Research on the impact of bike sharing on urban transportation--Take New York's citi bike as an example

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Abstract: In order to know the impact of bike sharing on urban transportation, we choose New York's citi bike as our research object, and we also take different influence into account, including traffic, health, economic and environment. We construct a balanced baseline transportation choice model to describe projected customer behavior in the absence of citi bike to analyze the effect of the bike sharing. By data mining, we get the corresponding data and analyze impact by importing data and drawing graphics. In general, the benefits of bike sharing on urban transportation outweigh the disadvantages.

1. Introduction

Citi Bike is the largest privately owned public bicycle sharing system in the United States,which launched in May 2013[1]. Rapidly growing bike sharing systems all over the world have attracted a lot of attention of urban analysts and researchers. In New York City several studies have been conducted for the optimization problem of Citi Bike rebalancing system, as well as predicting the demand of bike usage.

Many studies, especially those focusing on the environmental impact of Citi Bike, simply consider the difference between bike and car ridership, assuming that people would be driving instead. Such an assumption is clearly not realistic, as it could often be preferable, especially in the dense urban environment, to walk or to take public transportation, for example. Not all Citi Bike users even have access to private vehicles. In the present work we construct a balanced baseline transportation choice model to describe projected customer behavior in the absence of Citi Bike. The estimated travel time and cost savings are then computed together with the associated gas savings, emissions cut and additional exercise for the customers in order to assess the impacts of bike sharing.

2. The Model of the impact of bike sharing

2.1 Introduction

Without sharing bike, what would happen in New York? If people don't choose sharing bike as their vehicles, what alternatives would they choose? May be cars, bus, subway and so on. People seem to have different choices individually. This article we choose three typical modes of transportation including driving cars, taking subway and walking. For convenience, we ignore other trip modes. Because this three modes of transportation we take into consideration account for nearly 87.1 percent among all vehicles in New York city.

Similarly, sharing bike can have an effect on many parts of society including economy, environment, health and so on. For the same reason, here we just take three small parts into account including saving time, saving money and saving gas. The key to this problem is what would people choose without sharing bike. Traditional solution tends to solve this problem separately. We propose a new idea with combining all the probabilities together.

2.2 Assumptions

- bike speed: 7.456 miles per hour
- walk speed: 3.1 miles per hour

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- subway speed: 15 miles per hour (waiting time :15 minutes)
- car speed: 9.35 miles per hour
- average trip distance: 5.9 miles

2.3 Foundation

First, we collect some information about New York transportation as our prior knowledge[2]:
1) Market Share (normalization)
Car 32% →42%
Walk 23% →29%
Subway 23% → 29%
2) Distance Choice Model (normalization)

Table1: Distance Choice Model

	Short Distance	Medium Distance	Long Distance
Walking	0.45	0.15	0.01
Car	0.38	0.29	0.90
Subway	0.17	0.56	0.09

From above, we can have an intuition on how people tend to choose their vehicles based on different distance. We can infer that people favor walking if the distance is short. If longer, people would switch from walking to taking subway. If the distance is much longer, people have no choice but to drive cars. Obviously, if people want to travel a long distance, subway is unrealistic. Distance is a key factor as to what people choose the modes of transportation.

Table 2: Mode Perception

Mode Perception	convenient	reliable	fast	inexpensive	safe	comfortable
Walking	46	37	16	40	25	32
Subway	47	23	23	23	15	14
Cars	46	29	23	11	23	42
Bicycling	23	16	12	26	10	13

The table above shows that people choose their favorite transportation[1] for what reasons. Easily we can find walking, subway and cars have nearly the same scores in convenience. In other word, convenience can't decide whether people choose this mode of transportation. It is the same with 'reliable'. Though people may have some wrong thoughts about the speed of vehicles, the scores of the speed of the three sorts of vehicles still correspond with what we expect in our assumption. We compute a total score based on all kinds of items. For convenience, we just add all scores together according to each row. Then we normalize every item. The results are 0.38,0.28,0.34.

2.4 Joint analysis

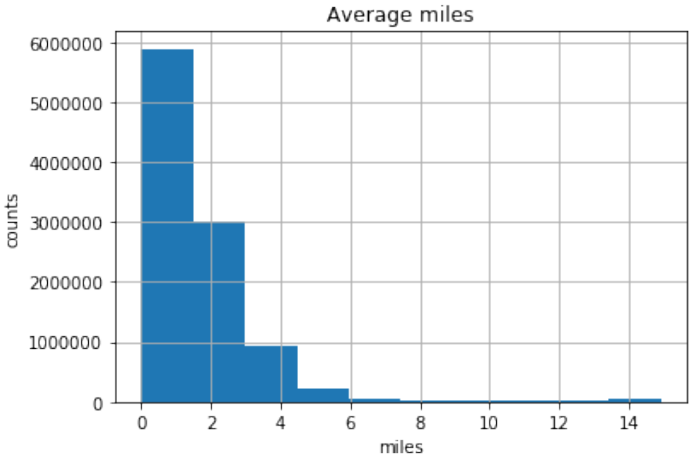

Fig 1: Data of Citi Bike In 2015

We collect the data of citi bike in 2015[3]. It can be seen that as the miles increase, the possibilities tend to decrease.

As we all know, 30 minutes' walk tend to be acceptable. According to computing, we can approximately think of distance within 1.7 miles of short distance. Then people tend to drive car while they travel a very long distance. For convenience, we look on as distance over 13.4 miles as long distance. We can infer that less than 1.7 miles, approximately 64 percent of people would choose walk as the mode of their transportation. More than 1.7 miles but less than 13.4 miles, the possibility is 0.35.And if miles are over 13.4, only less than 1% of people will choose cars. Because the user of bike tend to travel short or medium distance, without sharing bike, they are much more likely to use the former two vehicles.

Table 3: Data of Citi Bike In 2015

Miles(bins)	Counts	Possibility
0-1.7	6570699	0.642704
1.7-3.3	2629954	0.257245
3.3-5.0	724161	0.070833
5.0-6.6	135248	0.013229
6.6-8.3	50587	0.004948
8.3-9.9	25406	0.002485
9.9-11.6	17174	0.00168
11.6-13.4	11853	0.001159
13.4-15.0	58440	0.005716

2.5 Transfer probability:

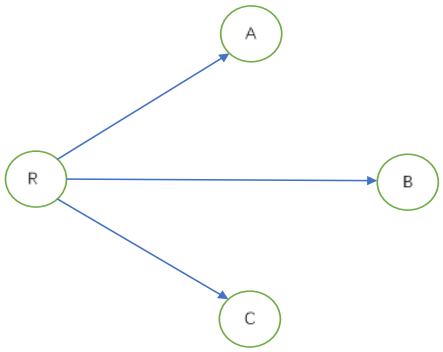

Fig2: The miles' influence on walk, car, and subway

R represents the miles' influence on walk, car, and subway. A, B, C stands for three different modes of transportation, namely walk, car, subway.

S, M, L stands for short distance, medium distance and long distance.

Define transfer(S, M, L) as the possibility of different distance(S,M,L)

Define distance (A, B, C) as the possibility of different modes of transportation based on different distance.

Define share (A, B, C) as the possibility of market share.

Define scores (A, B, C) as the possibility of scores based on people's comment.

R(A,B,C)=transfer(S,M,L)*distance(A,B,C)*share(A,B,C)*scores(A,B,C)

Finally we get three Weight coefficients: 0.34 for walk, 0.22 for subway and 0.44 for cars.

2.6 Total transfer possibility

Assume that all citi bike's users transfer to the three modes of transportation, according to total citi bike's users which reach up to 10223522 persons. One key point I need to explain that 10223522 don't represent the number of users. Instead, it stands for the records of use. However, if users transfer to other modes of transportation, we still focus on the records of use. For the sake of convenience, we just call it "the number of users".

We have got the weight of three modes of transportation. Then we can approximately get the total number of users who turn to other transportation from citi bike. We know that they are N1:3475997 for walk, N2:2249174 for subway and N3:4498349 for cars.

We define some variables below[4]:

Health benefit = Calorie (N1, N2, N3)*(N1 + N2 + N3)

Money savings = Money (N1, N2, N3)*(N1 + N2 + N3)

Time savings = Time (N1, N2, N3)*(N1 + N2 + N3)

Environmental benefit = ENV (N1 ,N2, N3)*(N1 + N2 + N3)

Table 4: Benefits

Benefits	
Health benefit	134,950,500
Money savings	1,401,985
Time savings/hour	1,212,557
Environmental benefit(CO2)/b	5,607,940

3. Conclusion

From what we have analyzed, we can easily find that sharing bike has great impacts on health, economic and environment. Riding by bike, you can exercise, enjoy the view, breathe the fresh air and even protect the environment! What's more, your wallet won't be much smaller than before. Comparing to walking, you can save time. Comparing to subway, you don't bother to wait for half an hour and even worse. Comparing to car, you don't bother to be afraid of polluting the environment. Obviously, it is wise for us to choose sharing bike as far as possible.

However, sharing bike still remains some troubles need to be solved. Firstly, sharing bike is convenient but not enough convenient. Sharing bike stations still need to be constructed. Secondly, the key to sharing bike is to open the last three kilometers. Sharing bike is not born to replace other modes of transportation. Sharing bike should combine all other modes of transportation together. Thirdly, now sharing bike is not enough comfortable to use. In the future, sharing bike should be more intelligent. With Internet of things developing, we hope that speech control can be popular. We can even use speaker recognition technology to match all the customers if the technology is enough mature. Someday we can liberate our hands just using our voice to experience totally different world. Speech interaction mode should be the mainstream of the future. Everything has souls, so will the sharing bike.

References

[1] Citi Bike Monthly Operating Report (2017). Retrieved from: https://www.CitiBikenyc.com/system-data/operating-reports

[2] http://www.nyc.gov/html/dot/downloads/pdf/nycdot-citywide-mobility-survey-report-2017.pdf

[3] https://rosap.ntl.bts.gov/view/dot/36435

[4] Sobolevsky S , Levitskaya E , Chan H , et al. Impact Of Bike Sharing In New York City[J].2018.