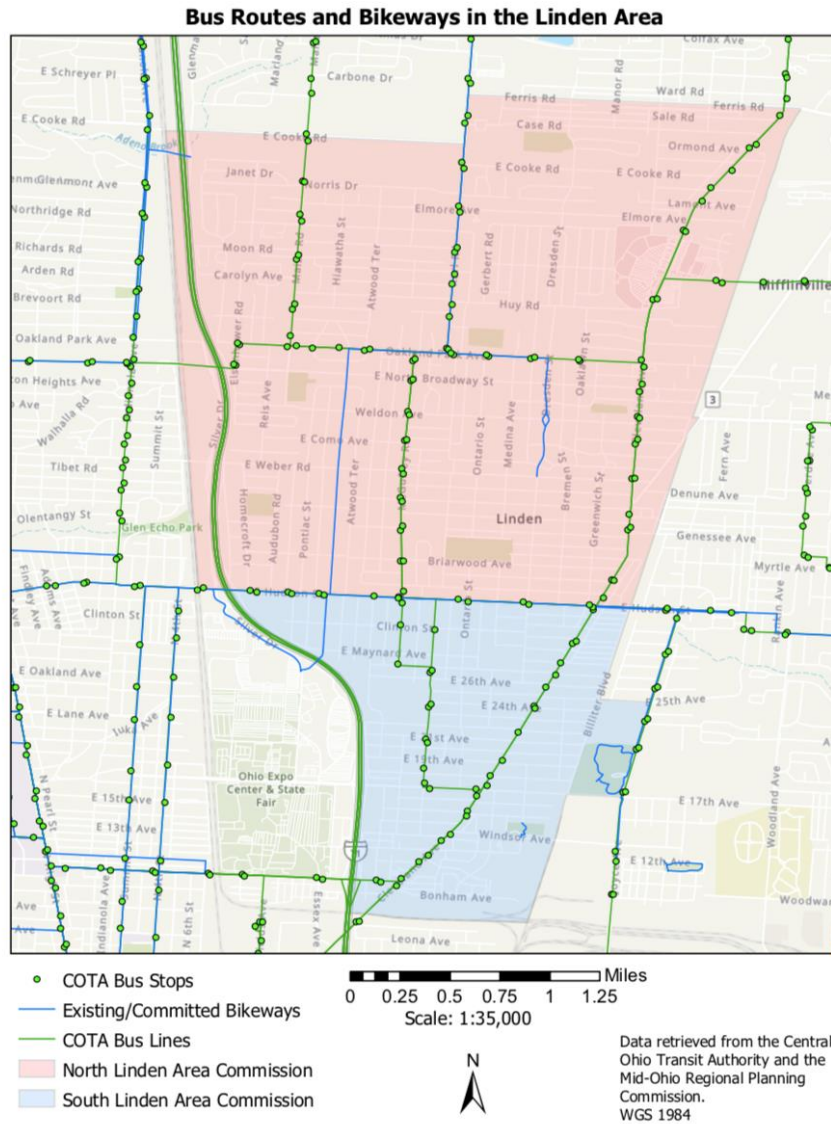


Figure 3: Map of Bus routes in Linden Neighborhood

3. Net inflow of total rides within both Linden neighborhoods and Clintonville is greater than net outflow

This finding can be seen in Table 4 below for both the Linden and Clintonville areas. Scooter rides ending in the two neighborhoods exceeds the number of rides starting in these areas. This shows that people are using scooters to get to the neighborhoods more often than leaving to go somewhere else. By data analysis, the team was able to discover that the rides that are ending in the two neighborhoods are often longer commutes than those starting in the neighborhoods.

	Number of Rides	% of Total Rides	Average Distance of Ride (Meters)
All Columbus Rides	252,347	100	1,869.1
Rides Starting in Linden	1,697	0.7%	3,745.7
Rides Ending in Linden	2,279	0.9%	4,202.2
Rides Starting in Clintonville	6,237	2.5%	2,883.4
Rides Ending in Clintonville	6,832	2.7%	2,928.5

Figure 4: Number of Rides Starting and Stopping in both Linden and Clintonville

4. Start and end data maps show that scooter trips gravitate towards Cleveland Avenue and existing transportation hubs

After GIS analysis, the heatmap below was developed. Cleveland Avenue serves as a hotspot of resources in the Linden Community. There are numerous bus stops and hubs of transportation that already exist on Cleveland Avenue. Smart Columbus has new Smart Mobility Hubs in their plan for this community, many of which will be also be located along Cleveland Avenue. The map in Figure 6 shows that scooter rides are gravitating toward Cleveland Avenue.

Visualizing these hot spots allowed a correlation to be seen from public transportation to scooter usage. The results suggest that scooters will be able to serve as a first-mile, last-mile solution in conjunction with the new Smart Mobility Hubs. after the implementation of these hubs, people will be able to ride scooters to and from public transportation drop offs and pick-ups in order to increase their efficiency and mobility.

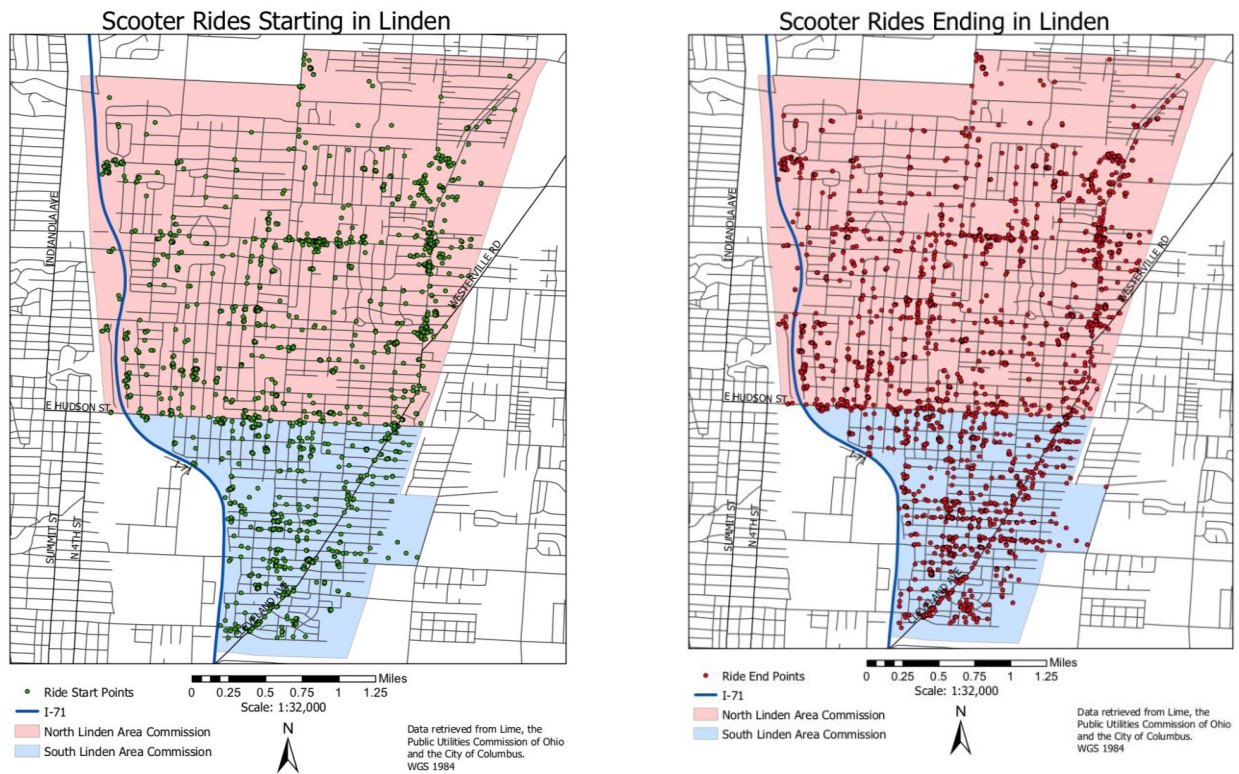


Figure 5: Start and Stop Map for Linden Neighborhood

Heatmap of Scooter Rides in Linden

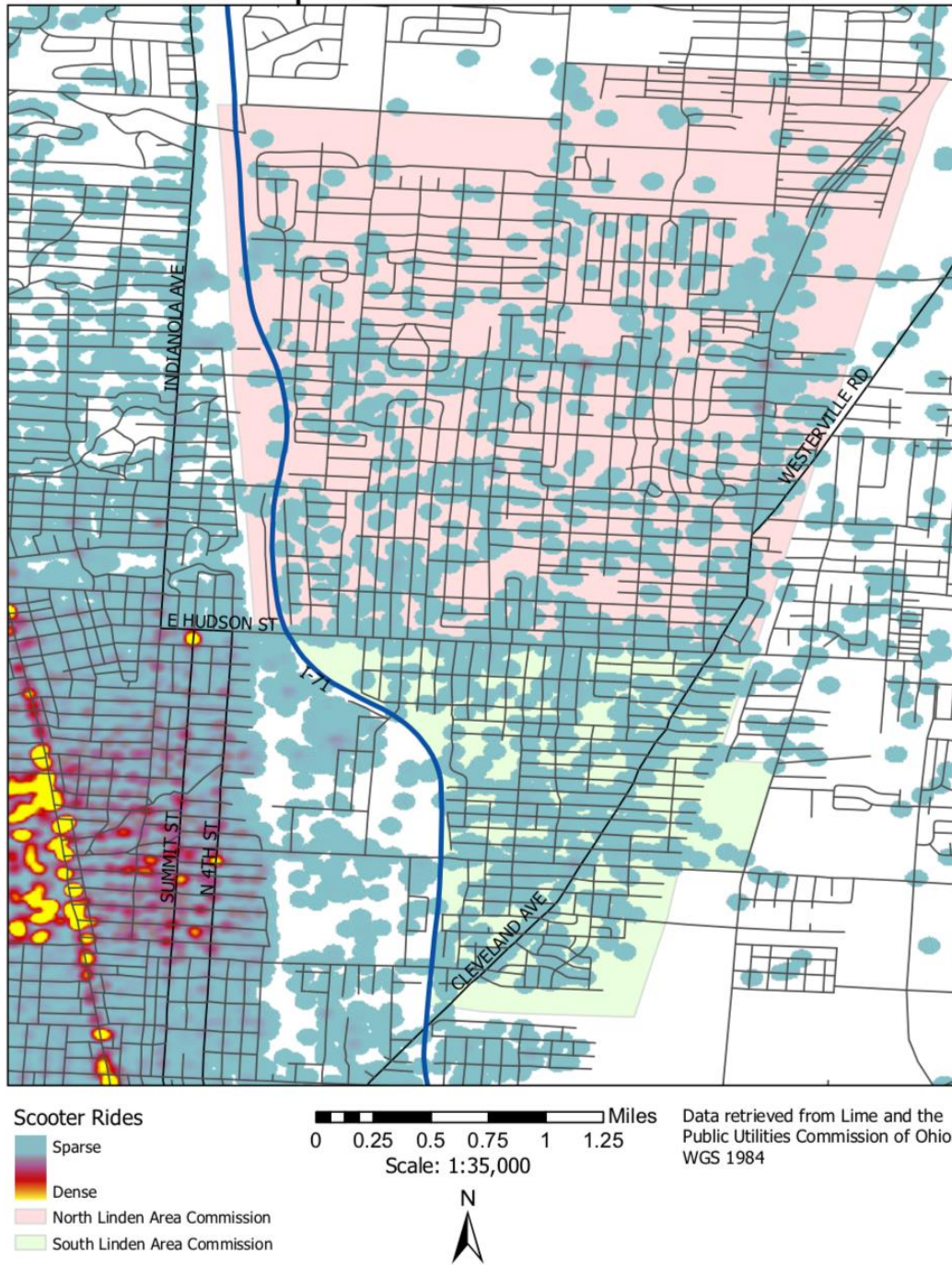


Figure 6: Heat map of all Start/Stop Rides in Linden

5. Ground-truthing suggests significant physical barriers to scooter usage: lack of bike lanes, curbed roads, and high-speed limits.

After ground-truthing in the Linden area, we were able to see many barriers that the residents of that area may face when deciding whether to ride a scooter or not. By driving up and down the main transportation corridors (Cleveland Avenue and Hudson Avenue), it was apparent that many people may not view these streets as safe for scooter usage. Main roads, such as Cleveland Avenue, had speed limits of 35 mph or greater, compared to the residential speed limit of 25 mph. Additionally, there are 4 or 5 lanes of traffic on major roads, rather than 2 lane roads in quieter residential areas. Since scooters are required to be ridden on the street, Lime scooters may be perceived as an unsafe mode of transportation within the area due to these conditions.



Figure 7: Ground-truthing in Linden. Photo credits: Riley Nowacki.

6. Inconvenient and under-marketed cash-only scooter payment programs erase many of the conveniences of dock-less scooters

Currently, the company Lime has affordable options for people that may need assistance in order to make their services more accessible to others. Lime offers a text to unlock a feature for residents that do not have a credit card, bank account or smartphone. This text-to-unlock feature allows people to send a simple text message in order to ride the scooter. They also have prepaid cards available for people that do not own a credit or debit card. Additionally, Lime offers a reduced rate by waving the one-dollar startup fee, as well as a discounted ride for people that are already participating in government-assisted programs. For this, the user has to apply for the discounted rate in order to be considered. Throughout our research, our team found that the programs that are offered seem to be under marketed and little known. For example, even when team members sought information on these programs, it was challenging to access information on them. Without knowing that these programs exist, they are next to impossible to learn more about within the Lime app and website. Finding new ways to market these government assisted programs would greatly benefit communities like Linden by reducing the barriers to scooter adoption.

7. Ground-truthing indicates that Bird Scooters are nearly absent in the Linden neighborhood

Throughout our time ground-truthing in Linden, we drove up Cleveland Avenue, as well as many side streets. Through this, the team obtained a better understanding of the area's characteristics for scooter riding, as well as an estimate of scooters available to ride. Our team discovered that there were no Bird scooters available in the Linden neighborhood, and none

could be found in the Bird smartphone app to rent either. Lime was the only scooter service available in the area This observation was subsequently confirmed by an article published by the Columbus Underground, which observed changes to Bird’s service area that now excludes many of the opportunity zones in Columbus that Lime continues to serve.

Recommendations

Like many short-term projects, our analysis left us with more questions than answers. While we have several strong takeaways from our research, we hope that it can act as a foundation for future groups to continue this work. Our intent was to understand how Linden scooter usage compares to other areas of Columbus, especially Clintonville. After understanding that there were discrepancies in usage between Linden and other communities, we began the work of identifying possible barriers to usage.

While this project focuses on the actions of private companies and the regulations of the City of Columbus, The Ohio State University can play the role of researcher and educator. We hope that our project has laid the groundwork for future projects to dive deeper into the barriers to scooter usage to better understand how they can be reduced. We have several recommendations for the organizers of AEDECON 4567, the City of Columbus and any other group looking to delve into this topic:

- Future efforts should focus more on barriers to adoption, and survey people within the communities to better understand what barriers exist.
- Extend the bus stop analysis to all communities within the operating boundaries of the scooters.
- Review the bus stop buffer width of 50 feet and keep or revise it.

- Enlist Bird and Lime to help administer surveys.
- Create an ongoing dialogue with Bird and Lime so that future groups have access to data that we could not receive.
- Meet with city officials who have been most involved with the permitting and regulating of scooters in Columbus.
- Get enrollment data for Lime and Bird's scooter assistance programs, which are aimed towards helping low-income communities like Linden.

While our group did the best we could with the information we were able to gather, there are some limitations to our work. Firstly, our project did not incorporate or attempt to incorporate the surveying of residents in the area. Our work does not contain the words or first-hand experiences of the residents of Linden, and our observations are from the position of an outsider.

Secondly, the team agreed on certain buffer boundaries to use with our GIS data in order to make the data useful for our project. These boundaries may not reflect the preferences and techniques of the City of Columbus. For instance, future groups may want to enlarge the 50ft buffer that we used in calculating the rides that started and ended near a bus stop. Additionally, our bus stop analysis should be applied to the COTA data for the rest of Columbus in order to see if scooters serve as a last-mile or first-mile transportation method.

Finally, there are several additional factors that could be examined in future studies. The scope of this expansion should include the entire city of Columbus, and all 44 opportunity zones within central Ohio.. The scope and depth of this project can be expanded to:

- Overlay speed limit data with scooter usage, and observe trends.

- Incorporate an in-app survey that was tentatively offered, but not delivered, by Bird Scooter.
- Further analyze the significant differences in average ride distances between Linden and Clintonville.
- Survey and perform statistical analyses on the other Opportunity Neighborhoods in Columbus, and every community in the Combined Metro Area.

Conclusion

Though trends in scooter usage are similar within both the Linden and Clintonville neighborhoods, the volume of scooter usage is significantly greater in Clintonville than in Linden. Both neighborhoods are equidistant to The Ohio State University -- a significant source of demand for scooters. Thus, both neighborhoods should be experiencing similar scooter usage trends. However, our research reveals that scooter adoption in Linden is limited. Ground-truthing and observing differences in socioeconomic data confirm that Linden residents face significant barriers to scooter adoption. However, our research indicates that scooters are used as a last-mile solution in conjunction with COTA busses. There are a multitude of possible next steps for research, which could include the surveying of Linden citizens. We look forward to future research that can explore how barriers to usage can be identified and alleviated.

Annotated Bibliography

“Bird’s Shifting Boundaries Exclude Some Neighborhoods”. *The Columbus Underground*,
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This article details the changes of Bird’s service area during the time that this project was being completed. It includes maps of Bird’s service areas in March and April of 2019, comparing the changes of service areas throughout this time.

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Household Income in South Linden, Columbus, Ohio (Neighborhood).” *The Demographic Statistical Atlas of the United States - Statistical Atlas*,

[statisticalatlas.com/neighborhood/Ohio/Columbus/South-Linden/Household-Income](https://www.statisticalatlas.com/neighborhood/Ohio/Columbus/South-Linden/Household-Income).

This online atlas was utilized to gather demographic information on the City of Columbus, specifically measures of household income. StatisticalAtlas.com sources its data “from the US Census Bureau, specifically from the 2010 census, and from the 2012-2016 American Community Survey.”

Lime Scooter Usage Data July 2018-January 2019. City of Columbus.

This excel document contained Lime scooter usage data, upon which the entirety of this project was based on. This data was provided to the team on February 7th by Zach McGuire, the manager of smart mobility adoption at Smart Columbus.

Van Blarcum, Miles E, et al. “Discussion with Sam Reed from Bird Scooter.” 6 Feb 2019.

This was the project group’s first phone call with Sam Reed, a representative of the company

Bird. Within this conversation, information on the company, its operations, and decision-making processes, was gathered.

Van Blarcum, Miles E, et al. "Second Discussion with Sam Reed from Bird Scooter." 21 Feb 2019.

This was the project group's second and last phone call with Sam Reed, a representative of the company Bird. Within this conversation, information on the company, its operations, and decision-making processes, was gathered.