Chicago Micro-mobility Analysis (Divvy)

15 Jan 2024

Contents

Introduction

Within the dynamic urban landscape of Chicago, the introduction of micro-mobility has reshaped local transportation, providing a flexible and eco-conscious alternative for short-distance travel. One such player in this evolving scenario is Divvy, a micro-mobility company offering bicycles and electric scooters to meet the increasing demand for convenient and sustainable mobility solutions.

This project initiates a thorough analysis of Divvy's operations, utilizing data sourced from the Open Data Portal of Chicago. The primary objective is to impartially evaluate the cost-benefit dynamics of Divvy's services and comprehend user travel patterns, with specific attention to electric scooter usage. Additionally, the analysis delves into the financial considerations associated with supplying micro-mobility to diverse parts of the city, aiming to provide insights for strategic decision-making.

As the exploration unfolds within Divvy's micro-mobility network, the goal is to discern trends, optimize service delivery, and contribute to a comprehensive understanding of Divvy's role in addressing the varied transportation needs of urban residents in Chicago. This integrated analysis includes the development of an Origin-Destination matrix, exploration of scooter usage patterns, and a comprehensive calculation of costs related to bike supply, all aimed at offering an impartial and holistic perspective on Divvy's impact in the urban transportation landscape.

Chicago, situated in the heart of the Midwest, stands as one of the most populous and influential cities in the United States. Nestled along the southwestern shore of Lake Michigan, it is the third most populous city in the nation and a pivotal economic and cultural hub. With a population exceeding 2.7 million residents, Chicago's metropolitan area extends its reach far beyond the city limits, encompassing a diverse tapestry of neighborhoods, industries, and communities.

The city's transportation infrastructure plays a crucial role in facilitating the daily lives of its residents and the mobility of the workforce. Chicago's comprehensive public transit system, operated by the Chicago Transit Authority (CTA), encompasses an extensive network of buses and trains that connect various neighborhoods and suburbs. Additionally, the city embraces a variety of transportation options, including ride-hailing services, bike-sharing programs, and micro-mobility solutions, contributing to the overall accessibility and fluidity of the urban mobility landscape.

As we delve into the analysis of micro-mobility data from June 2013 to December 2019, our focus extends beyond the city's bustling streets to understand the intricate relationship between micro-mobility, public transport, and private vehicles. This exploration aims to unravel the complexities of Chicago's transportation ecosystem, shedding light on how micro-mobility intertwines with broader mobility trends within the city and its contiguous areas.

Preliminary analysis

Data Cleaning Overview

- Before the data cleaning process, the dataset exhibited 21,242,740 rows (TRIP ID). Recognizing missing values in critical columns (LATITUDE, LONGITUDE, GENDER, BIRTH YEAR), the prioritized approach involved cleaning LATITUDE and LONGITUDE columns first. Subsequently, data cleaning for GENDER and BIRTH YEAR columns was executed separately, opting for the removal of rows with missing values.

- Post-cleaning, the dataset now features 21,241,850 rows for each column, with all essential columns (LATITUDE and LONGITUDE) free of null values. The data types encompass integers, objects, and floats, successfully addressing the identified 'bad data' concerns across multiple columns. Notably, the data cleaning process resolved 890 instances of 'bad data' in the dataset.

- Data Collection Period for Micro-Mobility Dataset: Commencement and Latest Timestamps
  Start: 27/06/2013 01:06:00
  Recent: 31/12/2019 23:57:17

Comprehensive Analysis of Micro-Mobility Trends:

Yearly Trend:

The data reveals a consistent upward trajectory in bike-sharing usage over the years, with a particularly pronounced surge from 2013 to 2014. This notable increase is partially attributed to the fact that our dataset commenced in June 2013, resulting in a seemingly dramatic rise as the initial months are underrepresented.

While the general trend indicates positive growth, it is noteworthy that a modest decline occurred from 2017 to 2018. Although we won't delve further into the specifics of this decrease, a plausible explanation could involve various factors such as seasonal variations, evolving user preferences, or adjustments in bike-sharing program dynamics during that period.

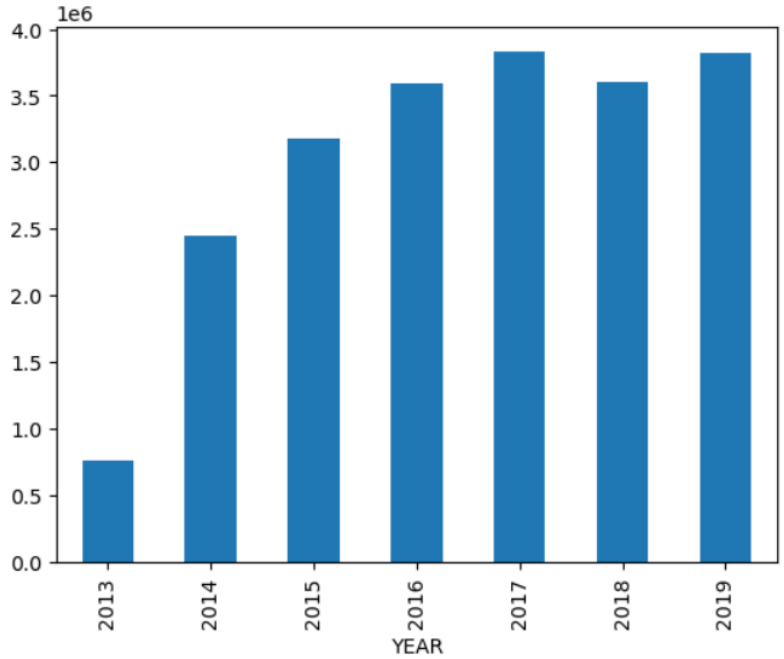


Figure 1: Number of Trips per Year

Monthly Trend:

The data illustrates a clear monthly and seasonal pattern, with the majority of bike-sharing trips occurring predominantly from June to October. During these warmer months, there is a noticeable uptick in user engagement, indicative of heightened interest and utilization of bike-sharing services. Conversely, the trend shows a decline in bike-sharing activity during colder months, suggesting a correlation between weather conditions and user engagement. This seasonal fluctuation aligns with the expected behavioral response to weather, where individuals are more inclined to participate in outdoor activities like bike-sharing during milder and warmer seasons.

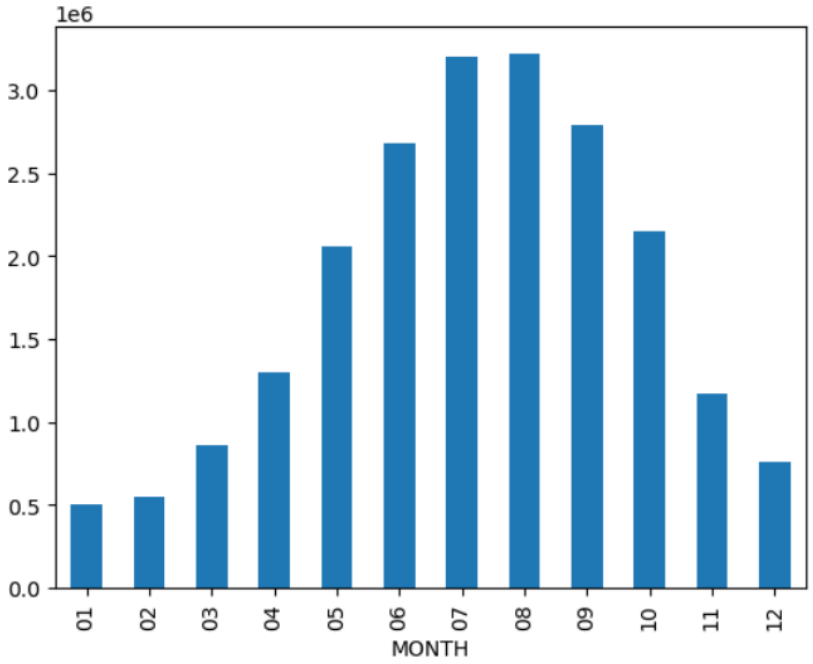


Figure 2: Number of Trips per Month

Also, the figure in below shows the amounts of trips by Divvy bikes in Chicago in each month of each year.

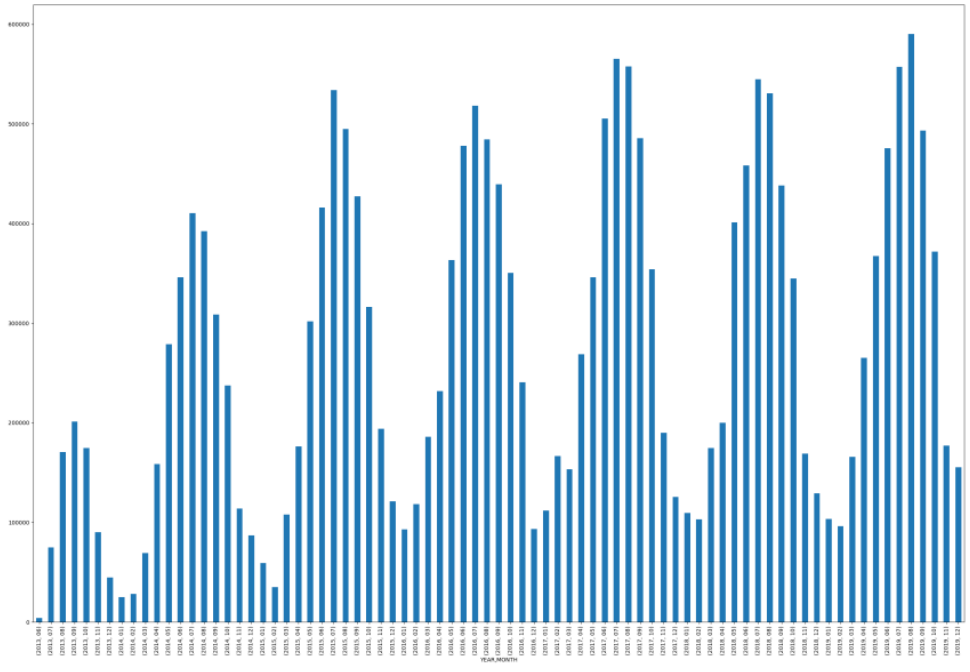


Figure 3: Number of Trips per Year and Month

The distribution of records per year and month in the micro-mobility dataset is presented in Figure 3. Notably, a significant concentration of data falls within the mid-year period, specifically from June to

October. This observation aligns with a consistent trend across the years, wherein the majority of recorded data points exhibit an upward trajectory. The overall pattern suggests a recurring increase in micro-mobility dataset entries annually, with a particular emphasis on the warmer months. This trend may reflect heightened user engagement and increased micro-mobility activity during the more favorable weather conditions typical of the mid-year period.

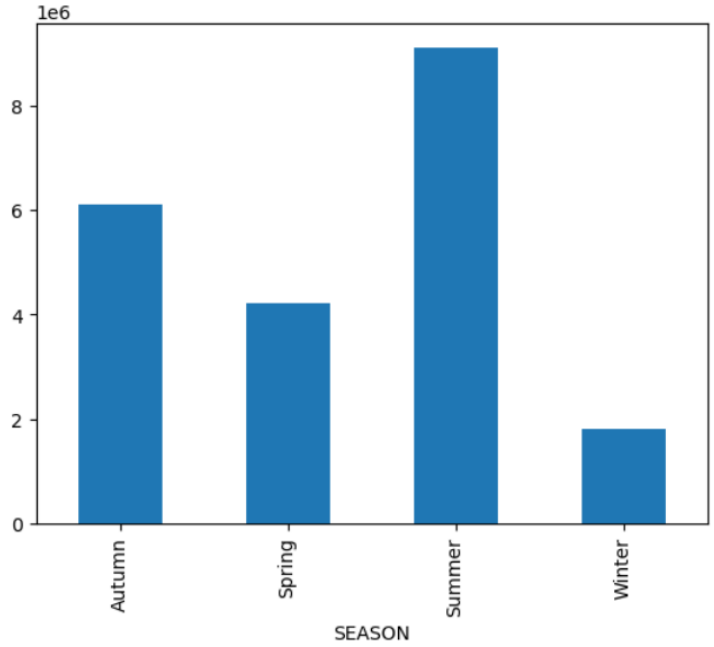


Figure 4: Number of Trips per Season

The data reveals a higher frequency of trips during the summer, followed by a notable presence in the autumn season.

Day of Week Trend:

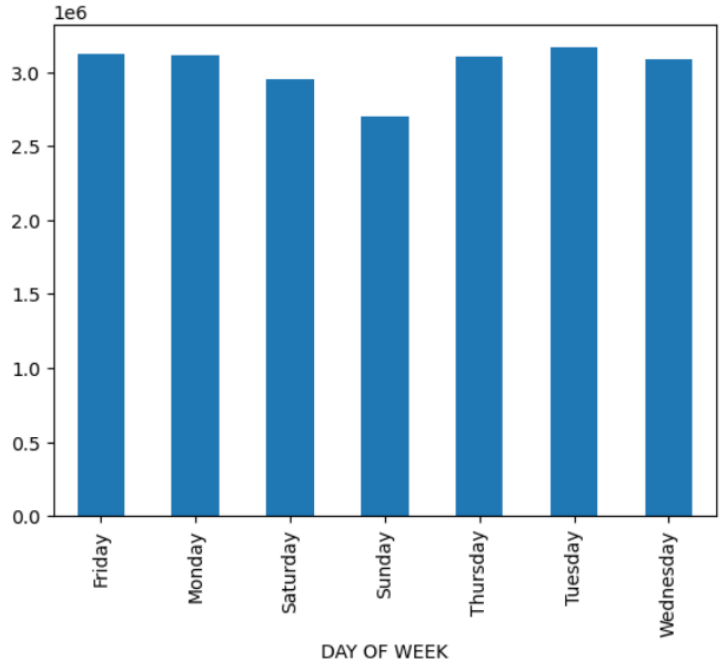


Figure 5: Number of Trips per Day

The examination of bike-sharing data for Chicago illuminates a noteworthy prevalence of trip occurrences on weekdays, suggesting that the bike-sharing system is particularly popular during regular workdays. Despite this emphasis on weekdays, an intriguing finding emerges as the observed disparity between weekdays and weekends is relatively marginal. This nuanced insight suggests that, while there is a slight dip in bike-sharing activities during weekends, the service maintains a consistent level of utilization throughout the week. This finding may point to a diverse range of users, including both commuters relying on the system for daily transportation needs during the workweek and individuals using it for recreational purposes on weekends. The subtle difference in usage patterns between weekdays and weekends adds depth to our understanding of how bike-sharing is integrated into the daily lives of Chicago residents.

Gender Trend:

The analysis demonstrates a consistent upward trend in the overall number of trips over the years. Notably, there has been a persistent disparity, with the proportion of male users consistently surpassing that of female users throughout the observed period.

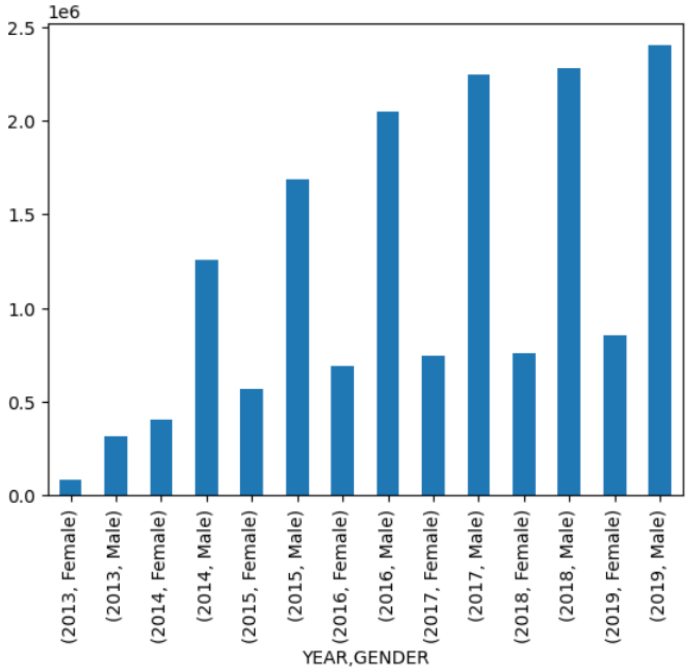


Figure 6: Number of Trips per Gender per Year

The consistent trend is observed across genders, where the preference for micro-mobility modes of transport is more pronounced during the warmer months.

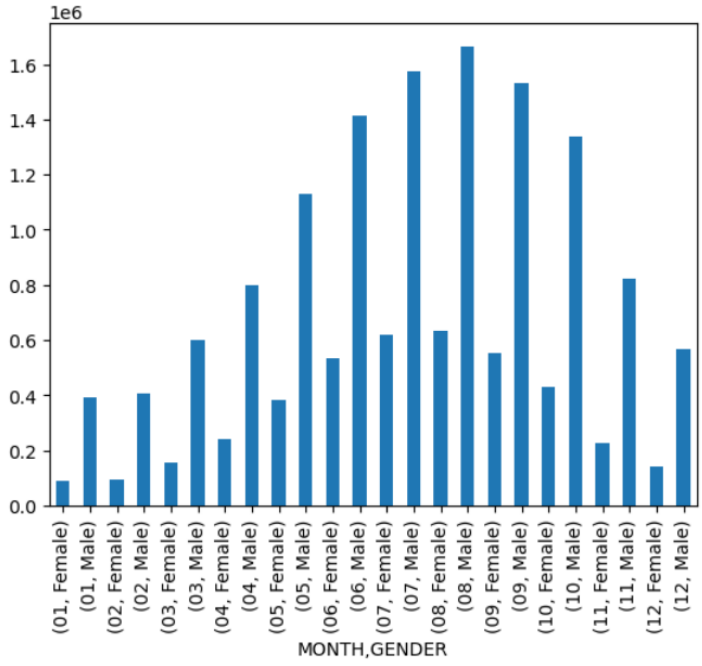


Figure 7: Number of Trips per Gender per Month

Age Trend:

The data analysis brings to light a notable trend, indicating that the predominant age group among bike-sharing users in Chicago falls within the 19-40 years old bracket. This age range emerges as the primary demographic segment, showcasing a strong affinity for utilizing bike-sharing services. The significance of this age group in the user base suggests that young to middle-aged individuals are key contributors to the popularity and adoption of bike-sharing in the city.

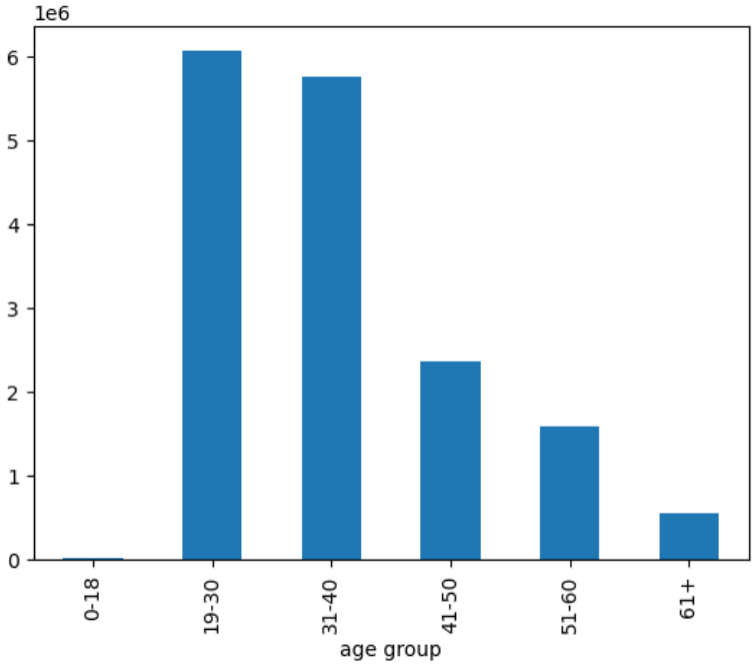


Figure 8: Number of Trips based on Users' Age Groups

OD Matrices

Introduction

Proceeding with the analysis, the next step involves the computation of Origin-Destination (O-D) matrices, representing the number of bookings originating in ward 'i' and concluding in ward 'j.' To enhance the interpretability of the results, efforts will be made to visualize the O-D matrices in a meaningful manner.

Following this, the project will progress towards the preparation of O-D matrices for different years and distinct age groups. Specifically, three O-D matrices will be created for each age group, covering a span of three consecutive years. The exploration aims to identify any discernible periodicities or trends within the data and assess potential differences between O-D matrices for various age groups.

As part of the visualization process, selected O-D matrices demonstrating trends or periodicities will be represented on a map. This spatial representation offers a more intuitive understanding of the mobility patterns across different wards over time.

For an added challenge, participants may choose to create a flow map, providing a visually compelling depiction of the O-D matrices. This advanced visualization technique can offer a comprehensive and dynamic view of the movement patterns within the specified wards over the given time frame.

Heat Map of OD Matrices

2016

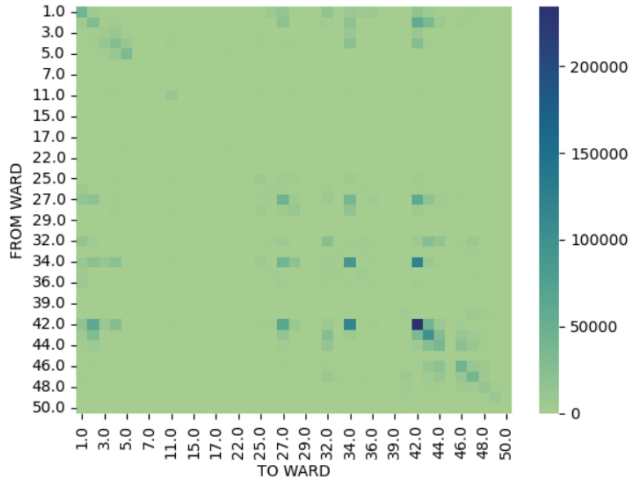


Figure 1- 2016 General Matrix

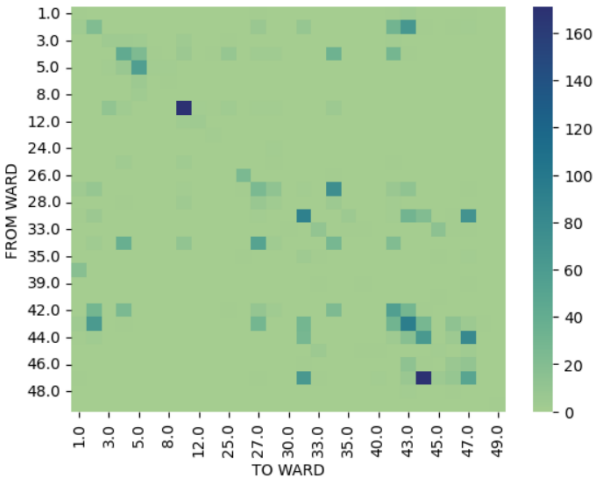


Figure 2- 2016 age under 18 Matrix

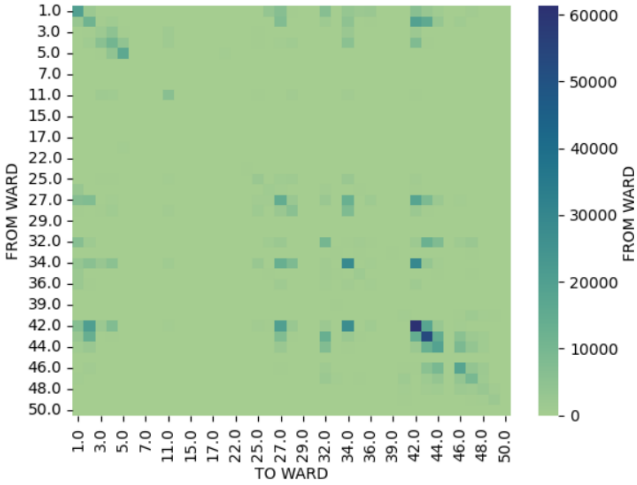


Figure 3- 2016 age 19-30 Matrix

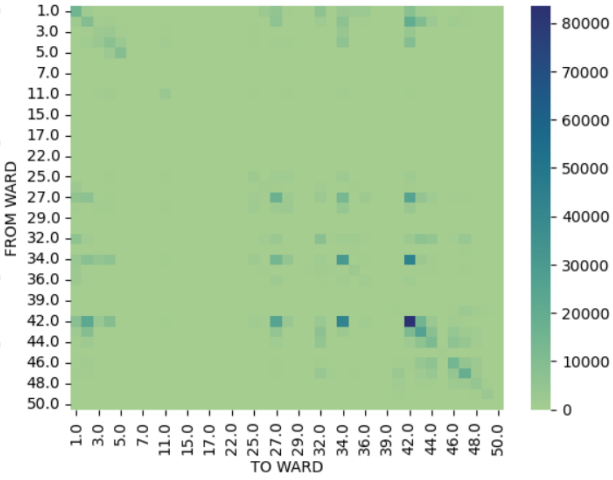


Figure 4- 2016 age 31-40 Matrix

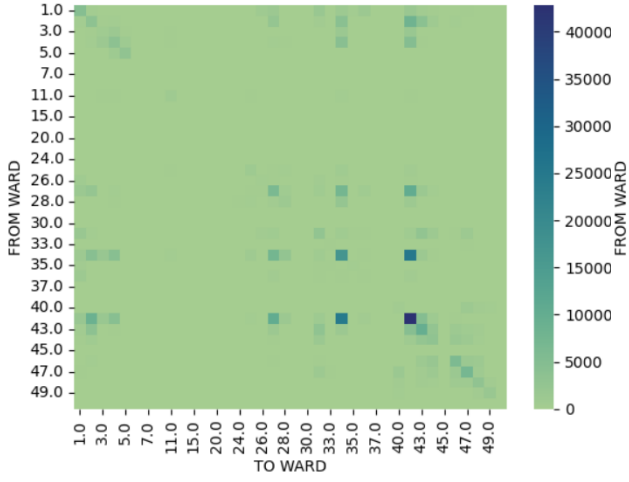


Figure 5- 2016 age 41-50 Matrix

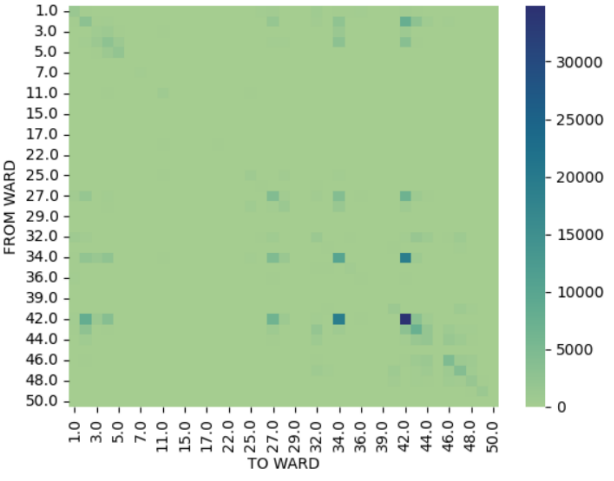


Figure 6- 2016 age 51-60 Matrix

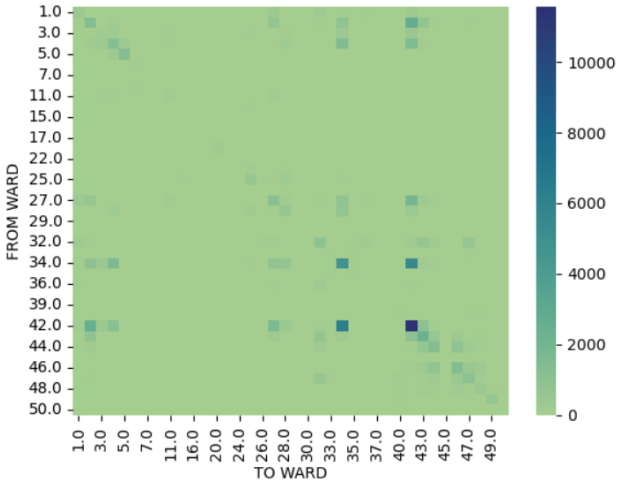


Figure 7- 2016 age more than 61 Matrix

Upon comprehensive analysis of the matrices, distinct trends in micro-mobility patterns across different wards and age groups have emerged. These observations shed light on the preferences and mobility dynamics within the specified regions over the course of the year. The following trends encapsulate the noteworthy findings:

- In 2016, Ward 42 emerges as the focal point for micro-mobility, hosting the majority of trips.
- Subsequently, Wards 34 and 43, along with trips connecting these three wards, constitute prominent mobility patterns in 2016.
- It shows that most of the teenagers' trips (under 18) in 2016 happened in ward 10 and 44. After that there are wards 27, 30, etc.
- For the age group of 19-30, Wards 42 and 43 take precedence as primary locations for trips in 2016.
- The age group of 31-40 exhibits a similar trend, with Ward 42 serving as the central hub for most trips in 2016.
- Additionally, Wards 43, 34, and 27, along with inter-ward trips, contribute significantly to the mobility patterns within this age group.
- Comparable patterns persist for the age groups of 41-50, 51-60, and above 61 years old, with Wards 42, 34, and 27 maintaining their significance.

In summation, it becomes evident that Wards 42, 34, and 27 emerge as pivotal locations for micro-mobility across various age groups. However, Ward 5 stands out as a distinct attraction for young people, predominantly accommodating their travel activities.

2017

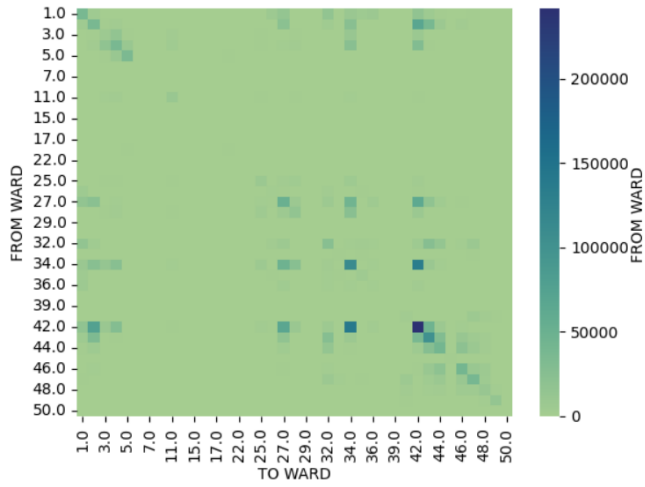


Figure 8- 2017 General Matrix

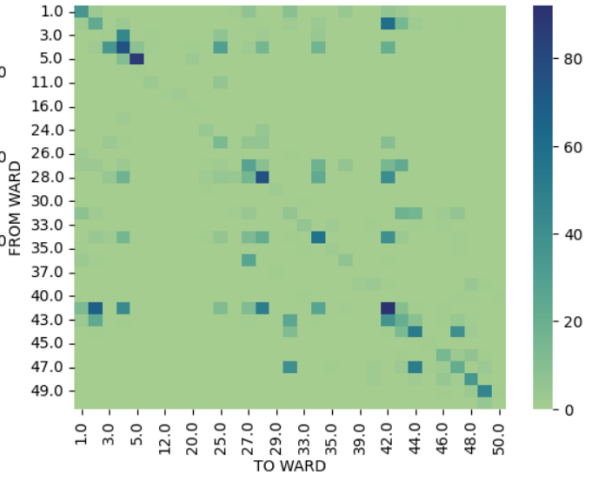


Figure 9- 2017 age under 18 Matrix

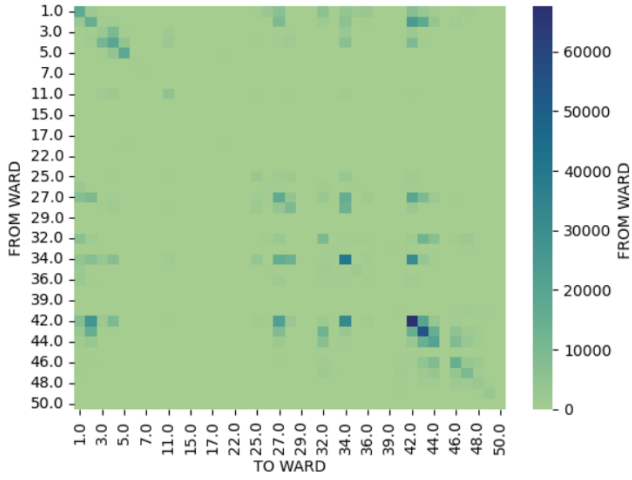


Figure 10- 2017 age 19-30 Matrix

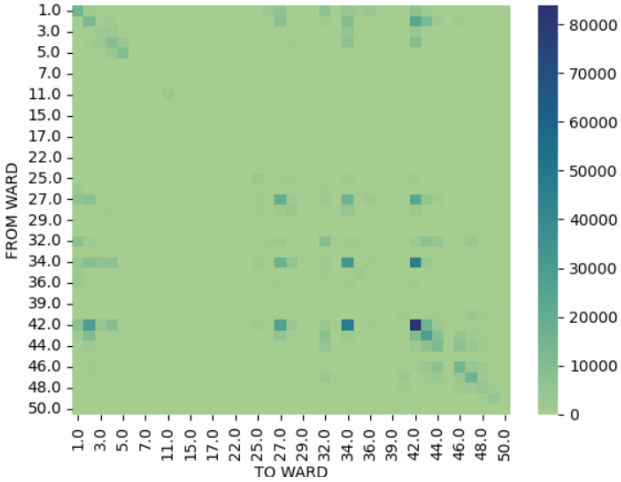


Figure 11- 2017 age 31-40 Matrix

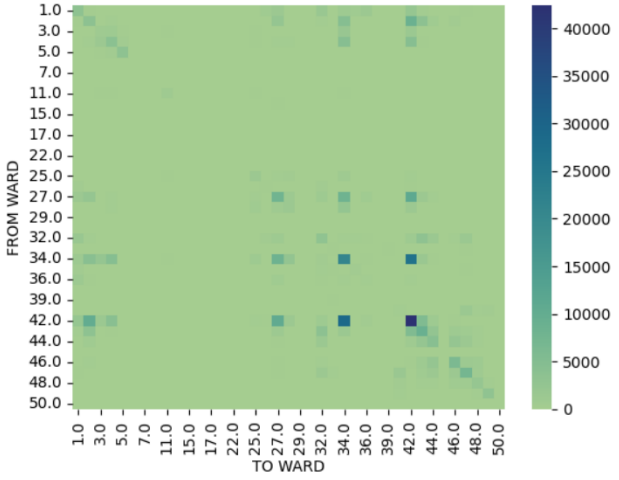


Figure 12- 2017 age 41-50 Matrix

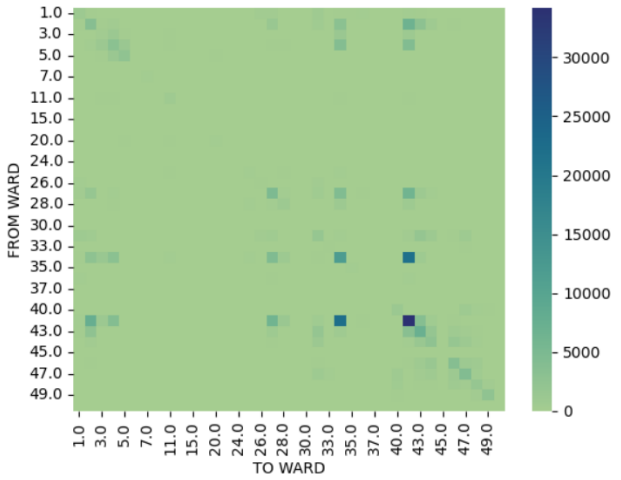


Figure 13- 2017 age 51-60 Matrix

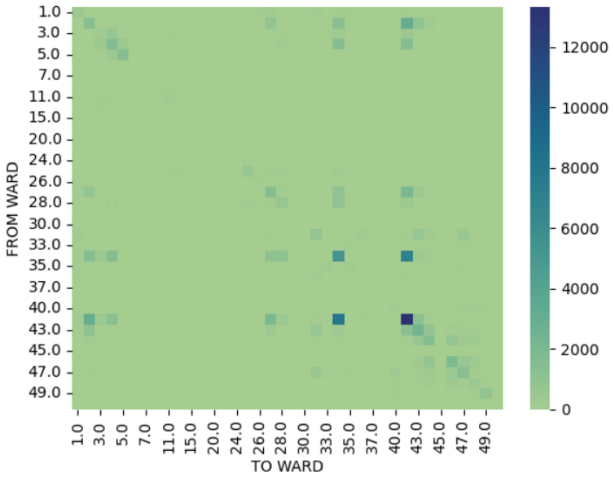


Figure 14- 2017 age more than 61 Matrix

In general, for the entirety of 2017, the predominant trips occurred within Ward 42, with subsequent significant movements from Ward 42 to Ward 34. Trips within Ward 34 and from Ward 34 to 42 followed closely in frequency.

- For individuals under 18 in 2017, trips mostly happened inside the ward 5 and 42. also from ward 42 to 2.
- Analysis of age groups reveals that, in 2017, the majority of trips for individuals aged 19-30 transpired in Ward 5, with subsequent prominent wards being 42, 43, and 34.
- Similarly, individuals aged 31-40 predominantly made trips in 2017 within Ward 42, with subsequent noteworthy movements in Wards 43 and 34, reflecting a consistent pattern among these age cohorts.
- Trips for individuals aged 41-50 in 2017 predominantly occurred in Wards 42 and 34, and this pattern persisted among individuals aged 51-60, showcasing a similarity in mobility trends among these age groups.
- This pattern extends to the older demographic (above 61), where trips were notably concentrated in Wards 42 and 34 throughout the year 2017.

2018

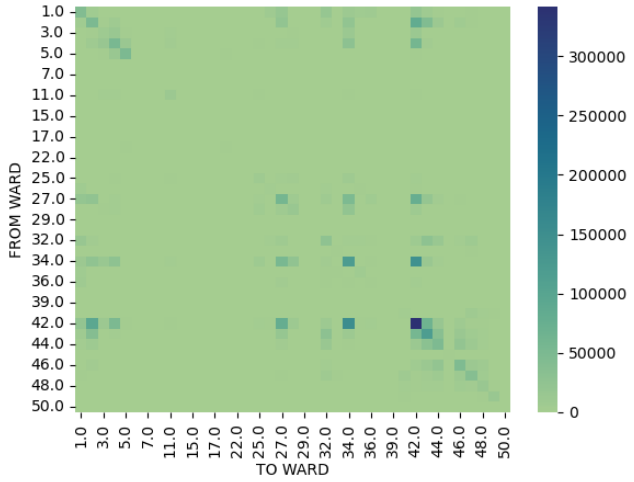


Figure 15- 2018 General Matrix

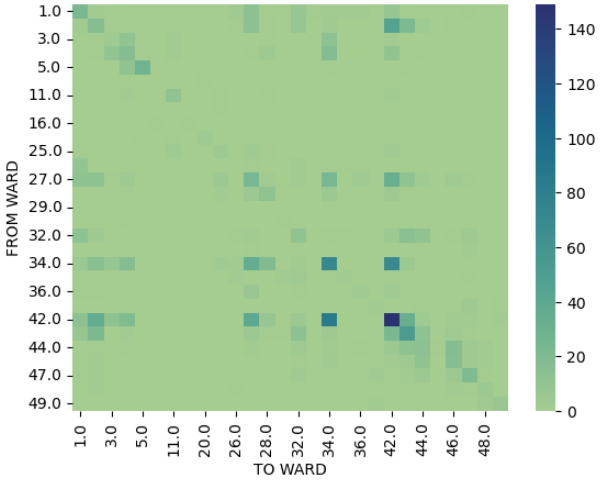


Figure 16- 2018 age under 18 Matrix

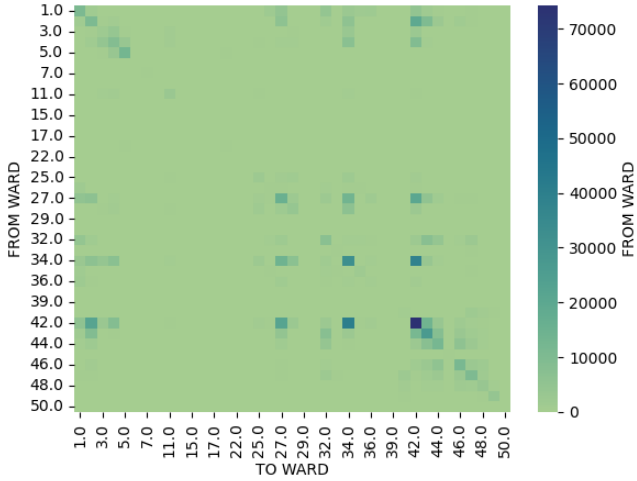


Figure 27- 2018 age 19-30 Matrix

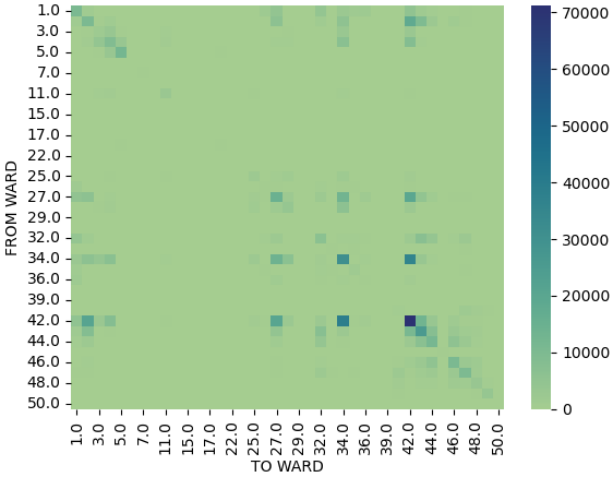


Figure 18- 2018 age 31-40 Matrix

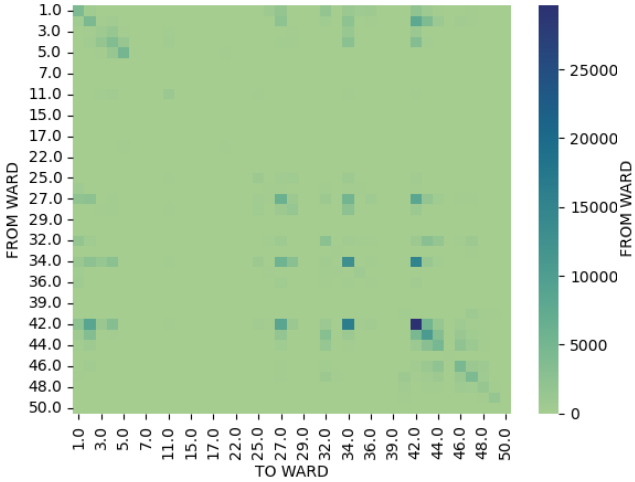


Figure 39- 2018 age 41-50 Matrix

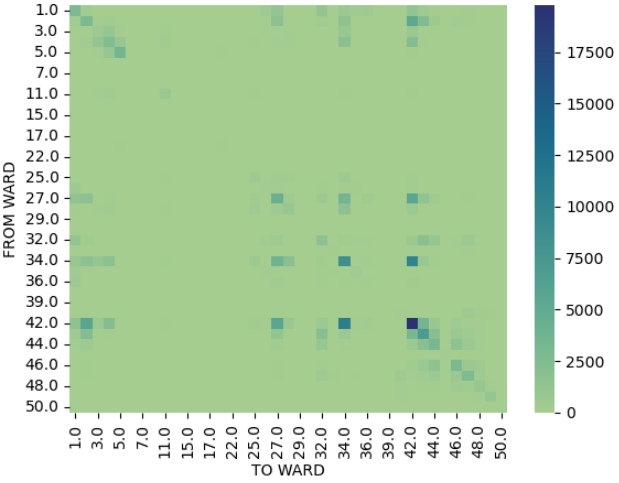


Figure 20- 2018 age 51-60 Matrix

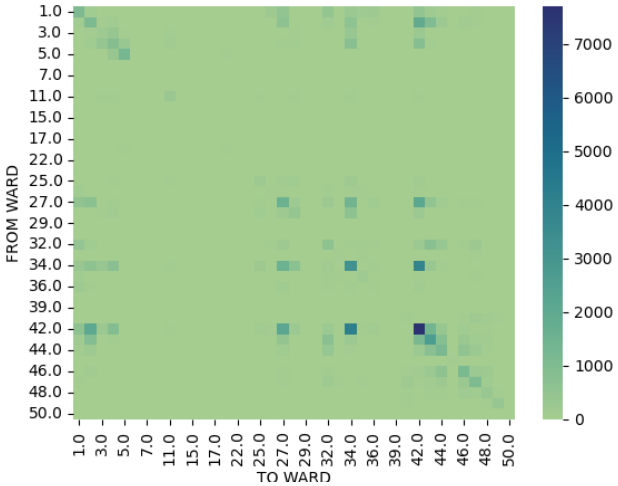


Figure 21- 2018 age more than 61 Matrix

- It shows that in 2018, the most of the teenagers' trips happened inside ward 42 and 34 and also between these two wards.
- Young Adults (19-30) in 2018 predominantly had their trips within Ward 5, highlighting its popularity among this age group. Ward 42, 34, and 44 followed in descending order of preference.
- Travelers aged 31-40 showed a different trend, with Ward 42 being the primary destination, and Ward 44 securing the second spot. Interestingly, Ward 5 was less appealing to this age group, unlike its popularity among the younger demographic.
- The 41-50 age group exhibited a similar pattern to the 31-40 group, with Ward 42 leading in trip occurrences, followed by Ward 34. Notably, there was a notable volume of trips between these two wards.
- The trend persisted for individuals aged 51-60, further emphasizing the significance of Ward 42 as a preferred zone for mobility, with Ward 34 maintaining its prominence.
- Travelers aged 61 and above displayed a distinct preference, mostly choosing Ward 42 for their trips, followed by movements between Ward 42 and Ward 34.

In summary, Ward 42 emerges as a pivotal zone in micro-mobility, with Ward 34 following closely. While Ward 5 remains a hotspot for young people, its appeal diminishes for other age groups.

Flow Map

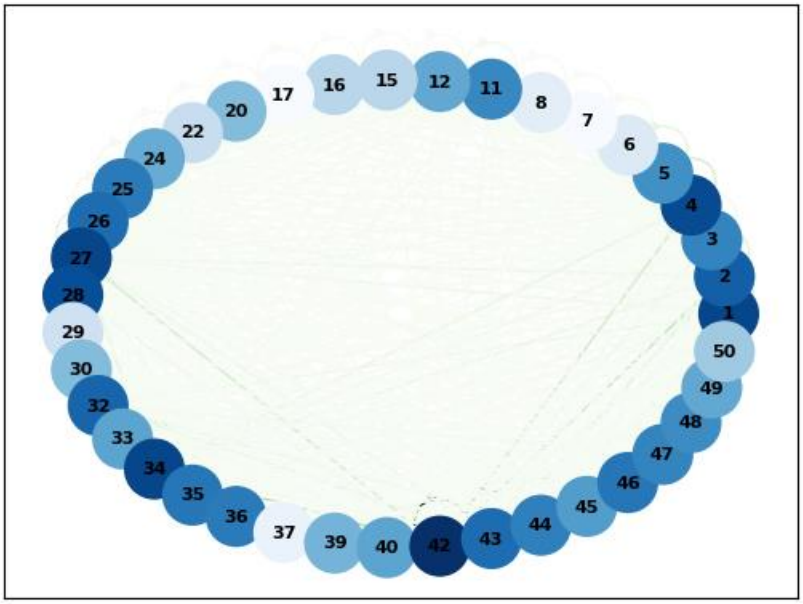


Figure 22- 2016 Flow-Map

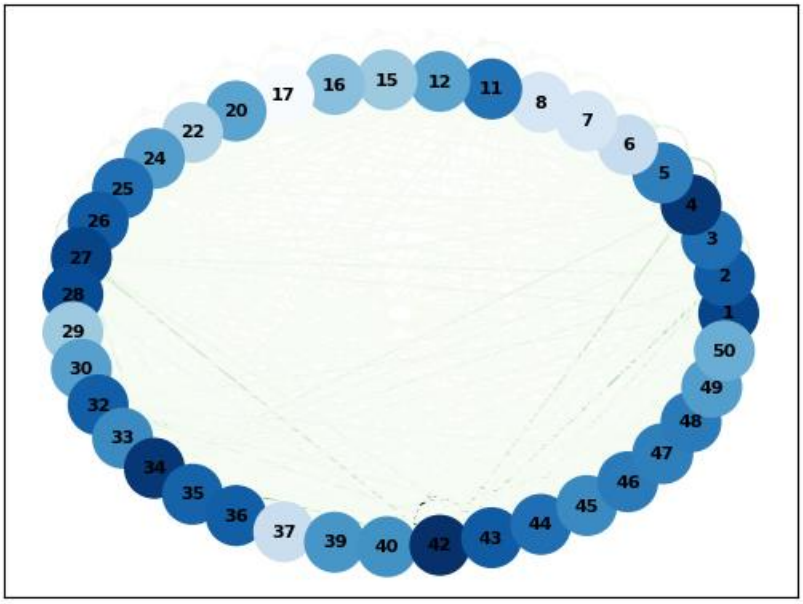


Figure 23- 2017 Flow-Map

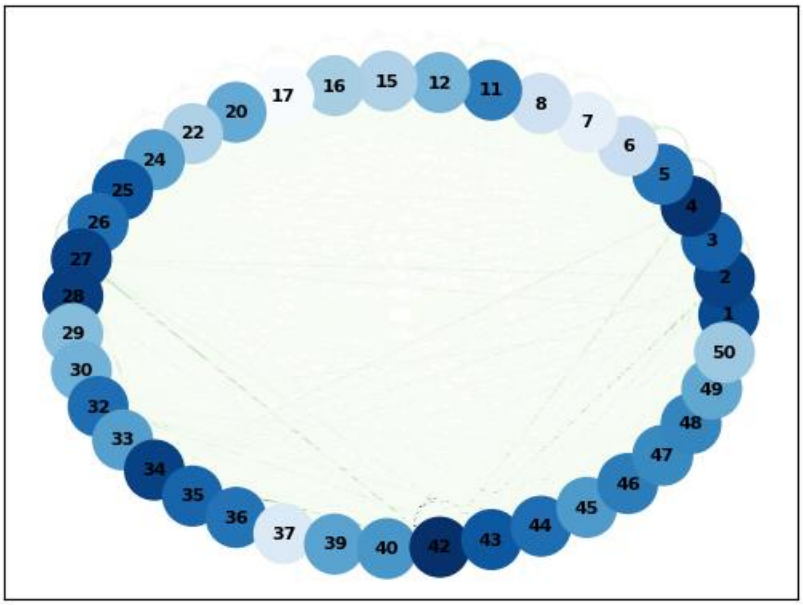


Figure 24- 2018 Flow-Map

Relation to Public transport line

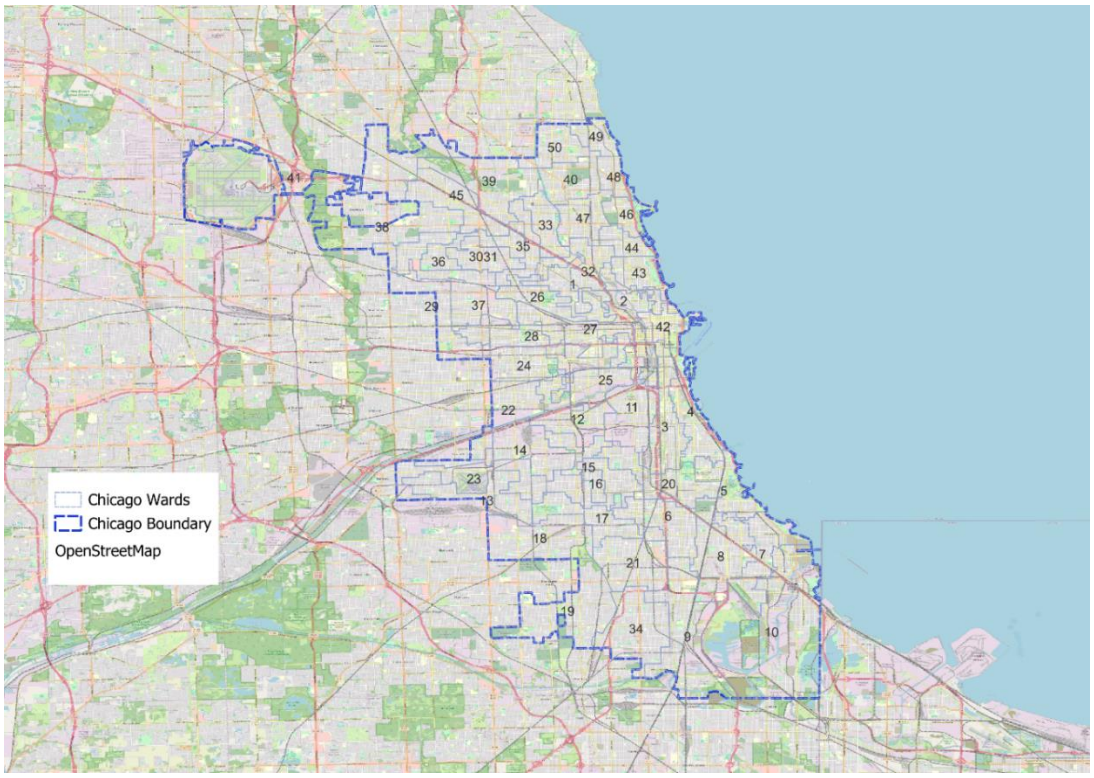
Comparing micro-mobility and public transportation of Chicago:

In this comparative analysis between Chicago's public transport system and its bike-sharing (micro-mobility) services, we've acquired KML files pertaining to public transport from the official Chicago website. This strategic approach allows us to delve into the spatial and geographical aspects of both transportation modes, extracting meaningful insights for a comprehensive evaluation.

By utilizing the KML files, we aim to explore the spatial distribution, connectivity, and accessibility of public transport routes across the city. This will enable us to identify key transit hubs, assess coverage in different neighborhoods, and evaluate the overall efficiency of the public transport network.

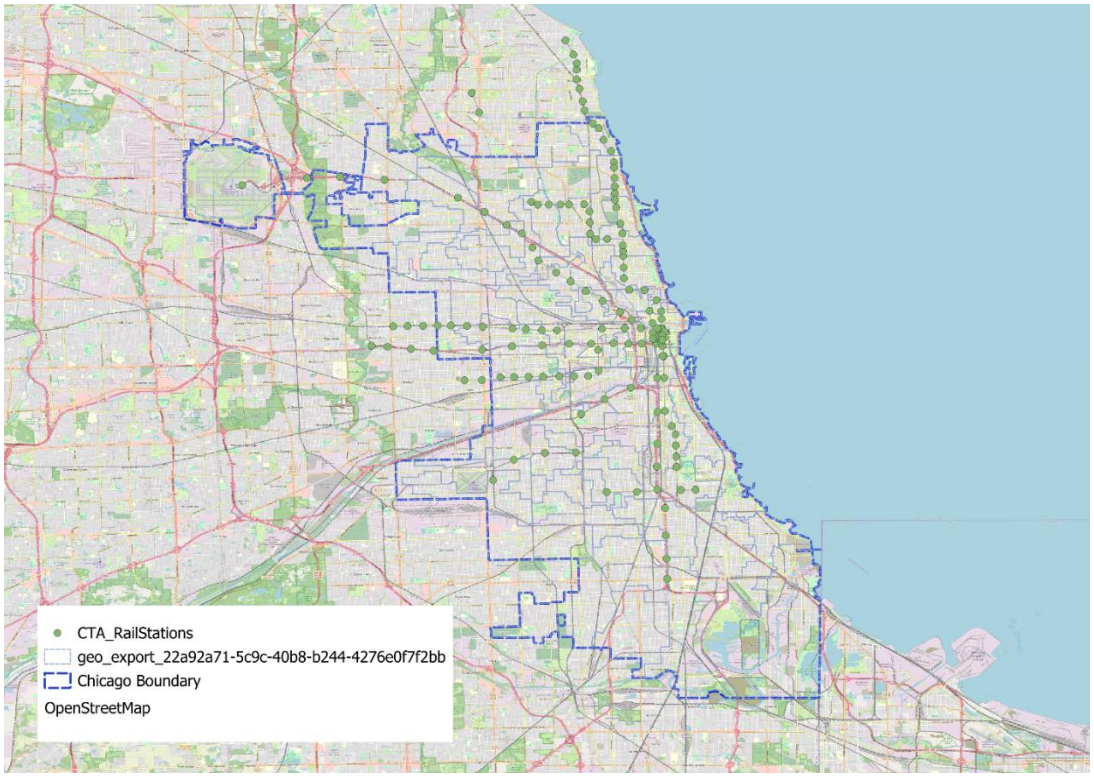
Simultaneously, we'll leverage the bike-sharing data to scrutinize the micro-mobility landscape. Analyzing the KML files associated with bike-sharing services will provide insights into the geographic reach, density of bike stations, and the connectivity of these micro-mobility options. We can also assess how well these services complement public transport, identifying potential areas for integration and improving overall urban mobility.

By combining these analyses, we aim to draw a comprehensive picture of the symbiotic relationship or potential gaps between public transport and bike-sharing services in Chicago. This information can be invaluable for urban planning, transportation policy decisions, and enhancing the overall efficiency and sustainability of the city's transportation ecosystem.



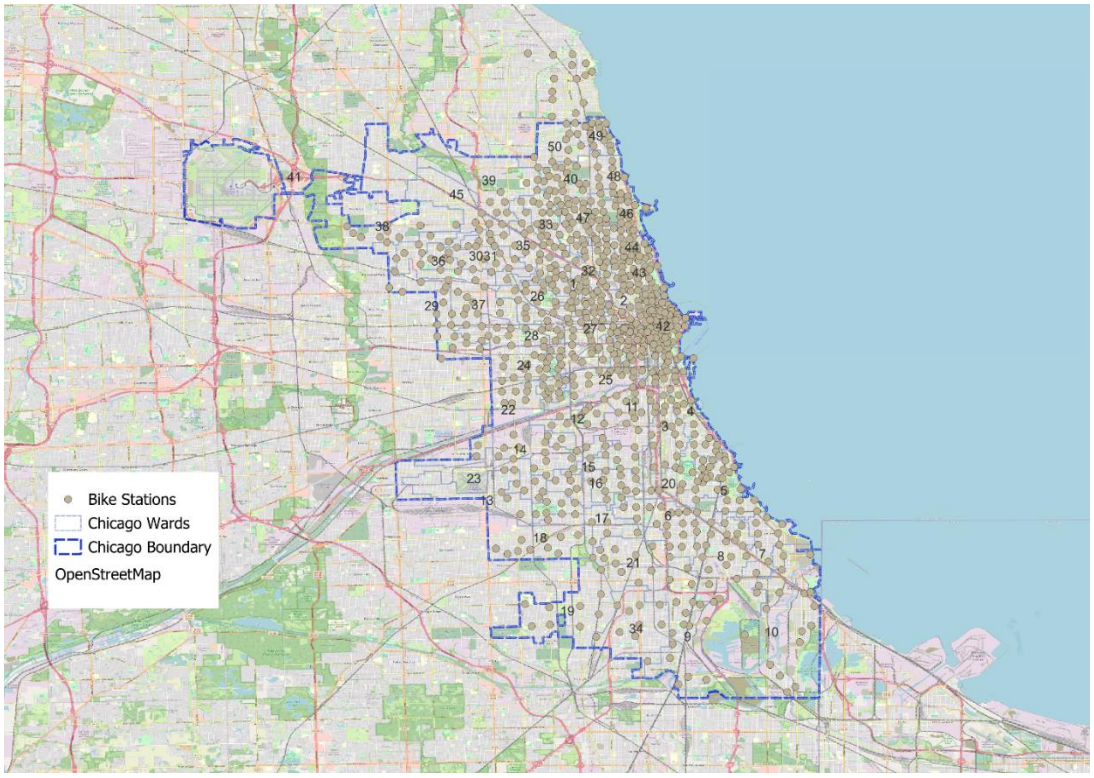
Map 1 – Chicago wards

Map 1 provides a visual representation of the geographical positions of each ward within the city of Chicago. This cartographic depiction serves as a spatial reference, illustrating the specific locations and boundaries of individual wards.



Map 2 – Chicago rail stations

Map 2 visually presents the distribution of rail stations across Chicago, offering valuable insights into the city's transportation infrastructure. A noteworthy observation is the concentration of rail stations, with the highest density observed in Ward 42. This spatial pattern suggests that Ward 42 serves as a focal point for rail transportation within the city.

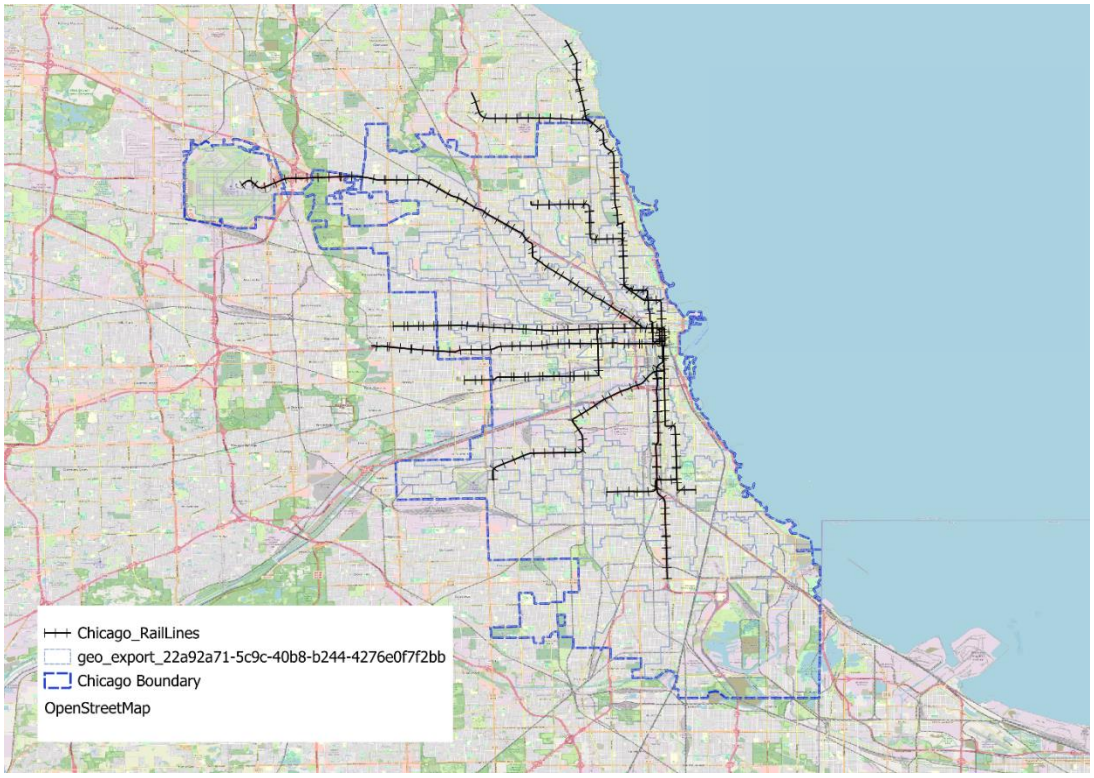


Map 3 – Chicago bike stations

Map 3, illustrating the distribution of bike stations in Chicago, presents a comprehensive and widespread coverage throughout the city. Notably, the concentration of bike stations is prominent in Ward 42 and the northern part of the city. This distribution pattern suggests a strategic placement of bike-sharing infrastructure to ensure broad accessibility and convenience for residents and visitors.

The extensive coverage of bike stations aligns with the goal of providing a micro-mobility solution that spans various neighborhoods and communities. Ward 42, acting as a central hub, appears to play a pivotal role in the placement of bike stations, possibly serving as a focal point for bike-sharing services and connectivity.

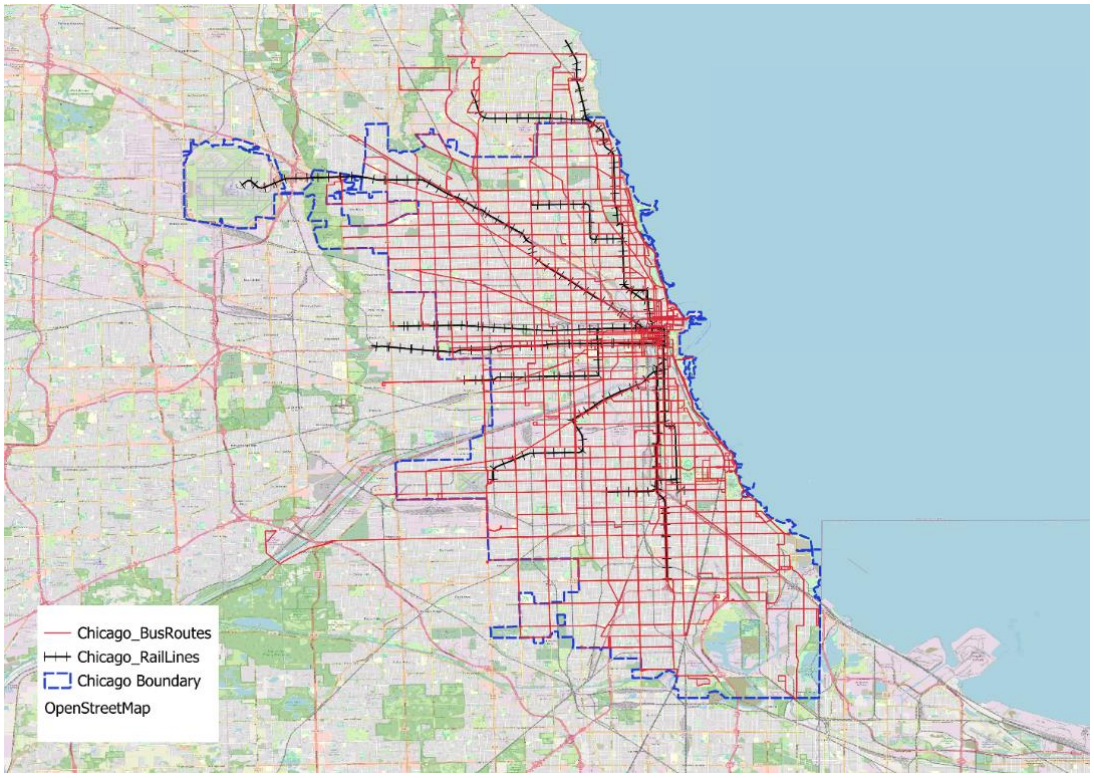
The concentration of bike stations in the northern part of the city may be influenced by factors such as population density, commercial activity, and recreational destinations. Understanding this spatial distribution is crucial for optimizing the placement of bike stations, ensuring their alignment with user demand, and enhancing the overall efficiency and popularity of bike-sharing services.



Map 4 – Chicago rail ways

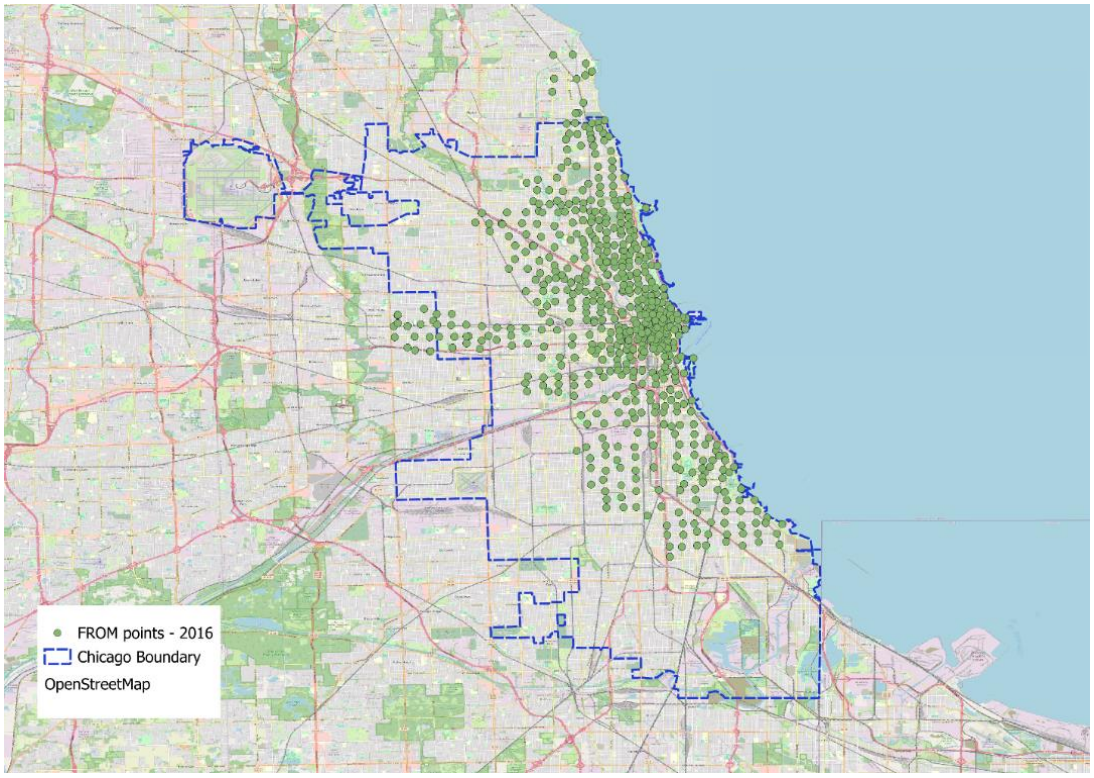
Map 4 provides a comprehensive visualization of the rail lines in Chicago, revealing distinctive patterns in the city's transportation network. One notable observation is the central role of Ward 42, acting as a significant hub from which numerous rail lines radiate outward, connecting various parts of the city. This hub-and-spoke pattern indicates the pivotal role of Ward 42 in facilitating connectivity and transit access throughout Chicago.

Furthermore, the map highlights a potential transportation disparity in the southern wards of the city, where a lack of rail lines is evident. This observation raises considerations about equitable access to public transportation in these areas. Understanding the distribution of rail lines across different wards is crucial for identifying transportation deserts and addressing potential gaps in mobility options for residents in the southern part of the city.



Map 5 – Chicago bus ways

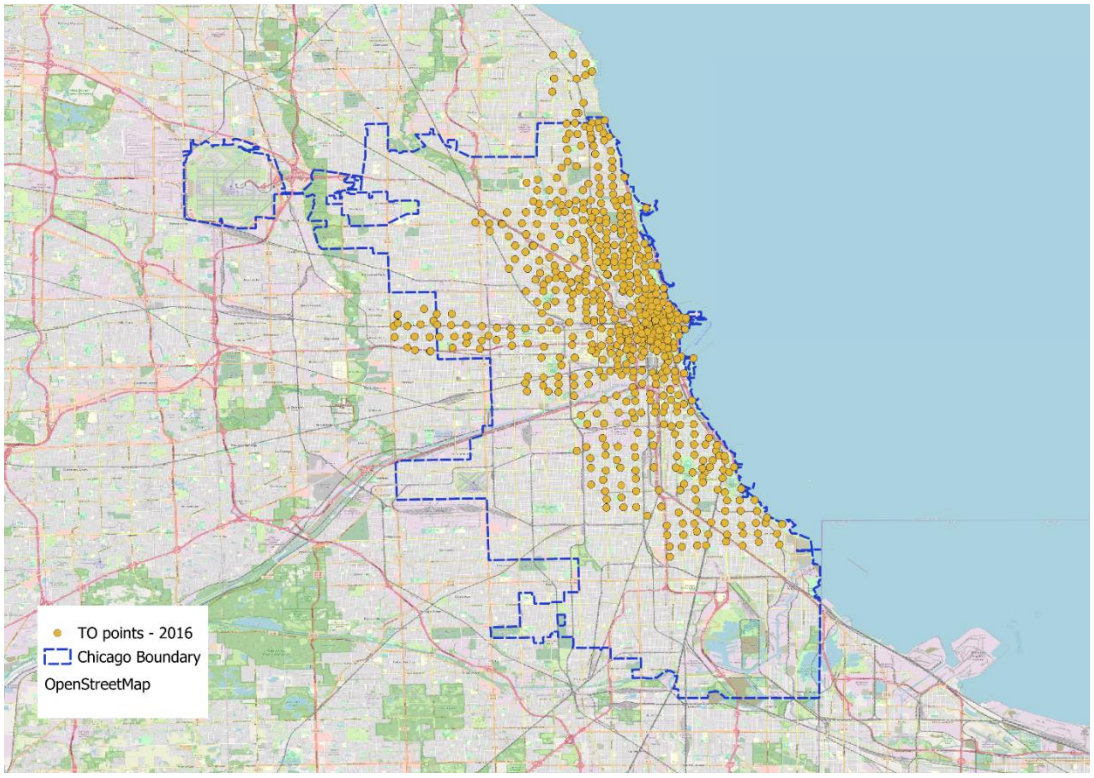
Map 5 provides a visual representation of the busways in Chicago, with a striking observation that Ward 42 acts as a central hub for this mode of transportation. The extensive coverage of busways across the entire city, excluding the airport, indicates a comprehensive and well-distributed network designed to serve various neighborhoods and communities.



Map 6 – Chicago start points of trips in 2016

Map 6 presents a spatial overview of the start trip points of micro-mobility, specifically Divvy bikes, in Chicago for the year 2016. The map reveals a discernible pattern where the concentration of start trip points is prominently centered around Ward 42 and the coastal line. As one moves away from the coast, there is a noticeable decrease in the number of start trip points.

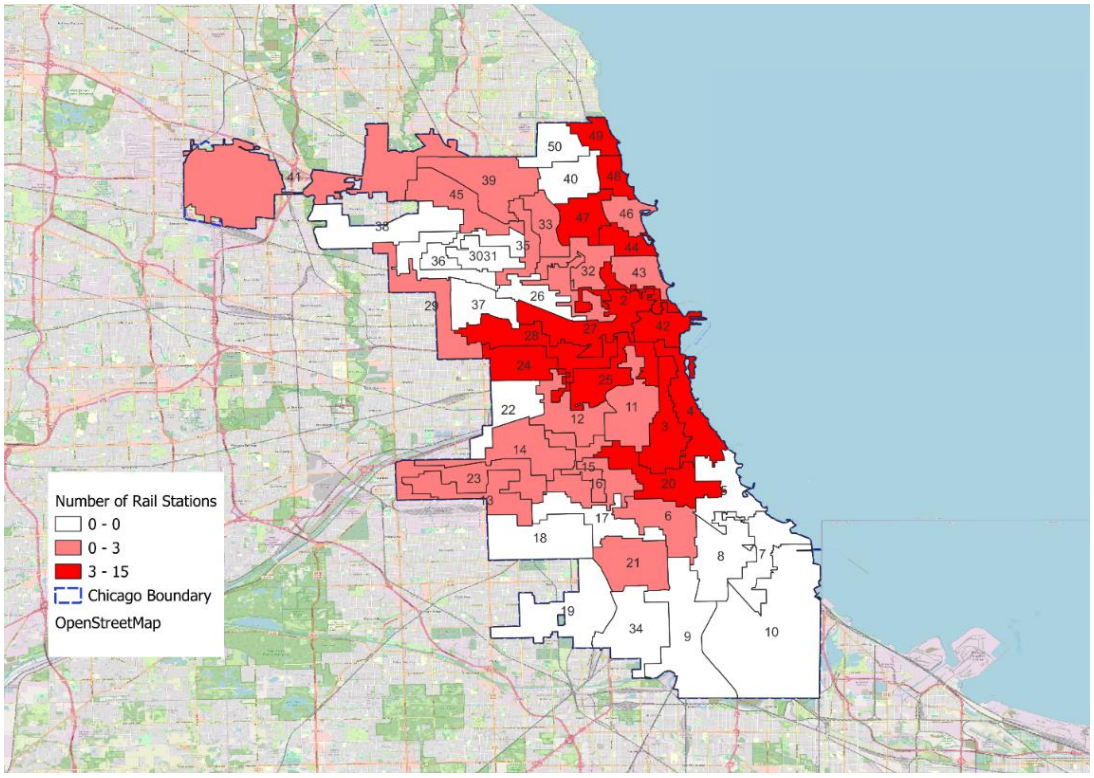
This geographic pattern suggests that Ward 42 plays a central role in micro-mobility utilization, possibly acting as a hub for Divvy bike trips. The elevated concentration along the coastal line may indicate a preference for micro-mobility services in areas with high population density, commercial activity, or recreational spaces along the waterfront.



Map 7 – Chicago end points of trips in 2016

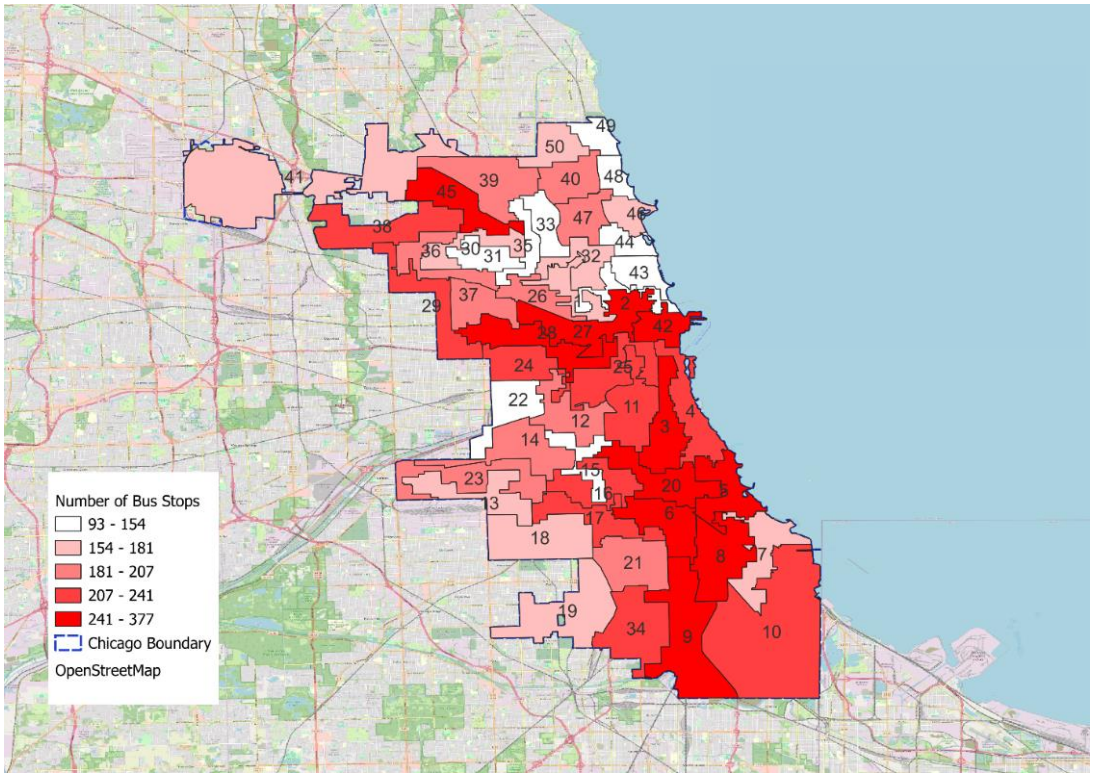
The observation that Map 7 depicts the end trip points of micro-mobility in Chicago in 2016, mirroring the pattern observed in the start trip points on Map 5, underscores the consistency in the geographic utilization of Divvy bikes. This symmetrical distribution suggests that users are completing their micro-mobility trips in similar locations where they initiated them, reinforcing the significance of certain areas, particularly Ward 42 and the coastal line, as key hubs for both the commencement and conclusion of Divvy bike journeys.

The matching patterns in start and end trip points indicate a cyclic and interconnected micro-mobility network, where users are likely engaging with Divvy bikes for short-distance travel within specific geographic clusters. This information is valuable for Divvy operators and urban planners, as it highlights the areas of sustained micro-mobility demand and helps guide decisions related to station placements, resource allocation, and infrastructure development.



Map 8 – Number of rail stations inside each ward

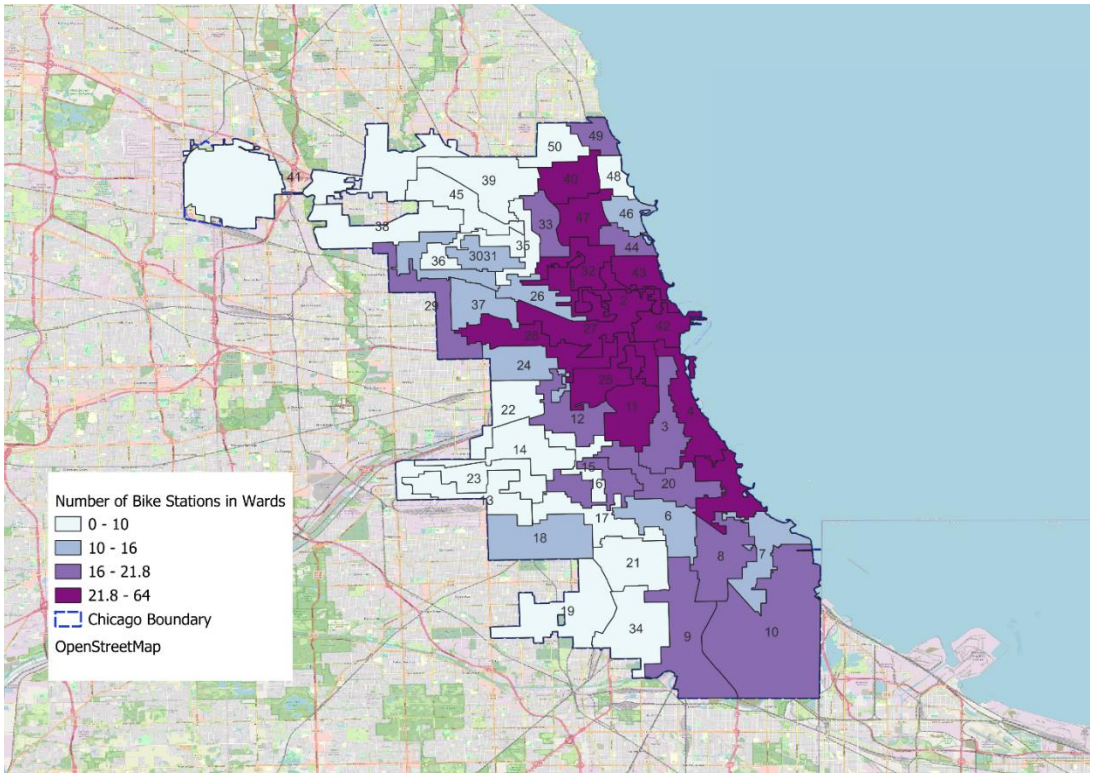
Map 8, illustrating the number of rail stations within each ward in Chicago, reveals a clear spatial concentration in the middle part of the city, particularly in wards 42, 27, 25, 28, 24, and others. This distribution pattern indicates a notable density of rail infrastructure in the central region of Chicago.



Map 9 – Number of bus stops inside each ward

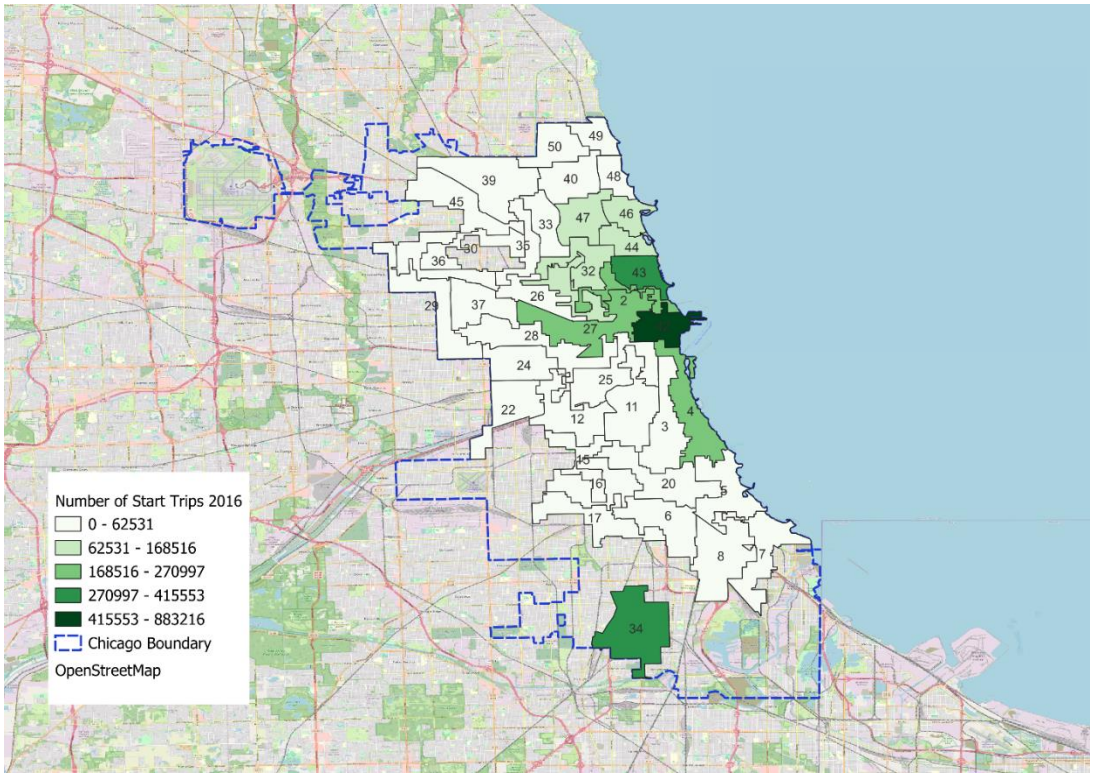
Map 9, depicting the number of bus stops within each ward in Chicago, reveals an interesting spatial distribution pattern. Similar to the concentration observed for rail stations, there is a notable density of bus stops in the middle part of the city, particularly in wards 42, 27, 25, 28, 24, and others. However, Map 9 also highlights a distinctive characteristic – enhanced coverage in the south part of the city, where the rail lines are comparatively sparse.

This observation suggests a strategic effort to bolster public transportation accessibility in the southern wards through an extensive network of bus stops. The higher concentration of bus stops in this region may serve as a vital mobility solution where rail lines may be less prevalent, contributing to improved connectivity and transit options for residents.



Map 10 – Number of bike stations inside each ward

Map 10, which displays the number of bike stations within each ward in Chicago, reveals a distinctive spatial distribution pattern. The concentration of bike stations is notably centered on the middle part of the city, encompassing wards such as 42, 27, 25, 28, and others. Additionally, there is a substantial coverage of bike stations in the southern part of the city.

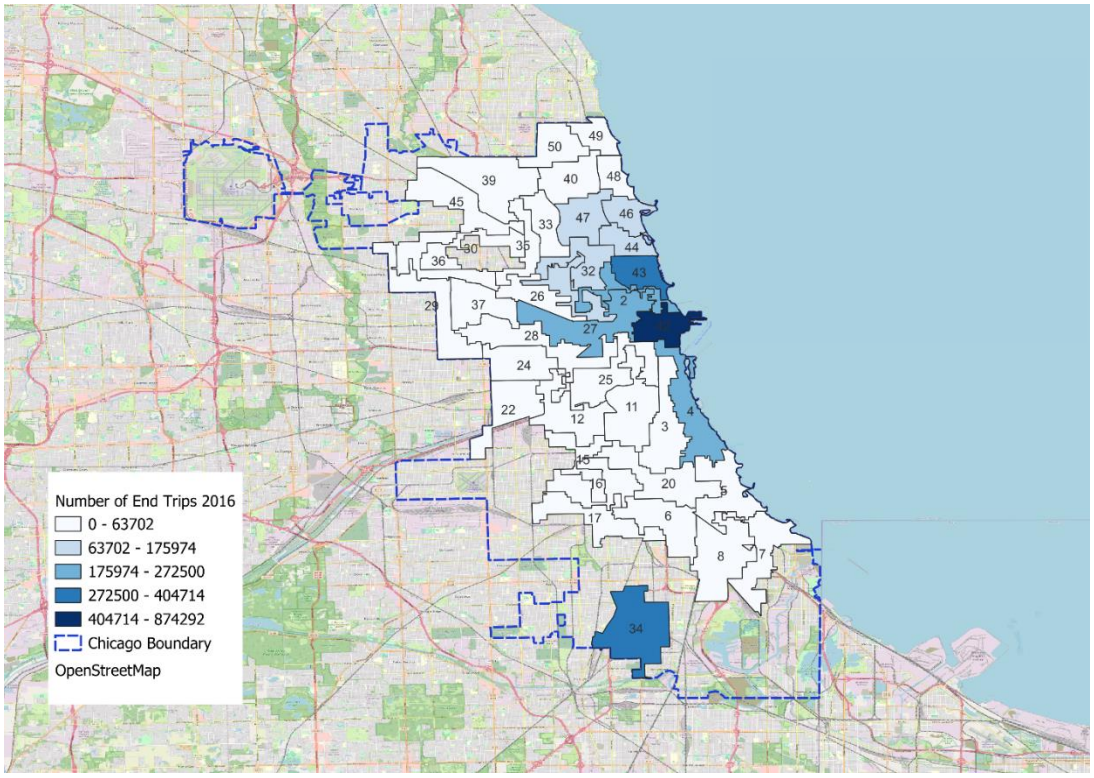


Map 11 – Number of trip start points inside each ward 2016

Map 11, depicting the number of start trip points within each ward in Chicago, provides insightful information about the dynamics of micro-mobility in the city. A clear trend emerges with Ward 42 standing out as the focal point for the most significant number of start trip points, indicating its prominence as a hub for micro-mobility activities with over 415,553 trips.

The subsequent significance of Wards 43 and 34 in terms of start trip points adds a nuanced layer to the understanding of micro-mobility patterns. Ward 43's proximity to Ward 42, aligned along the coastal line in the middle part of the city, was expected, given its strategic location. However, the significance of Ward 34, situated in the south part of the city where rail stations and bus stops are less prominent, underscores its importance as a hub for micro-mobility despite having a comparatively lower infrastructure density.

This observation highlights the unique role of Ward 34 in facilitating micro-mobility trips, showcasing that factors beyond traditional transportation infrastructure, such as the availability of bike stations or connectivity to rail lines, contribute to its importance for micro-mobility in Chicago.

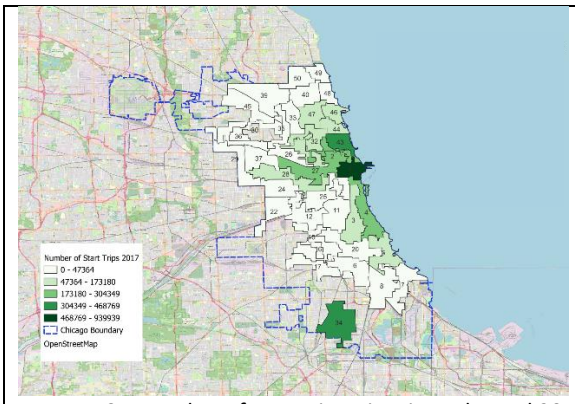


Map 12 – Number of trip end points inside each ward 2016

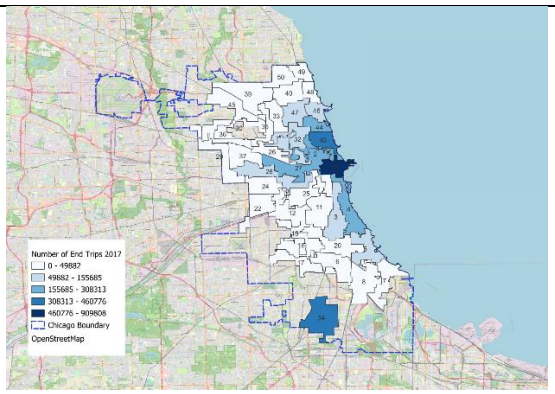
The consistency in the pattern between Map 12, illustrating the number of end trip points within each ward in Chicago, and Map 11, depicting start trip points, reinforces the spatial dynamics of micro-mobility in the city. Ward 42 continues to emerge as a central hub, witnessing a significant number of both start and end trip points, indicating sustained micro-mobility activities.

Wards 43 and 34 also maintain their prominence in terms of end trip points, aligning with the patterns observed in start trip points. The presence of significant end trip points in Ward 34, despite its lower prominence in traditional transportation infrastructure, underscores its continued importance as a destination or conclusion point for micro-mobility journeys.

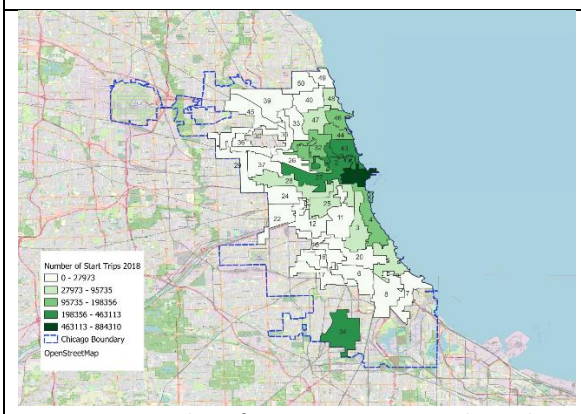
This consistency in patterns signifies the reliability and popularity of specific wards for both the initiation and conclusion of micro-mobility trips. It reinforces the notion that certain wards play a pivotal role in shaping the micro-mobility landscape of Chicago, serving as key nodes for residents and visitors utilizing bike-sharing services.



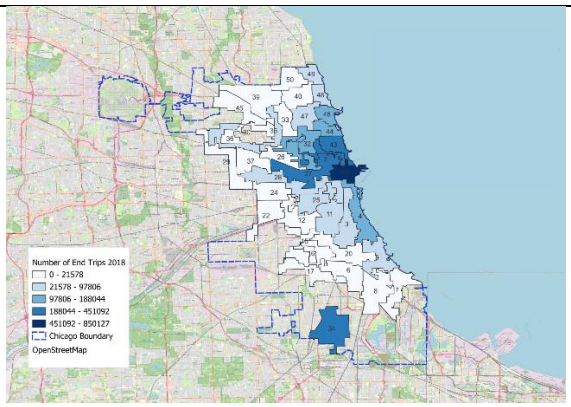
Map 13 – Number of start trip points in each ward 2017



Map 14 – Number of trip end points in each ward 2017



Map 15 – Number of start trip points in each ward 2018



Map 16 – Number of trip end points in each ward 2018

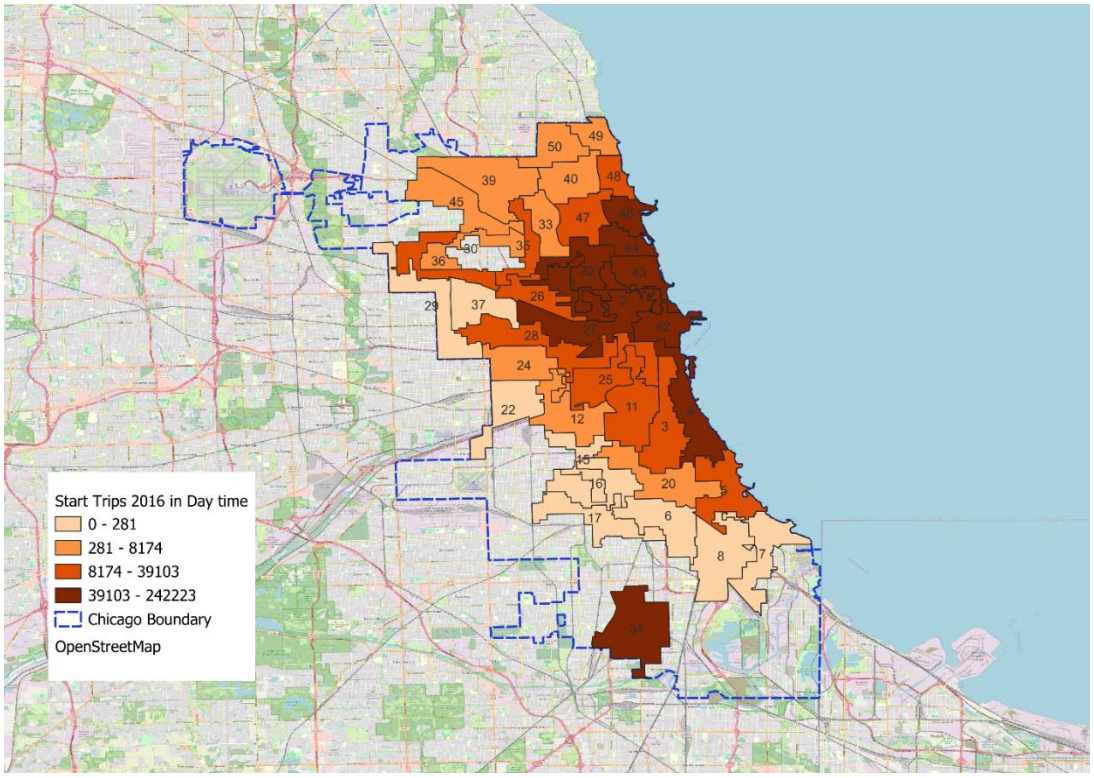
The observation of Maps 13, 14, 15, and 16, which depict the number of start and end trip points of micro-mobility in Chicago for the years 2017 and 2018, reveals an intriguing evolution in the micro-mobility patterns within the city.

In 2017, the pattern appears consistent with the previous year, primarily highlighting the prominence of Ward 42 and the significance of Wards 43 and 34 as major hubs for both start and end trip points.

However, the noticeable change in 2018, with the addition of Wards 2 and 27 experiencing a substantial number of start or end trips, suggests a shift in the dynamics of micro-mobility usage. These wards have now become significant contributors to micro-mobility activities, indicating changes in user behavior, preferences, or possibly alterations in the infrastructure and urban developments within these areas.

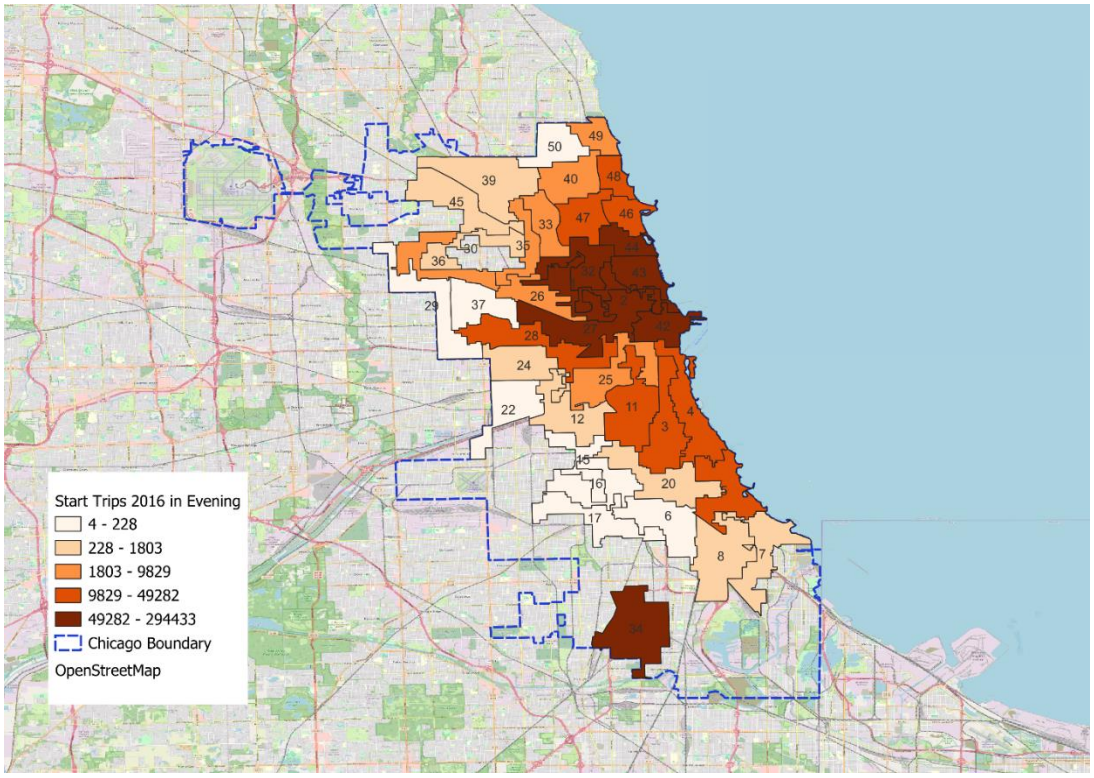
Comparing bike usage in different times of the day:

In this section, by dividing the trips based on their times into three distinct groups—Day time (from 8:00 to 16:00), Evening time (from 16:00 to 00:00), and Night time (from 00:00 to 8:00)—we provide a structured framework for analyzing micro-mobility patterns across different segments of the day. This temporal segmentation allows for a more granular examination of user behaviors, preferences, and the impact of time on trip distribution.



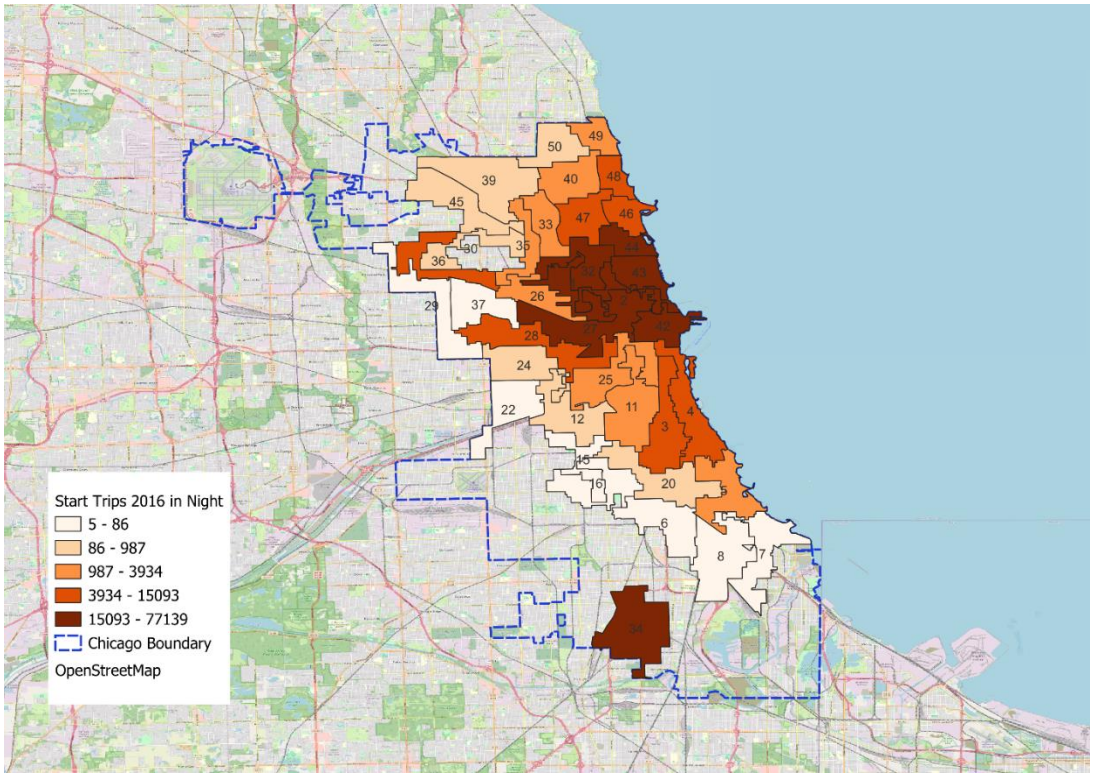
Map 17 – Number of start trips in Day time - 2016

Map 17 reveals that during Day time, the majority of micro-mobility trips in Chicago are concentrated in wards 42, 43, 2, 27, 32, 4, 44, 46, and 34. These wards serve as central hubs for daytime micro-mobility, with significant trip numbers ranging between 39,103 and 242,223. The coastal areas and central locations, such as Wards 42 and 43, continue to dominate, while other wards, including 27, 32, and 34, are emerging as key players in the daytime micro-mobility landscape. Understanding these patterns is essential for optimizing services and station placement to meet the evolving needs of users during daylight hours.



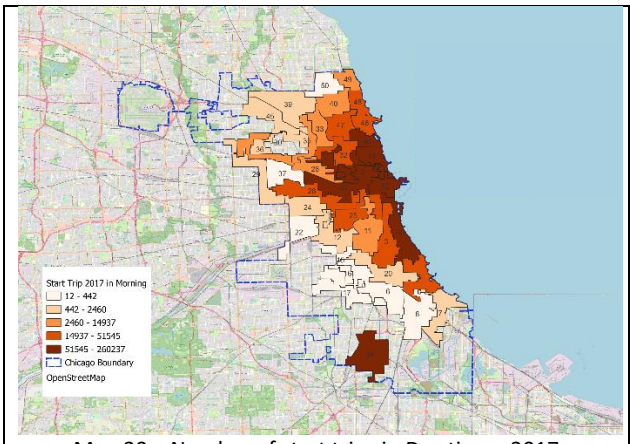
Map 18 – Number of start trips in Evening time - 2016

Map 18 indicates the evening micro-mobility trends in Chicago, revealing that central and coastal wards (42, 43, 44, 2, 27, 32, and 34) continue to dominate, with trip numbers slightly increasing compared to Day time, ranging from 49,282 to 294,433. Notably, wards 4 and 46 did not experience an increase in trips during the evening hours. This insight informs the dynamic nature of micro-mobility usage, helping optimize services and station placement to align with the shifting patterns during the evening in Chicago.

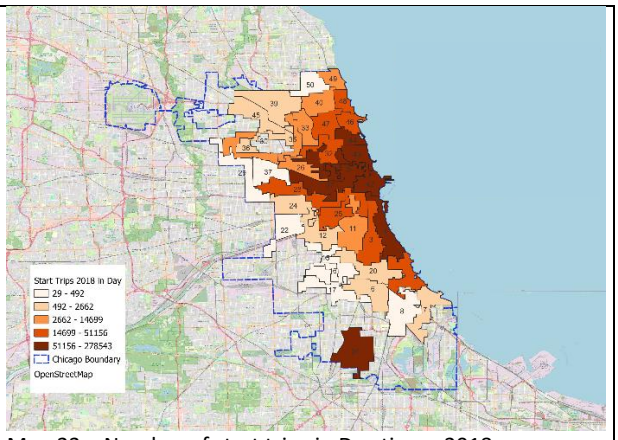


Map 19 – Number of start trips in Night time - 2016

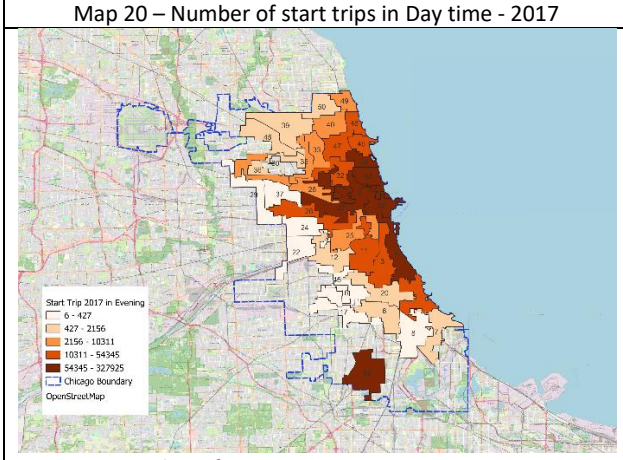
Map 19 illustrates that the wards dominating in Evening time also experience the highest number of trips in Night time, including wards 42, 43, 44, 2, 27, 32, and 34. However, there is a notable decrease in the number of trips during Night time, ranging from 15,093 to 77,139. This decline aligns with the typical decrease in overall activity during the night, reflecting a shift in micro-mobility patterns to fewer but still significant trips during these hours. Understanding this temporal variation is essential for tailoring micro-mobility services and station placement to accommodate the specific needs and preferences of users during the night in Chicago.



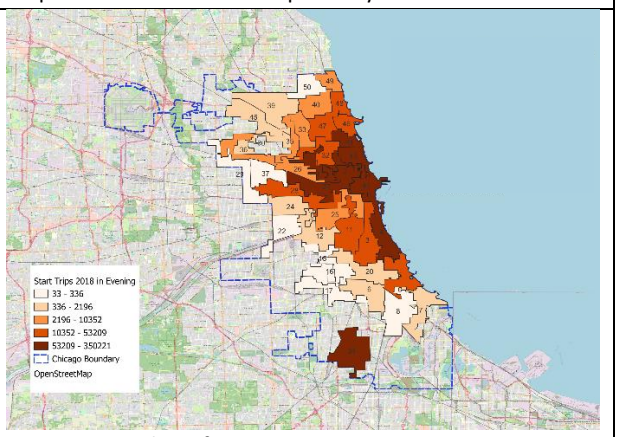
Map 20 – Number of start trips in Day time - 2017



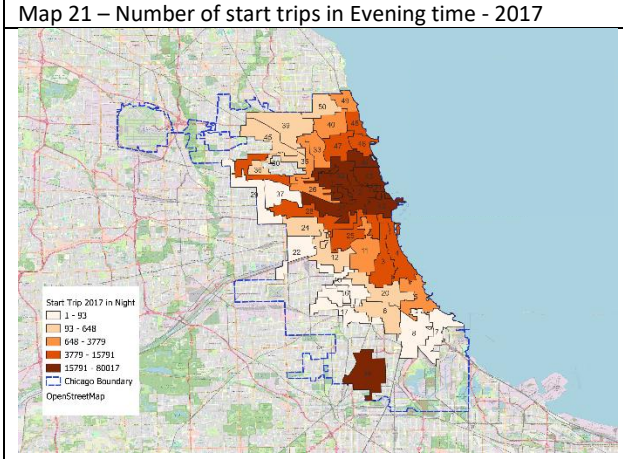
Map 23 – Number of start trips in Day time - 2018



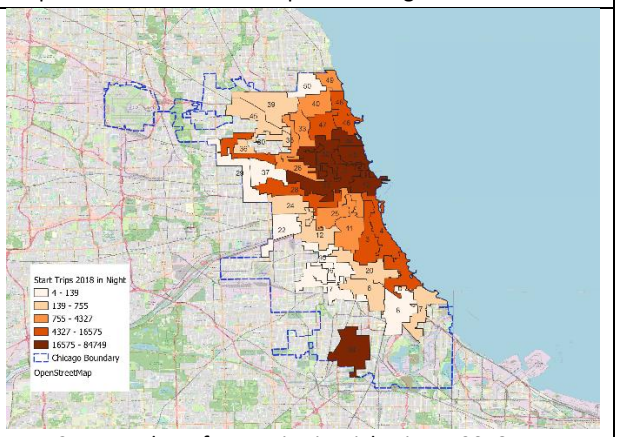
Map 21 – Number of start trips in Evening time - 2017



Map 24 – Number of start trips in Evening time - 2018



Map 22 – Number of start trips in Night time - 2017



Map 25 – Number of start trips in Night time - 2018

Maps 20, 21, 22 (2017) and Maps 23, 24, 25 (2018) consistently show that Wards 42, 43, 2, 27, 32, 4, 44, 46, and 34 are the primary hubs for micro-mobility trips during Day time and Evening time. The pattern remains stable across both years, with the highest trip numbers during Evening time. Night time trips, while slightly less frequent, still favor the same wards. Overall, micro-mobility trip numbers show consistency, with Day time trips ranging from 51,000 to 270,000, Evening time trips from 53,000 to

350,000, and Night time trips from 15,000 to 84,000. These findings underscore the persistent popularity of micro-mobility, particularly during the evening hours in Chicago.

Utilization of vehicles and costs

In this section, our focus is on the data from the latest available year, 2019, as we aim to analyze the company's cost, revenue, and the utilization percentage of bikes. To acquire the revenue per bike, we sourced information directly from the Divvy website, which indicates a figure of 17 snets per bike. In tandem, our research efforts involved a thorough investigation to provide a rough estimate for the cost associated with each bike. The ensuing results will be presented below for a comprehensive overview.

In our examination of Divvy Bike-Sharing Company's operational data, we have found that the average utilization percentage for the bikes in the fleet stands at 3.8%. This metric serves as a key indicator of the extent to which the bikes are actively utilized within the company's service network.

The current average of 3.8% suggests that, on average, each bike in Divvy's fleet is actively used for a relatively small proportion of its available time. This indicates a level of utilization that may be considered low to moderate.

Understanding this utilization percentage provides valuable insights for Divvy's operational planning, such as optimizing bike distribution across stations and gauging the overall effectiveness of the bike-sharing program. Moreover, it can serve as a benchmark for evaluating the success of promotional campaigns, infrastructure expansion, or other initiatives aimed at increasing bike usage in the city.

Continued monitoring of the utilization percentage can offer dynamic insights into the evolving patterns of bike-sharing in Chicago, helping stakeholders make informed decisions to enhance the accessibility and convenience of micromobility options in the urban landscape.

Revenue of Divvy in 2019:

The calculated revenue figure of at least 15.7 million dollars for Divvy in 2019 underscores the financial success and economic significance of the bike-sharing program in Chicago. This robust revenue reflects the substantial user base and the effectiveness of Divvy's pricing structure or membership models during that period.

The revenue generated by Divvy is not only a testament to the popularity of bike-sharing as a mode of transportation in Chicago but also serves as a critical financial metric for assessing the sustainability and

viability of the program. This financial success may be indicative of the positive reception and adoption of Divvy bikes as a convenient and eco-friendly transportation option among residents and visitors alike.

Costs of Divvy in 2019:

To better understand the financial landscape, a rough estimation of annual costs per classic bike has been conducted, encompassing various components associated with bike operation and maintenance.

Cost Components per each bike:

- Bikes Price: $300
- Maintenance: $50
- Infrastructure: $800
- Technology: $30
- Insurance: $10
- Operations: $60
- Marketing: $20
- Unexpected Costs: $20

Total Annual Cost per Bike = Bike Price + Maintenance + Infrastructure + Technology + Insurance + Operations + Marketing + Unexpected Costs

Total Annual Cost = Total Annual Cost per Bike * Number of bikes

So, in general the costs will be 7,7 M$ per year. And there were about 8 M$ interest for Divvy in 2019.

Utilization percentage during different day of week:

The average of utilization percentage of bikes for each day of week is shown in the table in below.

Day of week	Utilization percentage
Monday	0.662425
Tuesday	0.821461
Wednesday	0.724842
Thursday	0.739848
Friday	0.713160
Saturday	1.043443
Sunday	0.803796

The data analysis reveals a noteworthy pattern in bike utilization, indicating that, on average, there was a higher utilization rate during weekends compared to weekdays. This insight suggests that weekends witness a surge in the popularity and usage of bikes within the Divvy system.

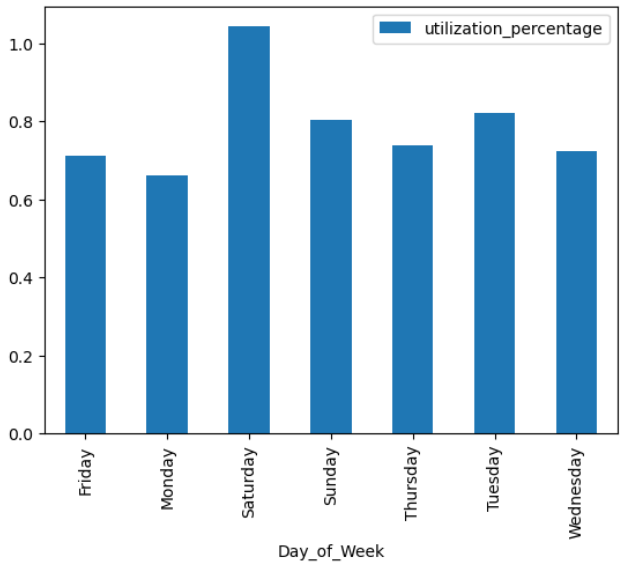


Figure – average utilization percentage of bikes during the week

The increased average utilization on weekends could be attributed to various factors, such as recreational activities, tourism, or a shift in commuting patterns during leisure days. Understanding this trend is crucial for Divvy in optimizing its bike distribution, marketing strategies, and operational planning to cater to the heightened demand during weekends.

This finding underscores the dynamic nature of bike-sharing usage, emphasizing the need for flexibility in service management to accommodate varying patterns of demand throughout the week. Further exploration of the factors contributing to this weekend-oriented surge in bike utilization could provide valuable insights for tailoring services to the preferences and behaviors of Divvy users.

For example, The analysis reveals that Bike 3846 exhibits a notable utilization percentage of 48%. This high level of utilization translates into a significant financial impact, generating approximately $31,519 in revenue over the course of 185,408 minutes of trips. The robust performance of Bike 3846 underscores its effectiveness in meeting user demand and contributing positively to the financial outcomes of the bike-sharing operation.