Bicycle Parking in the Narrow Streets of Copenhagen

An Interactive Qualifying Project

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Abstract

Our project, sponsored by Miljøpunkt Indre By, focused on optimizing bicycle parking in Inner City Copenhagen, specifically on the narrow street of Studiestræde. The habits of cyclists, the opinions of shop owners, pedestrians, and cyclists, and data gathered through observation and experiments all contributed to the generation of a Pugh Matrix detailing our top recommendations. By implementing these suggestions over time, the Inner City can gradually improve its bicycle parking to continue to attract citizens to cycling and further promote the city's environmental sustainability.

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Executive Summary

Background

In Copenhagen, a citywide investment in bicycle infrastructure has increased the daily use of bicycles by residents. Of Copenhagen's 438,000+ commuters, over 155,000 commute by bicycle, a proportion that has increased by 10% over the past three years (City of Copenhagen, 2015). While this influx of cyclists benefits the environment by reducing carbon emissions and bringing Copenhagen closer to its sustainability goals, there is a cost -- the city is now facing problems with congested bicycle parking. Confirming the fact that parking facilities have not kept pace with demand, a survey conducted in 2014 found that only 29% of Copenhagen's cyclists are satisfied with the available bicycle parking facilities (Otzen, 2014).

Recently, considerable focus and energy has been devoted to bicycle parking at metro and train stations, resulting in improvements in available bicycle parking at these high quantity areas. Bicycle parking in small space areas, such as narrow streets, are the next area of focus. Copenhagen has already moved bicycle parking to the median that separates bike paths from the road to prevent bicycles from taking up sidewalk space (Andersen, 2013). However, this solution is not always feasible: on narrow streets, sidewalks are often the only space available for bicycle parking. When bicycle parking creates congestion on the sidewalks, pedestrians are forced to walk on the street. This and many other problems caused by poor bicycle parking are what's causing bicycle parking to potentially become less appealing for citizens.

Methodology

This project was designed to assist Miljøpunkt Indre By-Chrsitianshavn in their effort to continue to improve the environmental sustainability of Inner City Copenhagen by exploring

bicycle parking solutions on the narrow street of Studiestræde, within the Inner City. Our team fulfilled this goal by accomplishing the following objectives:

1. Assess the current habits of cyclists
2. Identify the needs of stakeholders
3. Propose final bike parking recommendations

Assess the current habits of cyclists

In order to develop practical bicycle parking solutions to the narrow streets of Copenhagen, the current habits of cyclists in the area needed to be assessed. The first step in doing so involved splitting Studiestræde into four manageable zones. The zones allowed us to observe the entire street at one time, with each group member being assigned to a zone. The number of bicycles parked each hour as well as flow of bicycles parking on and leaving the street were tracked. The location of parked bicycles relative to the street's racks was also recorded. A bicycle tagging experiment was used to identify the amount of abandoned or "dead" bicycles on the street. Small strips of paper explaining the experiment were taped around the handle bars or hand breaks of all parked bicycles. Close considerations were taken to make sure the tape only touched the paper as to not potentially ruin the bicycle handlebars/breaks and anger the owner. These tagged bicycles were recounted twice a week for three weeks. A similar experiment was carried out on the neighboring street of Vestergade.

Identify the Needs of Stakeholders

The needs of cyclists, pedestrians, and shop owners/employees were used in deciding on solutions that would fit the needs of all stake holders. The needs of the cyclists and shop

owners/employees were determined through semi-structured interviews, while the needs of pedestrians were evaluated through observation. The number of pedestrians walking through the street was recorded hourly. This count included pedestrians who were forced to step off the sidewalk onto the road due to obstacles and overcrowded bicycle racks.

Propose Final Bicycle Parking Recommendations

In order to make final bike parking recommendations to on the bicycle-parking situation of Inner City Copenhagen, a variety of factors were considered in forming potential solutions. These factors included: the feasibility of the solutions, their financial impact on the community, and how each option meets the expressed needs of different stakeholders. The feasibility of the different physical ways to address the bike-parking issues of Inner City Copenhagen can be broken down into the areas of aesthetics, safety, legality, and space required to integrate.

After fully executing objectives one and two of our methodology, a Pugh Matrix was constructed. A Pugh Matrix compares all possible ways of fixing a problem and ranks them based on how well they address a variety of weighted design factors (Burge, 2009).

Results

The observation of the cyclists and their habits revealed that 76% of bicycle parking on Studiestræde was problematic. On weekdays there were, on average, 173 bikes parked on Studiestræde per hour, with the peak hours for bicycle parking occurring between 12 PM and 2 PM. Theses bicycles, on average, extended 9.54 meters out of designated rack space and into the street. On the weekends there were, on average, 182 bikes parked on the street with the peak hours for weekend bicycle parking occurring between 6 PM and 9 PM. On average, bicycles on the weekend extended 12.2 meters into the street.

The bicycle tagging experiment showed that after 23 days there were 52 abandoned bicycles on Studiestræde. These bicycles resulted in 37% of the street's 81 bicycle parking spots being unusable.

Interviews revealed that both cyclists' and shop owners' were frustrated with the current bicycle parking on Studiestræde. Cyclists' frustrations stemmed from there not being enough available parking spaces on the street. The shop-owners had daily frustrations with the street's bicycle parking because it often interfered with their business' aesthetics and accessibility.

406 pedestrians passed through Studiestræde per hour. Of these pedestrians 11.5% were forced to cross the street to the other sidewalk due to the lack of space on the sidewalk created by parked bicycles.

Recommendations

The results of this project led to the creation of 6 bicycle parking recommendations. The formulated 6 recommendations are the following:

1. Constraining Landmarks

2. Informative Signs

3. Flex Parking

4. Adding Additional Bicycle Racks

5. Improving the City's Current Bicycle Removal System

6. Campaigning

Constraining Landmarks

Constraining landmarks can be anything from a large potted plant to a colorfully designed rock. The only criteria for landmarks are that they must be sizable enough that when placed at the end of a bicycle rack, it will deter cyclists from parking beyond. The ability to stop bicycles from overflowing out of designated parking facilities will increase the safety of cars, pedestrians, and cyclists moving through the area.

Informative Signs

Informative signs can be strategically placed on the exteriors and windows of business could be used to encourage proper bicycle parking habits. Through interviews with shop owners, we've learned that approximately half would support the use of signs on their stores. Interviews with cyclists showed that most were unaware of all the options they had for parking facilities. These two pieces of data lead us to recommend the implementation of signs intended to inform cyclists of the locations of open and available parking facilities.

Flex Parking and Additional Bicycle Racks

On Studiestræde, bicycles extend from bicycle racks and into the street's car parking and take up approximately 2 spaces worth of car parking. Due to these extended bicycles, revenue is not being generated from these car parking spots. With no revenue currently being made, the conversion of car parking spots to bicycle parking does not come at much of a cost. This conversion can be done in two ways: Flex parking or adding new permanent bicycle racks. Flex parking involves a parking spot being shared between cyclists and motorists. At designated times the parking space is for bicycles parking leaving the other times for motorists.

Improving the City's Current Bicycle Removal System

The current bicycle removal system is inefficient. When data is compared across previous tagging and removals done by the city and our own tagging experiment, our data shows a significantly larger amount of abandoned bicycles on Studiestræde. The removal of these abandoned bicycles will result in a 37% increase in the amount of available designated bicycle parking spots on Studiestræde. The removal of these bicycles also comes at a cost one tenth the amount of adding additional bicycle racks. Improvements to this system can be made through greater funding of the program and possible improvements in the tracking of bicycles.

Campaigning

Campaigning to inform people of proper bicycle parking habits could be used as a long-term solution for the bicycle-parking problem in Copenhagen. Removing abandoned bicycle and creating additional bicycle parking racks will work as short term solutions; however, problems with congestion will again likely accumulate over time if people are not directly informed that what they're doing has an impact on the parking problems.

Conclusion

The recommendations presented in this report include a variety of potential solutions specifically tailored to the narrow street of Studiestræde. These options range in many factors, including money and other resources required to implement them in the area, all of which are clearly evaluated in the Pugh matrix. Ideally, the smaller and simpler to execute suggestions will be carried out immediately to have initial impact on the problem, while the larger scale solutions will be planned out in depth and then put in place to fix bike parking on Studiestræde for the long term.

Chapter 1: Introduction

Many European countries have implemented bicycle initiatives in an effort to reduce carbon dioxide emissions with the ideal of eventually becoming carbon neutral. Due to their significant push to increase bicycle use, Copenhagen has been praised for having the second best air quality of a European city (Vestergaard, 2015*).* Benefits like this have supported the growth of the cycling community, leading it to become the primary form of transport in Copenhagen (Vestergaard, 2015*).* The addition of ample bike parking facilities in strategic locations will help to further increase the number of citizens commuting by bicycle, allowing Denmark to reach its goal of carbon neutrality by 2025 (City of Copenhagen. 2011).

In Copenhagen, a citywide investment in bicycle infrastructure has increased the daily use of bicycles by residents. Of Copenhagen's 438,000+ commuters, over 155,000 commute by bicycle, a proportion that has increased by 10% over the past three years (City of Copenhagen, 2015). While this influx of cyclists benefits the environment by reducing carbon emissions and bringing Copenhagen closer to its goals, there is a cost -- the city is now facing problems with congested bicycle parking. Confirming the fact that parking facilities have not kept pace with demand, a survey conducted in 2014 found that only 29% of Copenhagen cyclists are satisfied with bicycle parking (Otzen, 2014).

Recently, considerable focus and energy has been devoted to bicycle parking at metro and train stations, resulting in improvements in available bicycle parking at these high quantity areas. Bicycle parking in small space areas, such as narrow streets, are the next area of focus. Copenhagen has already moved bicycle parking to the median that separates bike paths from

the road to prevent bicycles from taking up sidewalk space (Andersen, 2013). However, this solution is not always feasible: on narrow streets, sidewalks are often the only space available for bicycle parking. When bicycle parking creates congestion on the sidewalks, pedestrians are forced to walk on the street.

While the lack of space on the narrow streets in the inner city of Copenhagen contributes to bicycle parking congestion, bike parking habits are also problematic. Rather than moving on to check the next rack when one is full, cyclists frequently elect to leave their bikes leaning up against a wall or cast them on the ground (City of Copenhagen, 2011). These parking habits both create congestion and hinder the safety of all pedestrians and cyclists passing through. There also negative impacts for surrounding shops whose entrances may become blocked or difficult to enter. As such, this two-fold problem of lacking facilities and bad habits can potentially be addressed in two separate ways, by both physical alterations to the parking areas and "nudging" the behavior of cyclists.

This project was designed to assist Miljøpunkt Indre By-Chrsitianshavn in their effort to continue to improve the environmental sustainability of Inner City Copenhagen by exploring bicycle parking solutions on the narrow street of Studiestræde, within the Inner City. In order to assess the current parking habits of cyclists, we monitored the density of bikes both in racks and on the street as a whole, and tracked the bikes we believed to be abandoned by means of our own tagging system. Data representing the quantity of parked bikes by day and time was collected to be used in determining the proper amount of parking spaces needed for particular areas. Data reflecting the behaviors of cyclist was used to determine the best locations and

types of bicycle parking facilities that would be most used. In addition, the needs of cyclists, pedestrians and shop owners/employees were used in deciding the best possible solutions for all stakeholders. Once parking habits and the needs of the stakeholders were assessed, bicycle parking recommendations were proposed to Miljøpunkt Indre By-Christianshavn.

Chapter 2: Background

Bicycle Parking Congestion in Copenhagen

With over 150,000 commuters cycling to work or school each day, cycling is the most popular form of transportation in Copenhagen (City of Copenhagen, 2011). The city has worked hard to increase its cyclist population, focusing specifically on improving its bicycle infrastructure. The number of cyclists in Copenhagen will continue to increase as long as biking remains the most convenient form of transportation, leading to further improvements in physical and environmental health (City of Copenhagen, 2011). However, this increasing cyclist population has led to congested bicycle parking. Copenhagen's bike parking facilities have not kept up with the increase in cyclists leading to 71% of Copenhagen's cyclists being unhappy with the current parking facilities (Otzen, 2014). Cyclists prefer to park close to their destination; therefore, in popular areas, bikes are often left parked against buildings and poles, in the middle of sidewalks, and sometimes thrown haphazardly on the ground (Otzen, 2011). In some areas there are so many bikes parked that cyclists report it is nearly impossible to find their bicycles among the others (see Figure 1) (Banker, 2006). Unorganized bicycle parking takes up unnecessary space, while also creating obstacles and safety hazards for pedestrians (Otzen, 2014). Hazardous bicycle parking in the narrow streets of Copenhagen's inner city is a part of the city's larger bike parking problem that requires attention.

Figure 1: An Overly Congested Bike Parking Facility (Banker 2006)

Copenhagen's Growing Cycling Community

Copenhagen, the self-proclaimed "City of Cyclists," has set the goal of becoming carbon neutral by 2025, and in turn has taken on the challenge of becoming the top city for bicycles in the world. In 2011, the City of Copenhagen's Technical and Environmental Administration, and Traffic Department published *Good, Better, Best—The City of Copenhagen's Bicycle Strategy 2011-2025*, replacing the city's previous strategy, *Cycle Policy 2002-2012*. The report lays the framework for improving the city's already well established presence as a bicycle city, and explains the necessary steps to make Copenhagen the foremost cycling city. With its citizens cycling over 1.34 million kilometers every weekday on 492 kilometers of cycle-able terrain, Copenhagen is well on its way (City of Copenhagen, 2011).

The most recent 2014 *Bicycle Account*, a biannual report on Copenhagen's progress published by the City of Copenhagen's Technical and Environmental Administration, shows an

influx of cyclists: cycling has increased nearly 10% for both the trips of those living and working in Copenhagen (63%) and all commuters whose endpoint is in the city (45%) (2015). Table 1 shows the preferred mode of transportation to work and educational institutes for specific distances.

	0 - 2 km	2 - 4.9 km	5 - 9.9 km	10 - 14.9 km	> 15 km	ALL
WALK	30,000	6,000	0	0	0	36,000
BICYCLE	35,000	67,000	43,000	9,000	1,000	155,000
CAR	3,000	18,000	27,000	23,000	67,000	138,000
BUS	1,000	9,000	14,000	3,000	1,000	29,000
TRAIN	1,000	4,000	13,000	13,000	43,000	74,000
OTHER	0	0	1,000	1,000	4,000	6,000
ALL	70,000	105,000	98,000	49,000	116,000	438,000

Table 1: Copenhagen Work & Education Commuting by Distance (TU-data 2008)

One step toward reaching carbon neutrality by 2025 is increasing bicycle commuters in the City of Copenhagen from 36% to 50%. In order to do so, Copenhagen city officials plan to encourage 55,000 more citizens to choose bikes over other forms of transportation. Copenhagen hopes to convince many of its citizens who travel by car for trips under ten kilometers long to travel by bicycles instead (City of Copenhagen, 2011). To motivate citizens to switch from car to bike, Copenhagen must maintain and improve the biggest appeal of cycling: convenience. This can be done by decreasing travel time, increasing safety and comfort, and addressing the current bicycle parking concerns.

Time is a significant factor in electing to cycle rather than use other modes of transportation. According to cyclists, cycling is the “fastest and easiest way to get around” (City

of Copenhagen, 2011). The convenience of cycling is not solely dictated by the speed at which cyclists can ride, but also the route of travel. The ability to choose their own pace and having opportunities to take more direct routes play key roles in a Dane's decision to ride (Kjærgaard, 2014). The government's focus on improving bicycle infrastructure has had an impacted on cyclists travel times. Contraflow streets that allow cyclists to travel in either direction while cars are limited to one-way travel have eliminated the need for lengthy detours (City of Copenhagen, 2011). The contraflow cycle track in Bremerholm opened in July of 2013 and has since cut 3 to 5 minutes out of cyclists' commutes (City of Copenhagen, 2015). In comparison with the number of trips cycled in 2012, cyclists in 2015 cut, on average, one minute of travel time per five-kilometers traveled (City of Copenhagen, 2015). The appeal of a shorter commute is only one of many factors encouraging the rise of transportation by bicycle.

A sense of security or safety is another major factor in deciding whether or not to bike. Today 74% of Copenhagen's cyclists report feeling safe, while only 6% report feeling unsafe (City of Copenhagen, 2015). Feelings of safety and security are enhanced with cycle tracks or designated bike lanes in which the cyclists are physically separated from nearby motor traffic. These tracks can take the form of raised sidewalks or curbs as dividers. A study conducted on road safety and the perceived risk of bicycle facilities in Copenhagen by Soren Underlien Jensen shows that cyclists feel the safest on roads where cycle tracks are available and least safe in mixed traffic when there are no designated cycle tracks or lanes (see Figure 2) (Jensen, 2007). In these cases where cycle tracks are unable to be implemented, such as residential streets, traffic-calming initiatives are often set in place. Traffic calming imposes speed limits of 30km/hour and prohibits the use of the residential streets for through traffic (Pucher, 2008).

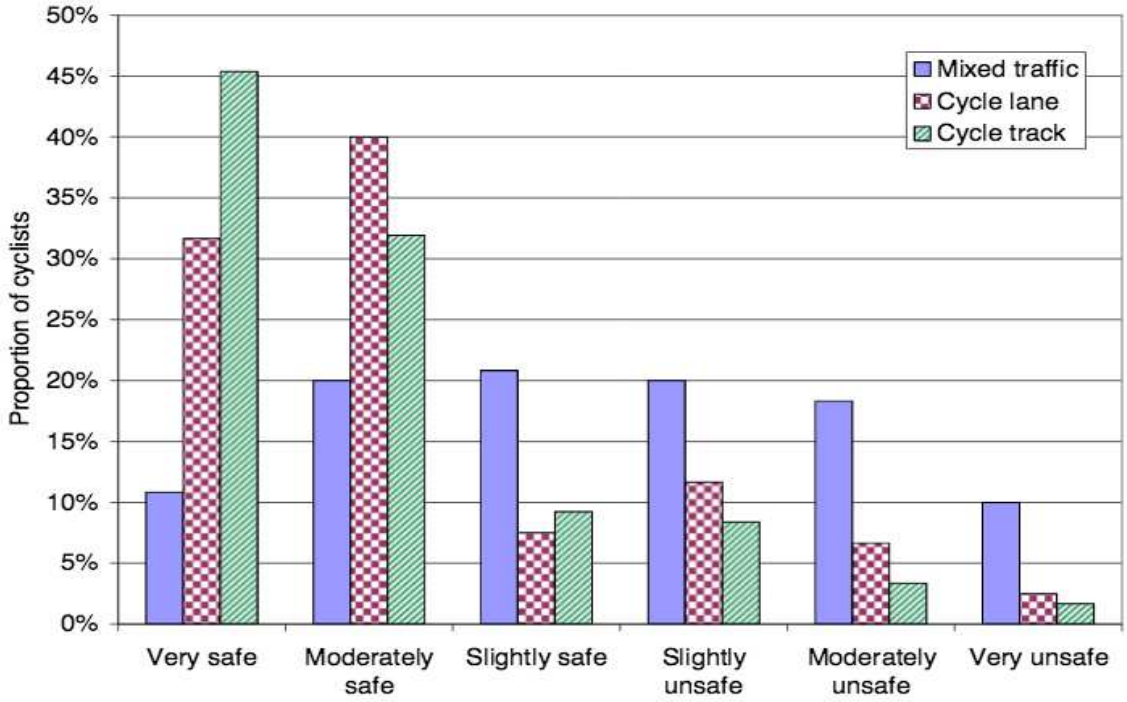

Figure 2: Level of Safety Felt by Cyclists Depending On Location (Jensen, 2007)

Recognizing that cyclists who feel comfortable are likely to continue cycling, Copenhagen strives to provide the best cycling experience for all who choose to participate. Cycle tracks and lanes are kept open at all times. During times of construction, sidewalks and car lanes are often closed or reduced in size, while bicycle lanes remain unaffected (Andersen, 2011). Cycle tracks are also often time cleared before streets during times of snow (See Figure 3). Copenhagen's efforts have been met with approval: according to a survey of cyclists in 2014 conducted by The City of Copenhagen approval ratings for cycle tracks have risen from 50% in 2004 to 63% in 2014 (City of Copenhagen, 2015).

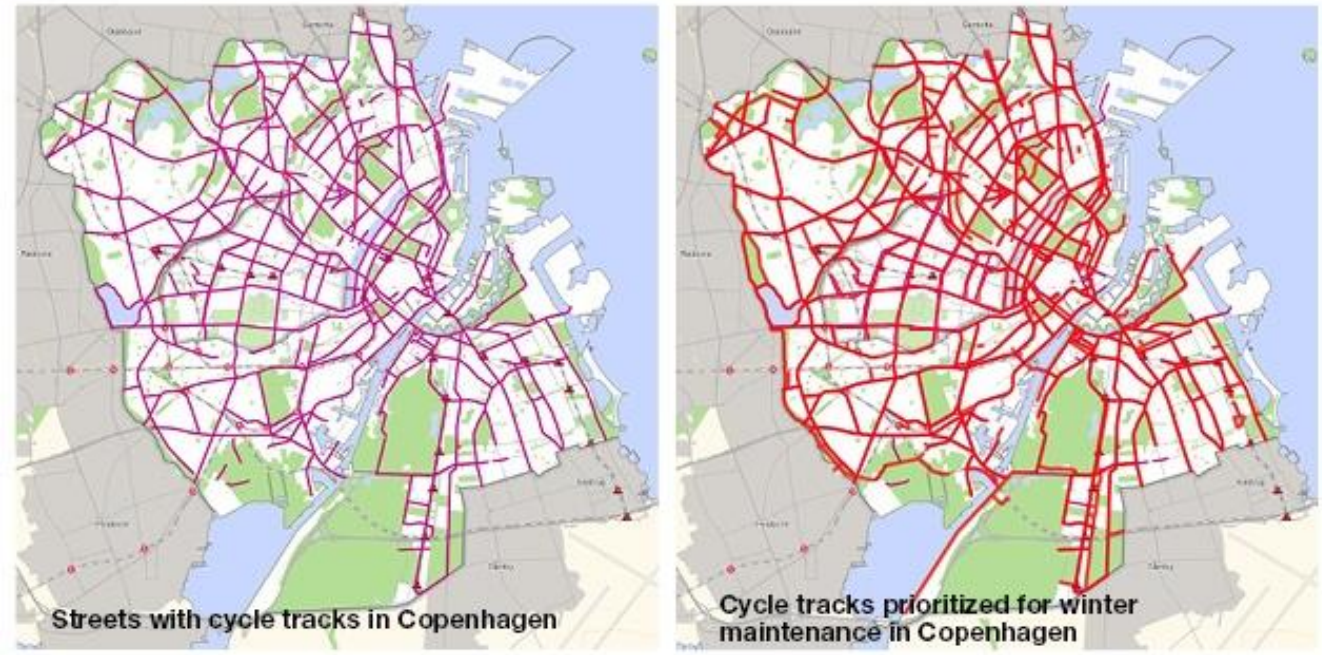

Figure 3: Maps of Cycling Tacks & Winter Maintenance Priority (Andersen, 2011)

Another factor in the decision of whether to bike or drive a car is often a car's ability to transport large items. A parent who needs to purchase groceries for dinner will commute by car, simply because a bicycle typically doesn't provide space to carry groceries (Goodyear, 2014). Cargo bikes can replace cars because they provide transportation while also providing space to transport goods. Cargo bikes range from 208 to 252cm in length and 58 to 90cm in width, with the average bicycle being 87cm wide and 208cm long (Christiana Bikes, 2016). Today, 26% of all families with two or more children in Copenhagen own cargo bikes or bicycle trailers (City of Copenhagen, 2015). Given the extended size and the popularity of cargo bicycles their unique parking requirements need to be considered.

Effects of Biking on the Copenhagen Community

Biking in the city of Copenhagen is so ingrained in the city's culture that it impacts many other areas of the city's operations. Aspects of Copenhagen life that have seen effects due to biking include environmental sustainability, as well as political and economic conditions.

Environmental Impact

Biking has a large impact on the carbon footprint of Copenhagen. In order to reach their aforementioned goal of becoming carbon neutral by 2025, Copenhagen cannot allow biking to lose popularity. Bicycles' impact on Denmark's environmental sustainability has increased over the past years by replacing motor vehicles as a mode of transportation. According to the article *Road Transportation Emerges as Key Driver of Warming*, motor vehicles are the greatest contributors to global warming due to their destructive greenhouse gases and lack of technology to prevent the emission of environmentally hazardous pollutants (NASA, 2010). The energy consumed by a car through gasoline is 42 times higher than the energy consumed by a bicycle through human energy (Glaskin, 2013). The high number of cyclists in Copenhagen prevents 90,000 tons of carbon dioxide from being emitted into the atmosphere each year (City of Copenhagen, 2006).

Many organizations, such as Miljøpunkt Indre By-Christianshavn, are investigating potential solutions to the bicycle parking situation in order to preserve the gains in environmental sustainability of Copenhagen achieved through cycling. Miljøpunkt Indre By-Christianshavn translates to "Environment Point Inner City and Christianshavn." As their name implies, the purpose of the organization is to improve the environmental sustainability of the neighborhoods of Indre By and Christianshavn (Miljøpunkt Indre By Christianshavn, 2012).

Copenhagen has four Miljøpunkt centers set up throughout the city to focus on improving different areas of the city, all in accordance with Agenda 21, the United Nations' 1992 plan for global environmental sustainability in the 21st century (United Nations, 1992). Agenda 21 centers set up around the world are all working towards the goal of continuing to provide clean air, land, and water for future generations (United Nations, 1992). As a result, Miljøpunkt Indre By-Christianshavn, the sponsor of this project, is committed to resolving the bike parking problem in Inner City, Copenhagen.

Political Impact

Politicians in Copenhagen support bicycle use, as they want to reduce traffic congestion and increase environmental sustainability. Almost all political groups agree with and openly support achieving a carbon neutral city by 2025. Leaders are aware that more infrastructure, including cycling routes and parking facilities, are needed to further expand the bicycling initiative. Politicians are however hesitant about expanding parking facilities as there is a perceived lack of proper behavior in using the existing facilities and respecting other's properties (Bike Parking Manual, 2008) Aggressive and irresponsible actions of cyclists around parking have slowed collaborative action (Bike Parking Manual, 2008). Politicians and other community leaders also need to consider the economic impact cycling has in Copenhagen: for every kilometer traveled by bike, taxpayers save 7.8 cents on the dollar (DKK 0.45). As a result of Copenhagen's residents traveling an estimated 1.2 kilometers daily, approximately 34 million dollars (DKK 225 million) are saved annually (Huffington Post, 2013).

Negatives Impacts of Poor Bike Parking

Copenhagen's current bike parking situation is a product of both the city's parking facilities and cyclists' habits. The parking facilities fall short with both their location as well as the quantity of parking spots, while the bad habits are a byproduct of over a decade of unregulated parking.

Congestion caused by parked bikes is a growing concern for pedestrians and business owners. As noted in a BBC article, "bikes are often parked randomly on the pavement, taking up pedestrian space and blocking entrances to shops and restaurants" (Otzen, 2014). The congestion on some sidewalks is so bad that it forces pedestrians to walk in the street (Otzen, 2014). Inconvenience also plays a large part in hindering the cycling system, as the piling of bicycles on top of each other makes it difficult for cyclists to find and extract their bikes in a timely manner. Piles of bikes are also aesthetically unappealing, especially in the historic Inner City of Copenhagen, an area that desires to be a destination that is attractive to tourists (City of Copenhagen, 2011). As long as bike parking remains unaddressed and the number of cyclists increases, discontent will rise (Otzen, 2014).

Cyclists choose parking spots based on the proximity to their destination, accessibility of the spots, and ease of use (City of Copenhagen, 2011). On average cyclists are only willing to walk a maximum of 30-40 meters from their parked bike to their destination, otherwise biking loses its convenience factor (Kjærgaard, 2014). Additionally, cyclists recognize that bikes are safer if they are parked in the vicinity of many other bikes (Otzen, 2014).

Copenhagen's congested bicycle parking problem is also the result of bicycles being abandoned and left in or around racks. These bicycles being left overnight or for long periods of time are due to cyclists commuting, bicycle theft, and cyclists losing their bikes.

Copenhagen's Municipality has a bicycle removal program in which bicycles that show signs of abandonment (dry chains, rusting, and or flat tires) are tagged with tape along their back wheel. If the tape is not broken after at least a month, signifying that the bicycle has not been used, the bicycle is then legally allowed to be removed. However, such removal is typically not the case because currently there are only 2 people working on the tagging and removal of abandoned bicycles throughout the entire city of Copenhagen (M. Kurth, personal communication, April 6, 2016). Due to the lack of resources, the system is not particularly effective.

The locations that get tagged in this process are either repeatedly visited by the workers who tag or are specifically requested to be visited by citizens. When a street is visited, the bicycles are assessed in order to determine which bicycles have been there for a week or more. The number of bicycles tagged on that street, as well as the date, is then recorded on an app. After at least a month has gone by, the street is revisited to remove the remaining tagged bicycles. The date and the number of bicycles picked up are again recorded on the app.

According to estimates calculated in 2015, there are around 70,000 abandoned bicycles throughout the city in both public and private areas. Approximately half of these "dead" bicycles are left in public areas. (M. Kurth, personal communication, April 19, 2016). In 2015, the removal system was able to tag and collect nearly 19% of the estimated abandoned bicycles.

A major problem in tagging bicycles that appear to be abandoned is that the only real indicators of a bicycle being in one spot for a long period of time are dry rusted chains or flat tires. Both of these indicators do not occur rapidly; it may take months in order for a chain to rust or a tire to deflate. It is tough to effectively tag all of the abandoned bicycles, as there is currently no available technology that can track how long a bicycle is parked in one spot. Mass tagging of streets has not occurred since 2013, as organized crime rate spiked during this time where people pretending to work for the municipality and would steal large quantities of bikes (M. Kurth, personal communication, April 6, 2016).

In 2015, 23,087 bicycles were tagged throughout the city of Copenhagen. Only 28.6% of these tagged bicycles were eventually removed. Since 2013, when the mass tagging on streets stopped, the highest collection rate was 31.8% in 2014(M. Kurth, personal communication, April 6, 2016). Table 2 shows the number of bicycles marked and collected each year.

Year	Marked	Collected	Percent
2011	13,075	7,271	55.6 %
2012	23,366	8,200	35.1 %
2013	40,250	10,363	25.7 %
2014	23,540	7,477	31.8 %
2015	23,087	6,598	28.6 %

Table 2: Total Number of Marked and Collected Bicycles throughout the City of Copenhagen

(M. Kurth, personal communication, April 6, 2016**)**

The extreme numbers of abandoned bicycles are not only the result of the city's ineffective bicycle removal system, but also the leniency of insurance companies when dealing with stolen bicycles. If a cyclist's bicycle is stolen and they report it to their insurance company

it takes 2 to 3 days to receive insurance money to purchase a new bike. Through the current removal system it would take approximately two month for a bike to reach lost property (M. Kurth, personal communication, April 6, 2016. The current system often times creates a comfortable habit for cyclists to not become too concerned if their bicycle is stolen. As the shop owner of Wasteland on Studiestræde explained, “Stealing someone’s bicycle in Denmark is like stealing someone’s lighter.”

Many cyclists do not know where to go when their bicycle is lost, but there is an established procedure. Bicycles that have been tagged and removed are brought to a storage facility in Amager. The bikes are then accessed by the police and those valued at least 500 Danish kroner are put in lost property. The identification number, VIN, is ran and the insurance company is contacted. If the insurance company has already paid the owner’s claim they can then resell the found bike. Unclaimed bicycles brought to lost property will be sold or auctioned off. Bicycles valued under 500 Danish kroner will go to scrap metal (M. Kurth, personal communication, April 6, 2016).

There are many gray areas in the bicycle removal system due to there only being two written laws on bicycle parking. The first is that cyclists are not allowed to park in security zones are anywhere that would cause traffic risk. The second is that no one is allowed to move someone’s bicycle. The police are not allowed to, the Ministry of Traffic is not allowed to, and even the removal system is not allowed to until they go through the entire tagging process.

As of January 2016 the number of bicycle parking spots throughout the City of Copenhagen accounts to 73,900 (TMF, 2016). According to data collected through systematic counting of bicycles at the Nørreport station and Israel square it has been estimated that on

average 10-15% of all bicycle parking spots throughout the city are taken up by abandoned bicycles. This percent varies at each station and area. The highest percentage calculated raises to 20-25%. That equates to approximately 362 unavailable bike parking spots at the Nørreport Station.

Existing Parking Solutions

Many types of bike parking strategies are available and in use today in Copenhagen. Many of these strategies can be grouped into three main concepts: stands or racks, lockers, and shelters or sheds. Bike stands and racks are easy to use for cyclists, do not take up much space, and can be sized to fit the appropriate number of bikes of the area. When space is limited, bike racks can be multilayered. Racks and stands are typically used for short-term parking, while lockers, shelters, and sheds are for long-term parking as they provide more protection (Banker, 2006). The cost of implementing a single traditional bicycle parking spot in Copenhagen is 2800 Danish kroner. The cost of constructing pavement along with a bicycle rack/stand is approximately 12,000 kroner per parking spot. A bicycle storage or locker would cost approximately 60,000 kroner per bicycle parking spot (TMF, 2016). These strategies address diverse cyclist considerations, different parking strategies are needed for different areas.

To combat Copenhagen's congested bicycle parking issues city leaders have looked at strategies used locally and globally (City of Copenhagen, 2011). For areas with little space and high bike parking density, underground parking facilities can be considered. The Netherlands has built underground parking at train stations. In November 2013, a new central railway station opened in Rotterdam containing 5,190 bicycle parking spaces. Cyclists enter the underground facility through the central railway station's square and take a bicycle escalator

down to the parking area filled with double stacked racks (Bicycle Dutch, 2014). In Tokyo, Japan, an eco-friendly Japanese company constructed an underground bike parking system called ECO Cycle. In this system a door detects the bicycle, grabs its front wheel and places it in one of the 204 available parking slots. The ECO Cycle system goes 11 meters deep into the ground and takes on average 8 seconds to park a bicycle. A membership is needed to use ECO Cycle. After the membership is purchased an identification chip is placed on the bike's front wheel. To retrieve a parked bike a membership card is scanned at the entrance and the bike with the matching identification chip is brought up and returned (Snellings, 2013). Underground bicycle parking is one way to save space; however, it is not an inexpensive or feasible option for problematic low-density bicycle parking areas.

A less expensive, low space bicycle parking solution can be found locally by integrating bicycle parking spots into Copenhagen's existing infrastructure. On Guldbergsgade, in Nørrebro where the streets are wide enough to accommodate both motor vehicle and bicycle lanes, bicycle parking has been used as a barrier. This solution frees up sidewalk space and creates a safety barrier between cars and bikes (See Figure 4) (Copenhagenize, 2013). Another solution is to convert existing car parking spaces into bicycle parking spaces. A single car parking space can provide space for up to twelve bicycles (Miljøpunkt Indre By, 2015). Further analysis regarding how overcrowded bicycle parking effects car parking in specific areas will help determine the pros and cons of various potential solutions.

Figure 4: Use of Bike Parking to Separate Transportation Lanes (Andersen, 2010)

A previously attempted bicycle parking solution for cargo bikes took place in the Vesterbro neighborhood of Copenhagen. The Cargo Bike Car, as shown in Figure 5, is a colored fiberglass shell of a car that contains four compartments. Each compartment holds one cargo bike, allowing four cargo bikes to be parked in the same space one car would. The car's shell included four solar powered headlights that automatically turn on when it became dark along with a solar powered light inside each compartment that turned on when the door was opened. Inside each compartment, hooks and nets were included to provide space for hanging clothes and other gear. The compartments opened with a purchased key or by paying a parking fee (Copenhagenize, 2009).

Figure 5: Cargo Bike Car, Parks Four Cargo Bikes (Copenhagenize, 2009)

Nørreport is one of the busiest train stations in Copenhagen. Of the 250,000 people passing through the station per day, 20,000 are cyclists (COBE, 2015). The station has recently been renovated to improve the accessibility and use of the 10.5 m^2 urban area (COBE, 2015). During the renovation, the circulation of pedestrians and cyclists was analyzed. Sunken bicycle beds (See Figure 6) were placed in specific areas to work in accordance with cyclist's habits. The bicycle beds are lowered 20 to 30 cm from the rest of the surface to reduce obstructing pedestrian's views. The new parking facilities provide 2,100 bicycle parking spots which is 200 spaces more than the original facilities (Kristensen, 2015).

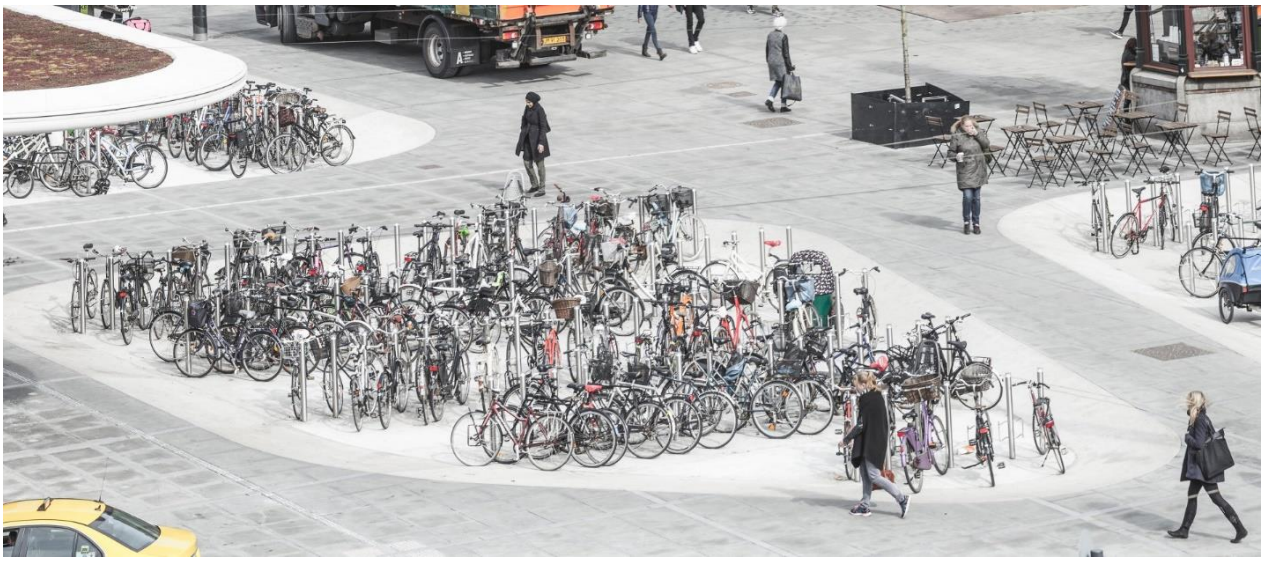

Figure 6: The sunken bicycle beds at the Nørreport Station (COBE, 2015)

Copenhagen's metro stations also include bicycle parking cellars. Bicycle parking cellars are spaces underground designated for bicycle parking. These cellars are often difficult to access and many cyclists do not know about them, resulting in low usage (Gautaki, 2016). In order to influence cyclists to use the bicycle cellars many strategies have been implemented, including a quick fix system, workshops, and Metrobikes. In the quick fix system cyclists can submit a request to get their bicycle fixed in one of the quick fix stations located in bicycle cellars at most metro stations (See Figure 7). When a bicycle is dropped off, the cyclist receives a metro ticket to continue on their way. A traveling mechanic will fix the bicycle and leave a personal note when done. If the bicycle cannot be fixed by the mechanic he or she will recommend a nearby cycle shop (Singh, 2016). A second strategy to use the bicycle cellar in an engaging way is DIY bike fixing corners. Along with the DIY corners in bicycle cellars, workshops have been organized to publicize bicycle cellars and bring different people to the metro station. Through the use of invitational fliers and online publishing, Nørreport has experienced three successful workshops. The workshops have included a DIY bicycle fixing workshop, a Tai-Chi

workshop, and a choir workshop (Goutaki, 2016). A third strategy used to influence the use of bicycle cellars is metro bikes. The Metrobike system allows cyclists to rent out their bicycles in exchange for a free metro ride. This idea strives to reduce city's bicycle clutter by bringing unused bicycles outside the metro stations inside the bicycle cellars (Kuhberg, 2016).

Figure 7: Advertisement for the Quick Fix (Singh, 2016)

Another strategy used by Copenhagen is flex parking. Flex parking is a parking spot shared between cyclists and motorists. At designated times the parking space is for bicycles parking leaving the other times for motorists. Flex parking is being tested on Ndr. Frihavnsgade, a street which is close to one of the High Schools in Copenhagen (Coleville-Anderson, 2011). Flex parking only works when cyclists and motorists need parking spaces at different times. Frihavnsgade is the ideal street to test out flex parking as it includes a school and residential areas. During the day students need room to park their bicycles. After school when the students leave and residents head home from work, the residents need a place to park their car. Flex parking allows for both cyclists and motorists to use the same area as there are no

cumbersome bicycle racks to remove. Most bicycles have kickstands and do not require a rack to stand upright (Hoe, 2012). The goal of the flex parking is to create a safe environment for students who bike to school (Coleville-Anderson, 2011). The flex parking logo as shown in Figure 8 is painted on the pavement as well as shown on surrounding signs explaining the times to help remind cyclists and motorists of the rules (Hoe, 2012). The biggest challenge of flex parking is the times in which parking switches from car to bicycles and from bicycles to car. A few time the area experienced a car or bicycle that was not removed. No major problems or accidents and resulted from this. However, there is currently no enforcement put into place for vehicles or bicycles that do not follow the time changes (Hoe, 2012).

Figure 8: Left; Flex Parking Sign Regulating Hours, Left; Flex Parking in Use on Frihavnsgade (Coleville-Anderson, 2011)

Constructing the correct bike parking facilities is only half of the solution to Copenhagen's congested bicycle parking. Constructing new parking facilities will not fix the problem if cyclists do not use them. Motivating citizens to change lifelong habits is not easy. Knowing what influences behavior is important in changing behavior. The Theory of Planned

Behavior states that behavior is dictated by intentions. Intentions are determined by attitudes, perceived control, and subjective norms (See Figure 9). Attitudes are evaluations of ideas, events, or people and are typically positive or negative. Perceived control refers to how easy or the hard the behavior will be to execute, while subjective norms are attitudes and behaviors that are considered normal and met with approval (CommonGap, 2009). The Planned Behavior Theory predicts people's behavior based on what they intend and want to do.

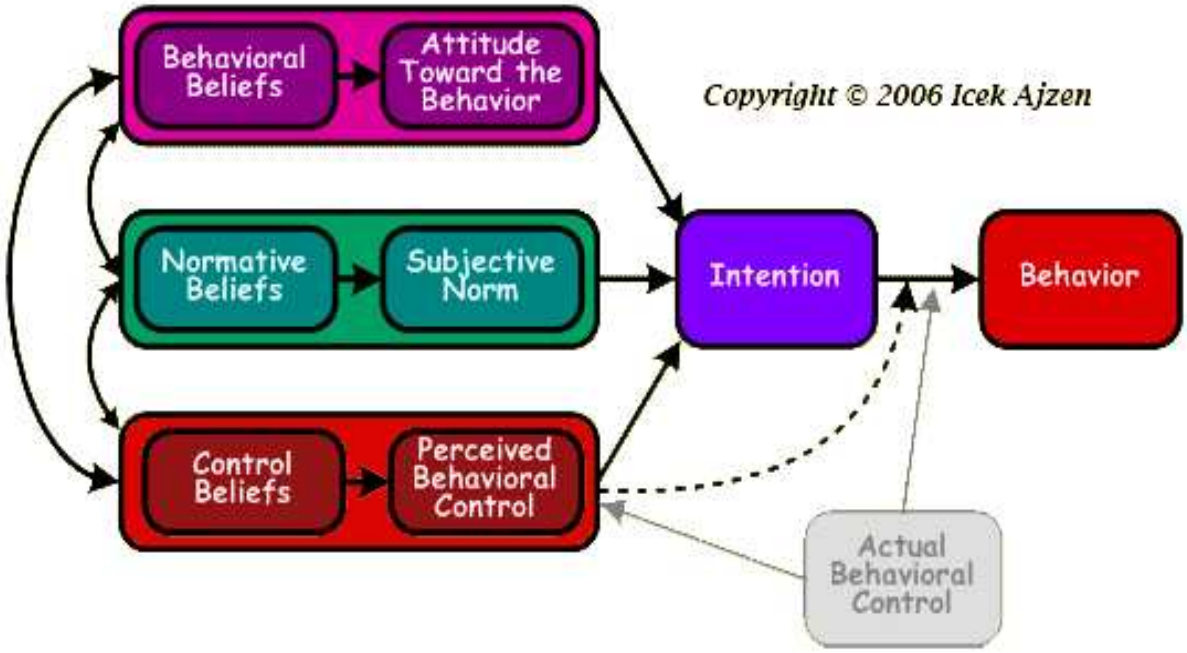

Figure 9: Theory of Planned Behavior (Boston University School of Public Health, 2016)

There are several limitations to The Planned Behavior Theory that must be understood. The first is that the theory assumes that the person has the available opportunities and resources required to be successful in performing the desired behavior. An individual may have the good intention to throw away a candy wrapper, but if no trash can is available how long will the good intentions of the individual last until he or she no longer wants to hold onto the candy wrapper? This alludes to a second limitation in which the time frame between intent and

behavioral action is not explained. The Planned Behavior Theory does not take into account other variables that may affect behavioral intention such as fear, threats, current mood, or past experience. Influences from society are considered through subjective norms but environmental and economic influences are not considered in the Theory. The Planned Behavior Theory assumes that behavior is the result of a linear decision-making process (CommonGap, 2009). The Theory simplifies behavior to be based on intention and motivation. This simplified idea is the first stepping stone to try and find ways to change bad behavior, which in this case is bicycle parking.

One way to encourage proper behavior is to make parking a bike in a proper spot fun and memorable. The idea of changing people's behavior by making something fun is known as the Fun theory and has been implemented in a subway station located in Stockholm, Sweden. In the subway station the stairs and the escalator are located side by side. To test if more people could be swayed to take the stairs over the escalator, the staircase was transformed into a giant piano, where each step played a musical note when stepped on. It was found that after the stairs were converted to piano keys, the number of commuters who took the stairs increased by 66% (Kelsey Ramos, Los Angeles Times). A second fun theory experiment focuses on encouraging the use trashcans and led to the construction of the World's Deepest Trash. When a piece of trash is thrown in it triggers what sounds like the trash falling down a very long hole and eventually hitting the bottom with a crash. It was found that this trashcan collected 41 kg more trash than the surrounding normal trashcans (Merchant, 2009).

Summary

The large influx of cyclists in Copenhagen has put a heavy strain on the parking infrastructure, leading to heavy congestion in areas such as narrow inner city streets. Our sponsor, Miljøpunkt Indre By-Christianshavn, is interested in assessing the parking habits in narrow streets and taking action to move forward and fix the problem. The physical trends of the parking and the motivations of cyclists behind these trends need to be better understood. With this knowledge, potential solutions could be generated.

Chapter 3: Methodology

This project was designed to assist Miljøpunkt Indre By in their effort to continue to improve the environmental sustainability of Inner City of Copenhagen by exploring possible bicycle parking solutions for narrow streets.

Our team fulfilled this goal by accomplishing the following objectives:

1. Assess the current habits of cyclists
2. Identify the needs of stakeholders
3. Propose final bike parking recommendations

Assess the Current Habits of Cyclists

In order to develop practical bicycle parking solutions for the narrow streets of Copenhagen, the current habits of cyclists in the area needed to be assessed. Using a map of the region and using natural observation, we identified the streets with the highest and lowest densities of congested bicycle parking. For the purpose of this project, streets with high levels of congested bike parking were defined as having overcrowded sidewalks, misused bike racks, and/or no bike racks. Streets with low levels of bicycle congestion were defined as having clear sidewalks, ample amount of bike racks and/or the correct use of bicycle racks. The observed streets were ranked on a scale of 1 through 3. A ranking of 3 meant the street experienced high levels of congested parking, while a ranking of 1 meant the street experienced little to no bicycle parking congestion.

Studiestræde, which received a ranking of 3, was identified as the local street that experienced the highest bicycle parking congestion. To further investigate the parking habits on

Studiestræde, the street was divided into four zones. The first zone included one bicycle rack outside a Law school with 25 bicycle parking spots. Across the street were a couple bars and food stores. In zone 2 there was a bicycle rack outside of The Living Room Café with 33 bicycle parking spots. Across the street was a piercing and tattoo parlor. In zone 3 there were two bicycle racks next to each other that combined for 23 total bicycle parking spots right outside of Atlas bar. There were also a few clothing stores on both sides of the street in zone 3. There are no bicycle racks in zone 4. The shops in zone 4 included a bar and clothing stores. In total there were 81 bicycle parking spaces on the street of Studiestræde.

Flow and Hourly Bicycle Counting

After splitting up the street into four zones, we began conducting a more in-depth analysis of how many bicycles arrived on the street and at what times these bikes are parked through routine observation. The amount of bicycles parked on the street, sidewalks, and racks were tallied from 6am to 9pm for two weeks on both weekdays and weekends. During the first week of observation, each group member was in charge of a zone over a four hour counting period. In these periods, the number of bikes were counted and photographed hourly. The number of bicycles parking and leaving the zone, as well as the parking habits of incoming cyclists, was noted. During the second week of observation, group members were assigned two zones per four hour counting period. In these periods, the number of bikes parked at each hour was counted, making note of where each bicycle was parked in respect to the bicycle rack. The amount of parked bicycles extended from the stand into existing car parking spots was also recorded along with the length they extended in meters (See Figure 10). See Appendix 1 for data recording sheets.

Figure 10: Bicycle's extending from Rack and into Street Car Parking

Bicycle Tagging Experiment

In order to determine how many bicycles were left on the street for extended period of times we conducted our own bicycle tagging experiment. On March 23rd during the hour of 9:00pm, when fewer bicycles are parked on the street, paper was taped around the handle bars or hand breaks of all parked bicycles (149). Close considerations were taken to make sure the tape only touched the paper as to not potentially ruin the bicycle handlebars/breaks and anger the owner. The pieces of paper stated the following:

This paper is used for a bike-parking project. Please throw this paper away when removed. Thank You

Dette papir anvendes til en cykel - parkering projekt . Venligst smide dette papir væk, når fjernet . Tak / Mange Tak

The remaining tagged bicycles and the amount of designated rack spots they blocked were then counted every Tuesday and Friday for three consecutive weeks.

To validate the experiment and see if similar patterns occurred on surrounding narrow streets, the experiment was repeated on a second street. On Tuesday April 12th, 93 bicycles

were tagged on the neighboring street of Vestergade. These tagged bicycles and blocked spots were recounted every Tuesday and Thursday for two consecutive weeks.

Identify the Needs of Stakeholders

A successful parking solution should consider and meet the needs of all stakeholders. For this project the stakeholders were defined as the cyclists of the area, the business owners whose shops are on the street, and the pedestrians/residents of the area.

The cyclists' and business owners' needs were evaluated through semi-structured interviews. 31 Cyclists and 16 businesses owners/employees were interviewed. Not all businesses on Studiestræde were interviewed as many were closed during the day time or bust with customers. See Appendix 7 for interview questions.

The needs of pedestrians were evaluated through observation. The counting was done outside of The Living Room Café in zone 2 and only the pedestrians, cars, and bicycles that passed by the Café were recorded. See Appendix 2 for pedestrian observation data recording sheets

Propose Final Bike Parking Recommendations

To be able to properly propose final recommendations to our sponsors on the bicycle parking situation of inner city Copenhagen, a variety of factors were considered in potential solutions. These factors included: the feasibility of the solutions, their financial impact on the community, and how each option met the expressed needs of stakeholders. The feasibility of the different physical ways to address the bike parking issues of Inner City Copenhagen can be broken down into the aesthetics, safety, legality, and space required to integrate.

Feasibility was also evaluated from the psychological side by asking stakeholders their opinions on solutions. From our interview with cyclists and shop owners, we were able to evaluate if specific solutions would be accepted by the population.

From the research conducted into bike parking, as well as the information that we gathered in the field and from our sponsor, we were able to assess each potential solution on whether or not it exhibited the three previously mentioned factors. The results of these assessments were listed in a matrix. This matrix was incorporated into the final stage of our analysis, where each factor was given a weighted value and then added to a Pugh Matrix along with other characteristics of the solutions.

The financial effects of changing the bike parking system in the inner city Copenhagen extends too many groups including shop owners, the local government, and the overall community itself. Factors such as cost of manufacturing a bike parking device and money lost from removal of paid car parking spots. This information was obtained through archival research as well as discussions with specific stakeholders including our sponsor and local experts such as the bike parking removal project leader.

After fully executing objectives one and two of our methodology, we were able to construct the Pugh Matrix. A Pugh Matrix compares all solutions being considered and ranks them based on how well they address a variety of weighted factors (Burge, 2009). An example of a Pugh Matrix is shown below in Table 3

Criteria	Baseline	Alternative Solution		
	Current Solution	Alternative 1	Alternative 2	Alternative 3
Feasibility	5	1	1	1
Cost	4	-1	-1	0
Long Term Benefit	1	0	-1	1
Maintainability	3	0	0	-1
Availability of Resources	2	1	0	-1
Sum of all Positives		7	5	6
Sum of all Negatives		4	5	5
Sum of all Neutrals		0	0	0
Total		**3**	**0**	**1**

Table 3: A Generic Example of a Pugh Matrix (whatissixsigma.net)

First, we selected the potential solutions that would be evaluated in the matrix. We did this by taking into consideration both ideas brought to us through interviews, on street observations, collected data, and research.

The next step was deciding the specific criteria that solutions would be evaluated on. To determine these criteria the available bicycle parking background research was reviewed along with the quantitative and qualitative results of objective one and two. This approached allowed us to easily summarize the information we had gathered into a single chart. The criteria selected included cost, safety, accessibility, space, aesthetics, and the opinions of the cyclists, shop owners, and pedestrians.

The final step in laying out the Pugh Matrix (See Table 4) was weighting the eight criteria on a scale of one to five in order to separate and group characteristics based on their importance. Cost and safety were the most important, receiving ratings of 5. Cost was an important factor because government funding has a large impact on organizations ability to fix the bike parking situation. Safety was also important because a recommendation that put

citizens' safety at risk would not be accepted. The next most significant factors were accessibility and space which received weights of 4. Accessibility must be considered as cyclists will not use solutions that are difficult to get to. There must also be enough physical space on the street to accommodate each recommendation. The opinions of cyclists were next with a weighting of 3. The recommendations were made with the cyclists' needs in mind; however they may require cyclists to change habits, meaning some resistance and required convincing would be acceptable. The aesthetics of the recommendations and the opinions of the shop owners were rated second to lowest, with weights of 2. Both were supporting elements of each recommendation, but neither was imperative to their success. Lastly, the opinions of pedestrians were weighted as 1. This is due to pedestrians being indirectly affected by the recommended solutions.

Pugh Matrix							
Criteria	Weight	Improved Removal	Constraining Landmarks	Flex Parking	Additional Racks	Informative Signs	Campaigning
Cost	5						
Safety	5						
Accessibility	4						
Space	4						
Cyclists' Opinion	3						
Aesthetics	2						
Shop Owners' Opinion	2						
Pedestrians' Opinion	1						
Total							

Table 4: A Blank Version of Our Final Pugh Matrix

Chapter 4: Results

To execute our mission statement of exploring potential bike parking solutions for the narrow street of Studiestræde, we followed our original three objectives. The street was divided up into four zones in order to collectively observe the entire area at one time. The demographics of the cyclists parking, the number of cyclists coming into and leaving the street each hour, and the total number of bikes parked at any given time were observed. How cyclists chose to use the available bicycle racks was also observed. These observations accounted for the number of bicycles parked each hour, the amount of vacant and blocked spots, as well as, how far parked bikes extended from the end of the racks and into the streets. We took this information from the hours of 6:00-21:00 in two groups classified as weekdays (Monday through Thursday) and weekends (Friday through Sunday). Two separate sets of data were taken for each group for validation. 31 Cyclists were interviewed as well as 16 shop owners/employees. Pedestrians were observed from 11:00-15:00 for two days to observe how bike parking affected them. Finally, a Pugh Matrix was constructed to generate our final recommendations.

This results section will discuss the averages of our findings. To see the in depth break down of our results consult Appendices 3 through 6.

Demographics

Studiestræde is most frequently visited by young males and females riding regular bicycles as shown in Figure 11. Of the 831 cyclists observed, 705 were younger while only 126 were older. Throughout the duration of the observation period a total of 15 cargo bikes were

seen. The observation of the cyclists and their habits revealed that 76% of bicycle parking on Studiestræde was problematic.

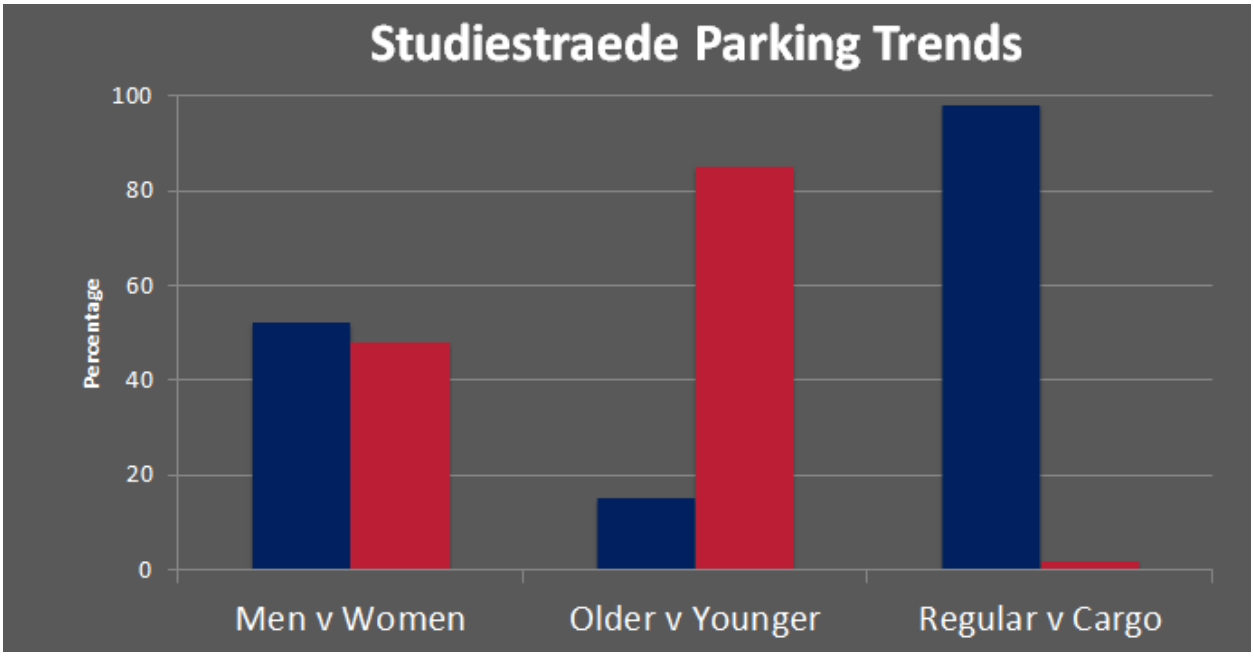

Figure 11: Demographics of the Cyclists parking on the street

Flow Data

The data gathered from constant monitoring of cyclists parking their bikes on Studiestræde provided information on the overall flow of bicycles on the street. The total tally of bikes on the street each hour, when plotted, provides a clear picture of the times of day when the most bicycle parking is needed.

The flow data also provides the magnitude of bikes moving through the street at every hour. These numbers are important because they capture how fifty bikes entering and fifty bikes leaving the street in an hour do not mean that there were no bikes traversing the street at that time. Rather the opposite in that it would display a spike of one hundred bikes flowing through Studiestræde. This information is relevant because it provides us with a true baseline

of how many bikes might actually use Studiestræde at any time. For example, at 13:00 on weekdays, there were approximately 225 bikes parked at the start of the hour. However, throughout the hour, approximately 120 bikes flowed through the street. This highlights how the area needs to still be easily navigable at high activity hours, meaning the facilities need to be able to accommodate everyone while also not crowding the space. This type of worst-case scenario should ideally be met by the culmination of all the recommendations we propose.

Weekday

On weekdays there were 173 bikes parked on Studiestræde per hour. Of these bicycles, 113 were parked within the rack, but only 59 were designated spots. There were 15 blocked spots throughout the racks and 7 open available spots. There were 15 bicycles that extend 9.5 meters out the stand and into the street. As seen in Figure 11, the peak hours for bicycle parking occurred between 12:00 and 14:00, with a maximum value of 244 bikes at 1PM. During this time frame students are going to Copenhagen Law School, which is on Studiestræde, and other people are going to lunch during the workweek.

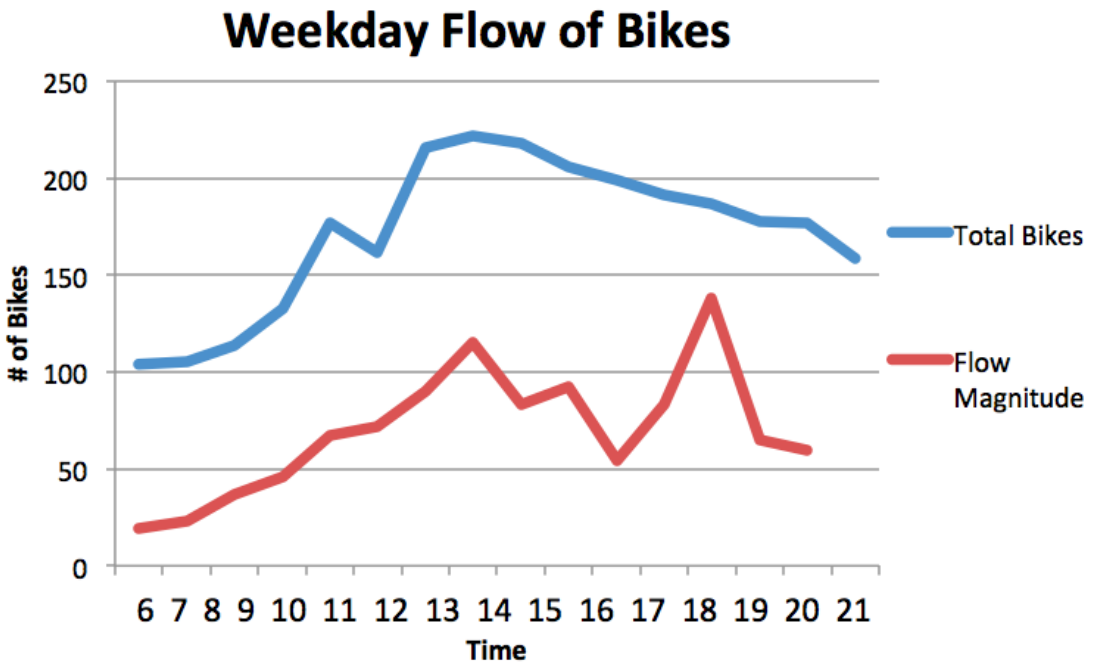

Figure 11: Total Number of Bikes and Number of Bikes In and Out of the Street vs Time on Weekdays

Weekend

On the weekends there were 182 bikes parked on the street. Of these bicycles, 117 were parked within the rack while only 56 of these were designated rack spots. There were 16 blocked spots throughout the racks and 9 open available spots. There were 19 bicycles that extend 12.1 meters out of the stand and into the street. As seen in Figure 12, the peak hours for bicycle parking occurred between 6 PM and 9 PM, with a maximum value of 206 bikes at 8PM. This data is comparable with people riding their bikes when they go out to socialize on the weekends.

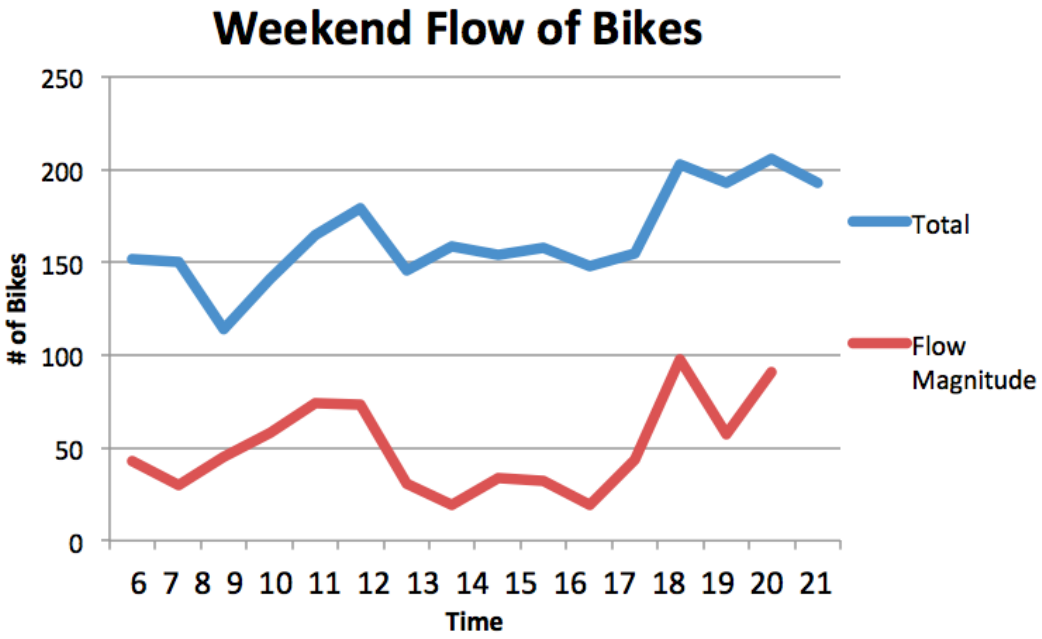

Figure 12: Total Number of Bikes and Number of Bikes In and Out of the Street vs Time on Weekends

Tagged Bicycle Experiment

On March 23rd a total of 149 bicycles parked on Studiestræde were tagged in order to track the number of abandoned bicycles. After 23 days, 52 tagged bicycles remained in the racks and along the stands. These 52 "dead" bicycles blocked 37% of the available 81 bicycle parking spots. Table 5 shows the data collected on each day of counting. It is important to note that on day 12 a total number of 59 remaining tagged bicycles blocked 30 spots, while on day 19 a lower number of remaining tagged bicycles (53) blocked a high number of spots (33). This was theorized to be the result of dead bicycles being moved and jostled around: instead of only blocking one spot, tagged bicycles that had been knocked down now blocked two spots.

	Date	Number of Tagged Bicycles			
Day 0	*March 23rd*	149			
	Date	**Remaining Tagged Bicycles**	**Percentage (%)**	**Blocked Spots**	**Percentage (%)**
Day 6	*March 29th*	**61**	**40.94**		
	Zone 1	10	6.71		
	Zone 2	22	14.77		
	Zone 3	25	16.78		
	Zone 4	4	2.69		
Day 7	*March 30th*	**59**	**39.60**		
	Zone 1	11	7.38		
	Zone 2	20	13.42		
	Zone 3	24	16.11		
	Zone 4	4	2.69		
Day 12	*April 4th*	**59**	**39.60**	**30**	**37.04**
	Zone 1	11	7.38	6	7.41
	Zone 2	18	12.08	14	17.28
	Zone 3	26	17.45	10	12.35
	Zone 4	4	2.68	0	0.00
Day 19	*April 11th*	**53**	**35.57**	**33**	**40.74**
	Zone 1	12	8.05	7	8.64
	Zone 2	17	11.41	14	17.28
	Zone 3	20	13.42	12	14.81
	Zone 4	4	2.68	0	0.00
Day 23	*April 11th*	**52**	**34.90**	**30**	**37.04**
	Zone 1	12	8.05	7	8.64
	Zone 2	14	9.40	11	13.58
	Zone 3	22	14.77	12	14.81
	Zone 4	4	2.68	0	0.00

Table 5: Data of Studiestræde Tagging Bicycles Experiment

On April 12th a total of 93 bicycles parked on Vestergade were tagged in order to track the number of abandoned bicycles. On Day 15, a total of 50 tagged bicycles remained in the racks and along the stands. These 50 "dead" bicycles blocked 33% of the available 134 bicycle parking spots (See Table 6).

	Date	**Number of Tagged Bicycles**			
Day 0	*April 12th*	93			
	Date	**Remaining Tagged Bicycles**	**Percentage (%)**	**Blocked Spots**	**Percentage (%)**
Day 3	*April 15th*	**62**	**66.67**	**53**	**39.55**
	Zone 1	16	17.20	14	10.45
	Zone 2	10	10.75	7	5.22
	Zone 3	17	18.28	15	11.19
	Zone 4	7	7.53	5	3.73
	Zone 5	12	12.90	12	8.96
Day 7	*April 19th*	**55**	**59.14**	**47**	**35.07**
	Zone 1	11	11.83	9	6.72
	Zone 2	7	7.53	6	4.48
	Zone 3	17	18.28	13	9.70
	Zone 4	6	6.45	5	3.73
	Zone 5	14	15.05	14	10.45
Day 15	*April 27th*	**50**	**53.76**	**44**	**32.83**
	Zone 1	10	10.75	8	5.97
	Zone 2	6	6.45	4	2.98
	Zone 3	17	18.28	14	10.45
	Zone 4	6	6.45	7	5.22
	Zone 5	11	11.83	11	8.21

Table 6: Data of Vestergade Tagging Bicycles Experiment

The results of Vestergade prove that dead bicycles taking up rack space is not a problem that's isolated to Studiestræde. This is what we believe to be the root cause of the problem that's creating congestion and frustration for the stakeholders.

Stakeholder Interviews:

Cyclists

Cyclists' frustrations with the current bicycle parking situation stemmed from there not being enough available parking spaces on the street. Studiestræde's racks were often full and had minimal spaces available to park bicycles. This was one of the main motivators as to why cyclists parked their bikes against walls or windows.

Another major frustration shared among most cyclists was the amount of bikes parked in the racks for extended periods of time. Of the 30 cyclists interviewed, around 23% said they had park overnight in a public rack. However, most of these cyclists admitted to doing so at metro or train stations. The interviews with cyclists provided no insight as to where the long term parked bicycles are coming from, leading us to infer that these "dead" bicycles are in fact abandoned.

Shop Owners

Shop owners are impacted by bicycle parking because their shops' accessibility and aesthetics were often negatively affected by cyclists' parking habits. While it is illegal to move other's bicycles, 56% of shop owners admitted to doing so with the purpose of clearing their windows so people could see into their stores. This was especially true of shops with ground level windows.

Studiestræde's shop owners accepted multiple solutions to solve the bicycle parking problem. Approximately 8 shop-owners have posted signs prohibiting cyclists from parking in front of their businesses. Many of these signs were ignored. Approximately 50% of shop owners support the implementation of new bicycle racks throughout the street. However, shop-owners

often contradicted themselves by recommending this solution but not volunteering to have these racks placed in front of their business, instead wanting the racks placed in front of neighboring stores. See Appendices 5 & 8 for the breakdown of the shop owner responses.

Pedestrians

Pedestrians account for 58% of the people traveling on Studiestræde. On average 91 cars drove past, 206 bicycles rode by and 406 pedestrians passed through the street per hour (See Table 7). Of these pedestrians 11.5% were forced to cross the street to the other sidewalk due to the lack of space on the sidewalk created by parked bicycles.

	Average Totals				
Hours	*Side*	*Pedestrians*	*Crossed Street*	*Bikes*	*Cars*
11	Left	185	13	181	72
	Right	147	21		
12	Left	234	22	192	86
	Right	208	28		
13	Left	231	23	226	147
	Right	195	45		
14	Left	223	21	225	59
	Right	199	24		
	Total	**1622**	**197**	**824**	**364**
	Per Hour	**406**	**49**	**206**	**91**

Table 7: Number of Pedestrians, Bicycles, and Cars using the street

Interestingly, the sidewalk containing the bicycle rack was used more frequently, despite their being more bicycles. A total number of 218 pedestrians per hour used the sidewalk passing the bicycle rack while 187 pedestrians used the opposite side. There was still more room to walk past the bicycle rack when compared to the other side of the street due to bicycles leaning against the wall overcrowding the sidewalk more as shown in the Figure 13.

Figure 13: Pedestrians trying to walk next to each other on the narrow sidewalk

Pugh Matrix

Pugh Matrix							
Criteria	Weight	Improved Removal	Constraining Landmarks	Flex Parking	Additional Racks	Informative Signs	Campaigning
Cost	5	0	0	0	-	0	-
Safety	5	+	+	0	+	0	+
Accessibility	4	+	0	+	+	0	0
Space	4	+	+	+	0	+	0
Cyclists' Opinion	3	+	-	0	+	0	0
Aesthetics	2	+	+	0	-	-	0
Shop Owners' Opinion	2	+	0	0	+	+	+
Pedestrians' Opinion	1	0	0	0	0	0	+
Total		20	8	8	7	4	3

Table 8: The Final Version of the Pugh Matrix

When completing the Pugh Matrix (See Table 8), each candidate solution was rated on if it improved, deducted from, or had no effect for each separate criterion. The lowest scoring option was campaigning to inform people about proper bike parking etiquette. A campaign would the improve safety, and was believed to be highly regarded by shop owners and pedestrians; however, the large cost of executing such a plan resulted in it being the lowest rated option. Next in the ratings were signs that encourage better parking habits. Signs were supported by shop owners and while there was both plenty of space to put them up, it would not be the most aesthetically pleasing solution. Adding more bicycle racks was found to be safe, accessible, and positively regarded by cyclists and shop owners. However, adding racks is expensive, and a large piece of metal on the side of the street would not be the most aesthetically pleasing option. Flex parking and constraining landmarks were rated as the second best options overall. Flex parking would be easily accessible, with clear signs detailing the times for cars and bikes to park there. The existing space on the street would be used in an efficient manner. Appealing landmarks, such as potted plants or large rocks, at the ends of bicycle racks would improve safety by restricting bicycles from parking into the sidewalk and street. The downfall of constraining landmarks is that cyclists could easily choose to ignore them. The highest rated recommendation was improving the current bicycle removal system. This recommendation would save the city money because removing bicycles from the existing racks is less expensive than constructing new racks. By creating more available parking spaces, it would make bike racks more appealing and accessible. Cyclists and shop owners were also highly supportive of this recommendation.

Chapter 5: Recommendations and Conclusions

Throughout the completion of this project, we collected quantitative data by studying the trends and habits of bike parking on the narrow street of Studiestræde, as well as analyzing the qualitative input of what cyclists and shop owners wanted to see changed. We did these through methods such as continuous counting of bicycles on the street, tagging bikes to see how long they remained in the same location and short interviews with cyclists and shop owners. From this information, we were able to create our Pugh Matrix of final recommendations, all of which we deem as viable partial solutions to the larger problem of bicycle parking in Copenhagen.

Constraining Landmarks

We recommend implementing constraining landmarks at the ends of bicycle racks throughout the entire Inner City. Constraining landmarks can be anything from a large potted plant to a colorfully designed rock. The landmarks have to be sizable enough that when placed at the end of a bicycle rack, it will deter cyclists from parking beyond. Keeping bicycles within the designated racks will increase the safety of cars, pedestrians, and cyclists moving through the area. Additionally, these objects can be made to be aesthetically pleasing, so shop owners could potentially strategically use them to improve the appeal of their stores.

Figure 14: Constraining Landmark Prevent Parked Bicycles from Extending Beyond Rack

This potential solution could be gradually implemented over time with certain racks being used as test racks. Place a large rock or pot at the end of bicycle rack and see if it deters cyclists from parking into the street (See Figure 14). If success is seen, more permanent and visibly appealing constraining landmarks could be implemented on other racks throughout the city. For a first test site, we recommend presenting the idea to owners of the bicycle racks on Studiestræde, since it's such a problem there. If the landmarks see success after a month or two, the ideas should be proposed and implemented on other streets.

Informative Signs

Informative signs strategically placed on the exteriors and windows of business could be used to encourage proper bicycle parking. Through interviews with shop owners, we've learned that approximately half would support the use of signs on their stores. Some shops on Studiestræde have already hung their own signs, as seen below in Figure 15, but have found that negative messages such as these do not change habits.

Figure 15: Negative Signs Currently in Use on Studiestræde

On the other hand, interviews with cyclists parking on Studiestræde showed that most were unaware of all the options they had for parking facilities such as the underground facilities provided by Copenhagen University's Law School to its students and apartment complexes to its residents. These two trends lead us to recommend positive or neutral signs in areas that people should not park, intended to inform them of the locations of available and open parking facilities.

We recommend this solution as an immediate short term approach in relieving the congested bicycle parking on Studiestræde. These signs could potentially gain a lot of momentum if proven to be successful on a small scale. Signs are simple to implement, and we would suggest anyone who has experienced difficulties with bikes parked outside their building try this strategy.

Converting Car Parking

Studiestræde sees upwards of 175 bicycles on any given day; however, there are only 81 designated parking spots on the street. The street's 3 racks can only account for 46.3% of the minimum amount of parked bicycles on the street. In order to create more space for parked bicycles the idea of converting car parking spaces into bicycle parking spaces in recommended.

Car parking spaces are generally 4.80 meters in length. If the bicycles on Studiestræde that extend from the three bicycles rack into existing car parking spots were totaled they would, on average, take up 10.8 meters or 2.25 car parking spots. Studiestræde is located in the red zone meaning motorists pay 30 kr an hour to park their vehicle. Converting car parking spaces to bicycle parking usually results in the city losing money on that spot. However, on the street of Studiestræde parked bicycles are already using space reserved for vehicles and the government is not receiving the revenue for these spots. Therefore converting car a parking spot into bicycle parking facilities does not result is any new loses. The 2.25 car parking spots can be converted into flex parking spaces or into space for new bicycle racks.

Flex Parking

Flex parking is a parking spot shared between cyclists and motorists. At designated times the parking space is for bicycle parking leaving the other times for motorists. This type of parking can be applicable to Studiestræde as there are peak hours on weekdays when bike parking extends from the existing stands. The peak parking hours occurred between 10:00 and 18:00. During this time bicycles extended from the stairs anywhere from 11.8 to 16.92 meters. This converts to 2.5 and 3.5 car parking spots respectively. Flex parking would allow the government to still earn revenue from parking spaces but also accommodate bicycle parking during designated hours.

Additional Bicycle Parking Racks

Studiestræde's lack of bicycle parking facilities could be remediated though the addition of more bicycle parking racks. Studiestræde's sidewalks do not have an ample amount of space to support the addition of bicycles racks; however, as previously mentioned car parking spaces

on the street can be converted to bicycle parking. The two designs we would recommend include keeping the current hoop racks used throughout the street or implement Varsity Bike Docks.

According to the hourly data collected on use of Studiestræde's three bicycle racks, we recommend that an addition of 32 bicycle parking spots be added to accommodate the bicycles parked against the shop walls, extended into car parking spaces, and against poles.

The addition of the current loop rack (See Figure 16) would keep the bicycle rack style the same throughout the street. Each loop or bicycle parking spot is separated by 50 to 55cm. The cost of implementing the simple loop rack is 3,000 KR per spot (J. Reghen, Personal Communication, April 13, 2016).

Figure 16: Current Rack on Studiestræde

When considering the second recommended design many options were analyzed with a high focus of space efficiency. Varsity Bike Docks, found through ParkaBike, appear to be the

most suitable for space efficient bicycle parking on Studiestræde (See Figure 17). The docks will save a considerable amount space due to the angle that allows two bicycles to be parked close together without having their handlebars overlapped (See Figure 18). Reducing the amount of space that bicycles take up allows for both a higher number of bikes to park and the space to be aesthetically pleasing. The slot designated for the wheel is designed specifically to keep the bicycle upright and prevent it from falling over.

Figure 17: Picture of the Bicycle Dock (ParkaBike, 2016)

These docks are the best choice in terms of meeting with the APBP (Association of Pedestrians and Bike Professionals) Guidelines and the specific needs of the area. Another advantage of the Bicycle Docks is that it provides a loop for cyclists to lock their bicycle. This increases the safety of the design.

Figure 18: Bicycles parked on Bicycle Docks (ParkaBike, 2016)

Varsity Bike Docks also include the option for customization (See Figure 19). Such customization could be used to promote city wide initiatives or campaigns, or could be potentially sold as an advertisement spot for local businesses which would offset the cost of implementing the docks.

Figure 19: Area available for Customization

Each ParkaBike dock is 0.47 meters wide, 0.59 meters long and has a height of 0.82 meters off the ground. The minimum distance needed between these docks is 0.81 meters from center to center. Simple bike racks that already are in use in Studiestræde have a distance from spot to spot of about a half meter, which is actually less than the ParkaBike docks measurements. However, the bike racks currently on Studiestræde only provide space for one bicycle within the half meter, while the Bicycle Dock provides enough space for two bikes.

The number of bicycle spots was compared to the average number of bicycles in and around the rack during both the weekdays and weekend. From this the number of bicycles per spot was calculated. The overall average number of bicycles per spot on weekdays (1.42) and weekends (1.48) calculates out to 1.45. The average number of bicycles parked outside of the rack for each zone was then multiplied by the average number of bicycles per spot on both weekdays and weekends. Zone 1 was not included in this calculation. In Zone 1 there is a corner next to the restaurant and outside of the law school building. The bicycles parked in this area were included in the number of bicycles parked against a wall, pole, or other and skews the data because that area overtime has become designated for parking by cyclists. Taking the average of the weekday (26) and weekend (39) results in 32 bicycle spots.

The length of the average car spot on Studiestræde is 4.8 meters. The bicycles extended from the racks take up about 9.5 meters on weekdays and 12.1 on weekends, or about two car parking spots along the street. If bicycles are already occupying the space, then it makes sense to designate the spots for bicycles either through flex parking or the addition of more bicycle racks. If the dock rack design is implemented, it would allow enough space for the number of

spots needed during the weekdays to accommodate the average number of bicycles parked against walls, poles, and other.

Improved Bicycle Removal System

The current bicycle removal system is inefficient. This is because both the system doesn't have the staff to operate how it's supposed to, and the methods for identifying an abandoned bike take too long to develop. In 2015, only 18.85% of the estimated amount of abandoned bicycles were collected (M. Kuth, personal communication, April 6, 2016). On Studiestræde in the last year, a total of 57 bicycles were tagged and 25 were collected. The highest number of bicycles tagged by the removal system was 30 on October 5th, 2015 (M. Kuth, personal communication, April 6, 2016). The data that we've collected shows that closer to 50 bikes may be abandoned on the street at a time, which would mean that the street either needs to be visited more frequently, or the criteria for a bike being tagged needs to be more lenient. The ideal removal system would be to have abandoned bicycles tagged and removed once a month. Table 9 shows that the bicycles on Studiestræde have been tagged and removed four times throughout the year, a third of what could be happening.

Date	*Marked*	*Collected*
1/22/2015	7	3
5/13/2015	4	3
7/6/2015	11	3
10/5/2015	30	16
2/2/2016	5	
Total	**57**	**25**

Table 9: Bicycles Tagged and collected on Studiestræde

(M. Kurth, personal communication, April 6, 2016).

Over the same period, January 2015 to February 2016, a total of 76 bicycles were tagged and 35 were collected from the street of Vestergade. Table 10 shows that the bicycles on Vestergade have been tagged and removed only three times in the year, one fourth as frequently as could be happening.

Date	*Marked*	*Collected*
3/10/2015	11	7
5/27/2015	14	13
10/5/2015	19	15
2/4/2016	32	
Total	**76**	**35**

Table 10: Bicycles tagged and collected on Vestergade

(M. Kurth, personal communication, April 6, 2016).

If employees were only able to visit Studiestræde four times and Vestergade three times this past year, it would be logical to increase the number of employees to six. Instead of adding more employees, technology can also be used to increase efficiency. The highest number of marked bicycle in a year was 40,250, which is over the estimated number of 35,000 abandoned bicycles. However, only 10,363 (26%) of these bicycles were actually removed (M. Kuth, personal communication, April 19, 2016). A better tracking system needs to be established so the correct bicycles are being marked and collected.

A short-term and inexpensive idea for tracking could be to create a cellphone application for the municipalities already existing tips website. In this application shop owners could report bicycles they have noticed parked in the same spot for many days from their phone while at work. The shop owners are the ones who are actually on the street every day

unlike the workers tagging and collecting bikes, making it a logical choice to provide a link between these two groups to improve efficiency. The removal system will then be able to see trends in what streets abandoned bicycles are piling up.

New technology could also be very useful for longer-term solutions. One potential solution could be to install pressure or motion sensors in bicycle racks throughout the city. This could provide another digital way to track if a bike needs to be removed or not. Officials could automatically be notified if a bike has been sitting dead in a rack for a week or more. Such an approach would save large amounts of both time and manpower: there would no longer need to be a staff of workers going to streets to tag and check bikes, but only to visit areas to remove them. However, it would also be a sizable monetary investment, so this option should be looked at as something to consider for the future, as it would set an automatic standard of bikes being able to stay in a rack for no longer than a week at the most.

The removal system can also be improved by deciding what happens to illegally parked bicycles. This includes deciding who is allowed to physically move illegally parked bicycles, as well clearly communicating where the bicycles are moved to. Copenhagen currently has no system of enforcing bicycle parking regulations. When a cyclist parks illegally, as shown in Figure 20, there are no consequences. It is against the law to move another person's bicycle. No one, not even the police, have an exception to that law.

Figure 20: A Bicycle parked under a no Bicycle Parking Sign

Commuting via bike each day is more popular than using a car in the City of Copenhagen. Many strategies used to enforce car parking can be applied to enforcing bicycle parking. For example, when a car is parked illegally, it is given a parking ticket or towed. If towed, the owner must go to the nearest impound lot, pay a fine, and retrieve it. Specifically in Copenhagen, if cars block sidewalks, disturb pedestrians, or they exceed limited parking time, they receive a fine of 510 DKK that must be paid immediately or the police have the right to tow the car("Driving in Denmark,")A similar system should be created for bicycles that congest sidewalks or disturb pedestrians and shop owners. The knowledge that your bicycle will be removed or ticketed could be a strong incentive for cyclists to park properly.

Improving the removal system will save the city money. The cost to implement new bicycle racks is 3,000 Danish Kroner per bicycle; however, the cost to remove an abandoned bicycle is only 197 Danish Kroner. (M. Kuth, personal communication, April 19, 2016). This 197 Danish Kroner has the potential to decrease with better technology and strategies. See Figure

21 for the effects of clearing out all the tagged bicycles on Studiestræde and how much space it potentially provides for the bicycles parked against the wall. See Appendix 9 for a more in depth description of the cost difference in construction new bicycle spots verse removing bicycles.

Figure 21: Average number of bicycles parked in Zone three (top). Average number of bicycles parked in Zone 3 after tagged bicycles are removed (bottom).

Campaigning

Campaigning to inform people of proper bicycle parking habits could be used as a long term solution for the bicycle parking problem in Copenhagen. It would be an investment of both time and money, but many shop owners and pedestrians believe that cyclists often park poorly because no one has directly told them not to. While removing abandoned bicycle and creating additional bicycle parking racks will work as short term solutions, problems with congestion will again most likely accumulate over time if people are not directly informed that what they're doing has an impact on the parking problems.

A campaign would require a fair amount of time and planning by a governmental organization within Copenhagen. For this reason, it would be best to initially campaign through smaller means such as previously mentioned signs or other minimalistic ways of informing the general public. Over time, a system could be put in into school curriculums to inform children how to properly park their bicycles. Teaching children at a young age would allow the future community will grow up with good habits.

Conclusion

The recommendations presented in this report include a variety of potential solutions specifically tailored to the narrow street of Studiestræde. These options range in many factors, including their cost and the other resources required to implement them in the area. These factors are represented in the Pugh matrix. Ideally, the smaller and less complex to execute suggestions will be carried out immediately in order to have an initial impact on the problem, while the larger scale solutions will need time to be planned out in depth before they can be implemented.

It is our hope that these recommendations are helpful in the way that they can be implemented and applied on other narrow streets. This theory is supported by the bicycle tagging experiment performed on Vestergade, where results similar to that of Studiestræde were found. Moving forward, we suggest a second similar study to be conducted in another section of the Inner City to validate the notion that these solutions could be applied to the entire larger area.

It is important to address these problems in bicycle parking in order to allow cycling to continue growing in the city. Citizens choosing to bike rather than drive provides undeniable green benefits, so continuing to promote this is crucial for the city reaching its goal of carbon neutrality. With that accomplished, Copenhagen, the city of cyclists, will be able to continue to set the worldwide standard for environmental consciousness.

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Appendix

APPENDIX 1: Objective 1 Data Recording Tables

Flow Data Tables

Date:			
Time:			
Loaction:			

Parking Density Observation

Time	Number of Bikes Parked	Number of Bikes Entering	Number of Bikes leaving
6:00am - 7:00 am			
7:00am - 8:00 am			
8:00am - 9:00 am			
9:00am - 10:00 am			
10:00am - 11:00 am			
11:00am - 12:00 am			
12:00am - 1:00 pm			
1:00pm - 2:00 pm			
2:00pm - 3:00pm			
3:00pm - 4:00pm			
4:00pm - 5:00pm			
5:00pm - 6:00pm			
6:00pm - 7:00pm			
7:00pm - 8:00pm			
8:00pm - 9:00pm			
9:00pm - 10:00pm			

Table I: Blank Continuous Flow Counting Table, All Zones

Date:		
Time:		
Location:		
HABITS OBSERBATION		
	Good Habits (Parks at rack/stand)	Bad Habits (Parks Haphazardly)
Cargo Elderly Women (50 +)		
Cargo Non-elderly Women		
Cargo Elderly Men (50+)		
Cargp Non-Elderly Men		
Regular Elderly Women (50 +)		
Regular Non-elderly Women		
Regular Elderly Men (50+)		
Regular Non-Elderly Men		

Table II: Blank Demographics Observations Table, All Zones

Rack Data Tables

	Zone 1/2/3								
Time	Total Number of Parked Bikes	Total Number of designated Bicycle parking spots	Number of Bikes in designated stand spots	Number of Bikes against/in the stand	Number of bikes against the wall, pole, and other	Number of available parking spaces	Number of blocked parking spaces	Number of bikes extended from the stand	Length (m) of parked bikes extend from stand
6:00									
7:00									
8:00									
9:00									
10:00									
11:00									
12:00									
1:00									
2:00									
3:00									
4:00									
5:00									
6:00									
7:00									
8:00									
9:00									

Table III: Blank Hourly Bike Rack Table, Zones 1-3

Zone 4			
Time	Total Number of Parked Bikes	Number of Bikes against the Wall	Number of Bikes parked against a pole
6:00			
7:00			
8:00			
9:00			
10:00			
11:00			
12:00			
1:00			
2:00			
3:00			
4:00			
5:00			
6:00			
7:00			
8:00			
9:00			

Table IV: Blank Hourly Bike Table, Zone 4

APPENDIX 2: Objective 2 Data Recording Tables

Pedestrian Counting Table

	Pedestrians			
Time	Number of Pedestrians	Number of bike walkers	Number of strollers	Number who crossed street or went around bike stand due to overcrowded sidewalk
11:00				
12:00				
1:00				
2:00				

Table V: Blank Continuous Pedestrian Counting Table

APPENDIX 3: Objective 1 Data Table Results

Flow Data Results- Weekday

Weekday Flow																
	Zone 1			Zone 2			Zone 3			Zone 4			Total			
Time	Start	In	Out	Start	In	Out	Start	In	Out	Start	In	Out	Total	In	Out	Flow Magnitude
6	19	1	1	33	9	8	43	0	0	9	0	0	104	10	9	19
7	19	8	2	34	6	5	43	1	0	9	1	0	105	16	7	23
8	25	20	4	35	3	5	44	3	0	10	2	0	114	28	9	37
9	41	24	5	33	6	2	47	2	1	12	6	0	133	38	8	46
10	74	25	19	37	8	3	48	5	3	18	3	1	177	41	26	67
11	50	27	12	42	8	6	50	10	2	20	3	4	162	48	24	72
12	95	23	15	44	15	12	58	4	6	19	6	9	216	48	42	90
13	103	30	21	47	21	11	56	11	5	16	9	7	222	71	44	115
14	84	17	22	57	6	6	59	10	9	18	5	8	218	38	45	83
15	79	25	29	57	9	8	54	6	6	16	4	5	206	44	48	92
16	75	7	14	55	5	7	54	10	9	15	1	1	199	23	31	54
17	68	10	19	53	3	5	55	25	13	15	5	3	191	43	40	83
18	42	20	23	61	18	16	67	21	26	17	6	8	187	65	73	138
19	39	8	5	63	6	13	62	11	11	14	7	4	178	32	33	65
20	42	7	6	56	6	14	62	7	14	17	1	5	177	21	39	60
21	43	0	0	48	0	0	55	0	0	13	0	0	159			0
Total	898	252	197	755	129	121	857	126	105	238	59	55	2748	566	478	

Table VI: Weekday Continuous Flow Data

Flow Data- Weekends

Weekend Flow																
	Zone 1			Zone 2			Zone 3			Zone 4			Total			
Time	Start	In	Out	Start	In	Out	Start	In	Out	Start	In	Out	Total	In	Out	Flow Magnitude
6	25	4	2	63	16	20	47	0	0	17	0	1	152	20	23	43
7	28	0	5	59	14	8	47	0	0	16	0	3	150	14	16	30
8	26	22	4	33	12	4	47	2	1	8	0	0	114	36	9	45
9	44	24	9	41	9	5	48	6	3	8	2	0	141	41	17	58
10	59	20	21	45	10	4	51	7	2	10	7	3	165	44	30	74
11	58	21	12	51	14	11	56	6	5	14	3	1	179	44	29	73
12	30	6	0	44	11	3	57	5	2	15	0	4	146	22	9	31
13	36	1	5	52	5	1	60	1	5	11	0	1	159	7	12	19
14	32	6	3	56	5	5	56	8	7	10	0	0	154	19	15	34
15	35	3	7	56	4	8	57	4	5	10	0	1	158	11	21	32
16	31	5	0	52	4	3	56	2	2	9	2	1	148	13	6	19
17	36	2	4	53	14	9	56	1	11	10	0	3	155	17	27	44
18	44	11	10	63	16	20	72	11	11	24	6	13	203	44	54	98
19	45	3	4	59	14	8	72	11	4	17	10	3	193	38	19	57
20	38	6	21	65	18	18	79	9	8	24	6	5	206	39	52	91
21	23	0	0	65	0	0	80	0	0	25	0	0	193			0
Total	590	134	107	857	166	127	941	73	66	228	36	39	2616	409	339	

Table VII: Weekend Continuous Flow Data

Demographics

Description	Good	%	Bad	%	Totals	%
YFR	84	49.122807	252	38.1818182	336	40.433213
YMR	62	36.2573099	298	45.1515152	360	43.3212996
OFR	8	4.67836257	50	7.57575758	58	6.97954272
OMR	16	9.35672515	46	6.96969697	62	7.46089049
YFC	0	0	2	0.3030303	2	0.24067389
YMC	1	0.58479532	6	0.90909091	7	0.8423586
OFC	0	0	2	0.3030303	2	0.24067389
OMC	0	0	4	0.60606061	4	0.48134777
Total	171	20.5776173	660	79.4223827	831	

Table VIII: Parker Demographics Data Raw

	Good	%	Bad	%	Total	%
Men	79	46.1988304	354	53.6363636	433	52.1058965
Women	92	53.8011696	306	46.3636364	398	47.8941035
Older	24	14.0350877	102	15.4545455	126	15.1624549
Younger	147	85.9649123	558	84.5454545	705	84.8375451
Regular	170	99.4152047	646	97.8787879	816	98.1949458
Cargo	1	0.58479532	14	2.12121212	15	1.80505415

Table IX: Parker Demographics Data Simplified

Rack Observation Results - Weekday

Zone 1									
Time	Total Number of Parked Bikes	Total Number of designated Bicycle parking spots	Number of Bikes in designated stand spots	Number of Bikes against/in the stand	Number of bikes against the wall, pole, and other	Number of available parking spaces	Number of blocked parking spaces	Number of bikes extended from the stand	Length (m) of parked bikes extend from stand
6:00	19	25	14	17	2	11	0	1	0.2
7:00	19	25	14	17	2	11	0	1	0.2
8:00	25	25	19	17	6	6	0	1	0.2
9:00	41	25	20	25	16	1	4	1	0.2
10:00	69	25	22	37	32	0	3	7	3.96
11:00	82	25	22	43	39	1	2	9	4.95
12:00	94	25	22	51	43	0	3	12	7.26
1:00	101	25	21	55	46	0	4	14	8.58
2:00	84	25	21	43	41	0	4	11	6.27
3:00	79	25	19	45	34	2	4	10	6.27
4:00	75	25	21	43	32	0	4	10	7.26
5:00	63	25	20	40	23	2	3	9	5.28
6:00	52	25	14	28	24	9	2	2	1.89
7:00	38	25	14	21	17	7	4	1	1.89
8:00	33	25	13	19	14	9	3	1	1.89
9:00	33	25	15	21	12	7	3	1	1.89
AVERAGE	56.6875	25	18.1875	32.625	23.9375	4.125	2.6875	5.6875	3.636875

Table X: Weekday Hourly Bike Rack Data, Zone 1

Zone 2									
Time	Total Number of Parked Bikes	Total Number of Designated Bicycle Parking Spots	Number of Bikes in designated stand spots	Number of Bikes against/in the stand	Number of bikes against the wall, pole, and other	Number of available parking spaces	Number of blocked parking spaces	Number of bikes extended from the stand	Length (m) of parked bikes extend from stand
6:00	33	33	20	30	3	8	5	1	0.66
7:00	34	33	21	31	3	7	5	1	0.66
8:00	35	33	22	32	3	6	5	1	0.66
9:00	40	33	23	34	6	5	5	2	1.32
10:00	49	33	25	41	8	1	7	3	2.31
11:00	52	33	25	46	6	0	8	7	4.95
12:00	54	33	26	48	6	0	7	7	4.62
1:00	57	33	26	48	9	0	7	6	4.29
2:00	56	33	21	40	16	1	11	8	2.7
3:00	57	33	25	42	15	1	7	9	3.1
4:00	55	33	25	39	16	3	5	8	3
5:00	53	33	26	38	15	0	7	8	3
6:00	55	33	25	39	16	2	6	0	0
7:00	54	33	29	42	12	0	4	0	0
8:00	50	33	27	39	11	2	4	0	0
9:00	49	33	25	37	12	4	4	0	0
AVERAGE	48.9375	33	24.4375	39.125	9.8125	2.5	6.0625	3.8125	1.954375

Table XI: Weekday Hourly Bike Rack Data, Zone 2

Zone 3									
Time	Total Number of Parked Bikes	Total Number of Designated Bicycle Parking Spots	Number of Bikes in designated stand spots	Number of Bikes against/in the stand	Number of bikes against the wall, pole, and other	Number of available parking spaces	Number of blocked parking spaces	Number of bikes extended from stand	Length (m) of parked bikes extend from stand
6:00	43	23	14	35	8	1	8	5	4.42
7:00	43	23	14	35	8	1	8	5	4.42
8:00	44	23	14	36	8	1	8	5	3.9
9:00	47	23	15	37	10	0	8	5	3.9
10:00	45	23	15	40	5	2	6	5	6.21
11:00	55	23	15	48	7	1	7	5	3.78
12:00	52	23	16	45	7	1	6	6	3.78
1:00	62	23	16	50	12	1	6	11	4.05
2:00	53	23	19	42	11	1	3	5	2.83
3:00	54	23	20	45	9	1	2	4	3.24
4:00	54	23	20	42	12	1	2	6	3.24
5:00	55	23	15	40	14	3	5	4	3.24
6:00	58	23	16	41	17	0	7	6	4.42
7:00	66	23	15	40	26	0	8	7	4.42
8:00	54	23	16	39	15	0	7	6	3.64
9:00	40	23	18	40	10	1	4	6	3.64
AVERAGE	51.5625	23	16.125	40.9375	11.1875	0.9375	5.9375	5.6875	3.945625

Table XII: Weekday Hourly Bike Rack Data, Zone 3

Zone 4			
Time	Total Number of Parked Bikes	Number of Bikes against the Wall	Number of Bikes parked against a pole
6:00	9	9	0
7:00	9	9	0
8:00	10	10	0
9:00	11	11	0
10:00	20	19	1
11:00	23	22	1
12:00	21	20	1
1:00	24	23	1
2:00	19	19	2
3:00	16	16	0
4:00	15	15	0
5:00	15	15	0
6:00	13	13	0
7:00	18	18	0
8:00	19	19	0
9:00	14	14	0
AVERAGE	16	15.75	0.375

Table XIII: Weekday Hourly Bike Data, Zone 4

Totals									
Time	Total Number of Parked Bikes	Total Number of Designated Bicycle Parking Spots	Number of Bikes in designated stand spots	Number of Bikes against/in the stand	Number of bikes against the wall, pole, and other	Number of available parking spaces	Number of blocked parking spaces	Number of Bikes extended from stand	Combined Length of parked bikes extend from stand
6:00	104	81	48	82	22	20	13	7	5.28
7:00	105	81	49	83	22	19	13	7	5.28
8:00	114	81	55	85	27	13	13	7	4.76
9:00	139	81	58	96	43	6	17	8	5.42
10:00	183	81	62	118	65	3	16	15	12.48
11:00	212	81	62	137	75	2	17	21	13.68
12:00	221	81	64	144	77	1	16	25	15.66
1:00	244	81	63	153	91	1	17	31	16.92
2:00	212	81	61	125	87	2	18	24	11.8
3:00	206	81	64	132	74	4	13	23	12.61
4:00	199	81	66	124	75	4	11	24	13.5
5:00	186	81	61	118	67	5	15	21	11.52
6:00	178	81	55	108	70	11	15	8	6.31
7:00	176	81	58	103	73	7	16	8	6.31
8:00	156	81	56	97	59	11	14	7	5.53
9:00	136	81	58	98	48	12	11	7	5.53
AVERAGE	173.1875	81	58.75	112.6875	60.9375	7.5625	14.6875	15.1875	9.536875

Table XIV: Weekday Hourly Bike Rack Data, Total

	Total Number of Parked Bikes	Total Number of Designated Bicycle Parking Spots	Number of Bikes in designated stand spots	Number of Bikes against/in the stand	Number of bikes against the wall, pole, and other	Number of available parking spaces	Number of blocked parking spaces	Number of Bikes extended from stand	Average Length of parked bikes extend from stand
Maximum	244	-	66	153	91	20	18	31	16.92
Time	1:00 PM	-	5:00 PM	1:00 PM	1:00 PM	6:00 AM	2:00 PM	1:00 PM	1:00 PM
Minimum	104	-	48	82	22	1	11	7	4.76
Time	6:00 AM	-	6:00 AM	6:00 AM	6AM/7AM	12PM/1PM	9:00 PM	-	8:00 AM

Table XV: Weekday Hourly Bike Rack Data, Min/Max

Rack Observation Results -Weekend

Zone 1									
Time	Total Number of Parked Bikes	Total Number of designated Bicycle parking spots	Number of Bikes in designated stand spots	Number of Bikes against/in the stand	Number of bikes against the wall, pole, and other	Number of available parking spaces	Number of blocked parking spaces	Number of bikes extended from the stand	Length (m) of parked bikes extend from stand
6:00	40	25	16	30	10	5	4	3	2.64
7:00	38	25	15	28	10	7	3	3	2.64
8:00	35	25	13	25	10	9	3	4	2.97
9:00	38	25	13	27	11	9	3	4	2.97
10:00	42	25	16	30	12	3	6	4	2.64
11:00	51	25	18	33	18	3	4	4	2.64
12:00	52	25	18	34	18	2	5	5	3.3
1:00	62	25	20	38	24	1	4	7	3.96
2:00	59	25	20	39	20	2	3	6	2.97
3:00	61	25	19	32	29	2	4	10	6.24
4:00	53	25	18	28	25	6	1	7	4.94
5:00	53	25	18	29	24	4	3	6	5.2
6:00	81	25	22	34	47	1	2	15	7.02
7:00	92	25	24	38	54	1	0	17	9.36
8:00	84	25	23	33	51	0	2	17	8.58
9:00	95	25	24	37	58	0	1	21	10.66
AVERAGE	58.5	25	18.5625	32.1875	26.3125	3.4375	3	8.3125	4.920625

Table XVI: Weekend Hourly Bike Rack Data, Zone 1

Zone 2									
Time	Total Number of Parked Bikes	Total Number of Designated Bicycle Parking Spots	Number of Bikes in designated stand spots	Number of Bikes against/in the stand	Number of bikes against the wall, pole, and other	Number of available parking spaces	Number of blocked parking spaces	Number of bikes extended from the stand	Length (m) of parked bikes extend from stand
6:00	35	33	19	30	5	8	6	2	0.66
7:00	37	33	19	32	5	8	6	2	0.66
8:00	38	33	20	33	5	7	6	2	0.66
9:00	38	33	19	33	5	8	6	2	0.66
10:00	48	33	15	32	16	8	10	4	3.63
11:00	58	33	19	39	19	3	11	6	4.62
12:00	65	33	23	53	12	0	10	7	5.61
1:00	65	33	21	53	12	3	9	6	4.95
2:00	66	33	24	54	12	1	8	8	6.6
3:00	74	33	26	49	25	3	4	2	3.9
4:00	66	33	20	44	22	6	7	2	1.82
5:00	56	33	22	38	18	7	4	2	1.82
6:00	61	33	27	46	15	4	2	8	4.42
7:00	64	33	28	46	18	0	5	8	4.68
8:00	79	33	28	51	28	0	5	1	4.68
9:00	72	33	28	44	28	0	5	1	4.68
AVERAGE	57.625	33	22.375	42.3125	15.3125	4.125	6.5	3.9375	3.378125

Table XVII: Weekend Hourly Bike Rack Data, Zone 2

Zone 3									
Time	Total Number of Parked Bikes	Total Number of Designated Bicycle Parking Spots	Number of Bikes in designated stand spots	Number of Bikes against/in the stand	Number of bikes against the wall, pole, and other	Number of available parking spaces	Number of blocked parking spaces	Number of bikes extended from stand	Length (m) of parked bikes extend from stand
6:00	44	23	14	41	3	3	6	8	4.62
7:00	44	23	14	42	2	3	6	8	4.62
8:00	44	23	14	42	2	3	6	8	4.62
9:00	44	23	14	42	2	3	6	7	4.62
10:00	55	23	15	49	6	2	6	2	1.2
11:00	56	23	15	49	7	2	6	3	1.5
12:00	51	23	15	45	6	2	6	3	1.5
1:00	52	23	15	46	11	2	6	9	3.3
2:00	60	23	17	45	15	0	6	11	3.9
3:00	59	23	15	43	16	1	7	4	4.05
4:00	54	23	16	40	14	0	7	3	2.97
5:00	41	23	12	34	7	5	6	0	0
6:00	72	23	17	44	28	0	6	13	6.21
7:00	76	23	16	43	33	2	5	13	6.21
8:00	96	23	16	42	54	0	7	14	6.21
9:00	90	23	15	40	50	1	7	11	5.67
AVERAGE	58.625	23	15	42.9375	16	1.8125	6.1875	7.3125	3.825

Table XVIII: Weekend Hourly Bike Rack Data, Zone 3

Zone 4			
Time	Total Number of Parked Bikes	Number of Bikes against the Wall	Number of Bikes parked against a pole
6:00	24	24	0
7:00	24	24	0
8:00	24	24	0
9:00	24	24	0
10:00	20	20	0
11:00	22	22	0
12:00	23	23	0
1:00	22	22	0
2:00	24	24	0
3:00	30	30	0
4:00	23	23	0
5:00	25	25	0
6:00	29	29	0
7:00	30	30	0
8:00	25	25	0
9:00	34	34	0
AVERAGE	25.1875	25.1875	0

Table XIX: Weekend Hourly Bike Data, Zone 4

Totals										
Time	Total Number of Parked Bikes	Total Number of Designated Bicycle Parking Spots	Number of Bikes in designated stand spots	Number of Bikes against/in the stand	Number of bikes against the wall, pole, and other	Number of available parking spaces	Number of blocked parking spaces	Number of Bikes extended from stand	Combined Length of parked bikes extend from stand	
6:00	143	81	49	101	42	16	16	13	7.92	
7:00	143	81	48	102	41	18	15	13	7.92	
8:00	141	81	47	100	41	19	15	14	8.25	
9:00	144	81	46	102	42	20	15	13	8.25	
10:00	165	81	46	111	54	13	22	10	7.47	
11:00	187	81	52	121	66	8	21	13	8.76	
12:00	191	81	56	132	59	4	21	15	10.41	
1:00	201	81	56	137	69	6	19	22	12.21	
2:00	209	81	61	138	71	3	17	25	13.47	
3:00	224	81	60	124	100	6	15	16	14.19	
4:00	196	81	54	112	84	12	15	12	9.73	
5:00	175	81	52	101	74	16	13	8	7.02	
6:00	243	81	66	124	119	5	10	36	17.65	
7:00	262	81	68	127	135	3	10	38	20.25	
8:00	284	81	67	126	158	0	14	32	19.47	
9:00	291	81	67	121	170	1	13	33	21.01	
AVERAGE	199.9375	81	55.9375	117.4375	82.8125	9.375	15.6875	19.5625	12.12375	2.204318182

Table XX: Weekend Hourly Bike Rack Data, Total

	Total Number of Parked Bikes	Total Number of Designated Bicycle Parking Spots	Number of Bikes in designated stand spots	Number of Bikes against/in the stand	Number of bikes against the wall, pole, and other	Number of available parking spaces	Number of blocked parking spaces	Number of Bikes extended from stand	Combined Length of parked bikes extend from stand
Maximum	291	-	68	138	170	20	21	38	21.01
Time	9:00 PM	-	7:00 PM	2:00 PM	9:00 PM	9:00 AM	11AM/12 PM	7:00 PM	9:00 PM
Minimum	141	-	46	100	41	0	10	8	7.02
Time	8:00 AM	-	9:00 AM	8:00 AM	8AM/9AM	8:00 PM	6pm/7pm	5:00 PM	5:00 PM

Table XXI: Weekend Hourly Bike Rack Data, Min/Max

Combined Week one and Week 2 Results

	Cumulative Max Bike Parking Data																			
	Weekday 1					Weekend 1					Weekday 2					Weekend 2				
Time	Zone 1	Zone 2	Zone 3	Zone 4	Total	Zone 1	Zone 2	Zone 3	Zone 4	Total	Zone 1	Zone 2	Zone 3	Zone 4	Total	Zone 1	Zone 2	Zone 3	Zone 4	Total
6	19	33	43	9	104	25	63	47	17	152	19	33	43	9	104	40	35	44	24	143
7	19	34	43	9	105	28	59	47	16	150	19	34	43	9	105	38	37	44	24	143
8	25	35	44	10	114	26	33	47	8	114	23	35	44	10	112	35	38	44	24	141
9	41	33	47	12	133	44	41	48	8	141	36	40	47	11	134	38	38	44	24	144
10	74	37	48	18	177	59	45	51	10	165	69	49	45	20	183	42	48	55	20	165
11	50	42	50	20	162	58	51	56	14	179	82	52	55	23	212	51	58	56	22	187
12	95	44	58	19	216	30	44	57	15	146	94	54	52	21	221	52	65	51	23	191
13	103	47	56	16	222	36	52	60	11	159	101	57	62	24	244	62	65	57	22	206
14	84	57	59	18	218	32	56	56	10	154	84	56	53	21	214	59	66	60	24	209
15	79	57	54	16	206	35	56	57	10	158	79	57	54	16	206	61	74	59	30	224
16	75	55	54	15	199	31	52	56	9	148	75	55	54	15	199	53	66	54	23	196
17	68	53	55	15	191	36	53	56	10	155	63	53	54	15	185	53	56	41	25	175
18	42	61	67	17	187	44	63	72	24	203	52	55	58	13	178	81	61	72	29	243
19	39	63	62	14	178	45	59	72	17	193	38	54	66	18	176	92	64	76	30	262
20	42	56	62	17	177	38	65	79	24	206	33	50	54	19	156	84	79	96	25	284
21	43	48	55	13	159	23	65	80	25	193	33	49	50	14	146	95	72	90	34	291

Table XXII: Hourly Max Bike Parking Data, Weeks 1 & 2

Bike Tagging Experiment Results

Table XX: Data of Tagging Bicycles Experiment					
	Date	**Number of Tagged Bicycles**			
Day 0	*March 23rd*	149			
	Date	**Remaining Tagged Bicycles**	**Percentage (%)**	**Blocked Spots**	**Percentage (%)**
Day 6	*March 29th*	**61**	**40.94**		
	Zone 1	10	6.71		
	Zone 2	22	14.77		
	Zone 3	25	16.78		
	Zone 4	4	2.69		
Day 7	*March 30th*	**59**	**39.60**		
	Zone 1	11	7.38		
	Zone 2	20	13.42		
	Zone 3	24	16.11		
	Zone 4	4	2.69		
Day 12	*April 4th*	**59**	**39.60**	**30**	**37.04**
	Zone 1	11	7.38	6	7.41
	Zone 2	18	12.08	14	17.28
	Zone 3	26	17.45	10	12.35
	Zone 4	4	2.68	0	0.00
Day 19	*April 11th*	**53**	**35.57**	**33**	**40.74**
	Zone 1	12	8.05	7	8.64
	Zone 2	17	11.41	14	17.28
	Zone 3	20	13.42	12	14.81
	Zone 4	4	2.68	0	0.00
Day 23	*April 15th*	**52**	**34.90**	**30**	**37.04**
	Zone 1	12	8.05	7	8.64
	Zone 2	14	9.40	11	13.58
	Zone 3	22	14.77	12	14.81
	Zone 4	4	2.68	0	0.00

Table XXIII: Studiestræde Bike Tagging Experiment Data

Table XX: Data of Tagging Bicycles Experiment					
	Date	**Number of Tagged Bicycles**			
Day 0	*April 12th*	93			
	Date	**Remaining Tagged Bicycles**	**Percentage (%)**	**Blocked Spots**	**Percentage (%)**
Day 3	*April 15th*	**62**	**66.67**	**53**	**39.55**
	Zone 1	16	17.20	14	10.45
	Zone 2	10	10.75	7	5.22
	Zone 3	17	18.28	15	11.19
	Zone 4	7	7.53	5	3.73
	Zone 5	12	12.90	12	8.96
Day 7	*April 19th*	**55**	**59.14**	**47**	**35.07**
	Zone 1	11	11.83	9	6.72
	Zone 2	7	7.53	6	4.48
	Zone 3	17	18.28	13	9.70
	Zone 4	6	6.45	5	3.73
	Zone 5	14	15.05	14	10.45
Day 14	*April 26th*				
	Zone 1				
	Zone 2				
	Zone 3				
	Zone 4				
	Zone 5				

Table XXIV: Vestergade Bike Tagging Experiment Data

APPENDIX 4: Objective 1 Calculations

Recommended Number of Bicycle Spots

	Weekday				Weekend			
	Number of Bikes against/in the stand	Total Number of designated Bicycle parking spots	*Calculations*	Number of Bicycles per spot	Number of Bikes against/in the stand	Total Number of designated Bicycle parking spots	*Calculations*	Number of Bicycles per spot
Zone 1	33	25	*32.63/25*	1.31	32	25	*32.63/25*	1.29
Zone 2	39	33	*39.13/33*	1.19	42	33	*39.13/33*	1.28
Zone 3	41	23	*40.94/23*	1.78	43	23	*40.94/23*	1.87
Average				1.42				1.48

Table XXV: Calculated Number of Bicycles Per Designated Spot

	Weekday			Weekend		
	Number of bikes against the wall, pole, and other	*Calculations*	Number of Needed Spots	Number of bikes against the wall, pole, and other	*Calculations*	Number of Needed Spots
*Zone 1 numbers not included due to all the bicycles parked in corner were counted in this category						
Zone 2	10	*10/1.45*	7	15	*10/1.45*	11
Zone 3	11	*11/1.45*	8	16	*11/1.45*	11
Zone 4	16	*16/1.45*	11	25	*16/1.45*	17
Total	21		26	31		39

Table XXVI: Calculated Number of Needed Bicycle Parking Spots

	Length (Meters)	*Calculations*	Enough Space for…
Length of Car Parking Spot (m)	4.8	*10.83/4.8*	2.26
Regular Rack distance between hoops (m)	0.55	*10.83/0.55*	19.69
Dock Rack distance between docks (m)	0.81	*10.83/0.81*	13.37

Table XXVII: Facilities Able to Fit in 10.83 Meters

APPENDIX 5: Objective 2 Results

Shop Owner Results

Opinion on Studiestræde's Current Parking Situation		
	Amount of Shop Owners	**Percentage**
Positive	1.0	6.3
Negative	12.0	75.0
Indifferent or No Opinion	3.0	18.8
Actions Taken		
	Amount of Shop Owners	**Percentage**
Moves Bicycles	9.0	56.3
Doest Move Bicycles	2.0	12.5
No Response	4.0	25.0
Opinion on Bicycle Parking Affects Their Business		
	Amount of Shop Owners	**Percentage**
Affects	2.0	12.5
Doesn't Affect	2.0	12.5
Unsure if Affects	2.0	12.5
No Response	10.0	62.5

Opinion on the Addition of New Bicycle Racks		
	Amount of Shop Owners	**Percentage**
Supports	7.0	43.8
Does Not Support	1,0	6.3
No Response	8,0	50.0
Opinion on Using Signs		
	Amount of Shop Owners	**Percentage**
Supports	3.0	18.8
Doesn't Support	1.0	6.3
No Response	12.0	75.0
Opinions on Current Removal System		
	Amount of Shop Owners	**Percentage**
Needs Improvement	3.0	18.8
Doesn't Need Improvement	0.0	0.0
No Response or Doesn't Know About It	13.0	81.3

Table XXVIII: Specific Responses of Shop Owners to Improvements

Pedestrian Counting Results

	Monday, April 11th 2016				
	SideWalk	Pedestrians	Bike Walkers	Strollers	Crossed street
11:00	Left	230	12	4	13
	Right	148	5	1	7
12:00	Left	292	32	1	23
	Right	185	8	3	21
13:00	Left	301	16	3	23
	Right	187	12	2	63
14:00	Left	294	21	0	24
	Right	223	17	4	35
	Totals	**1860**	**123**	**18**	**209**
	Percentage	**81.1%**	**6%**	**0.9%**	**11%**

Table XXIX: Pedestrian Counting Data, Day 1

	Wednesday, April 20th 2016				
	SideWalk	Pedestrians	Bike Walkers	Strollers	Crossed Street
11:00	Left	139	2	2	12
	Right	145	11	6	22
12:00	Left	176	8	1	20
	Right	230	8	4	35
13:00	Left	161	5	1	23
	Right	202	16	5	27
14:00	Left	152	9	1	17
	Right	175	13	3	12
	Totals	**1380**	**72**	**23**	**168**
	Percentage	**81%**	**5%**	**2%**	**12%**

Table XXX: Pedestrian Counting Data, Day 2

APPENDIX 6: Objective 1 Graphs

Flow Data Figures- Weekday

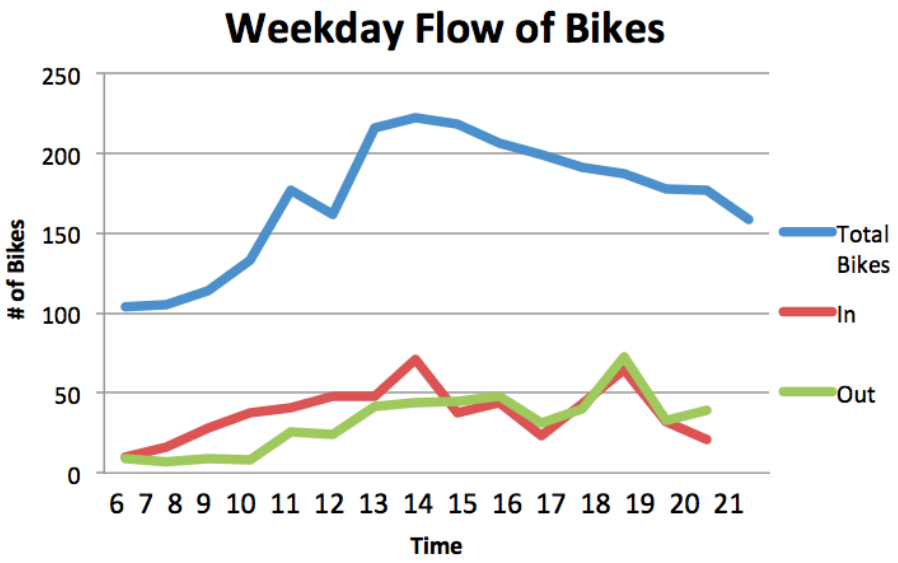

Figure I: Weekday Flow Graph, Total vs In vs Out

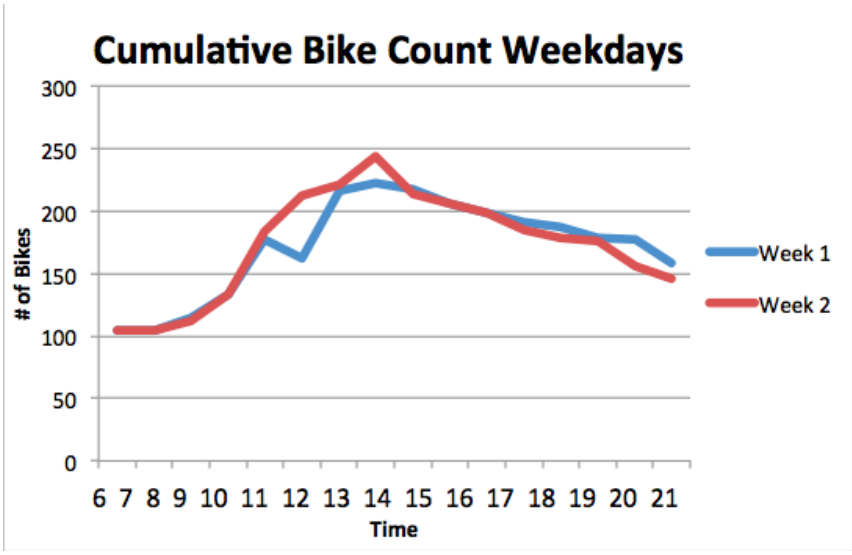

Figure II: Weekday Hourly Bike Count Graph, Week 1 vs Week 2

Flow Data Figures- Weekend

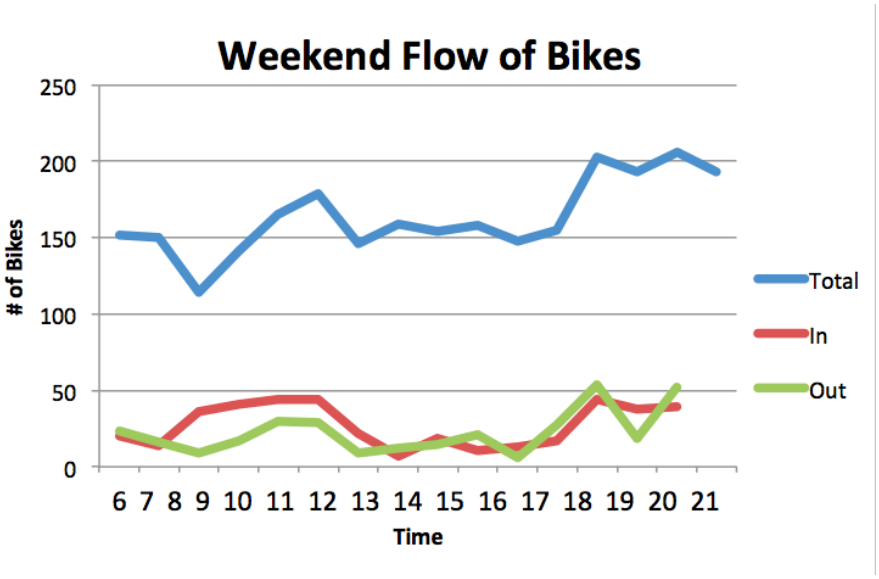

Figure III: Weekend Flow Graph, Total vs In vs Out

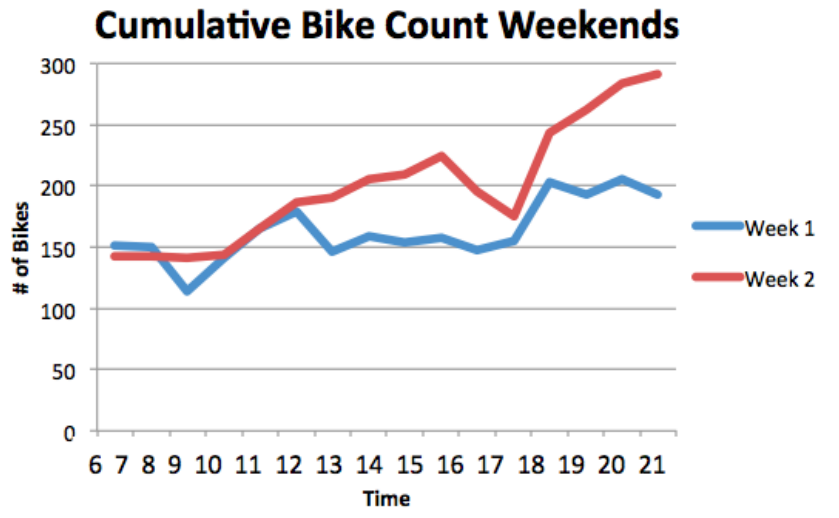

Figure IV: Weekend Hourly Bike Count Graph, Week 1 vs Week 2

Demographics

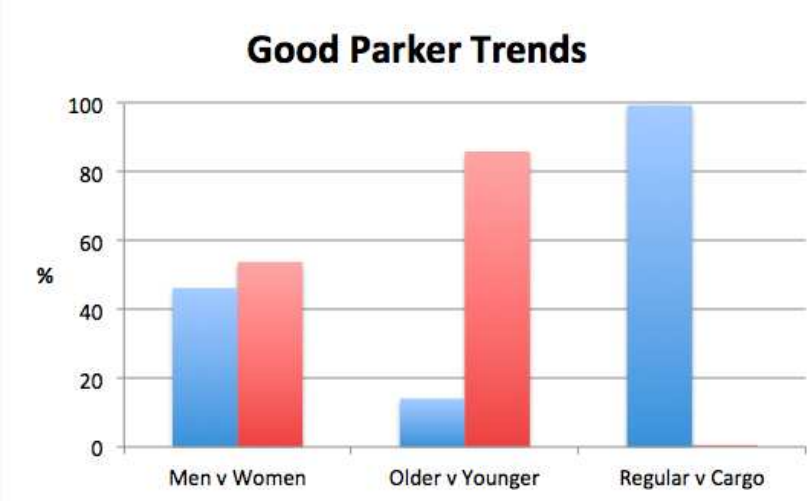

Figure V: Demographics of Good Parkers

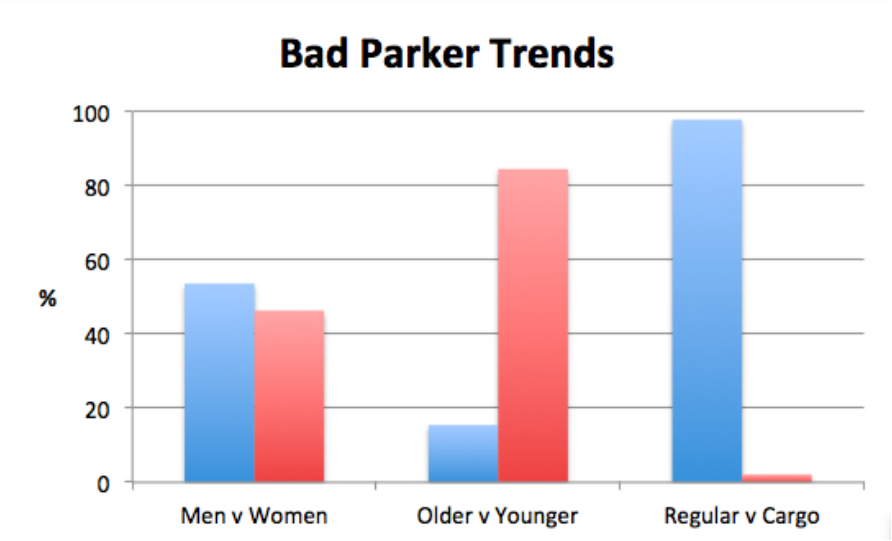

Figure VI: Demographics of Bad Parkers

Figure VII: Habits of Parkers

APPENDIX 7: Interview Questions

We are a group of students from Worcester Polytechnic Institute in Massachusetts. We are conducting a survey of cyclists/shop owners/ pedestrians to learn more about bicycle parking habits and bicycle parking congestion on the narrow streets of Inner City Copenhagen. We strongly believe this kind of research will ultimately enhance the bike parking experience of the residents of Inner City Copenhagen.

Your participation in this survey is completely voluntary and you may withdraw at any time. Please remember that your answers will remain anonymous. No names or identifying information will appear on the questionnaires or in any of the project reports or publications.

This is a collaborative project between Miljøpunkt Indre By-Christianshavn and WPI, and your participation is greatly appreciated. If interested, a copy of our results can be provided at the conclusion of the study.

Cyclists

1. What are you opinions about the bicycle parking along this street?

2. How long are you planning to park you bike?

3. Have you ever parked your bike over night or for an extended period of time in a public rack?

Shop Owners

1.What are your opinions on bicycle parking in the area?

2. Have you ever moved a parked bicycles that blocked your windows or entrance?

3. Do you believe the parking habits of the area have an effect on your business?

4. Have you ever considered using signs to prevent people from parking their bicycle in front of your shop?

5. What are your thoughts on adding additional bicycle racks along the street?

APPENDIX 8: Interview Responses

Cyclist Interview Responses

Young Men:

1. He lives in the building in front of the bike stand. Complains there isn't enough bike parking spaces along the street. He usually parks his bike in the cellar or in the bike stand depending on the situation.
2. Attends the law school (zone1) and complains that when he arrives there are not enough bike parking spaces. He is extremely frustrated because it is time consuming to find a spot. He does not leave his bike overnight.
3. Frustrated about the current bike parking situation because there are not enough spaces and has to park his bike outside the bike rack. He is a current student at the Law school.
4. (2 person interview) People throw their bikes wherever and that's the main reason why bikes get stolen. Bicycles describe "Who I Am." He chains his bike in his backyard for safety. When he parks in Norreport in basement when he parks overnight.
5. People park wherever they want and the smallest issue for him is the parking and biggest one is the weather. At the coffee stand and he usually takes bus because he doesn't know how to drive. Thinks the big problem is that no one actually thinks about bike parking. It would be ideal to collect old bikes and re-sell them for a perfect business opportunity. He doesn't park overnight and shop-owners are the most likely to move the bikes.

6. Very nice guy and thinks there are too many bicycles and not enough space. He parks everyday (6 hrs). He leaves his bike overnight central station over the weekend when he visits his parents at Aarhus.
7. The bicycle racks are always crowded and it would be nice if there were better facilities. Parks bicycles for around 2-6 hours depending on his schedule during the week. Left his bike overnight only once at a station. He is from out of town and leaves bike just one night.
8. There is not a lot of space but have basement for the winter months/all day. Parks his bike for around 3-4 hours and does not park over night.
9. He has no frustrations but wonders why people would actually leave bikes for so long. He bought his bike online from yellow tag auction and says people collect yellow-tagged bikes and auction them off. He owns an office and parks there for couple of hours. Misplaced a bike once and went to insurance company. When he goes on vacation he leaves his bike for days/weeks at the train station.
10. Uses bicycle rack when he sees them but if not will just park against a wall. Is not going to go out of his way to find bicycle racks. Will park a bicycle from 10min to a couple hours. At night leaves bicycle outside of apartment against a wall. One time left bicycle at train station and bicycle lights were stolen.

Young Women:

11. (2 Person interview) Irritated about bike parking in the area due to lack of facilities because the current ones are always full. Doesn't park overnight. Walk a lot because she is a Law school student and bike parking is time consuming.

12. Visiting the living room lounge (zone 2) to do some work for about 2-3 hours. She does park overnight but only at her apartment where she has parking spaces.
13. Complains about not having enough bike parking spaces. She was in a hurry and doesn't do overnight parking. Doesn't know how long she is going to park since she will be at the law school doing work.
14. Very annoying situation and difficult to solve it. Now she needs to leave her bike halfway through the sidewalk because the bike doesn't fit and that would be inconvenient to others. She doesn't park overnight and she will park her bike for 20 min that's she left it like that.
15. It is extremely difficult to find parking spaces here. Planning to park approximately for 2h (usually). Doesn't park overnight in the racks outside the school because she always parks at home.
16. It is very difficult to find a bicycle parking spot because there are a lot of bicycles. She normally parks there but doesn't come too often and doesn't park overnight.
17. It is very hard to find a spot. People should start using the underground basement more to park their bikes. She goes to school in 5 minutes currently and stays 4 hours at the library. No overnight parking.
18. In her opinion bikes should be rejected. Parking her bicycle for 3 hours. Sometimes leaves her bike at the train station to visit her boyfriend's parents. Has been out with bike when he is drunk.
19. There is no room ever to park bikes. She parks around 2-3 hours a day depending on her schedule. She doesn't park overnight.

20. She is taking her friend's tagged bike who lost it weeks ago and just found it. Likes to park on the outside of the stand to have something to lock it to. There should be bike stands that have something to lock bike to it.
21. She parks near her house on the outside and if parking for long period of time then she parks it in the courtyard because wheels get ruined and the seat might get stolen. She thinks that the police are the ones who take the tagged bikes.
22. She never finds any spots available and usually parks in front of shops and they get mad. She stays at school for around 4-8 hours and she is not leaving bikes overnight because she lost 2 already doing that. Learned her lesson and not doing it anymore.
23. She just doesn't get frustrated anymore because she parks wherever and says that if there were enough spaces close to her location then everything would be much easier. She leaves her bike overnight when she goes out because she doesn't wants to bike back. She lost her bike once but found it a couple days later.

Old Women:

24. The space in the street is overcrowded due to lack of spaces and she does leave her bike at the rail station overnight. She parks her bike all day (extended period of time) in this bike rack because she owns the shop in front. When she parks overnight she locks her bikes with extra lock.
25. Parking spaces are always way too crowded and it's very frustrating. She leaves her bike parked overnight at the metro and she was parking for short period because she was visiting a shop.

26. Bike parking here is “messed up” because there are no space and she parked in this spot because she saw it was empty. She non-accidentally made another bike fall because there wasn’t space hitting it. She never parks overnight.
27. She doesn’t have any bike parking concerns and think there isn’t a problem at all. She doesn’t park overnight and thinks there should be an immediate solution.

Shop Owner Interview Responses

Store 1

- Finds the bicycle parking in the area annoying: they have to move the bikes all the time to put their benches and stuff out.
- Unsure if it affects their business; just more so a hassle.
- Believe that maybe one more rack would help because the close one (law school) it always full.

Store 2

- Bicycle parking on the street is really poor. The two stands are always full. Cargo Bikes park in the street.
- There isn't enough space.
- He parks his personal bike against the building because it's safer to have it locked to something. People steal like crazy in Copenhagen.
- Crowded bike parking doesn't affect, most of his customers are students that are walking past.
- Extra facilities would be helpful. Replace car spots. He sometimes travels by car, so the spots are nice, but there are far more bikes than cars.
- Signs that show were parking is allowed rather than where not to.

Store 3

- There is not enough room for all the bikes. It would be nice if the parking could be more spread out.

- Unsure if bikes affect the business. Sidewalks are blocked by people talking and gathering outside while they enjoy of nice weather.
- Believes the amount of car spaces on the block is unnecessary; could be converted into racks.

Store 4

- Bike parking is horrible, very horrible. It's almost impossible to park.
- Rides bike every day; parks at the law school where there is no room. Only gets a spot because she gets there earlier. When she does get a spot, it's almost impossible to get out.
- Has to go out every half hour or so to tell people to move their bikes; she often times gets asks where else they should move their bike.
- Good idea to add more racks as long as they are not in front of their shop on their side of the street

Store 5

- Bike parking is fucked up. Lots of Danes ride their bikes into town and need somewhere to park, but most of the racks are full.
- A lot of the bikes are abandoned and this needs to be cleaned up. Believes they only do this once a year.
- People will park in front of his shop window; he wants people to be able to look into his window. Shop window is big for his commercial value.
- Supports addition of racks through car spaces. If you bring a car to work and can't find a spot it isn't because of the bikes. Would rather have bikes in the city than cars. Wants people to ride bikes or ride the bus (if it was cheaper, no one would drive). Lessen amount of cards in the city by also making the metro more accessible like NYC. Having a car in the city is fucked up, but so is sitting on the bus for 45 minutes and paying 20kr.
- Parking problems could be kept down if the abandoned bikes are cleared out, maybe once a quarter.
- Bike rack in front of his store may decrease his window value; concerned about window space and believes it wouldn't make sense to have one there.
- There are so many bikes at the law school, but they need to be there. Vestergade (one street over) doesn't seem to have the problems of this street: potential to shuffle some of the parking over there.

Store 6

- It's not a problem here, he parks right next to his store's wall.
- In the morning there are bicycles parked around the front of the shop; he just moves them around.

Store 7

- Move bicycles from the windows in front of his store.
- Their business would probably improve if there is a bike parking closer.
- Their own bikes are parked on the back of their business

Store 8

- They Think that "a month is to long with tape" and should be decreased to eliminate congestion faster.
- There needs to be an improvement of both, Habits and more space available for bike parking.
- 20-30 year olds have no empathy so they are the main cause of the problem.
- Owner already asked the police if its legal to move bikes,
- People park anywhere and more convenient.

Store 9

- The bike parking is very annoying.
- Owner mover bikes that are parked in front of her window.

- Doesn’t matter if they are locked, she carries and moves them.
- Considering putting sign in front of her business to prohibit bike parking.
- She parks her bike against a wall.
- Most of shop owners hate bikes.

Store 10

- Doesn’t care because he doesn’t own a bike.
- Can’t move bikes parked in front if his business.

Store 11

- They get annoyed that bikes park in front of their business.
- They personally think if the bike parking gets extended in front of their store they will get annoyed.

Store 12

- The owner used to move the bikes parked in front of her store but now she doesn’t care anymore.
- There was a sign on the street but people made it a sarcastic joke.
- Pole would be efficient and probably work
- Its Copenhagen, people bike too much and this is a problem difficult to handle.

Store 13

- Move bikes
- Great place to hang outside with tables and its been disturbed because of bikes.
- Clear all the spaces would be ideal for more tables.
- Doesn't like bike parking at all.
- He owns a cargo bike and doesn't have a place to park it.
- Good idea would be to spread out bike racks.

Store 14

- People park in front of his windows.
- He punches tires if bikes park in his place.
- Bike parking has become a huge trouble for ship-owners.
- Clearing all the car parking would be ideal.
- There are too many bikes and that the problem (him and his wife own 6 bikes)
- He parks his bike in his basement because he owns a very expensive bike.

Store 15

- Cyclists are fucking annoying, specially the ones who parked against the window.
- People ride their bikes in their own world and don't care about others.
- They are so selfish and care about their own convenience only.
- They own 3 signs that have been there or a while.
- The shop-owner had a designer bike and got stolen despite he had a huge lock.

- The bikes that are parked against their window, they move them to the bike stand where they originally belong.
- If they see the owner parking the bike they will tell him immediately to move.
- They always park their bike in the bike stand and try to be good role models.
- Have had signs for 20 years, people ignore them. They don't listen to signs since they ignore them.
- "We suck as bicyclists"

Store 16

- The current situation is very crappy due to too many bikes and seen that in 4 years only have been 2-bike removal.
- There is no parking problem, will tell them somewhere else they just toss them into the rack.
- She bikes to work and parks it in any of the two racks that are in front of her shop.

APPENDIX 9: Recommendation Calculations

Nørreport	Number of bicycles in the rack (Cykeltaelling, 2015)	Estimated Number of Abandoned Bicycles (15%)	Number of Bicycles Left Continuously (48 every 6 weeks)	Cost of Bicycle Rack Construction (Danish KR)	Price of Cleanup per Bicycle (197 KR per Bicycle)
Calculations	-	2411*0.15	(48*8) + (362-48)	*a) (362/3)*2,800* *b) (362/3)*12,000* *c) (362/3)* 60,000*	698*197
	2411	362	698 per year	a) 337,867 b) 1,448,000 c)7,240,000	137,506
				Total: 9,025,867	Total: 137,506

Table 7: Compared cost of implementing more Bicycle racks verse removing them at Norreport

Indre By	Number of bicycles in the rack (TMF, 2016)	Estimated Number of Abandoned Bicycles (15%)	Number of Bicycles Left Continuously (194 every 4 weeks)	Cost of Bicycle Rack Construction (Danish KR)	Price of Cleanup per Bicycle (197 KR per Bicycle)
Calculations	-	9700*0.15	(194*12) + (1455-194)	*a) (1455/3)*2,800 b) (1455/3)*12,000 c) (1455/3)* 60,000*	3598*197
	9700	1455	3598 per year	a) 1,358,000 b) 5,820,000 c) 29,100,000	707,033
				Total: 36,278,000	Total: 707,033

Table 7: Compared cost of implementing more Bicycle racks verse removing them at Indre By