CornellEngineering
Civil and Environmental Engineering

# Big Bike Theory

**FEASIBILITY OF COMBINED CORNELL-ITHACA BIKESHARE**

M.Eng in Engineering Management Project | CEE 5910 | 2017

# Table of Contents

# 1. EXECUTIVE SUMMARY

The students at Cornell University are planning a sustainable mode of transportation for the city of Ithaca by introducing a bikeshare system called the 'Big Bike Theory'. The bikeshare initiative will provide a cheap and environmentally friendly means of commuting while enjoying the gorgeous and picturesque beauty in Ithaca. The bikeshare system is both convenient and easily accessible and requires no commitment of buying your own new bicycle. One of the major benefits of bike shares is that they eliminate the last mile problem by giving people an option for the last leg of the commute. When people are given the option to hop on a bike, they might get the most exercise they have gotten in months. People who are sedentary in their everyday life probably will not go out and buy a bike. However, bikeshare provides an easy option, and they might enjoy the workout.

The Big Bike Theory project started with a market survey which received a large response from the residents of Ithaca and the motivations for the interest in the bikeshare system was identified to be Travel and Exercise together, Convenience, Environment friendly and Cost effectiveness. Based on the survey results and insights we have planned a docked bikesharing system with 200 bikes and 21 docking stations. The objective of the project is to produce a report and presentation that are useful to two local organizations: Bike Walk Tompkins, representing Ithaca, and Cornell Transportation and Mail Services.

We estimated the cost for each component including bike price, dock price, labor cost, administration fee, and other costs.  Also, a pricing model was designed based on market survey data. Finally, a capital budget plan for the whole project was fabricated based on these data. A thorough operating framework was considered for our bikesharing system including how many stations we need, how many bikes to be assigned each day, how to maintain the system and how to move the bike from one station to the other station. We came up with some feasible technologies related to this project like technologies for locating the bike, locking the bike, and technologies for payment system and special design for bikes based on the uncommon topography in Ithaca.

The revenue streams over the ten years following initiation were estimated with the help of scenario analysis. It was shown that the project is financially feasible with some initial finance support in order to cover the initial capital investment. It was also shown that the project starts developing profits in the second year of its operation.

## 2. DISCLAIMER

This report does not necessarily represent the opinion of Cornell University. It was produced by students for educational purposes only and is not an engineering or design work product. All information in this report is provided "as-is." The authors assume no liability or responsibility to any person or entity with respect to any loss or damage related directly or indirectly to the information in this report. No warranties of any kind, express or implied, are made. The authors will provide no remedy for indirect, consequential, punitive, or incidental damages arising from this report, including such from negligence, strict liability, or breach of warranty or contract, even after notice of the possibility of such damages.

# 3. ADVISOR'S INTRODUCTION

The following report on bikesharing in the Ithaca area is the latest in a series of reports on transportation technologies and systems from the Engineering Management program at Cornell University dating back to 2004, and ranging in subjects from advanced public transportation to plug-in hybrid electric vehicles, battery swapping systems, and hydrogen fuel cell vehicles. It also falls under the heading of reports aimed at developing a sustainable livable community in the Ithaca area and Tompkins County that focus on sustainable energy, buildings, and transportation. This report as well as previous ones can be downloaded at www.lightlink.com/francis/.

Our system for forming engineering management project teams and carrying out projects is the following. At the beginning of the semester, faculty members offer a limited number of project topics, and then the students (who come from a range of engineering and related disciplines) choose their preferred topic and form a team. Thus the team members are not free to independently choose any topic that they desire, and they may or may not have previous experience with the topic that they choose. Instead, the team must draw on whatever experience they have and the engineering management skill set that they have in common to evaluate the technology or system and produce a report.

In the report that follows, the 14-member team has taken on the subject of bikesharing, including an online survey of likely users of bikesharing. They have proposed a system with 21 stations and 200 bikes for the combined area in the plain of downtown Ithaca and on East Hill including Cornell University. Their cost of operations includes a funding stream and operational plan for repositioning bicycles especially in cases where riders use them one-way to travel downhill, in which case the system must rebalance bicycles to the top of the hill. They have also considered innovative technologies such as chainless transmission from the pedals to the rear wheel and puncture-proof tires. Lastly their report also explains a tradeoff between having enough bicycles and available empty docks for the convenience of the users without purchasing and operating so many bicycles that they are on average underutilized.

In closing, I would like to thank representatives of Cornell Transportation and Mail Services on the academic side as well as Bike Walk Tompkins and Ithaca Carshare on the community side who gave input to this study. While their assistance is gratefully acknowledged responsibility for any errors and omissions lies with the team and with myself as advisor.

Respectfully submitted,

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Senior Lecturer, School of Civil & Environmental Engineering

# 4. INTRODUCTION

## 4.1. Motivation

Bike share systems are good for the environment as it produces no emissions. Without it, we can only assume that the people riding them would have ridden in a cab or a bus instead. When tourists visit a city, they can either drive their own cars or take public transportation. If they have their cars, they will drive around for their entire trip, causing more traffic and extra pollution. If they do not bring their cars, they will probably take cabs, since they are unfamiliar with the public transportation system. Bikesharing gives these people an alternative to experience the city by bike, which is both less expensive and more convenient. Even commuters cut down on pollution by using bike shares. With bike share stations all over the city, they will be more tempted to give it a try. There is less commitment to using a bike share than buying a nice bicycle, so they might leave their car at home for the very first time. This option also leads to the next benefit of bike shares. Bike share systems are convenient. If you commute to work in a city, you know that there are sometimes public transportation dead zones. You might get as close as you can to your office, but there is still than 15-minute walk down to your door. This might not seem like a lot in the long run, but when you're rushing to the office at 8:00am, it can feel like a lifetime. Bike share systems completely eliminate this problem. You can hop off the train, hop on a bike, and make a beeline for your office. If you are lucky, there might even be another station around your destination, so you will only pay for the 15 minutes. This dead zone is called the "last mile" problem in urban development.

## 4.2. Team members' background

*Sarita Singh* is from Mumbai, India and completed her undergraduate degree in Electronics and Telecommunications from Mumbai University. She has worked for 2 years in Diebold Inc. as a Software Engineer. She is currently pursuing her graduation in Engineering Management at Cornell University.

*Nilesh Jain* is from Delhi, India. He completed his undergraduate studies in Instrumentation and Control from Delhi University. He has worked for a year with KPMG as a Risk analyst before pursuing masters at Cornell University.

*Jingyuan Hou* is from Dalian, China, and finished his undergraduate degrees in both Engineering Physics and Management at Tsinghua University. He has internships in Mckinsey & Company and China Construction Bank in China.

*Hanyu Li* is from Changsha, China and finished her undergraduate degrees in both Transportation System Engineering and Applied Economics at Beijing Institute of Technology. She has internships in China Development Bank in China.

*Christine Varkeyachan* is from India and she completed her Bachelor of Technology in Chemical Engineering from National Institute of Technology. She is currently pursuing her Masters in Engineering Management and is looking to build her career in Product Marketing.

*Zhujia Shi* is from China and finished her undergraduate degrees in both Mechanical Engineering and Business Administration from Tsinghua University. She is currently pursuing her Masters in Engineering Management in Cornell University.

*Menghan Zhou* is from China and graduated with bachelor's and master's degree of Materials Science and Engineering at Beihang University.

*Zhongze Huang* is from China and finished his undergraduate degrees in Civil Engineering in Southeast University.

*Jie Ma* is from Tianjin, China and completed his Bachelor of Engineering in Food Science and Nutrition in Zhejiang University.

*Leo Zhu* is from Nanjing, China. He got his bachelor in Software Engineering at Wuhan University and spent one year at Berkeley studying computer science and other topics.

*Shweta Poojary* is from Mumbai, India. She received her Bachelor's degree in Electronics and Telecommunication Engineering from Mumbai University. She is currently pursuing her Master's degree in Engineering Management and her concentration is in Supply Chain and Operations.

*Rahul Joshi* is from Chennai, India. He received his bachelor's degree in Chemical Engineering from Anna University and is pursuing his masters in engineering management at Cornell University.

*Lei Zhou* is from Ningguo, China. He received his bachelor's degree in Urban Planning from Hefei University of Technology and is pursuing his masters in engineering management at Cornell University. His favourite courses are business operations and project management.

*Jialin Jess Li* is a master student majoring in Civil and Environmental Engineering. She has an undergraduate degree from UCLA and is now continuing her interest in the field of Civil Engineering with the focus in transportation engineering.

# 5. MARKETING

Marketing Research is of primary importance as it helps us define the focus of the research and in deciding the required data collection methods. It helps us in determining the required sample method and data analysis methods. Conducting an in-depth market research helps us in identifying opportunities and lowers the risk of launching a new product/service to a great extent. Market research is an efficient way to stay updated in terms of rapidly changing market and consumer needs.

## 5.1. Marketing Funnel

A marketing funnel helps us in understanding the process of converting potential customers to full time customers. The marketing funnel divides the entire consumer purchase journey into four different stages: Awareness, Trial, Purchase and Repeat. Potential customers are attracted to this stage by advertising and promotional activities. Once the consumers learn more about the company it is vital to be able to attract the consumers into 'Trial' step. In this step the potential consumers have been converted to qualified leads. Marketers are required to provide the consumers with sufficient information about the product. This step is significant as the impression formed in the 'Trial' phase will persuade the qualified consumers to move into the 'Purchase' step. Once the consumers have reached the 'Purchase' step, the marketers have to provide additional customer service and loyalty programs in order to make sure the customers repeat the purchases.

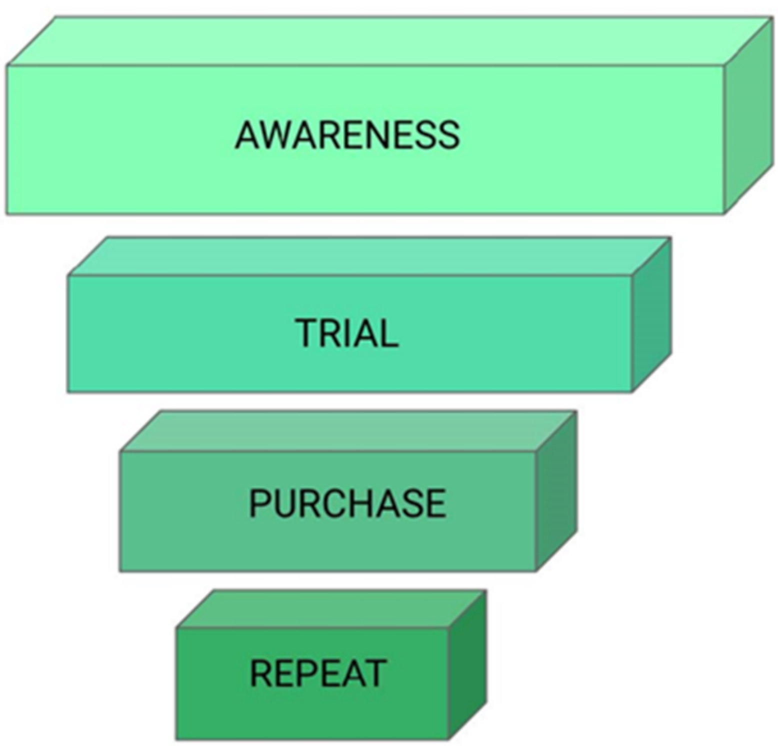



Figure 1. The marketing funnel

## 5.2. Market Research Process

The bikeshare concept is an introductory model for the residents of Ithaca and Cornell University. Although there was a Bikesharing initiative by the Big Red Bikes in 2011, it faced certain operational issues resulting in the service being discontinued. Thus, to ensure that we plan a viable and optimal solution for Bikeshare in Ithaca, case studies of current bike share initiatives were a major part of the qualitative market analysis. Apart from understanding the operational and financial strategies adopted by the Big Red Bikes, we performed three in-depth case studies to recognize the challenges and issues they faced. The choice of these bike sharing locations was based majorly on geography, topography and university setting.

The case studies formulated the secondary research and qualitative studies and based on the data and insights from these we planned our primary research questionnaire. The primary research comprised of in-depth interviews and launching a market survey. We conducted 6 in-depth interviews inclusive of faculty and students from Cornell University (2 Professors and 4 Students). The in-depth interviews were helpful in making final edits to the list of questions we had considered for our survey thereby making it more concrete and focused.

The key areas we targeted is the presence of a market and the associated needs and demands of this market at Cornell University. We focused on who our heavy/light users will be and what will be the distinctive characteristics of these users. We paid close attention to the key usage drivers for the bike share system. Additionally, we aimed to find out the size of the different targeted segments and what their preferences and expectations are as a user. We focused our research on the optimal market offering that suits the preferences and desires of the targeted segments and what are the appropriate communication channels to boost the adoption in order to increase the awareness of the bike share system. Another focal point of this research was to find out the optimal pricing structure and scheduling for the users at Cornell University. We also centered our research on the various drawbacks in the existing bike share systems and tried to customize our bike share to best suit the needs of users at Cornell University.

We focused on the various pain points we might face during the implementation of our project. Some of the major problems bike sharing might face in Ithaca were anticipated to be with respect to the climate and the terrain. Since Ithaca experiences long winters, this might pose as a problem for the bike sharing system as it is not very practical to ride bikes in those harsh climatic conditions. Through our surveys, we narrowed down the time frame (in a year) during which bike sharing can work most efficiently. Another factor we focused on was Ithaca terrain.

#### 5.2.1. Secondary Research

The secondary research comprised of qualitative study of three bikeshare systems globally. We picked bike sharing systems in three different countries that differ in the way they function, in the technology they use and in the terrain they operate in. We chose to study the following systems:

1. Citi Bikes in New York, USA
2. Santander in London, UK
3. Ofo bikes in Beijing, China

##### 5.2.1.1. Citi Bike - New York, USA

**Background**

Citi Bike is the largest bike share program in North America, and a major contributor to New York City's transportation network. Due to the problems of heavy traffic in a crowded city like New York, Citi Bike gained instant popularity providing cheap and relatively convenient mode of commutation. [1]

After running a five-day pilot program to test the feasibility of Bike share system in New York, it was announced in 2012 that a Bike share program would be launched with 10,000 bikes and 600 stations and would be operated by ALTA Bicycle share. Citi Bike was launched in May 2013 with 330 stations and 5,000 bikes in the lower half of Manhattan and few regions of northwest Brooklyn, including Williamsburg and downtown Brooklyn. On the day of the launch of Citi Bikes, 16,000 people had already signed up as annual members. By early 2015, Citi Bike riders had taken more than 13.6 million trips with an average of 34,000 trips daily. Currently, Citi Bike has 10,000 bikes with 600 stations and spans 55 regions in and around the city of New York.

**Finance**

During its launch, Citi Bike secured sponsorship from Citibank with an amount of $41 million for a duration of 5 years. Citibank was the 'title sponsor' for Citi Bikes and hence both the bicycles and the docking stations displayed the company's logo. MasterCard was also a sponsor and dedicated $6.5 million to be the 'Preferred Payment Partner'. Although the amount provided by Citibank seemed sufficiently huge at the time of the launch, Citi Bike currently needs an estimated $20 million for maintenance and expansion. However, they are facing problems to collect funds and sponsors since the name itself markets and promotes only Citibank thereby leaving no scope for other sponsors to contribute. Citibank used the perfect marketing campaign wherein its logo is riding across one of the leading cities of the world; however this decision served to be a constant pain point for Citi Bike to gather funding for its daily operations.

**Operations and Logistics**

The Bike: The bikes used in Citi Bike bike share system are solid, light-weight (around 45 pounds) simple and sleek in design. It is made by Public Bike System Company (PBSC, a.k.a Bixi). It helps one drive smoothly even on jagged surfaces and provides a decent pace combined with good quality brakes. [2]

The Docking stations: One of the major factors for Citi Bikes success is attributed to the density and spread of the docking stations (see figure below). It is very convenient for the bike riders to locate and return the bikes and thus minimize their overall transit time. During its launch, 74% all Citi Bike stations, 243 of 330, were within a quarter-mile of a subway station entrance; 38% are within 500 feet; 16% are within 200 feet; and 10% are within 100 feet (see figure below).

Almost all the bike hubs are located within 750 feet of each other. As of now about 10000 bikes are present along with 600 bike stations spread across Manhattan, Queens, Brooklyn and Jersey City.

Citi Bike's popularity has created such a high demand that some stations regularly lack bikes or are completely full, making it hard to take or park a Citi Bike. Rebalancing is the process of redistributing bikes between 'attractive' and 'repulsive' stations. As commuters ride to work in the morning, 'repulsive' stations empty out and leave few to no bikes. Conversely, 'attractive' stations in busy neighborhoods fill up, leaving no place for riders to dock their bikes. Stations that are full or empty are an "outage." Under contract with the city, NYC Bike Share faces financial penalties when adjacent station outages occur for more than one hour. To avoid outages, dozens of rebalancing teams shuttle bikes between full and empty stations using big box trucks, sprinter vehicles, and bicycle trailers. New smartphone apps built by civic hackers mitigate these issues by helping Citi Bike riders find stations with open docks or available bikes. These apps include the official Citi Bike app as well as NYC Bikes, Availabike, and NYC Bike Share. Despite the varied forms of rebalancing, Citi Bike still struggles to meet demand for riders. Although the main bike warehouse is in Sunset Park, Brooklyn, Citi Bike opened three hubs near Penn Station, Pier 40, and Delancey Street, where broken bikes can be repaired and working bikes can be staged for vehicle pickup. This proximity shortens the travel distances of rebalancing vehicles, avoiding the potentially hour-long trip from Sunset Park to Midtown, which could exceed the one-hour outage limit. [3]

In addition to rebalancing, Citi Bike has struggled to maintain its bikes and stations. A city audit in December 2014 found that New York City Bike Share failed to maintain equipment per its contract with the Department of Transportation. Failures to perform station inspections and maintenance checks result in rider-generated signals where knowledgeable riders will turn the seat around on a broken bike to alert future riders. Citi Bike is now upgrading the software and payment systems and docking equipment at all stations, which will likely produce an improvement in these issues.

**Pricing**

Citi bike offers three options as its pricing strategy:

1) Day pass
2) 3 Day pass and
3) Annual membership.

The day pass costs $12 and offers unlimited 30 minute rides for 24 hours. The 3-day pass costs $24 and offers unlimited 30 minute rides for 72 hours. For both these options an additional $4 has to be paid for every 15 minutes if the rider exceeds 30 minutes. The annual membership costs $163 and offers unlimited 45 minute rides. An additional $2.50 is charged for every 30 minutes if the rider exceeds 45 minutes, $6.50 is charged for the subsequent 30 minutes and $9 for each additional unit of 30 minutes after that. Citi bike charges a security deposit of $101 on each bike when it is rented. The rider has to pay $1200 for stolen or lost bikes. This is the general pricing strategy used by Citi bike. [4]

**Marketing**

Citibank had taken an estimated $476 billion in the form of public cash and guarantees during the financial crisis. Launching Citi Bike proved to be a great success for Citigroup. Citi received much appreciation for this initiative. "Favorable impression of Citi'', ''is an innovative company'', '' is a socially responsible company'' were some of the recognitions they received. The launch of Citi Bike also helped Citi climb from negative to positive territory in the New York market within a month of Citi Bike's launch. Another strategy used by the Citi group was to place most of the docking stations next to the Citigroup branches or ATMs. They also incorporated Citi groups cobalt blue color onto the bikes for further marketing. Ultimately, Bike-share sponsorship netted $4.4 million dollars in earned media for Citi.

The following challenges have arisen for Citi Bike:

1) High demand leads to shortage of bikes available at some stations (repulsive) and shortage of docks at some stations (attractive). These situations lead to bike outages.
2) Financial penalties on Citi Bike share whenever outage occurs.
3) Dozens of rebalancing teams shuttle bikes between empty and full stations using big box trucks, bicycle trailers and sprinter vehicles.
4) Failure to perform regular bike and dock maintenance.

**Future Plan**
In October 2014, the principals of the Related Companies and Equinox formed an investment company called Bike share Holdings that purchased Citi Bike's parent company, Alta Bicycle Share, renamed to Motivate. Plans were announced to double Citi Bike's users by 2017. Residents of Harlem, Long Island City, Greenpoint, Williamsburg, Bedford-Stuyvesant, Red Hook, Park Slope, Astoria, Prospect Heights, and Crown Heights will be among those to benefit from the increase from 330 to 700 stations and 6,000 to 12,000 bicycles. This expansion will likely be a boon for the outer boroughs, where the "last mile" from transit to home or work can be a much longer distance than in Manhattan

### 5.2.1.2. Santander Cycles - London, U.K.

**Background**
Santander Cycles is a public bicycle hire scheme in London, United Kingdom. In August 2007 Ken Livingstone, the Mayor of London, announced that he was planning to implement a bikeshare system modelled on the successful example in Paris. After several discussions, Livingstone officially unveiled the plans for London cycle hire scheme in February 2008. BCH commenced operations in July 2010 with 5,000 bicycles and 315 docking stations distributed across the City of London area and parts of eight London boroughs.

The operation of the scheme is contracted by Transport for London to Serco. PBSC Urban Solutions provides bikes and docking stations. The scheme is sponsored by Santander UK from April 2015 and Barclays Bank was the first sponsor, from 2010 to March 2015.
A study showed cyclists using the scheme are three times less likely to be injured per trip than cyclists in London as a whole, possibly due to motorists giving cycle hire users more road space than they do other cyclists. Moreover, recent customer research showed that 49 percent of Cycle Hire members say that the scheme has prompted them to start cycling in London. The record for cycle hires in a single day is 73,000 (2005). **[5]**

**Financing**
In May 2010, this bike share scheme received sponsorship of £25 million from Barclays Bank (£5m a year in each of the five years) and in February 2015, it received another £43.75 million from Santander (£6.25m a year in each of the seven years).

However, the revenue in early stage is not satisfying: In the first three months of the scheme, 95 percent of journeys did not exceed half an hour, earning TfL access fees but no usage fees. The scheme generated £323,545 in revenue for usage in the first 96 days.

The cycle hire scheme gross revenue for 2014 to 2016 was the following:

2014 £13.6 million
2015 £15.6 million
2016 £15.6 million

It is believed that the number of users will increase in the future and the gross revenue will increase as a result.

**Operations and Logistics**
The platform behind the bike share system is created by 8D Technologies, who also supply the server technology for BIXI Montréal, Citi Bike in New York City, Capital Bikeshare in Washington DC, Melbourne Bike Share in Australia, and others.

8D Technologies' bike share solution defines the next generation of hardware and software in the bike share industry. 8D Technologies' bike share solution defines the next generation of hardware and software in the bike share industry.

8D’s state-of-the-art modular solution and components are developed to meet the latest industry standards in high technology. Created to be robust, flexible and secure, our bike share system allows for future expansions to be integrated as needed. The turnkey bike share product line includes the following features:

1) Integrated bike key dispenser in the terminals that allows customers to instantaneously retrieve their access keys as soon as they register
2) Extremely dependable bike locking mechanism
3) Bike docks that allow for quicker and easier release of bikes
4) Thoughtfully designed bikes and payment terminals
5) Extremely efficient power management system

To demonstrate it clearly, here shows some specific technologies used at the bike share system. They are hands on experience, advanced monitoring and management tools, company web and mobile application, ease of installation and maintenance, operation configuration flexibility, interoperability, backward and forward compatibility, data security and backward and forward compatibility. **[6]**

**Pricing**

There are two kinds of customers using Santander Cycle: regular users and casual users.

Regular users benefit from the following characteristics:

- Quicker bike access after paying the one-off fee of £3 for a key
- Access to 24-hour use, 7-day use and one-year use. Regular users can save money with the annual membership for £90
- All other costs are the same and regular users can check 12 months of account history online
- The company will automatically renew these users’ chosen bike access period when they next hire a bike after their previous bike access period has ended.
- Regular users can have up to four keys on one account if they want extras for friends or family

Casual users benefit from the following characteristics:

- Only access to 24-hour use and 7-day use
- Use a credit or debit card to release a bicycle
- Bike access for 24 hours for £2
- First 30 mins of each journey is free
- Each extra 30 mins or less incurs a charge of £2

Through these regulations we can see usage of no more than 30 minutes at a time is free of charge. Usage charges, additional to the access charge, are weighted to favor shorter use.

Replacement and Repair of bicycles:

- Serco is the company contractor for bicycle operations
- Every day more than 30 bikes are being repaired as of February 2011

- At any one time around 200 of the 5,400 strong fleet were off the road for maintenance

4. Return Policy
    - Users must return a bike within 24 hours
    - A User could be charged up to £300 if he or she damages a bike or does not return it

**Marketing**

Santander Cycles has become top 1 bike hiring program in London since it was launched in 2010. The service covers from Camden Town in the north to Battersea in the south, and from Stratford in the east to Shepherd's Bush in the west. The targeted customers are mostly citizens who want to use it as a casual daily transportation method and visitors who enjoys this way of exploring the city. As studied from the market, there are nearly 2 million children has been trained through the "Bikeability" program since 2007; 645,000 cycled journey staged a day in 2014; and there were around 10.1 million cycle hires in 2014. The market is huge and promising given existent data. And the service has grown from 6,000 bikes to 11,500 bikes as of August 2016. And there were over 785 docking stations and more than 21,083 docking points by the same month. **[7]**

Behind the rapid growth is the contract with TfL, Transportation for London, and sponsorship provided by a Spanish bank, Santander, from 2015. Before that, the cycle hiring program was sponsored by Barclays, which boosted its brand awareness to 72% at peak.

The partnership with TfL brought much convenience and chances for Santander Cycles to stride into the market. As TfL promote this program as a transformation of traditional transportation system. The public are relatively more willing to accept this new way to travel in the city. The promotion of other official visiting websites of London, e.g. visitlondon.com, also attract visitor customers to use cycle hiring. Other than that, periodical promotion strategies includes weekend of free access, promo code, launching online app, etc.

**Future Work**

TFL has awarded Serco a new five-year contract to maintain the popular bike share service. This includes the manufacture of an upgraded bike, which will be made by British company Pashley Cycles at its factory in Stratford-upon-Avon.

This next generation bike will retain the popular features of the existing model, but will be lighter and more maneuverable with smaller wheels, a lower frame, a new gear hub and a more comfortable seat. It is anticipated that they will be on the streets in 2018, with around 500 supplied to replace older models each year.

Both the London government and the Serco are optimistic about Santander Cycle. They believe their next challenge now is to begin another successful six years and play a more important role in making it easier and more accessible for people to enjoy the beauty of London.

#### 5.2.1.3. Ofo Bike Sharing – China

**Background**

China's cities are seeing a rapid growth in the use of bikes as bike sharing through apps has become a rage. There are over 450 million bikes in China at the moment. 78% of the households in China own a bike. Men use bike share services more than women by around 60-40 margin. The users are required to pay a fee (ranging from $15-$40) upon downloading the app to use the services. Ofo and Mobike are the major industry leaders and occupy about 70% of the market. This fact can be further confirmed with the funding recently received by both Mobike and Ofo. OFO raised $130M in a series C offering in Sep 2016 and Mobike raised $210M from a similar series C funding in Jan 2017.[8]

Bike sharing is growing at a rapid pace in China and many industry analysts believe it is likely that Mobike and Ofo will eventually merge in the same way as taxi hailing apps did in China. In our market survey, we mainly focused on the Ofo bike sharing platform.

Ofo was founded in 2014 which focused on the tier one cities in China like Beijing, Shanghai, Shenzhen and Chengdu. This project was funded by Didi (the biggest Chinese taxi hailing company) and Xiaomi (a famous technology company in China).

**Financing**

For the very beginning, a Peking University alumnus was impressed by the idea of three student founders of ofo, and agreed to invest. The project took off in Dec, 2014. Then, with Ofo's development, it started seeking venture funding. Ofo raised US $130 million by Didi-Chuxing and CITIC Private Equity in Sep, 2016 and Series C at a US $370 million valuation. Soon, Ofo began to expand its business, for now Ofo is valued at US $500 million. The business has spread to 100 campuses all around China, with 32,918 and counting Ofo bicycles in use.

**Operations and Logistics**

Ofo developed the operation system according to the “Bikes on demand, anytime, anywhere” principle to make the bike-sharing as convenient as possible. To use the bikes, users must take the following steps:

1. The users need to use their phone number to register on Wechat, a App similar to WhatsApp in China.
2. Then users can key in the unique license number of the bike they want to use according to the bike’s license plate to get the password of keypad lock. Or they also can do it by scanning the QR code. After that, they can unlock the bike.
3. When they want to return it, it is also very convenient that they don’t need to find a dock to park, they can leave it to any bike parking area as they want. They only need to reset the passcode and pay the fee on Wechat.

There are three main steps for bike management:

1. The operator gives each bike a unique license plate and QR code to identify them.  They then use the keypads to lock the bikes.
2. When user get and return the bike, they will use the Wechat, by which the positions of bikes are uploaded to Internet.
3. The staff will relocate the bikes every morning according to the position information and the demand of different places.

For all the bike-sharing system, one of the most important decisions is to decide how many bikes they need to provide. Taking the Ofo bike-sharing in Peking University campus as an example, the operator collects the related data from market that each user uses the Ofo 2-3 times a day. And for each bike, it is used 12-15 times per day. There are about 15,000 students in Peking University. At the Yanyuan Campus, the average usage required is 2500 bikes to allow each user to have 4-5 usages per day.

**Pricing**
Ofo being in a university setup follows a single pricing strategy of 2 yuan per ride for all their users.

**Marketing**
According to Roland Berger's report concerning on global bicycle demand in 2020, there will be a US$5.8 billion market of bicycle. And this market will expand 20% annually. If we look back to China's domestic market, there have been over 5 million registered users now. Number of bikes in China has been over 450 million and about 78% of households own a bike.

When talking about bike sharing market in China, there are mainly two market leaders-Ofo and Mobike with a lot of comparatively smaller competitors like hellobike, 1 steps bike, Xiaoming Bike, Uni Bike, bluegogo and Qibei[9]

If we analyze the gender of users of Ofo, it's not difficult to find that nearly 72% of users are males and 28% are females. These unbalance components reflect men are more inclined to use bike sharing service provided by Ofo than women for now.

As for charging aspects, Ofo has been running in China mainland and charging at CNY 1-2 per hour, estimated to be USD 0.15-0.28 per hour. Which is comparatively cheaper than its largest competitor- Mobike, which charges nearly double the price. Also, Ofo discloses its plan to run in the United States this year, and the planned fee might be USD 1 per hour. For deposit, Ofo requires CNY 99/ USD 14 per user now.

How can Ofo profit? What does its business model look like? From online resources, we summarized Ofo's profit sources into three kinds: Advertising, Community Platform and Diversified Rate. Firstly, Ofo profits from their bikes body advertising painting and put advertising on its official APP and online Wechat public account. Secondly, it targets its online platform which mostly is comprised of students and white-collar workers. Hot topics coming with relevant product recommendations are the most common way to profit. Lastly, like most APP, Ofo also provides specific membership fee to get rid of advertising. And recently, Ofo started to encourage users to undertake their own bikes with a fee. According to one of the founders of Ofo, "We will definitely be profitable in 2017," Dai said. "We have already inked partnership deals with many bicycle makers in China. Even though we have to ship bicycles to other countries, our cost is still about one third of those provided by Western competitors." As for supplier of Ofo, Shanghai Phoenix plans to produce a larger bicycle suitable for the western physique.

**Future Work**
Ofo released its global strategy on Dec.23 2016, declaring its plans to launch trial operations in the Silicon Valley and London. Payments will be made using credit cards during the trial operation period."Ofo bicycles" will soon appear on the premises of such companies as Google and Facebook in the Silicon Valley. Ofo said it also plans to launch "mega city sharing" plans in overseas markets in the future.

Under the plan, several thousands of bicycles will be offered during trial operations. The overseas versions of yellow "ofo bicycles" will be designed according to the average height, body build and preferences of European and American users, and will have larger dimensions than "yellow bicycles" in China.

Ofo decided to start with North America and Europe, because of the higher penetration rate of mobile internet, strong demand for short-trip vehicles and rich local "bicycle culture" in these regions, notes ofo's founder and CEO, Dai Wei. In the future, ofo will launch bicycle sharing services in other parts of the world.

### 5.2.2. Primary Research

#### 5.2.2.1. In-depth Interviews

Our team conducted 6 in-depth interviews with people between the age group of 23-40 years and who travel frequently across campus where the bike sharing service is implemented. The selected subjects were students and faculty members who would be interested in implementing a bike sharing system at Cornell University. The subjects were chosen based on the number of years they have been in Cornell University and on their interest towards bike sharing service. In general, all the subjects showed great excitement and enthusiasm towards the idea of bike sharing but they also had certain relevant concerns regarding weather, terrain and safety.

Table 1: Interview Profiles

| **Age** | **Profession** |
|---|---|
| 40-45 | Professor |
| 35-40 | PhD Student |
| 30-35 | MBA student |
| 25-30 | MBA student |
| 20-25 | MEng Student |
| 20-25 | MEng Student |

**Results from In-depth Interviews**

From our interviews, we have observed that our participants commute to different places in and around campus either by walking or by taking the TCAT bus service. One major concern shown by most of the participants was the extreme weather conditions that prevail in Ithaca for almost 4-5 months. Since Ithaca faces long winters, participants raised safety concerns while riding bikes in those months. They felt that riding bikes with snow boots and winter wear would be highly uncomfortable and undesirable. Another major concern expressed by the participants was the undesirability in riding bikes due to the hilly terrain. Theft and tampering issues were some of the maintenance problems pointed out by the participants. Moreover, concerns were also raised regarding liability and insurance related to bike accidents.

The total amount of time allowed for checking out bikes was discussed to be between 45-60 minutes. Pricing structure of this bike-sharing system was a major topic of discussion in each of the interviews conducted. Participants concluded that they would like to have either a 'pay per ride' or 'pay every month' option. Discussions on the pricing structure showed that participants agreed to pay between $10 and $40 per month for bike sharing. They said they would like to see bike sharing docks in locations where they cannot commute to using the TCAT service. Additionally, they suggested that bike sharing docks should be present in areas with high density of students and high traffic flow. All participants agreed that biking is a good form of exercising and they would love to bike due to this additional benefit. They also said that riding a bike is recreational and also benefits from the "cool factor."

### 5.2.2.2. Market Survey

As a part of our primary research, we designed an extensive survey to gain key insights from our target customers. Through this survey we wanted to gauge certain attributes of our customers that would allow us to design our bike sharing system in the most profitable and efficient manner. Moreover, surveys are an efficient way to collect unbiased data rather than basing our entire analysis on assumptions or gut feelings. In addition, we wanted to support our decisions on solid data and derived insights.

The survey consisted of 17 different questions aimed at deriving valuable consumer drivers. We collected over 600 responses from different students and faculty at Cornell University and residents of Ithaca. Around 47% respondents were Cornell students, 23% Cornell faculty/staff and 30% non-Cornell Ithaca residents. The results from the survey conducted are discussed below in detail along with the distributions.

**Age group**

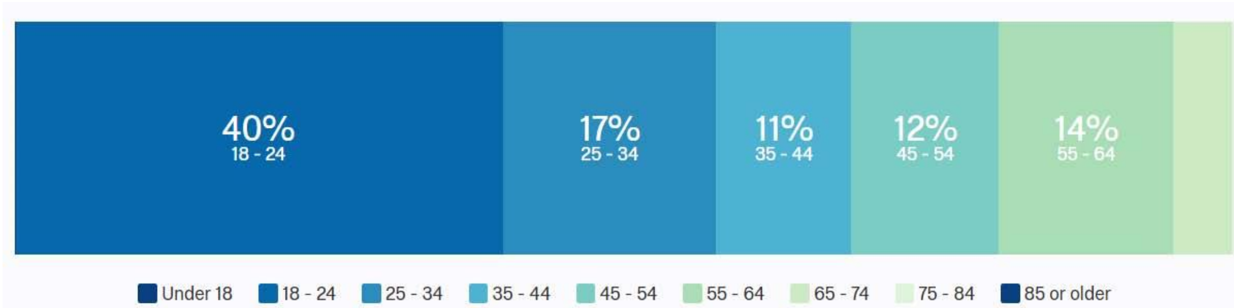
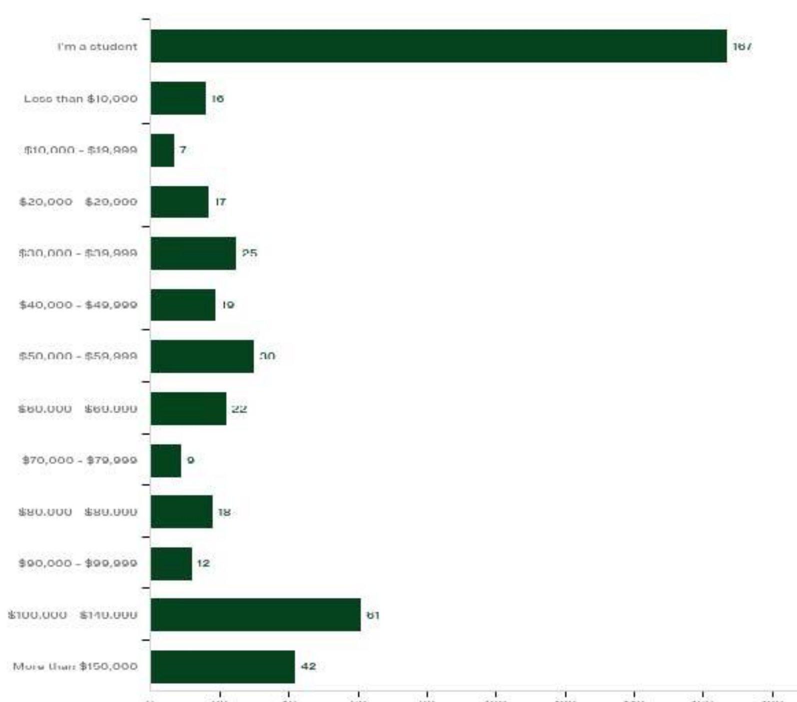



Figure 2: Age Group

Our aim behind collecting this particular demographic information was to narrow down our target segment based on their age. The results showed that around 67% of our survey respondents were between the age group of 18-34. Almost 40% of them were between the age group of 18-24 since most of our responses were from Cornell students. And around 17% of them were between the age group of 25-34. From this we understand that majority of our target segment is below the age of 25 and we need to focus our promotional and advertising strategies towards this market segment.

**Annual Income**

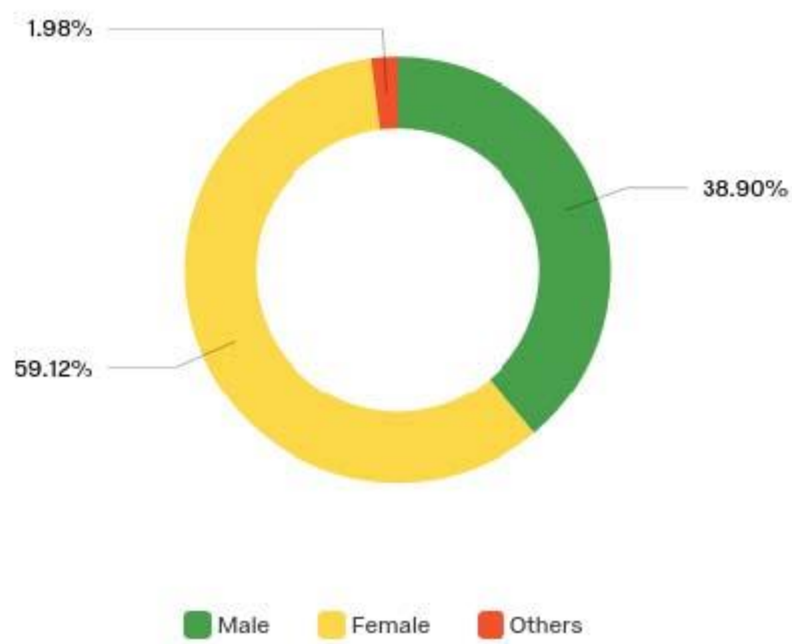
Figure 3: Annual Income



We further asked our participants about their annual income in order to get a fair estimation of how much our target segment earns. Majority of our participants, around 40% are students as seen from the graph above and around 23% earns from 100,000-200,000 and these we assume are faculty and other residents of Ithaca. We believe this information is vital in building different pricing schemes for our target audience.

**Gender**

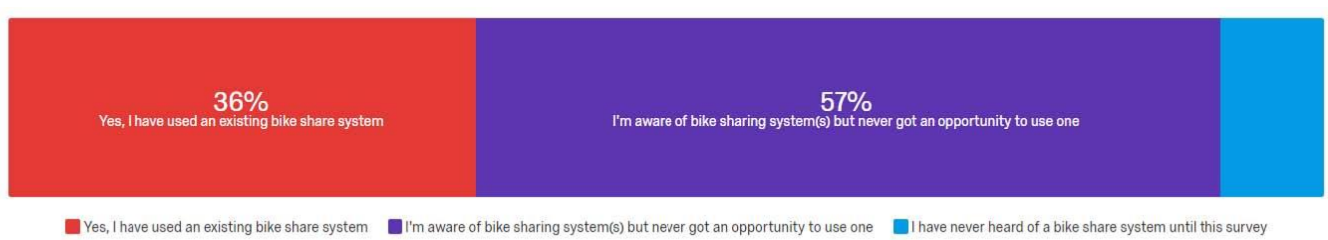
Figure 4: Gender




We see that about 60% of our survey respondents are females and about 40% are males.

**Awareness**

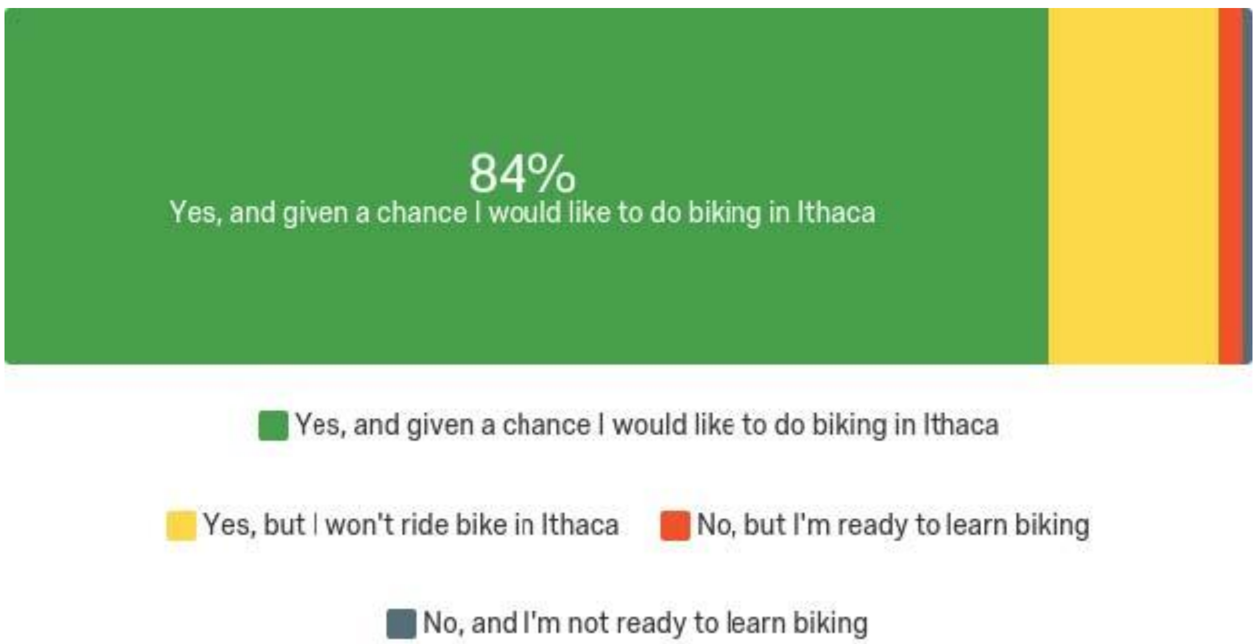
Figure 5: Awareness



The survey respondents were asked if they are aware of bike-sharing systems and if they have used any such systems. The results showed that around 36% of respondents have tried an existing bike sharing system whereas 57% of the respondents are aware of bike-sharing but have not got an opportunity to try one. From this data we understand that consumers in general are aware of the service we are offering and are not completely new to what we have to offer.

**Interest**

Figure 6: Interest




After determining the awareness, we wanted to find out if our respondents are interested in bike-sharing. The data shows that around 84% of the respondents are interested in bike sharing and would like to use the service if provided.

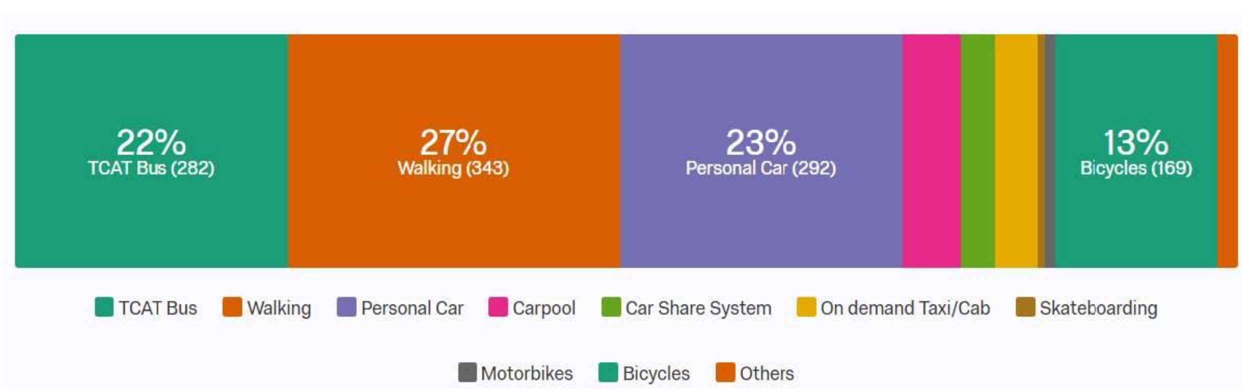
**Motivation**


Figure 7: Motivation

In order to promote and sell our service it is vital to understand 'why' our consumers would use bike sharing. Around 17% of the consumers said that they would use bike sharing due to the fact that they travel and exercise at the same time, another 17% said that it is convenient, 13% of them said that it saves time, another 13% said that it is cost effective. It was interesting to see that around 16% consumers would use bike sharing as it is environmental friendly. We calculated the individual proportions by dividing the total number of selected responses by the total number of respondents. This information is extremely important to marketers as we need to think of different strategies and campaigns to promote bike sharing service.

**Modes of transport**

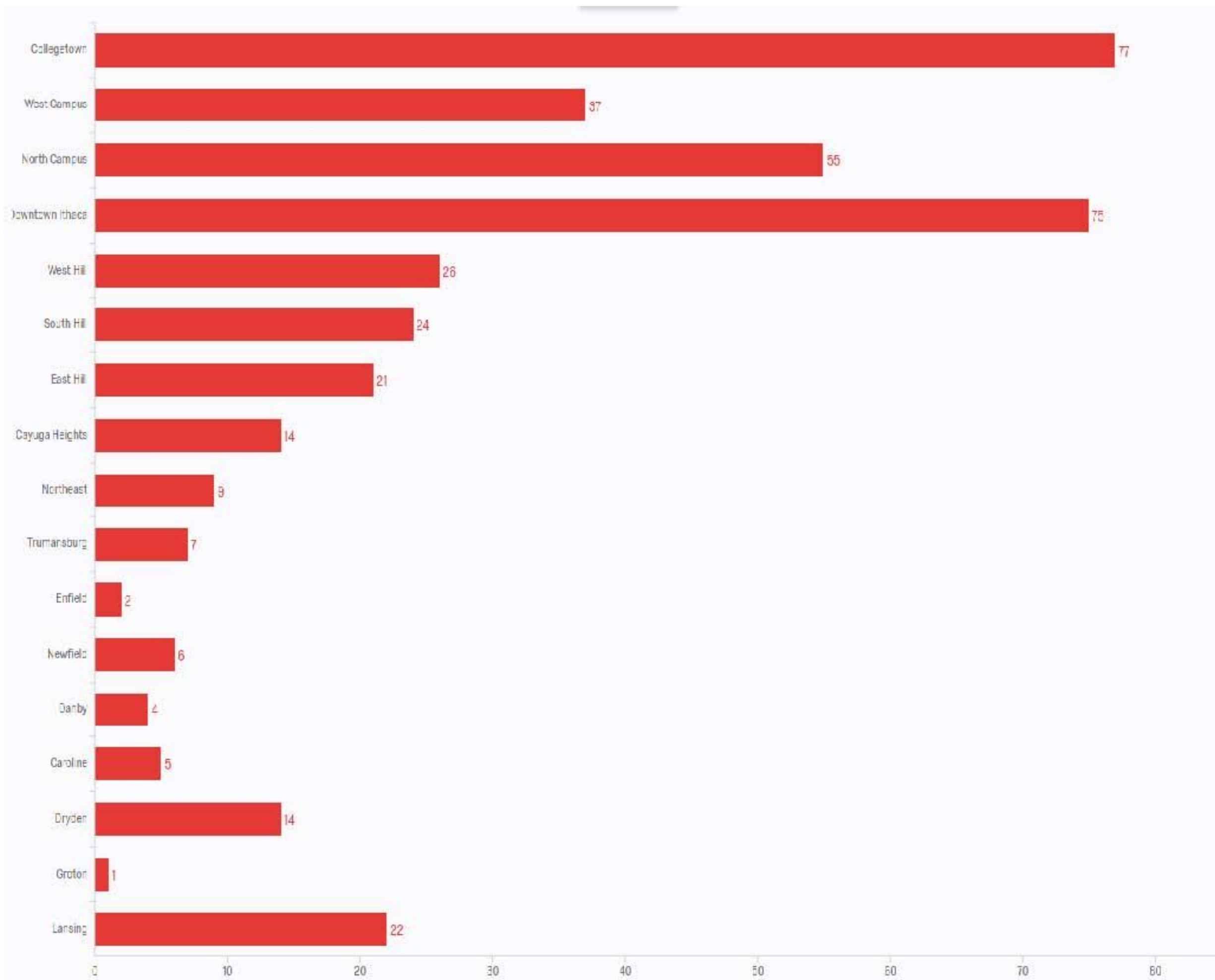
Figure 8: Modes of Transport




After gauging the general interest of our respondents, we further asked what are the different modes of transport they use to travel in Ithaca. We see that around 27% of them walking, followed by another 22% percent who use TCAT bus service followed by 23% who use personal car. The rest use carpooling, carsharing, taxi, skateboarding, or motorbikes.  We see that around 13% of the respondents already use their personal bicycles.

**Residence**

We further asked our respondents where they currently reside in order to find out where most of our target segment resides so that we can strategically place our bike stations in order to achieve maximum profitability. We find out from the distribution that a major portion of our target population lives in 4 different clusters: College town, Downtown Ithaca, North campus and West campus.



**Docks Preference**

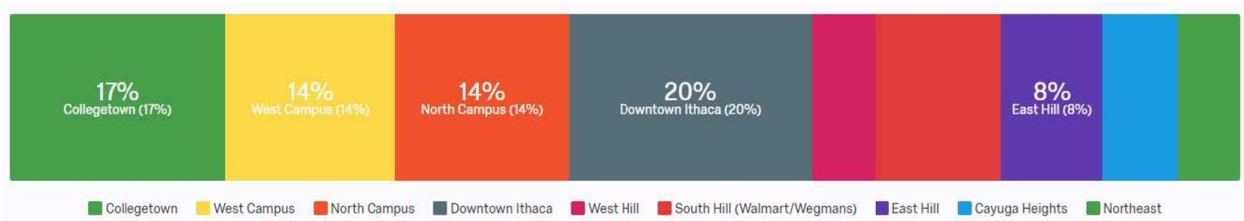



Figure 10: Dock Preference

After determining where our target customers currently reside, we further asked them about their dock station preference in order to correctly optimize the most efficient routes. We see that distribution for this question was very similar to the earlier questions, that is, respondents preferred to see docks in College town, Downtown, North Campus and West Campus.

**Usage Pattern**


Figure 11: Usage Pattern

After finding out preferred dock positions we further asked our respondents what they would use a bike sharing system for. We see from the results that around 23% of the total respondents would use bike sharing for leisure riding, 16% of them said that they would use bike sharing to run errands, 15% of them would use it to exercise, 14% would use the service to move between buildings at Cornell university and around 9% and 11% said that they would use bike sharing for commuting to work and shopping respectively. This insight would help us position the service in the market

**Monthly Expenditure**

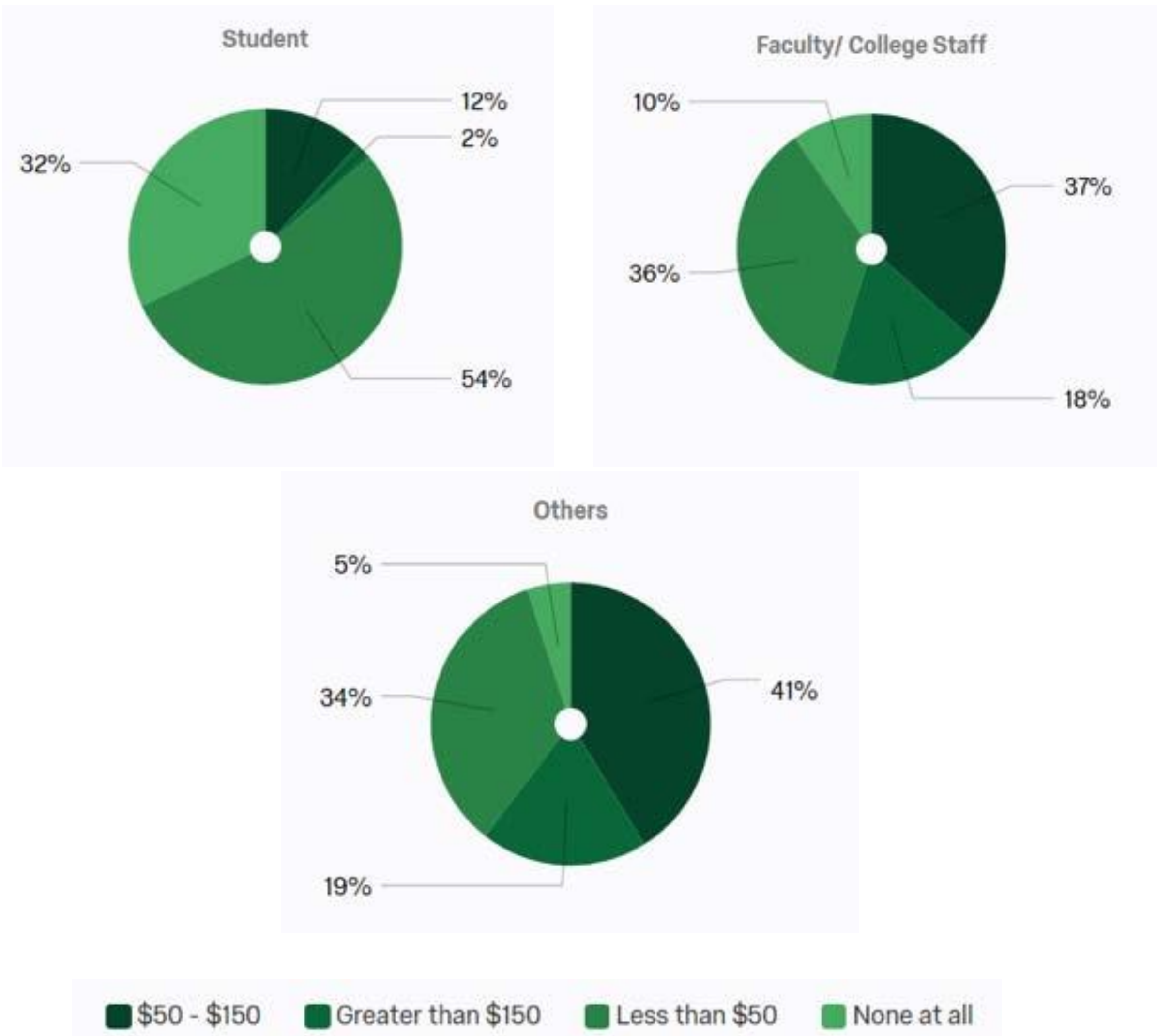



Figure 12: Monthly Expenditure

We see two very different distributions for students and faculty when asked about their monthly expenditure on transportation. Majority of the students spend lesser than $50 on monthly transportation. However, we see that, when it comes to faculty/staff members, around 36% of them spent less than $50 and around 37% of them spend between $50-$150. From this information we are trying to gauge how much we should be pricing our membership's schemes in order to make the maximum market penetration.

**Membership schemes**

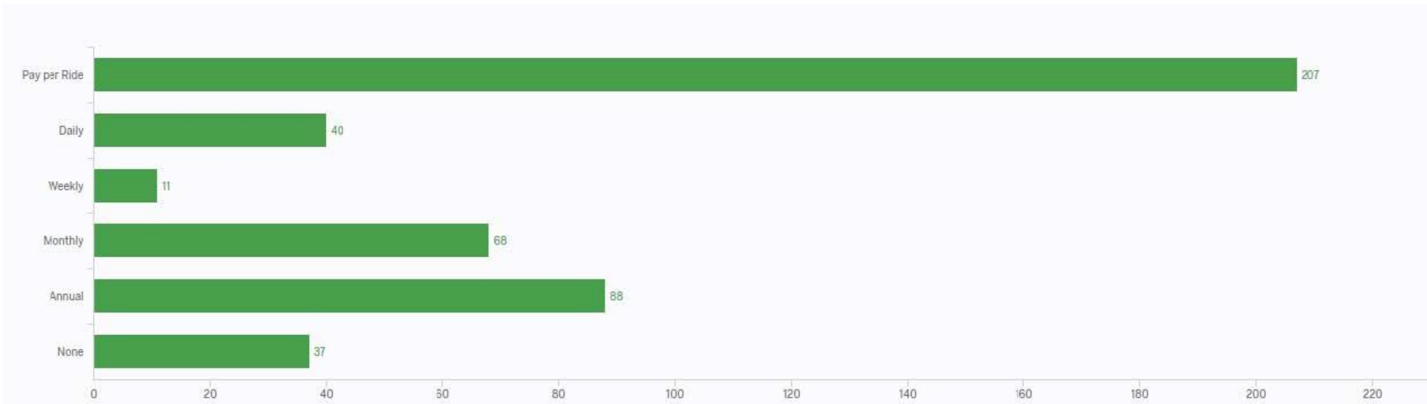
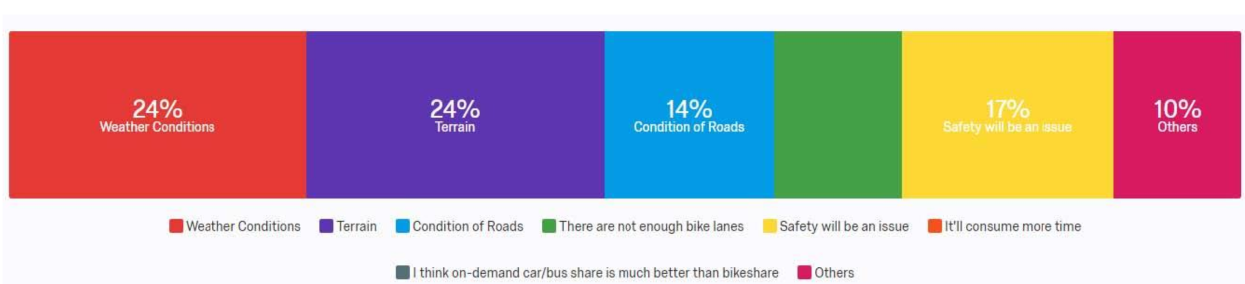



Figure 13: Membership Schemes

We see from the above data that most of the respondents prefer pay per ride scheme, followed by annual membership, and followed by a monthly scheme, followed by the daily pass and then the weekly pass. From this we understand that most of our consumers prefer pay per ride as they do not want a long term commitment towards bike sharing. We also see that after pay per ride, consumers then prefer annual membership which is for $30. This information would be crucial while developing the financial model.

**Pain Points**

Figure 14: Pain Points




We further asked our survey respondents regarding the different challenges they think they would face during biking at Cornell University. From the data collected we see that weather conditions and terrain make up almost 50% of the concerns. Others included condition of roads and safety. This data is relevant as it is important to know what are the possible pain points our consumers anticipate when considering our service so that we can think of possible ways to overcome these challenges.

**Season Preference**

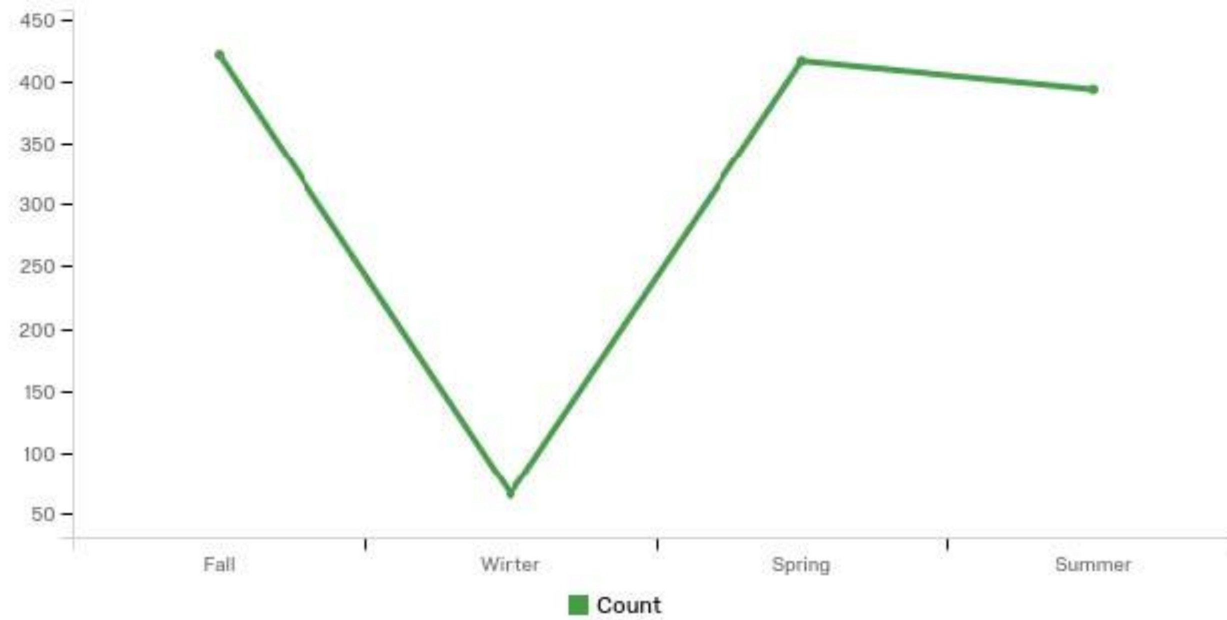



Figure 15: Season Preference

In order to optimize our duration of operation during the year we asked our respondents about their preference of seasons they would like to bike in. From the data, is it quite evident that almost all respondents prefer biking during fall, spring and summer. Since Ithaca faces a very harsh winter, we can assume that no respondents would be interested in biking during this season.

# 6. PRODUCT

## 6.1. Bike Technology

### 6.1.1. Bike shifter

We consider using the bike shifter in our bike because Ithaca area is a mountainous region. Our customer can use the bike shifter to control the gearing mechanism and select the desired gear ratio which will make riding uphill easier.


Figure 16: Bike Shifter

### 6.1.2. Smart Lock

Bluetooth lock system is also an emerging technology which will be implemented in our bikeshare system. The Bluetooth-enabled ring lock is mounted to the bike frame and encircles the rear wheel. When engaged, the lock prevents the rear wheel from spinning. Two sturdy cables, one securely attached to each station dock and one retracted inside each bike connects to the ring lock allowing riders to tether bikes to stations at the end of their trips. This ensures availability of bikes. With an ingenious design, intelligent power management, advanced battery technology, low power radio and actuation system, a smart lock can have a 5-year-battery life.[10]

### 6.1.3. Solid Tires

The tires we use in our bike are solid. There are many advantages through using solid tires instead of inflatable tires. For example, we do not need to inflate the tires of our bike periodically and prevent sharp objects from piercing tires. Also, the cost of common solid rubber tires is almost the same as the cost of the inflatable tires. If we have a loose budget, we can improve our customers' riding experience by choosing another type of improved tires. We plan to use honeycomb tires made of improved rubber which is showed in Figure 17.[11]

Such tires reduce the weight of common rubber tires to a large extent. Furthermore, honeycomb tires solve the problem of cushioning by enhancing the elasticity and the ability of absorbing the impact of the tires.

In addition, such kind of improved rubber is non-toxic and environmentally friendly. It is easier to recycle and decompose than the common rubber tires.

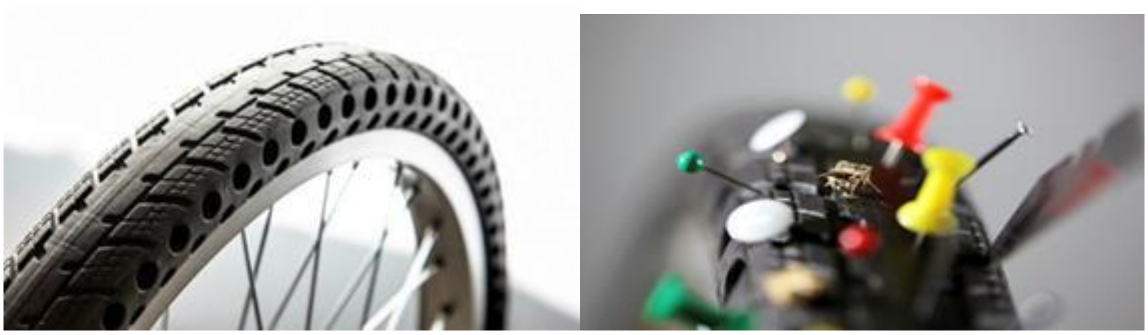


Figure 17: Honeycomb Tires

### 6.1.4. GPS and GSM chip

GPS and GSM chips not only enable customer to interact with the bikeshare system through their mobile phones, but also help our company to locate our bikes if some bikes are missing. We plan to adopt MobileTek L218 chip, which is a low power and high performance four frequency GSM/GPRS (850/900/1800/1900) module, and integrates high-performance global positioning navigation Chip.[12] Now it has been widely used in various dockless bikeshare system. When our customers decide to use our bikeshare system, they can open the App in their mobile phone first and locate the nearest bike based on the information provided by this GPS chip. When they find the bike and scan the OR code on the bike, the GSM chip will send a message to the server to check whether the bike is ready to use. All in all, GPS chip functions for the location and GSM chip plays the role of communication medium between our users and the system server.[13]

### 6.1.5. Transmission Shaft for Chainless Structure

Chainless bicycle is a bike that transmits power to the wheels through other mechanism other than a metal chain. Though it is not very common in the bike market, it has a long history; as early as 1898, Hildick Chainless Bicycle Gear appeared.

Nowadays, shaft-driven bicycle is the most widely used kind of chainless bicycle. Simply put, when users pedal, they turn a drive shaft (enclosed inside a sealed aluminum or steel case) that turns a bevel gear which turns your rear wheel to move forward. No chain is required.[14]

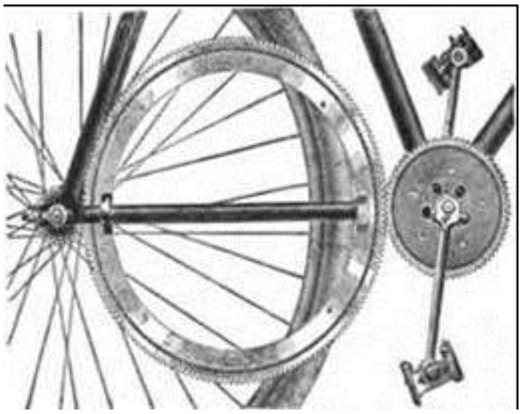


Figure 18: Hildick Chainless Bicycle Gear 1898

Figure 19: Shaft-driven Bicycle Sample

Compared with traditional chain bicycle, shaft-driven bicycle has the following advantages:

- Reduce the maintenance cost and the frequency of repairing to almost zero, especially avoiding the issue of “chain off”. Decreasing the maintenance cost is critical to a bike sharing system.
- Avoid making consumers’ leg pants dirtied and caught up in the chain
- Provide stronger strength of the bike body.

However, it also bears some drawbacks:

- Higher design and production cost, especially at the early stage.
- Lower transmission efficiency than chain bicycle.
- Heavier weight of the whole bicycle.

**6.1.6. Dynamo Hub and Dynamo Bike Lights**

A dynamo hub is an energy-generating hub built into the front wheel of a bicycle that typically powers lights. Dynamos can also power USB ports and all manner of fun things, if our clients are interested.

Dynamos are tire-driven, resembling small bottles mounted to a bicycle's fork and turned by the tire or rim as it moved.

Dynamo Lights are [15]:

- Safe. Dynamo lights are powerful and highly visible.
- Convenient. Always with you. Always on.
- Durable. Long-lasting LEDs.
- Consistent. No half-charged or lost lights.
- Sustainable. Reduce your environmental impact by freeing yourself from batteries.
- Secure. Much more difficult for someone to steal.

Figure 20: Dynamo Bike Lights

## 6.2. Cost

### 6.2.1. Basic Bike

To meet different capital budgets, we provide two kinds of bike: the advanced bike and the basic bike. The cost of the advanced bike is more expensive but it improves the customer's riding experience. Besides the essential components of a normal bike, such as the aluminum frame, saddle, and plastic pedals, the basic bike also includes the dynamo bike lights with dynamo hub to provide the power. Collaborating with the GPS and GSM chip, it could be easy to locate the bike and connect the users in case the bike is missing.[16] The smart lock will unlock the bike once our customer scan the QR code on the bike.[17] The total cost of the basic bike is about $381. The detailed price chart is shown in Figure 21.

Figure 21: Basic Bike & the Cost

| | |
|---|---|
| Aluminum Frame | $100.00 |
| Fenders | $15.00 |
| Saddle | $10.00 |
| Plastic Paddles | $10.00 |
| Stainless Steel | $5.00 |
| Clutch lever | $5.00 |
| Tail Light | $5.00 |
| Dynamo Bike Lights | $15.00 |
| Dynamo Hub | $80.00 |
| Smart Lock | $129.00 |
| GPS&GSM Chip | $6.69 |
| **Total Cost** | **$380.69** |

### 6.2.2. Advanced Bike

Beside the components in the basic bike, we add three more things to our advanced bike: bike shifter, transmission shaft for chainless structure, and solid tires. Our customer can use the bike shifter to control the gearing mechanisms and select the desired gear ratio which will make our customer easier to ride uphill. The total cost of an advanced bike is about $562 and the increase is most contributed by the use of transmission shaft for chainless structure.[18]

Figure 22: Advanced Bike & the Cost

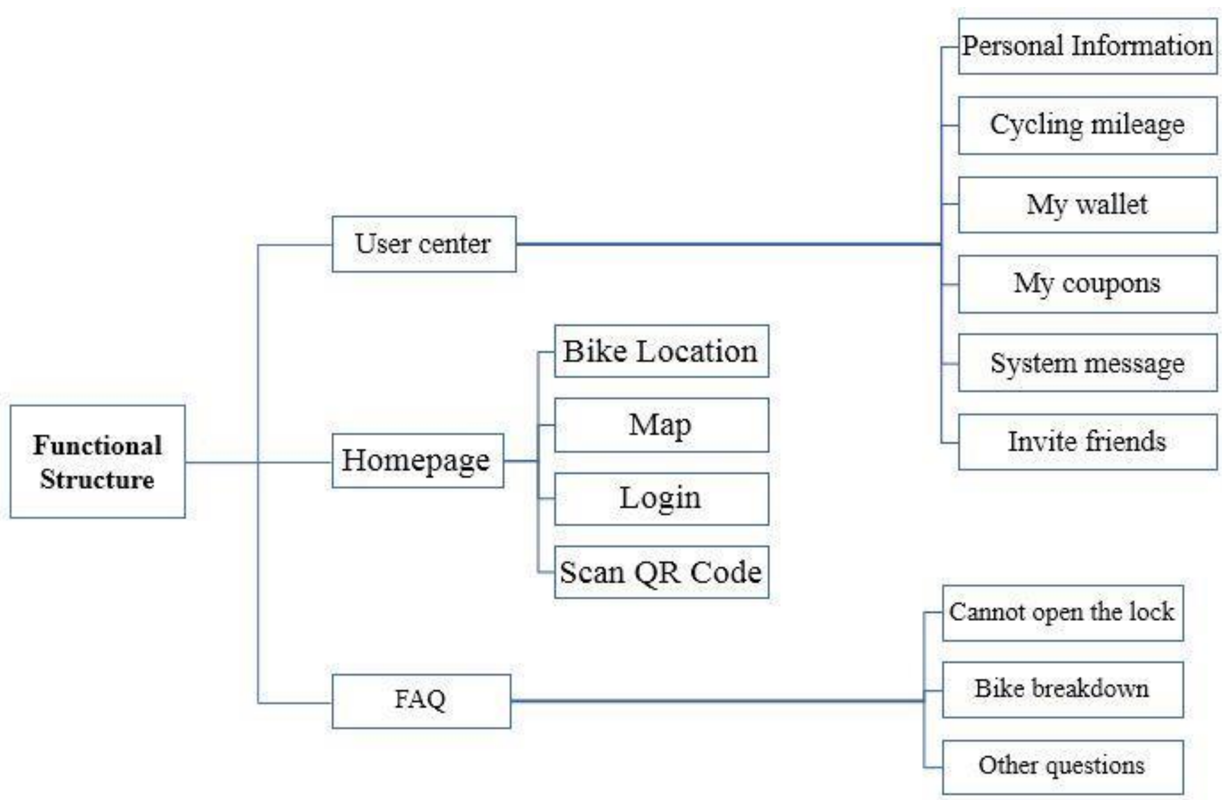

| | |
|---|---|
| Aluminum Frame | $100.00 |
| Fenders | $20.00 |
| Saddle | $10.00 |
| Plastic Paddles | $10.00 |
| Stainless Steel | $5.00 |
| Clutch lever | $5.00 |
| Tail Light | $5.00 |
| Dynamo Bike Lights | $30.00 |
| Dynamo Hub | $80.00 |
| Smart Lock | $129.00 |
| GPS&GSM Chip | $6.69 |
| Bike Shifter | $15.00 |
| Transmission Shaft for Chainless Structure | $145 |
| Solid Tyre | $1.50 |
| **Total Cost** | **$562.19** |

## 6.3. Smartphone Application

### 6.3.1. Customer instruction

The application on smartphone is one of the critical components in our bikeshare system. It plays the role of user registration and management, bike localization, timing and charging, and promotion. The detailed information about the functional structure of the App is shown in Figure 23.

Figure 23: Functional Structure




It is very easy and convenient for our customers to use the bikeshare system. They need to follow the following four steps:

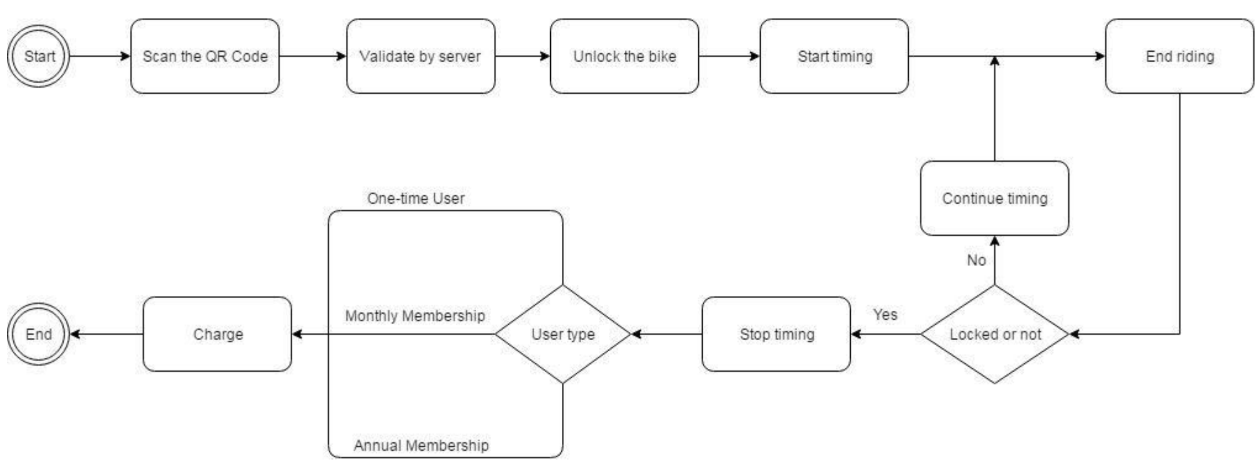
- Open App on your smartphone, register and charge to your account, Then locate the nearest bike station and you can see whether there are available bikes real-time.
- Pick up a bike and scan the QR code on it, the smart lock will open automatically and it begins to record your using time.
- Ride and have fun.
- When you finish your ride. Return your bike to a dock and lock it with the dock. Then click “END RIDE” on your phone.


Figure 24: Customer Instruction

### 6.3.2. Flow Chart

The flowchart below shows the working principle in detail. First, if a customer wants to ride a bike, he or she needs to scan the QR code on our bike. Once the customer scans the code, the system server will receive the order and validate whether the bike is ready for the customer to use. After validation, the server will unlock the bike so the customer is able to use this bike. Simultaneously, the bike starts to time and our customer will enjoy the riding. Once the bike stops, the server will judge whether the bike is locked or not. If the customer does not lock the bike correctly, the server will send a message to the customer's App and the riding time will be still accumulating. If the bike is locked, the server will stop timing and it will check the user's type to use different charge mode.

Figure 25: System Work Flow Chart



# 7. OPERATION

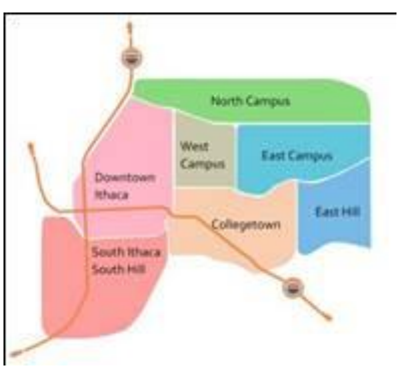
## 7.1. Overview

Operations design for Bikeshare system in Ithaca is mainly comprised of three parts. First, we applied market survey outcomes to specify bikeshare service range and divisions as well as design bike stations layout with bikes allocation. Second, we conducted a comprehensive operations simulation with Non-Homogeneous Poisson Process. Then, we design the reposition route according to our daily simulation results and also look into the maintenance issues.

## 7.2. Demand Analysis & Station Layout Design

Firstly, based on market survey results, we locate bikeshare geographical range near New York State Routes 79 and 13 in the City of Ithaca. These two high-level roads could provide larger-scale transportation support for operations of Bikeshare system. For example, when we reposition our bikes every day at midnight, there would be a big truck for loading and unloading our bikes. These major routes enable us to transport large amounts of bikes and also help us to move all bikes to the warehouse in winters when the system is closed. Also, given the demand intensity and locational consideration, there are mainly seven sub-division areas with highest bikeshare service demands. They are:

1. South Ithaca/ South Hill
2. Downtown Ithaca
3. Collegetown
4. Cornell West Campus
5. Cornell East Campus
6. Cornell North Campus
7. East Hill



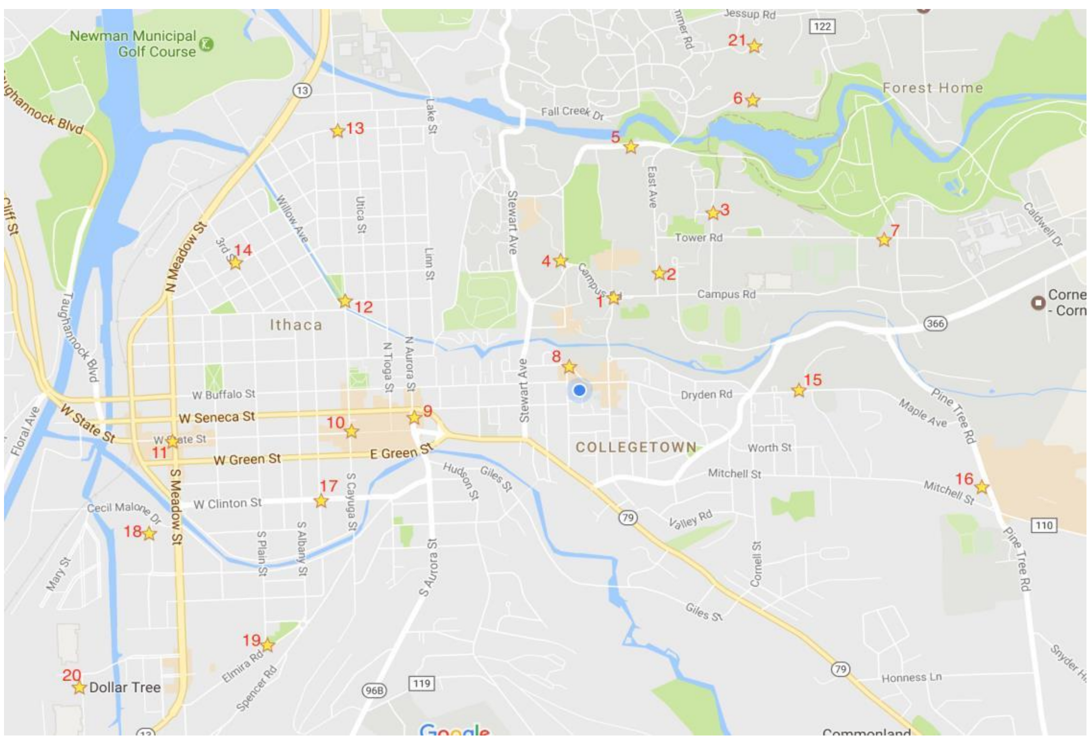

Then, we sort out the rankings for bikeshare service demands in these areas. The resulting rank of the seven areas from highest to lowest is the following:

1. Downtown Ithaca (22%)
2. Collegetown (20%)
3. Cornell West campus (16%)
4. Cornell North Campus (16%)
5. South Ithaca/ South Hill (11%)
6. East Hill (9%)
7. Cornell East Campus (6%)


North Campus 16%
West Campus 16%
East Campus 6%
Downtown Ithaca 22%
Collegetown 20%
East Hill 9%
South Ithaca South Hill 11%

We later assign different number of bikes into each area according to their demand percentage. When deciding the number of dock stations, we consider the comparatively large area we want to cover and uneven distribution of people within this range, so we decide to take a strategy called “more stations, more coverage” which requires 21 stations to satisfy all demand requests. The locations of bike stations are shown in figure 26. In addition, 2.5 minutes of walking distance (around 682 feet according to 3.1 mph of average walking speed) is a threshold for bikeshare service’s accessibility, longer than that distance would discourage people to use bikes, so we define the walking distance range around each of 21 stations is the range where our system mainly want to cover. By deploying 21 stations in appropriate locations, it allows us to improve our coverage ratio to over 38%. Since people mainly stay or visit some places quite concentrated, it allows us to improve our accessibility greatly since all stations face to the hottest places in our service range.

Figure 26: Station Layouts



All 21 stations location are listed below: from the surveyed

| | Latitude(N) | Longitude (W) | latitude(N) | Longitude (W) | Elevation (feet) | Location |
|---|---|---|---|---|---|---|
| 1 | 42°26’42.2” | 76°29’05.8” | 42.445064 | -76.484934 | 764 | college ave. & campus Rd SE |
| 2 | 42°26’45.85’’ | 76°28’57.25’’ | 42.446069 | -76.482546 | 812 | 7 East Ave. |
| 3 | 42°26’54.9” | 76°28’46.9” | 42.448574 | -76.479694 | 871 | Garden Ave |
| 4 | 42°26’48.0” | 76°29’15.9” | 42.446652 | -76.487764 | 692 | 217 West Ave |
| 5 | 42°27’04.5” | 76°29’02.6” | 42.451241 | -76.48405 | 810 | 863-883 University Ave |
| 6 | 42°27’11.4” | 76°28’39.3” | 42.453179 | -76.477584 | 856 | 163 Cradit Farm Drive |
| 7 | 42°26’50.9” | 76°28’14.2” | 42.447474 | -76.470596 | 897 | 411 Tower Rd |
| 8 | 42°26’32.1” | 76°29’14.5” | 42.442263 | -76.487358 | 690 | 428 Eddy St |
| 9 | 42°26’24.6” | 76°29’44.1” | 42.44016 | -76.49559 | 411 | 115 N Aurora St |
| 10 | 42°26’22.6” | 76°29’56.2” | 42.439601 | -76.498946 | 411 | 101 W State St |
| 11 | 42°26’21.1” | 76°30’30.5” | 42.439183 | -76.508466 | 390 | 100 S Meadow St |
| 12 | 42°26’41.8” | 76°29’57.3” | 42.444938 | -76.49924 | 390.2 | 101 Farm Street |
| 13 | 42°27’06.9” | 76°29’58.8” | 42.451913 | -76.499664 | 388.3 | 1019 N Cayuga Street |
| 14 | 42°26’47.5” | 76°30’18.4” | 42.446532 | -76.505106 | 383.2 | 301 3rd Street |
| 15 | 42°26’28.8” | 42°26’28.8” | 42.441321 | -76.474751 | 875.3 | 142 Maple Ave |
| 16 | 42°26’14.4” | 76°27’55.4” | 42.437324 | -76.465389 | 926.6 | 302 Pine Tree Road |
| 17 | 42°26’12.3” | 76°30’02.0” | 42.436757 | -76.500566 | 402.1 | 300 South Geneva Street |
| 18 | 42°26’07.4” | 76°30’34.9” | 42.435396 | -76.509696 | 389.5 | 118 Cecil Malone Drive |
| 19 | 42°25’50.9” | 76°30’12.3” | 42.430815 | -76.503412 | 383 | Baker Park |
| 20 | 42°25’43.9” | 76°30’48.4” | 42.42885 | -76.513441 | 387.9 | 106 Fairgrounds Memorial Dollar Tree |
| 21 | 42°27’12” | 76°28’42” | 42.455416 | -76.47757 | 850 | RPCC |

Table 2: Station Layouts

Thereafter, by ranking by the tendency to use bikeshare system populati on, we get a general look on how the system should designate stations to each different region. The ranking also informed us intuitively where to put most effort to satisfy the need for bikeshare system. The following table explains our rationale to allocate demand ratio between stations.

First, we evenly distributed the area average demand ratio among all designated stations in each area. It is reasonable to do so because we have divided the whole large area into several small segments, and in different segments there are a different number of bike stations according to its own demand and popularity. However, since people's cognitive area divisions may differ from our operations areas division, it is highly likely that some stations lie between the borders of two or three areas such as stations 1 and 3, we conservatively assign its demand ratio with higher station average demand ratio. The reason why we choose the higher one because it stands for our capacity is enough to meet the highest demands. For example, when deciding the station average demand ratio for station 1, since it has two different station average demand ratio values in Collegetown (6.62%) and West Campus (5.18%), we assign its demand ratio is 6.62% (the higher one rather than the cumulative). After that, combining with our assumption of rush hour demand as 200 per hour, we calculate the action rate at each station.

Table 3: The Demand Analysis of Areas and Stations

| Area | Percentage of Survey Response | Designated Stations | Total Station Quantity | Area Average Demand Ratio | Station Average Query Ratio | Action Rate at Each Station |
|---|---|---|---|---|---|---|
| Downtown Ithaca | 82.13% | 9, 10, 11, 12, 13, 14, 17 | 7 | 22% | 3.17% | 6 |
| Collegetown | 73.55% | 1, 8, 15 | 3 | 20% | 6.62% | 13 |
| North Campus | 58.47% | 3, 5, 6, 21 | 4 | 16% | 3.95% | 8 |
| West Campus | 57.54% | 1, 2, 4 | 3 | 16% | 5.18% | 10 |
| South Hill | 42.46% | 18, 19, 20 | 3 | 11% | 3.82% | 8 |
| East Hill | 34.57% | 15,16 | 2 | 9% | 4.67% | 9 |
| Northeast | 21.35% | 3, 7 | 2 | 6% | 2.88% | 6 |

## 7.3. Simulation of Operating Dynamics

In a need to understand the bikeshare system's working pattern and, in particular, how the dynamics would be of bikes rent out and returned back, it is required for us to collect bike using data and draw some insights from them. However, no precedent data is available. Only data from those bikeshare systems which operate in a similar situation, in terms of demography and topography, would be informative and applicable. Since this is a customer-centric service whose operation condition would highly depend on local inherent characteristics, any study of other unrelated data can be misleading. Thus, we decided to run a simulation on a general trend. The purpose is not to see any precise interaction between bikes and stations. Instead, the interest is in getting a sense of how the trend would impact the dynamics of the operation.

In order to simulate the operation for each station, we first generated empirical renting rate and returning rate of bikes for each station. The assumption is the process of renting bikes or returning them follows a Poisson process.

It is justifiable in that the action of renting a bike is a stochastic process with each action is totally independent from one another in a certain period of time, so is returning bikes. Therefore, we can simulate how the number of bikes changes at each station on an hourly basis.

Simulation cannot only help with understanding any design defects such as insufficient bikes at popular station, but also demonstrate the pattern of the customers' utility and the insight of potential refinement for future planning.

### 7.3.1. Model Formulation

#### 7.3.1.1. Basic Assumptions

Table 4: A List of Basic Assumption

| | |
|---|---|
| ***Assumption 1*** | Each dock has different but limited capacity |
| ***Assumption 2*** | Request for Bike ride follows a nonhomogeneous Poisson Process (with different mean arrival rate during different time interval) |
| ***Assumption 3*** | Request for Bike returning follows a nonhomogeneous Poisson Process (with different mean arrival rate during different time interval) |
| ***Assumption 4*** | Each request only represents one customer |
| ***Assumption 5*** | Total number of bikes in the system is fixed (N = 168) |
| ***Assumption 6*** | Requests are served based on the f*irst-come-first-serve* principle |

#### 7.3.1.2 Notation

7.3.1.3 Table 5: List of Notations

| | |
|---|---|
| $N$ | Number of docks in the system. Each dock has different but limited capacity, *N=21* |
| $Ti,j$ | Time interval, i ∈ [1, 24] |
| $\lambda i,j$ | Demand rate for getting the bike at each station at the end of each time interval, e.g.  means demand rate for station 1 during 9am-10am |
| $\mu i,j$ | Demand rate for returning the bike at each station at the end of each time interval, e.g.  means returning rate for station 1 during 9am-10am |
| $Ri,j$ | Number of bikes remaining at each station at the end of each time interval, e.g.  means number of bikes remained at station 1 during 9am-10am |

### 7.3.1.3. Data Inputs

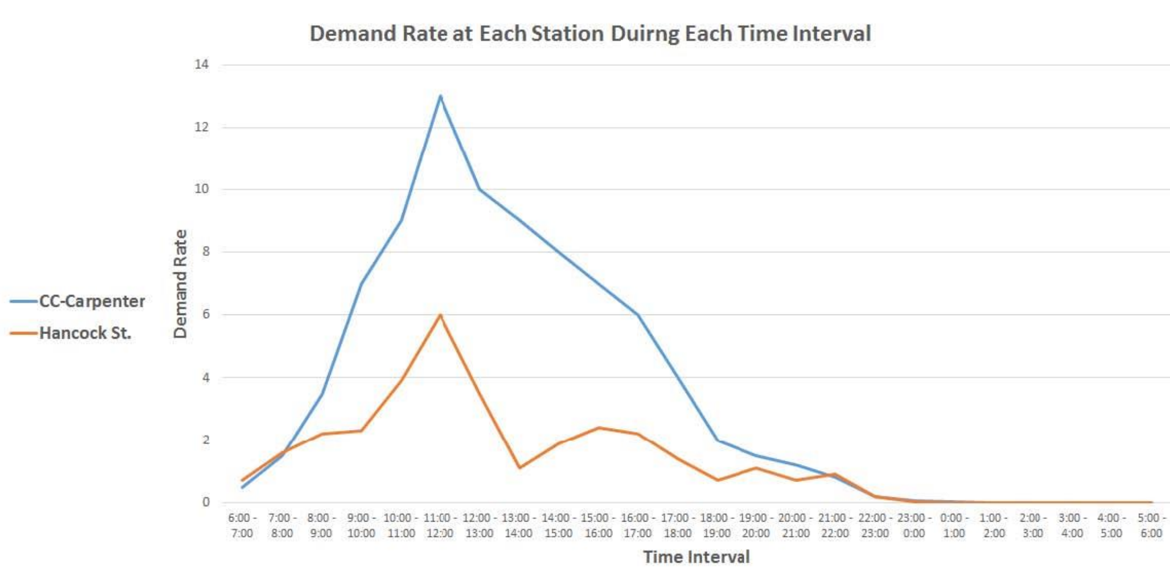
We have four kinds of data input listed below for our simulation model. Each has been designed based on the empirical data and marketing survey.

*Demand rates of requesting/renting bikes:*

Demand rates of requesting/renting bikes are designed based on the empirical data and marketing survey. For example, in our model, we set the Carpenter Station as the station with highest bike sharing demand rate and Hancock Street Station with the lowest demand rate in our model because this is a residential area at the North Ithaca with relatively low demand rate.

Altogether, we have 21 bikeshare stations in total. For each station, we designed the data for 24 intervals in each day. Thus, we have a 21 by 24 matrix for demand rate as an input for simulation. Figure 27 shows the visualization of the demand rate for each station during different time interval. As we can see from the graph, each station has different demand patterns during different time intervals. But most of the demand rate peaks between 9 a.m. to 2 p.m. And demand rate in the early morning from 1a.m. to 6 a.m. will be static and extremely low which closes to zero. So we just set them as zero for simplicity.

Figure 27: Demand rates for Carpenter Station and Hancock Street Station



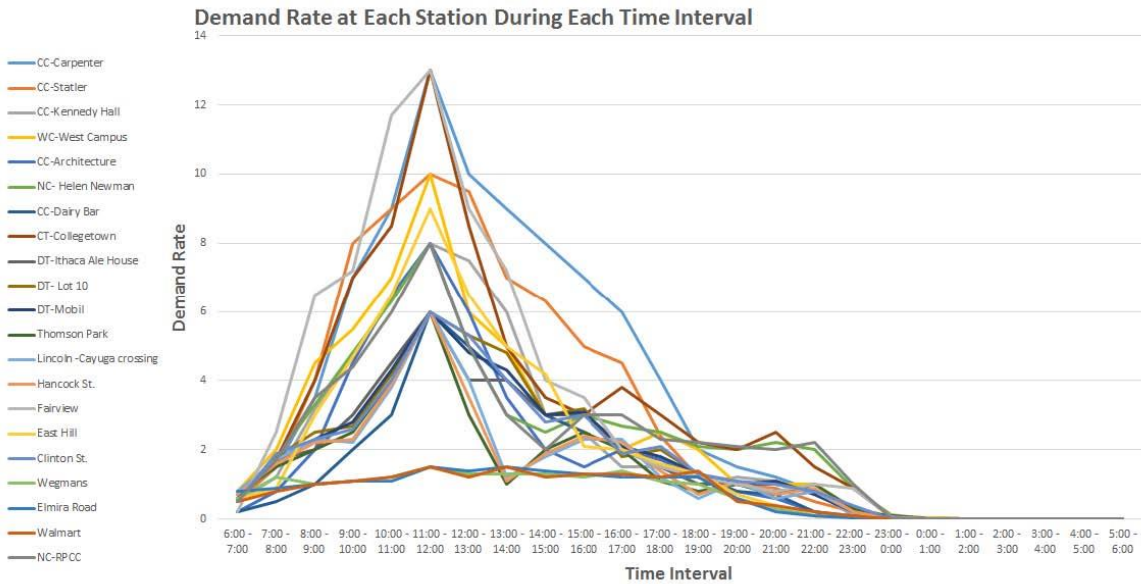
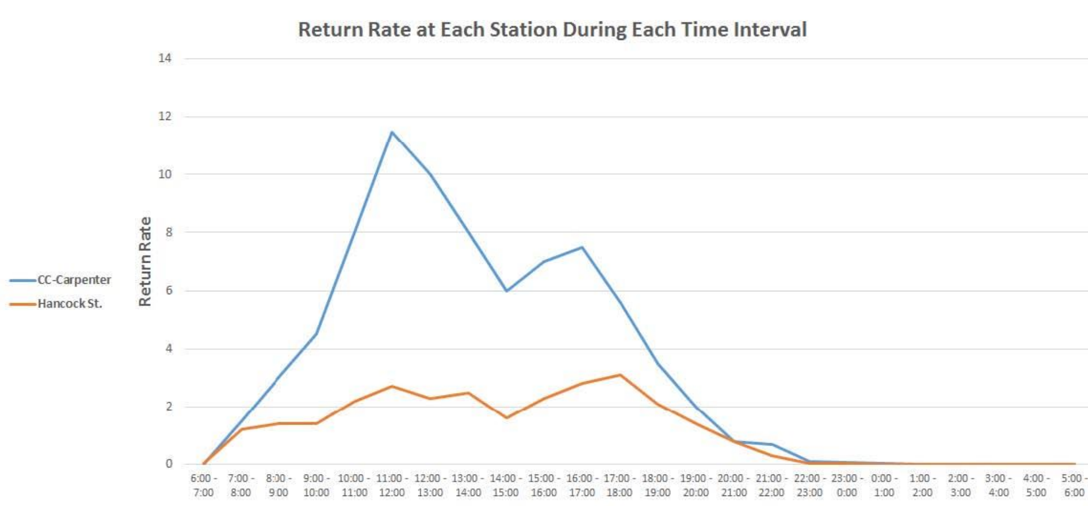



Figure 28: Visualization of demand rate matrix for all stations

*Demand rates of returning bikes*

Demand rates of returning bikes are also designed based on the empirical data and marketing survey. In our model, we have 21 bike sharing stations in total. For each station, we designed the data for 24 intervals in a day with different demand patterns. Figure 4 shows the visualization of the returning rate matrix. As we can see from the Figure 29, each station has a different follows a slightly different returning rate pattern. But most of the peak of returning rate occurs between 10 a.m. to 3 p.m. which is slightly different from the demand rate setting. We also consider the returning rate in the early morning from 1am to 6am will be static and extremely low. So we set them as zero for simplicity.

Figure 29:  Returning rate for Carpenter Station and Hancock Street Station



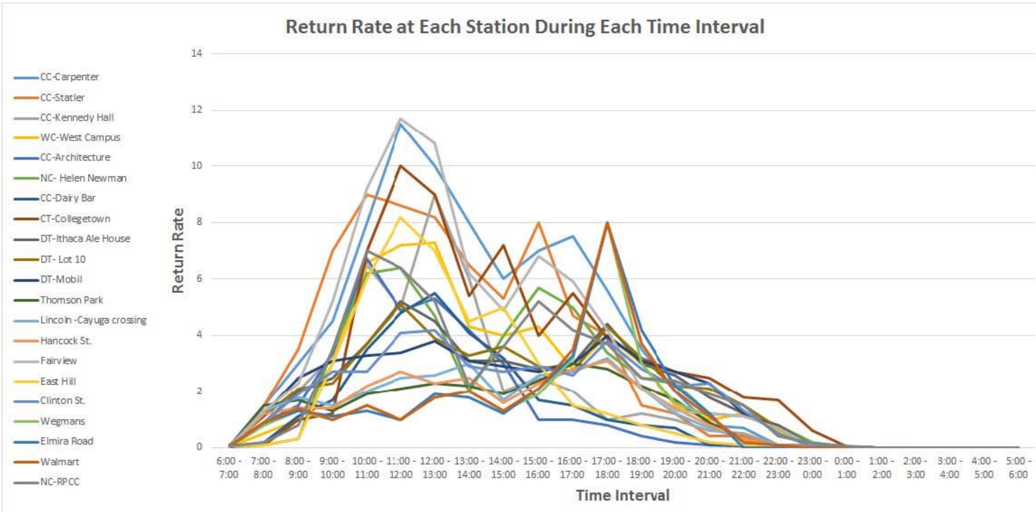


Figure 30: Visualization of returning rate matrix for all stations

*Dock Capacity & Bike Initialization*

Dock capacity is different but limited for each station in our simulation model. Table 6 summarizes the dock capacity for each station in this system and the number of bikes we use as initialization for bike sharing system for each station. Dock capacity is designed based on the demography and topography features for each station. For example, Wegmans station has the largest dock capacity but much less initial number of bikes because people are more likely to ride the bike to supermarket for shopping and taking a bus to come back. Furthermore, stations at the downslope area have higher capacities than the upslope stations. People always prefer to ride towards downhill. For instance, stations like Carpenter and Statler on the uphill has lower dock capacities than stations at the downhill like Wegmans and Walmart. Initial number of bikes are adjusted based on the simulation results. We try to optimize the initial number of bikes at each station to maximize the satisfaction rate for each station. And finally we choose this group of data with as our bike initialization with maximum satisfaction rate.

| Index | Station | Dock Capacity | Initial Number |
|---|---|---|---|
| 1 | CC-Carpenter | 10 | 10 |
| 2 | CC-Statler | 10 | 10 |
| 3 | CC-Kennedy Hall | 10 | 10 |
| 4 | WC-West Campus | 10 | 10 |
| 5 | CC-Architecture | 10 | 6 |
| 6 | NC- Helen Newman | 15 | 12 |
| 7 | CC-Dairy Bar | 10 | 6 |
| 8 | CT-CollegeTown | 10 | 10 |
| 9 | DT-Ithaca Ale House | 10 | 8 |
| 10 | DT- Lot 10 | 10 | 8 |
| 11 | DT-Mobil | 15 | 10 |
| 12 | Thomson Park | 10 | 6 |
| 13 | Lincoln -Cayuga crossing | 10 | 6 |
| 14 | Hancock St. | 10 | 6 |
| 15 | Fairview | 15 | 10 |
| 16 | East Hill | 10 | 10 |
| 17 | Clinton St. | 10 | 6 |
| 18 | Wegmans | 20 | 3 |
| 19 | Elmira Road | 20 | 3 |
| 20 | Walmart | 20 | 3 |
| 21 | NC-RPCC | 15 | 15 |
| Total | | 260 | 168 |

### 7.3.2. Simulation Results

#### 7.3.2.1. Model Description

Consider a bikeshare system that operates a dynamic demand queries. All queries are served based on the first-come-first-serve principle. Passengers come to the dock to pick up the bike for ride. If there is a bike available at the dock, passengers are allowed to pick one for ride. If there is no bike available at the dock, demand queries will be blocked. After the ride, passengers have to return the bike to whatever dock they like with vacant spot. If there are no available spot at that station for them to return the bike, returning queries will be blocked and customers have to find some other available spaces at another station.

Based on that, we developed an important measure of our system - satisfaction rate. The satisfaction rate is defined as: $SR = Number\ of\ satisfied\ queries\ (renting/returning)/Number\ of\ total\ queries$

Thus, system design (dock capacity and bike initialization) will be analyzed based on the two criteria: the probability of finding no bike to rent at a station, and that of finding no vacant spot to park the rented bike. And we aim to maximize the satisfaction rate by lowering those two probabilities while still under the constraint of financial budget for this bike sharing system.

The satisfaction rate we are using here is different from those in bikeshare industry which generally are data surveyed by asking the public for their subjective satisfaction ratings. Thus, we didn't find any similar measurement result from existing bikeshare systems to compare with our performance.

#### 7.3.2.2. Results Visualization & Analysis

Two measurements are used to represent our simulation results. *Remained Number Matrix* is used to store the number of bikes remained at the end of each time interval. Satisfaction rate for each station during each time interval is calculated and stored in the *Satisfaction Rate Matrix*.

Simulating the program for 100,000 times with one-month schedule and storing the simulation results at the end of each time interval (24 intervals for a day). By taking the average of the simulation results, we have a 21 by 24 *Remained Number Matrix* and a 21 by 24 *Satisfaction Rate Matrix*.

Figure 5 shows the number of bike remained during each time interval for each station. As we can see from this figure, the number of bikes dropped rapidly from 9 a.m. to 2 p.m. with higher demand and returning rate which is in consistent with our model setting.

From 11 pm to 6 am, the number of bikes remained at each station remains as a constant in this system which implies good opportunity for bike repositioning.

Figure 31: Number of bike remained during each time interval for each station

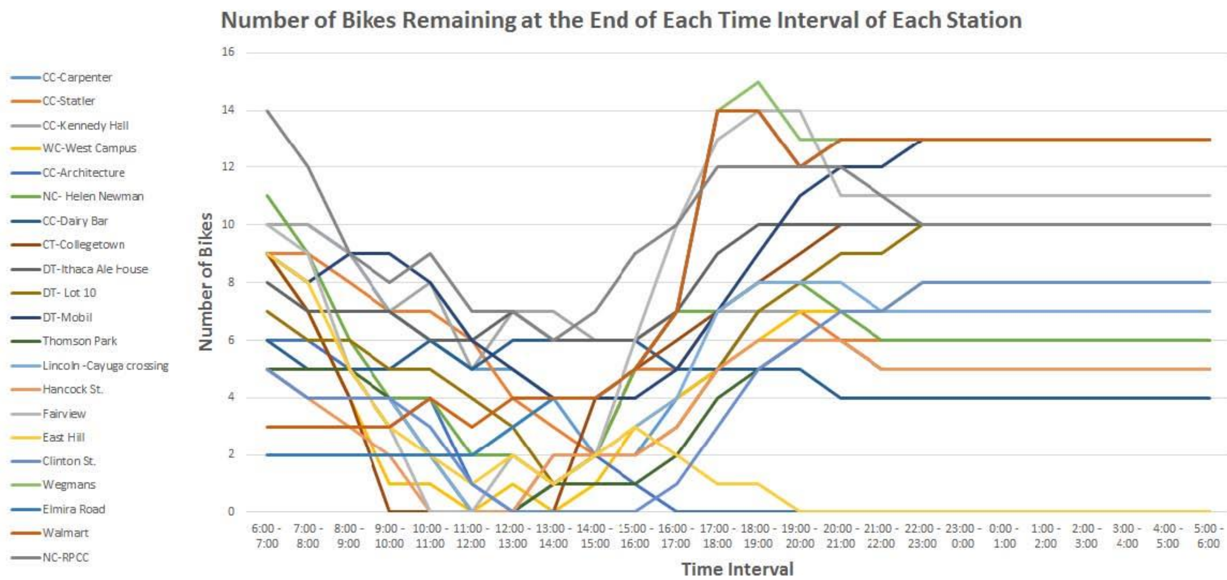



Figure 4.7 shows the satisfaction rate range for each station. More than half of stations keep 100% satisfaction rates for all time intervals. For the rest of stations, they have at least 50% satisfaction rate and most of them keep the satisfaction rate between 75% to 100%. In fact, on average, the mean of satisfaction rate of each station is up to 92.51%. It is considered a success in satisfying customers’ demands, either renting a bike or return a bike.

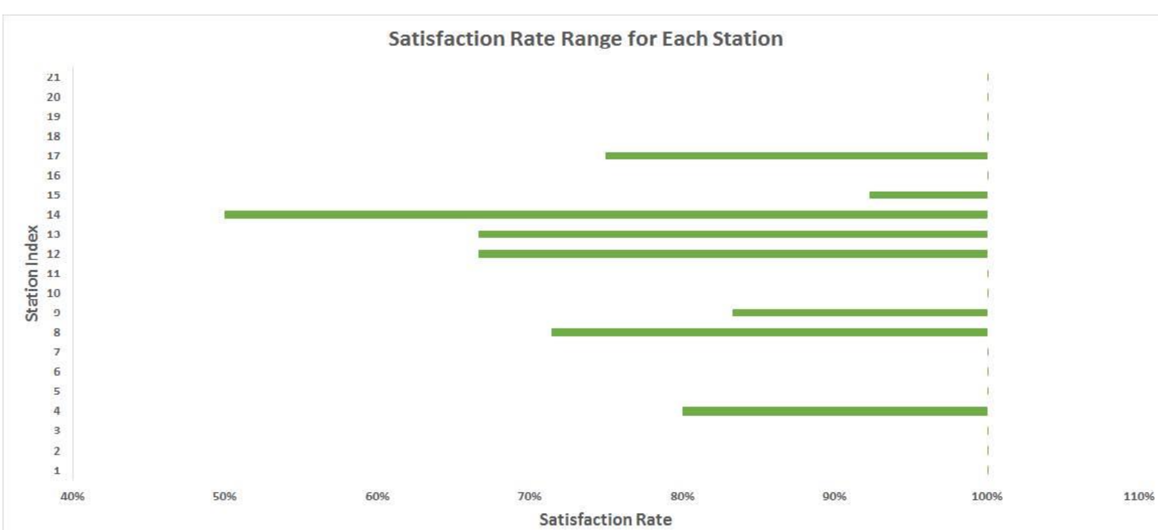



Figure 32: Satisfaction Rate Range for Each Station

## 7.4. Repositioning Strategy

After each day's operation, the number of bikes at each station usually will not be optimal as we planned. Bike rebalancing has become an important issue so that the customer demands can be met on an ongoing basis. Keeping in mind Ithaca's terrain it especially becomes important to strategize the repositioning as the lower terrain areas will always have more bikes remaining by the end of the day whereas the demand is higher at the higher terrains especially all the stations at Cornell.

While optimizing the repositioning route, two objectives had to be met:

1) The route designed should cover all the stations and such that the overall distance covered is minimal.
2) The route designed should cover the stations in such a way that the bike demand at each stations is satisfied i.e. neither any station is left with surplus bikes nor is it short of any bikes.

To meet these two demands, we started with creating a distance matrix that calculated the distances for all the stations to all the other stations. The distance matrix is shown in Appendix B. The matrix was used to find the minimum distance from one station to another and directly choose the path that gives you the least distance. But since one more objective of perfect rebalancing had to be satisfied we couldn't directly use the distance matrix. The simulation data obtained was used to find the number of bikes at 5 am every day at each bike station. The number of bikes remaining was compared to number of bike required at each of these stations.

Since we are using a truck for the repositioning purpose, we need to know the truck's capacity. Using the average capacity for the truck to hold 40 bikes we start off with holding 2 bikes in the truck initially. This is used as a backup in case any bikes are found to be damaged and/or bikes at the station are lesser than the simulation data results. Since the truck can hold 38 more bikes, we would start from the stations where there are surplus bikes. Usually these stations are the ones in the western and the southern parts of Ithaca. Thus, we start the repositioning from station 13 and go towards Southern Ithaca mainly South Hill area which has stations at Walmart, Wegmans, etc. These extra bikes are picked up and the route is followed to drop off the bikes at Collegetown and Cornell stations once the truck has reached its capacity and cannot pick up more bikes. For this reason, we used Microsoft Excel to find the minimum distance that the truck should follow and alongside update the bikes in the truck at each station once the bikes are dropped or picked up. Hence using Excel, the station j was chosen such that the distance from station i to station j is the least. And it was checked to see if the truck had the capacity in case of surplus bikes or had enough bikes to drop off some if that station needed it. If this was not satisfied then the station with the next minimum distance was chosen and again the same conditions were checked. This was done for all the 21 stations checking for the conditions every time and the route was updated. If the simulation results were to change, then our designed route will also automatically change so that the two objectives mentioned are always satisfied.

Table 7 shows the route the truck must cover form one station to another. The total distance covered by the truck is 12.4 miles. The data that shows the bikes needed and updates bike number in the truck is shown in table 8.

| Route Followed | Station Name | Miles Covered |
|---|---|---|
| 13 | 1019 N Cayuga Street | 0 |
| 14 | 301 3rd Street | 0.6 |
| 11 | 100 S Meadow St | 0.8 |
| 18 | 118 Cecil Malone Drive | 0.5 |
| 20 | 106 Fairgrounds Memorial PkwyDollar Tree | 0.8 |
| 19 | Rpcc Loading Dock | 0.8 |
| 17 | 300 South Geneva Street | 0.5 |
| 12 | 101 Farm Street | 0.7 |
| 10 | 101 W State St | 0.4 |
| 9 | 115 N Aurora St | 0.4 |
| 8 | 428 Eddy St | 0.6 |
| 1 | college ave. & campus Rd SE | 0.4 |
| 2 | 7 East Ave. | 0.2 |
| 3 | Garden Ave | 0.3 |
| 4 | 217 West Ave | 0.7 |
| 5 | 863-883 University Ave | 0.5 |
| 6 | 163 Cradit Farm Drive | 0.4 |
| 21 | Rpcc Loading Dock | 0.6 |
| 7 | 411 Tower Rd | 1.4 |
| 15 | 142 Maple Ave | 1.2 |
| 16 | 302 Pine Tree Road | 0.6 |
| | **TOTAL** | **12.4** |

Table 7: Accumulated miles in repositioning

| Route Followed | Station Name | Bikes at 5:00 a.m. | Predetermined Num of Bikes | Surplus Bikes | Updated Bikes in the Truck |
|---|---|---|---|---|---|
| 13 | 1019 N Cayuga Street | 6 | 6 | 0 | 2 |
| 14 | 301 3rd Street | 5 | 6 | -1 | 1 |
| 11 | 100 S Meadow St | 13 | 10 | 3 | 4 |
| 18 | 118 Cecil Malone Drive | 14 | 3 | 11 | 15 |
| 20 | 106 Fairgrounds, Memorial Pkwy Dollar Tree | 14 | 3 | 11 | 26 |
| 19 | Rpcc Loading Dock | 14 | 3 | 11 | 37 |
| 17 | 300 South Geneva Street | 8 | 6 | 2 | 39 |
| 12 | 101 Farm Street | 4 | 6 | -2 | 37 |
| 10 | 101 W State St | 9 | 8 | 1 | 38 |
| 9 | 115 N Aurora St | 10 | 8 | 2 | 40 |
| 8 | 428 Eddy St | 10 | 10 | 0 | 40 |
| 1 | college ave. & campus Rd SE | 7 | 10 | -3 | 37 |
| 2 | 7 East Ave. | 8 | 10 | -2 | 35 |
| 3 | Garden Ave | 3 | 10 | -7 | 28 |
| 4 | 217 West Ave | 7 | 10 | -3 | 25 |
| 5 | 863-883 University Ave | 0 | 6 | -6 | 19 |
| 6 | 163 Cradit Farm Drive | 8 | 12 | -4 | 15 |
| 21 | Rpcc Loading Dock | 10 | 15 | -5 | 10 |
| 7 | 411 Tower Rd | 3 | 6 | -3 | 7 |
| 15 | 142 Maple Ave | 12 | 10 | 2 | 9 |
| 16 | 302 Pine Tree Road | 2 | 10 | -8 | 1 |

Table 8: Updates through repositioning path

# 8. FINANCE

## 8.1. Pricing Strategy

Pricing is one of the most vital and highly demanded component within the theory of marketing mix. It helps consumers to have an image of the standards the firm must offer through their products, creating firms to have an exceptional reputation in the market. The firm's decision on the price of the product and the pricing strategy impacts the consumer's decision on whether to purchase the product. When firms are deciding to consider applying any type of pricing strategy they must be aware of the following reasons to make an appropriate choice which will benefit their business. The competition within the market today is extremely high, for this reason, businesses must be attentive to their opponent's actions to have the comparative advantage in the market. A business can use a variety of pricing strategies when selling a product or service. The price can be set to maximize profitability for each unit sold or from the market overall. It can be used to defend an existing market from new entrants, to increase market share within a market or to enter a new market[18].
The user uses the bikeshare application to pay for the services.
For our Bikeshare business model, the assumed pricing strategy is as shown in Table 9.

Table 9: Pricing Model

| | |
|---|---|
| Annual membership fee | $30 |
| Monthly membership fee | $15 |

## 8.2. Expenses

In common usage, an expense or expenditure is an outflow of money to another person or group to pay for an item or service, or for a category of costs. For a tenant, rent is an expense. For students or parents, tuition is an expense. Buying food, clothing, furniture, or an automobile is often referred to as an expense. An expense is a cost that is "paid" or "remitted", usually in exchange for something of value. Something that seems to cost a great deal is "expensive". Something that seems to cost little is "inexpensive". "Expenses of the table" are expenses of dining, refreshments, a feast, etc.

In accounting, expense has a very specific meaning. It is an outflow of cash or other valuable assets from a person or company to another person or company. This outflow of cash is generally one side of a trade for products or services that have equal or better current or future value to the buyer than to the seller. Technically, an expense is an event in which an asset is used up or a liability is incurred. In terms of the accounting equation, expenses reduce owners' equity.

The various types of expenses assumed in the financial model of bikeshare system are listed below.

### 8.2.1. Capital Expenditure

Capital expenditure, or Cap-Ex, are funds used by a company to acquire or upgrade physical assets such as property, industrial buildings, or equipment. It is often used to undertake new projects or investments by the firm. Companies also make this type of outlay to maintain or increase the scope of their operations. These expenditures can include everything from repairing a roof to building, to purchasing a piece of equipment, or building a brand-new factory[19].

In the bikeshare model, the capital expenditure includes the initial cost of the bikes and the docks purchased. Since our model covers a major area of Ithaca, we needed a total of 200 bikes and 21 docks. The cost of one bike as calculated by the technical subdivision of the team was $380. For the cost of a unit dock, a thorough research was conducted with regards to the docks used in Santander Bikeshare system in London, UK [20] and Citibikes in New York City, US [21]. Hence, the final cost of a unit dock was considered as $3100. The capital expenditure of our bikeshare system is shown in the figure below.

Bikes54%
Docks46%
Capital Expenditure
Bikes
Docks

Figure 33: Capital Expenditures

### 8.2.2. Marketing Expense

A marketing expense is "an amount of money the company spends on marketing," according to Cambridge Dictionaries Online. Marketing expenses are an important consideration for all businesses because marketing is a primary business function that creates a customer for the business. It is critical for business owners to understand the significance of marketing expenses, accounting definition of marketing expense, marketing expense management and tax treatment.

Typically, some common marketing expenses include marketing salaries, marketing research, promotions, public relations, and advertising costs.

While marketing may be considered an expense under a profit and loss statement, it is an investment in supporting your greatest asset, your brand. Where possible, it is important to measure your marketing expense against its return on investment. Although marketing can be called an expense for accounting purposes, a profitable marketing campaign that returns a net profit should be considered a practical investment and primary driver of immediate sales and revenues.[22]

Marketing expenses in the bikeshare model were assumed to be a fixed percent of the revenue generated in that fiscal year. For our model, we considered marketing expense to be a cumulative 5% of the total revenue generated in that fiscal year.

### 8.2.3. Research and Development Expenses

Research and development (R&D) describes activity or expense associated with the research and development of a company's goods or services. R&D expenses are a type of operating expense and can be deducted as such on a business tax return.[23]

R&D is a type of systematic activity conducted by a company, which combines basic and applied research to discover solutions to problems, or to create or update goods and services. The act of a company conducting its own R&D often results in the ownership of intellectual property in the form of patents or copyrights.

In the model, research and development expenses include development fee for the mobile based application that is being used by the user for using the bike service. For subsequent years, it was assumed that the related expenses would include only the annual maintenance fee for the mobile based application. The application development fee was assumed to be equal to $5000 whereas the application maintenance fee was assumed as an annual payment of $1000.

Development83%
Maintenance17%
R & D Expenses
Development
Maintenance

Figure 34: Research & Development Expenses

### 8.2.4. Storage Expenses

Given the weather conditions in Ithaca, it was assumed that the bikeshare model would be in operation from the beginning of April till the end of November. This assumption is based on the fact that in Ithaca, the roads would be partially inaccessible due to light to heavy snowfall. During this time, there is a need to store all the bikes securely so that they wouldn't get damaged due to extreme weather conditions.

For storage expenses, a thorough research was conducted and a basketball half court size warehouse was found in Watkins Glen with a rent of $250 per month. It is not planned to store the bikes in the warehouse located in Watkins Glen. The monthly rent of the warehouse was only taken as a reference for the average monthly storage expense. Bikes would be stored in a warehouse in Ithaca only. The total storage expense was calculated close to $1500[24]

### 8.2.5. Maintenance Expense

The costs incurred to keep an item in good condition and/or good working order. When purchasing an item that requires upkeep, consumers should consider not just the initial price tag, but also the item's ongoing maintenance expenses. Maintenance expenses are a major reason home ownership can be more expensive than renting, for example. However, sometimes even items that are merely leased, not owned, such as a leased car, will require the owner to pay maintenance expenses.

In the bikeshare model, the maintenance expense is considered as a combination of maintenance fee for bikes and the same for the docks. It was found that the maintenance fee for a unit bike would be close to $60 and for a unit dock, would be close to $100.

### 8.2.6. Depreciation Expense

Depreciation expense is the allocated portion of the cost of a company's fixed assets that is appropriate for the accounting period indicated on the company's income statement. For instance, if a company had paid $2,400,000 for its office building (excluding land) and the building has an estimated useful life of 40 years, each monthly income statement will report straight-line depreciation expense of $5,000 for 480 months.

For the depreciation expense of the bikes, we have considered a straight-line depreciation with a useful life of 10 years. Hence, depreciation expense per year for a unit bike is equal to $32. For docks, the depreciation is assumed to follow a straight-line depreciation as well. Useful life of a dock is considered to be 10 years as well. Hence, the yearly depreciation expense for a dock can be considered as nearly $259.

#### 8.2.7. Rebalancing Expense

As provided by the operations team, the complete route for rebalancing was calculated to be nearly equal to 13 miles. The total rebalancing expense was calculated as the product of total rebalancing miles, cost of fuel in dollars per gallons, and the amount of gallons per mile. For the model, the rebalancing expense is the sum of the rebalancing expense, the labor fee, the rent for the trucks and the insurance fee for the trucks, bikes and the docks. It is assumed that the project would require hiring two people who would be looking after all the operations of the bikeshare system.

### 8.3. Assumptions

The cost of each bike and each dock is $380 and $3100 respectively and they are specially designed to be more durable in our bike share program. We assume that 4% of the total bikes would be damaged or stolen in each year and the maintenance for bikes and docks enables the remains to go through the first ten years. After comparing the relevant bike share programs in China and information provided by our technology group, we set the maintenance fee for each bike and dock is $60 and $100, considering they are only used for 7 months in a year and the wear and tear would not be so serious in daily use.

Other expenses are gained from marketing research, including marketing fee, storage fee, app expenses and rebalancing fee. Marketing expense counts for 5% of the total revenue each year. For storage of the bikes, we choose Ithaca nearby warehouse which is large enough to accommodate our 200 more bikes. Transportation fee is not concerned in this process for daily rebalance can totally complete this job. App development fee is $5000 which is not too much since we don’t require many functions. And the maintenance fee for the app is $1000 for software update, customer service online each year. Rebalancing part is relatively complicated and will be discussed in the expenses part in detail.

For income source, we have a specific pricing model, and we get the data of potential customers from marketing team. The detailed portion of people choosing different plans is calculated from the sample we gained from our market survey. When we calculate net income, we assume the average effective tax rate is 35% in the duration of our bike share project. And when we calculate net present value, we set inflation rate 2.4% and discount rate 7.5%. The inflation rate is obtained from the historical national inflation rate and the discount rate is based on bank information.

### 8.4. Scenario Analysis

The expected cash flows that we use to value risky assets can be estimated in one or two ways. They can represent a probability-weighted average of cash flows under all possible scenarios or they can be the cash flows under the most likely scenario.

While the former is the more precise measure, it is seldom used simply because it requires far more information to compile. In both cases, there are other scenarios where the cash flows will be different from expectations; higher than expected in some and lower than expected in others. In scenario analysis, we estimate expected cash flows and asset value under various scenarios, with the intent of getting a better sense of the effect of risk on value. In this section, we first consider an extreme version of scenario analysis where we consider the value in the best and the worst-case scenarios, and then a more generalized version of scenario analysis[25].

With risky assets, the actual cash flows can be very different from expectations. At the minimum, we can estimate the cash flows if everything works to perfection – a best case scenario – and if nothing does – a worst case scenario. In practice, there are two ways in which this analysis can be structured. In the first, each input into asset value is set to its best (or worst) possible outcome and the cash flows estimated with those values. Thus, when valuing a firm, you may set the revenue growth rate and operating margin at the highest possible level while setting the discount rate at its lowest level, and compute the value as the best-case scenario. The problem with this approach is that it may not be feasible; after all, to get the high revenue growth, the firm may have to lower prices and accept lower margins. In the second, the best possible scenario is defined in terms of what is feasible while allowing for the relationship between the inputs. Thus, instead of if revenue growth and margins will both be maximized, we will choose that combination of growth and margin that is feasible and yields the best outcome. While this approach is more realistic, it does require more work to put into practice.

How useful is a best case/worse case analysis? There are two ways in which the results from this analysis can be utilized by decision makers. First, the difference between the best-case and worst-case value can be used as a measure of risk on an asset; the range in value (scaled to size) should be higher for riskier investments. Second, firms that are concerned about the potential spillover effects on their operations of an investment going bad may be able to gauge the effects by looking at the worst-case outcome. Thus, a firm that has significant debt obligations may use the worst-case outcome to make a judgment as to whether an investment has the potential to push them into default. In general, though, best case/worse case analyses are not very informative. After all, there should be no surprise in knowing that an asset will be worth a lot in the best case and not very much in the worst case. Thus, an equity research analyst who uses this approach to value a stock, priced at $50, may arrive at values of $80 for the best case and $10 for the worst case; with a range that large, it will be difficult to make a judgment on a whether the stock is a good investment or not at its current price of $50.

Multiple scenario analysis: Scenario analysis does not have to be restricted to the best and worst cases. In its most general form, the value of a risky asset can be computed under several different scenarios, varying the assumptions about both macroeconomic and asset specific variables[26].

The steps in scenario analysis are the following:

- The first is the determination of which factors the scenarios will be built around. These factors can range from the state of the economy for an automobile firm considering a new plant, to the response of competitors for a consumer product firm introducing a new product, to the behavior of regulatory authorities for a phone company, considering a new phone service.

- In general, analysts should focus on the two or three most critical factors that will determine the value of the asset and build scenarios around these factors.
- The second component is determining the number of scenarios to analyze for each factor. While more scenarios may be more realistic than fewer, it becomes more difficult to collect information and differentiate between the scenarios in terms of asset cash flows. Thus, estimating cash flows under each scenario will be easier if the firm lays out five scenarios, for instance, than if it lays out 15 scenarios. The question of how many scenarios to consider will depend then upon how different the scenarios are, and how well the analyst can forecast cash flows under each scenario.
- The third component is the estimation of asset cash flows under each scenario. To simplify the estimation at this step, we focus on only two or three critical factors and build relatively few scenarios for each factor.
- The final component is the assignment of probabilities to each scenario. For some scenarios, involving macro-economic factors such as exchange rates, interest rates 4 and overall economic growth, we can draw on the expertise of services that forecast these variables. For other scenarios, involving either the sector or competitors, we must draw on our knowledge about the industry. Note, though, that this makes sense only if the scenarios cover the full spectrum of possibilities. If the scenarios represent only a sub-set of the possible outcomes on an investment, the probabilities will not add up to one. The output from a scenario analysis can be presented as values under each scenario and as an expected value across scenarios (if the probabilities can be estimated in the fourth step). This quantitative view of scenario analysis may be challenged by strategists, who have traditionally viewed scenario analysis as a qualitative exercise, whose primary benefit is to broaden the thinking of decision makers. As one strategist put it, scenario analysis is about devising "plausible future narratives" rather than probable outcomes; in other words, there are benefits to considering scenarios that have a very low probability of occurring. 1 The benefits of the exercise are that it forces decision makers to consider views of what may unfold than differ from the "official view".

For scenario analysis in the bikeshare model, the total number of annual members, monthly pass members and the pay per ride users were taken as variables. The best case was chosen as the most optimistic value attained from the marketing team with regards to the total number of people interested in annual membership and the rest of the membership plans. The weakest case was considered as the pessimistic numbers as provided by the marketing team.

## 8.5. Results

With the assumptions taken, the model showed that the project is feasible in Ithaca. Initial financial support would be required for meeting the capital requirements. For the different scenarios, the results are shown below.

| Sponsorship | 2017 | 2018 | 2019 | 2020 | 2021 |
|---|---|---|---|---|---|
| **Weak Case** | $197,025 | $18,606 | $15,308 | $11,929 | $8,550 |
| **Base Case** | $197,618 | - | - | - | - |
| **Strong Case** | $198,285 | - | - | - | - |

Table 10: Scenario Analysis

In the weak scenario, financial support is required for the first five years in operation whereas in the strong and the base case the financial support is only required during the first year only.

## 8.6. Funding Strategies

There are a number of ways in which the initial financial support can be attained. A few of them are listed below.

### 8.6.1. Loans

Banks can be pursued for the loans in order to cover for the initial investment required for the bikeshare systems.

### 8.6.2. Sponsorships

Private companies can be pursued for the initial investment required for the bikeshare system. Generally, the bikeshare system is being used as a marketing tool by the sponsors as the same can be seen in the case of Citi-bikes in New York City, USA. Local examples include Wegmans or Cayuga Medical Care Centre.

### 8.6.3. Governmental Funding

Funding for initial investment can also be obtained from governmental channels. Examples include the government of Tompkins County.

## 9. CONCLUSION

The major objective of this project was to conduct a feasibility analysis of bike sharing in Ithaca and to identify the presence of a market. Based on the analysis done by the marketing, operations, product and finance team, we have concluded that there is an existing market for bike sharing in the location and has focused on narrowing down our target segment in order to develop a suitable model to maximize usage and profitability. The market survey showed us that there is a great deal of interest for bike sharing in Ithaca and our model has been designed to capitalize on this opportunity. Our operating route has been optimized based on the demand and prime locations.

With the help of scenario analysis in the financial model, it was shown that in all possible cases, the project was financially feasible over the course of ten years. In the strong and the base case, the project started making profits in the second year and reaches breakeven in six years, whereas in the weak case, the project started making profits in the sixth year of operation while the breakeven was reached at the end of tenth year. The financial analysis also helped in estimating the amount of financial support required in the initial years of the operation of bikeshare system. A pricing strategy was developed for the bikeshare system which catered to both Cornell students and faculty, and the local Ithaca residents. With the help of results obtained from the operations team with regards to the rebalancing, an optimal rebalancing cost was estimated for the project. Conclusively, it was shown that the project is financially feasible.

## 10. RECOMMENDATIONS FOR FUTURE WORK

1. Once the model developed is implemented, we can get more idea about the changes that is needed to be made by collecting data. This responsive data will be used to update our model and develop a more market responsive model.

2. Since rebalancing of the bikes comes with a cost, we plan to develop strategies and schemes that can help us get rid of these or at least reduce it as much as possible so that the revenues earned can be used to expand the system.

3. To avoid the rebalancing cost, we can come up with promotions or incentives for the customer to rebalance the bikes between stations. We can let them ride uphill at no cost or give them heavy discounts during peak hours.

4. We can also introduce E-bikes in the future so that it gets easier to ride uphill.

5. A further effort could be to affiliate with the TCAT and develop a bus-bike model to rebalance the bikes using the TCAT bus services and also give the customers some beneficial offers such that they can use the bike and the bus at low costs which will help encourage more customers to use the bikeshare service.

6. Another important factor to consider are separate bike lanes. There are very few roads in Ithaca that have separate bike lanes. With the success of this model, we can persuade the government to construct the roads such that they can have bike lanes incorporated. This will drive more customers in the future to use the bikeshare system.

7. We can also add some advanced bikes with better technology that will be safer and easier for the customers to ride, but then it will become important to convince the customers to pay some extra amount to use these bikes as it will cost us more to buy these new bikes.

# 11. TABLE INDEX

## Figure Indexes



## Table Indexes

## 12. REFERENCES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27. Corporate Finance – Ross, Westerfield and Jaffe

# 13. APPENDIX

## 13.1. In-depth Interview Questions:

1. Tell us how do your mode of travel to and fro from the Cornell University campus? Do you use the same mode for traveling to different buildings in the campus too?

2. Why do you prefer to use the mode of transport that you just mentioned? For example, is it more convenient and/ or cost effective?

3. Given a chance, what would you like to improve related to the mode of transport that you mentioned before?

4. On an average, what is your monthly expenditure on transportation?

5. Do you ride a bicycle?  If yes, then given the opportunity, would you like to use a bicycle instead?

6. If Yes, then what are the advantages do you find in doing so? If No, then what are the problems or disadvantages?

7. Have you heard of a bike share system? If yes, have you ever had a chance to use a bike share system in the past (if no, we'll explain them the system)? If yes, how was your experience?

8. Do you think such a system will be beneficial for Cornell University? If no, why not? If yes, why?

9. Do you think adding motorized bicycles will help solve some of these problems?

10. In your opinion, what can be done to encourage/attract more people to use a bike-share system?

11. How much would you be willing to spend on a bike share system per month?

12. What according to you would be a good schedule for payments? Should it be monthly, semi-annually or annually? Or should it simply be on a pay per use basis?

13. What kind of trips would you use the bikes for? For example, traveling to dining halls, libraries, leisure trips, etc.

14. Any general comments/suggestions that you would like to provide us?

## 13.2. Market Survey Questions:

Cornell Bike Share:
Bike sharing is a growing transportation option in many major cities and universities across the world. Bike riding offers a healthier and sustainable option for commutation across short distances compared to conventional options such as shuttles, cars, buses etc. Moreover, across university campuses with high parking permit fees, bike sharing provides a cost effective and convenient solution for transportation. As a result, bike sharing is the most common mode of transit used by the community in various cities across the US.The students of Masters in Engineering Management program at Cornell University are working to identify the need and the necessary features of such a system in the city of Ithaca and would appreciate the valuable time you take in completing this survey. This survey should not take more than 10 minutes. (Please be assured that all your responses will be treated with the highest level of confidentiality)
A bike share is a transportation system where the users can pick up a bicycle at any self-service station, use it as and when they need it and return it back to either the same or any other self-service station located in the operating range of the system.

Q1 What modes of transport do you use for your local travel? (Please check all that apply)
☐ TCAT Bus (1)
☐ I generally walk (2)
☐ Personal Car (3)
☐ Carpool (4)
☐ Car Share System (5)
☐ On demand Taxi/Cab (6)
☐ Skateboarding (7)
☐ Motorbikes (8)
☐ Bicycles (9)
☐ Others (10) ____________________
Q2 Have you had the opportunity to use an existing bike share system before?
☐ Yes, I have used an existing bike share system (1)
☐ I'm aware of bike sharing system(s) but never got an opportunity to use one (2)

▯ I have never heard of a bike share system until this survey (3)

Q3 Do you know how to ride a bike?
▯ Yes, and given a chance I would like to do biking in Ithaca (1)
▯ Yes, but I won't ride bike in Ithaca (3)
▯ No, but I'm ready to learn biking (2)
▯ No, and I'm not ready to learn biking (4)

Q4 Would you like to see a bike sharing system in Ithaca?
▯ Yes, absolutely (1)
▯ I 'd be fine with/without it (2)
▯ No, I don't think it will be a good idea (3)

Q5 What attracts you to bike share? (Please check all that apply)
▯ It'll give me a chance to exercise and travel at the same time (1)
▯ It'll save time (2)
▯ It'll be cost-effective (3)
▯ Convenience (4)
▯ I want to be Environment friendly (5)
▯ Help me in accessing places not served by public transport (6)
▯ I won't have to wait for buses anymore (8)
▯ I think it's cool to ride a bicycle (9)
▯ Others (7) ____________________

Q6 If a bike share system were implemented in Ithaca, what kind of trips would you use it for?
▯ Commuting to School/University (1)
▯ Commuting to my workplace (2)
▯ Exercise (3)
▯ Leisure Riding (exploring Ithaca and nearby places) (4)
▯ Going for shopping to shopping centers/malls (5)
▯ Commuting between bus stops (6)
▯ Run errands (7)
▯ Others (8) ____________________

Q7 What seasons of the year would you prefer to use the bike share system? (Please check all that apply)
▯ Fall (1)
▯ Winter (2)
▯ Spring (3)
▯ Summer (4)

Q8 Where in Ithaca or Tompkins County do you live? (Please choose the location that fits the best)
 Collegetown (1)
 West Campus (2)
 North Campus (3)
 Downtown Ithaca (4)
 West Hill (20)
 South Hill (5)
 East Hill (6)
 Cayuga Heights (7)
 Northeast (8)
 Trumansburg (9)
 Enfield (10)
 Newfield (11)
 Danby (12)
 Caroline (13)
 Dryden (14)
 Groton (15)
 Lansing (16)
 I live outside the Tompkins County (19)

Q9 In what locations would you like to see the bikesharing bikes made available? (Please choose all that apply)
 Collegetown (1)
 West Campus (2)
 North Campus (3)
 Downtown Ithaca (4)
 West Hill (9)
 South Hill (Walmart/Wegmans) (5)
 East Hill (6)
 Cayuga Heights (7)
 Northeast (8)

Q10 What are the factors that make you think bikesharing is not a good option for Ithaca? (Please check all that apply)
 Weather Conditions (1)
 Terrain (2)
 Condition of Roads (3)
 There are not enough bike lanes (4)
 Safety will be an issue (5)

□ It'll consume more time (6)
□ I think on-demand car/bus share is much better than bikeshare (8)
□ Others (7) ____________________

Q11 Approximately how much do you spend on your local transport each month?
□ None at all (4)
□ Less than $50 (3)
□ $50 - $150 (2)
□ Greater than $150 (1)

Q12 What is the best estimate of your yearly household income?
□ I'm a student (13)
□ Less than $10,000 (1)
□ $10,000 - $19,999 (2)
□ $20,000 - $29,999 (3)
□ $30,000 - $39,999 (4)
□ $40,000 - $49,999 (5)
□ $50,000 - $59,999 (6)
□ $60,000 - $69,999 (7)
□ $70,000 - $79,999 (8)
□ $80,000 - $89,999 (9)
□ $90,000 - $99,999 (10)
□ $100,000 - $149,999 (11)
□ More than $150,000 (12)

Q13 What is your occupation?
□ Student (1)
□ Faculty/ College Staff (2)
□ Service/Repair (5)
□ Sales (6)
□ Production/Construction/Crafts (7)
□ Others (4) ____________________

Q14 What kind of subscription plan would you prefer for a bike share system?
□ Pay per Ride (5)
□ Daily (1)
□ Weekly (2)
□ Monthly (3)
□ Annual (4)
□ None (10)

Q15 Upto how much will you be willing to pay for your preferred subscription plan?
________ US $ (1)

Q16 What is your gender?
▢ Male (1)
▢ Female (2)
▢ Others (3)

Q17 What is your age?
▢ Under 18 (11)
▢ 18 - 24 (12)
▢ 25 - 34 (13)
▢ 35 - 44 (14)
▢ 45 - 54 (15)
▢ 55 - 64 (16)
▢ 65 - 74 (17)
▢ 75 - 84 (18)
▢ 85 or older (19)