

Background

Unlike the past, these days the use of non-fuel powered vehicles has developed significantly and has become an inseparable and necessary part of each society. Bike sharing system is a clear example of this and is becoming of most common form of transportation among big cities. These sorts of newly emerged facilities exert positive impacts on many aspects of society and individuals lives, for instance, economy, environment, energy consumption and public health; therefore, this makes authorities and different entities investing on such means of transportation to encourage people.

Capital Bikeshare network is owned by DDOT and serves across Washington DC and other around cities and was named the biggest among its counterparts until 2013. Goldbeck and his team as bicycle programming specialist are investigating Capital Bikeshare for the betterment of its functionality and services through conducting a study based on appropriate data.

Problem Statement

Based on the data, a fluctuating demand is seen among bike station across the whole system. At the first sight it was evident that during the warmer seasons the demand saw an upward trend and on the opposite side throughout the cold months has reduced. Moreover, Goldbeck realized that other climatic changes cause influence even when daily traveling is almost the same. However, the main question which has come to the programmer team's mind was if the same behaviour was experienced during the year 2016 to 2018 as well as how this affects the overall function of the system. On the whole, the answer to these questions is at least to meet the goal of adding 40 new bike rental stations in the most possible appropriate way.

Capital Bike Share Dataset

- ✓ A large dataset
- ✓ Providing information related to 3 consecutive years (2016,2017,2018)
- ✓ Gives us information about last 3 months for 2016, whole year of 2017 and first 9 months of 2018
- ✓ For the above mentioned years, majority of data is sorted into:

1) Number of rented bikes 2) climatic effective factors

| year | month | day | hour | member | weekend | season | temperature | dewpoint | humidity | windspeed | windgust | pressure | precip | precipaccu | weather | rental |
|------|-------|-----|------|--------|---------|--------|-------------|----------|----------|-----------|----------|----------|--------|------------|---------|--------|
| 2016 | 10 | 1 | 0 | 80 | 1 | fall | 18.33 | 65 | 100 | 6 | 0 | 30.1 | 0 | 0 | 3 | 103 |
| 2016 | 10 | 1 | 1 | 53 | 1 | fall | 17.78 | 64 | 100 | 10 | 0 | 30.1 | 0 | 0 | 3 | 63 |
| 2016 | 10 | 1 | 2 | 27 | 1 | fall | 17.78 | 64 | 100 | 10 | 0 | 30.1 | 0 | 0 | 3 | 33 |
| 2016 | 10 | 1 | 3 | 20 | 1 | fall | 17.78 | 64 | 100 | 10 | 0 | 30.1 | 0.1 | 0 | 3 | 23 |
| 2016 | 10 | 1 | 4 | 11 | 1 | fall | 17.78 | 64 | 100 | 9 | 0 | 30.1 | 0 | 0 | 3 | 11 |
| 2016 | 10 | 1 | 5 | 14 | 1 | fall | 17.78 | 64 | 100 | 9 | 0 | 30.1 | 0 | 0 | 3 | 15 |
| 2016 | 10 | 1 | 6 | 38 | 1 | fall | 17.78 | 64 | 100 | 12 | 0 | 30.1 | 0 | 0 | 3 | 42 |
| 2016 | 10 | 1 | 7 | 104 | 1 | fall | 17.78 | 64 | 100 | 13 | 0 | 30.1 | 0 | 0 | 3 | 115 |
| 2016 | 10 | 1 | 8 | 133 | 1 | fall | 17.78 | 64 | 100 | 14 | 0 | 30.1 | 0 | 0.2 | 3 | 146 |
| 2016 | 10 | 1 | 9 | 145 | 1 | fall | 17.78 | 63.5 | 98 | 9 | 0 | 30.1 | 0.05 | 0 | 3 | 174 |
| 2016 | 10 | 1 | 10 | 228 | 1 | fall | 17.78 | 63.5 | 98 | 8.75 | 0 | 30.1 | 0.08 | 0 | 3 | 272 |
| 2016 | 10 | 1 | 11 | 353 | 1 | fall | 18.61 | 64.5 | 96.5 | 10 | 0 | 30.1 | 0 | 0 | 2 | 477 |
| 2016 | 10 | 1 | 12 | 382 | 1 | fall | 18.89 | 65 | 96 | 8 | 0 | 30.1 | 0 | 0 | 2 | 562 |
| 2016 | 10 | 1 | 13 | 286 | 1 | fall | 18.89 | 65.2 | 96.8 | 8 | 0 | 30.1 | 0 | 0 | 4 | 416 |
| 2016 | 10 | 1 | 14 | 326 | 1 | fall | 19.31 | 66 | 97.75 | 9.75 | 0 | 30.1 | 0 | 0 | 3 | 463 |
| 2016 | 10 | 1 | 15 | 424 | 1 | fall | 18.89 | 65 | 96 | 9 | 0 | 30.1 | 0 | 0 | 2 | 625 |
| 2016 | 10 | 1 | 16 | 368 | 1 | fall | 19.07 | 65 | 95 | 9 | 0 | 30.1 | 0 | 0 | 2 | 551 |

Capital Bike Share Dataset

Below, the number of unique factor for each type of given data is provide

| | |
|-------------|------|
| year | 3 |
| month | 12 |
| day | 31 |
| hour | 24 |
| member | 1423 |
| weekend | 2 |
| season | 4 |
| temperature | 490 |
| dewpoint | 461 |
| humidity | 408 |
| windspeed | 286 |
| windgust | 191 |
| pressure | 86 |
| precip | 48 |
| precipaccum | 39 |
| weather | 4 |
| rental | 1659 |

| Feature | Description |
|------------------------|--|
| year | Year |
| month | Month |
| day | Day |
| hour | Hour of the day (using the 24-hour system) |
| member | Number of registered user rentals initiated |
| weekend | Whether the day is a weekend |
| season | Season (spring, summer, fall, or winter) |
| temperature (in °C) | |
| dewpoint | Relative dew point |
| humidity | Relative humidity |
| windspeed | Wind speed (in mph) |
| windgust | Wind gust (in mph) |
| pressure | Pressure (kPa) |
| precip | Precipitation (in inches) |
| precipaccum | Precipitation Accumulation (in inches) |
| weather | 1: fair; fair/windy; partly cloudy; partly cloudy/windy 2: mostly cloudy; mostly cloudy/windy; cloudy/cloudy windy; mist; shallow fog 3: light drizzle; light rain; light rain with thunder; light sleet/windy; light snow/windy; rain/windy; light drizzle/windy; light rain/windy; light sleet; light snow; light snow and sleet/windy; rain 4. haze; heavy rain/windy; patches of fog; snow; squalls/windy; thunderstorm/windy; thunder/windy; wintry mix; heavy rain; fog; heavy thunderstorm; snow and sleet; thunderstorm; thunder; thunder in the vicinity; wintry mix/windy |
| rental | Number of total bike rentals |

Analysis of data

The following pages provides some graphs which were generated using JUPITER notebook along with a brief explanation.

Initial Steps

- After applying datafile to jupyter notebook, to make investigate the data more clear, some columns were added to the data set:
- **nonmember** (to distinguish non-member users from members)
- **hourbyrange**(an interval for “hour” column of the dataset defines different ranges of hours.e.g. (0,6)-(6,9)-(9,15)-(15,19)-(19,24). One reason is to highlight the rush hours.)
- **temperaturebyrange**(an interval for “temperature” column of the dataset defines different temperature.e.g. (0,6)-(6,9)-(9,15)-(15,19)-(19,24).)

Initial Steps

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- **temperaturebyrange** (an interval for “temperature” column of the dataset defines different temperature.e.g. (0,6)-(6,9)-(9,15)-(15,19)-(19,24).)



| | year | member | rental | nonmember |
|-------|------|--------|--------|-----------|
| 17461 | 2018 | 416 | 541 | 125 |
| 17462 | 2018 | 278 | 379 | 101 |
| 17463 | 2018 | 233 | 301 | 68 |
| 17464 | 2018 | 148 | 203 | 55 |
| 17465 | 2018 | 83 | 113 | 30 |

| | year | temperature | temperaturebyrange |
|-------|------|-------------|--------------------|
| 17461 | 2018 | 21.67 | (20, 30] |
| 17462 | 2018 | 21.67 | (20, 30] |
| 17463 | 2018 | 21.11 | (20, 30] |
| 17464 | 2018 | 20.00 | (10, 20] |
| 17465 | 2018 | 20.00 | (10, 20] |



| | year | day | hour | hourbyrange |
|-------|------|-----|------|--------------|
| 17461 | 2018 | 30 | 19 | (15.0, 19.0] |
| 17462 | 2018 | 30 | 20 | (19.0, 24.0] |
| 17463 | 2018 | 30 | 21 | (19.0, 24.0] |
| 17464 | 2018 | 30 | 22 | (19.0, 24.0] |
| 17465 | 2018 | 30 | 23 | (19.0, 24.0] |

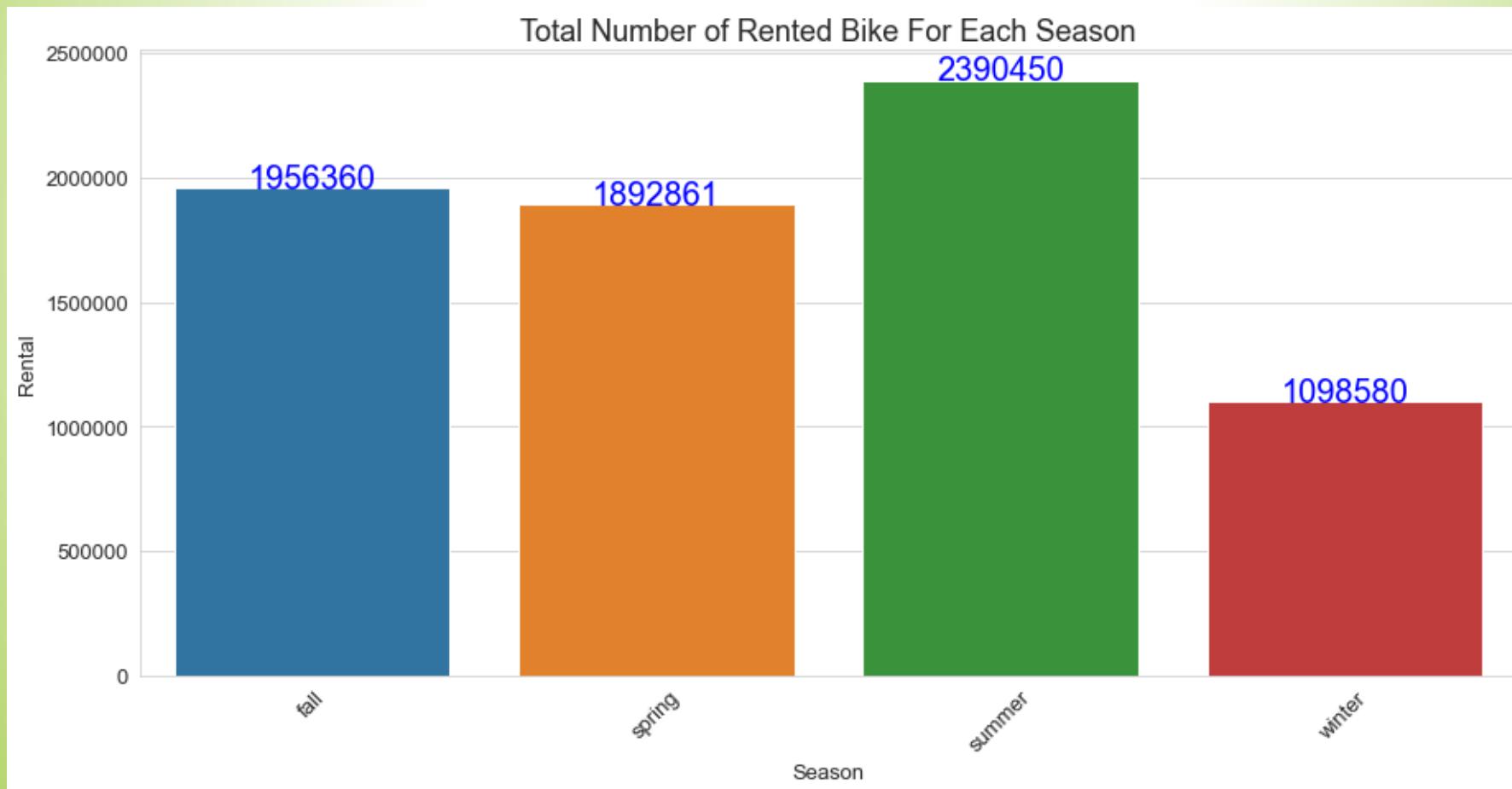


Number of Rentals Per Year and Season

In the next slides we can observe the whole number of rentals for each year as well as each month
Moreover, we can see the pattern how many rentals were by members and nonmembers

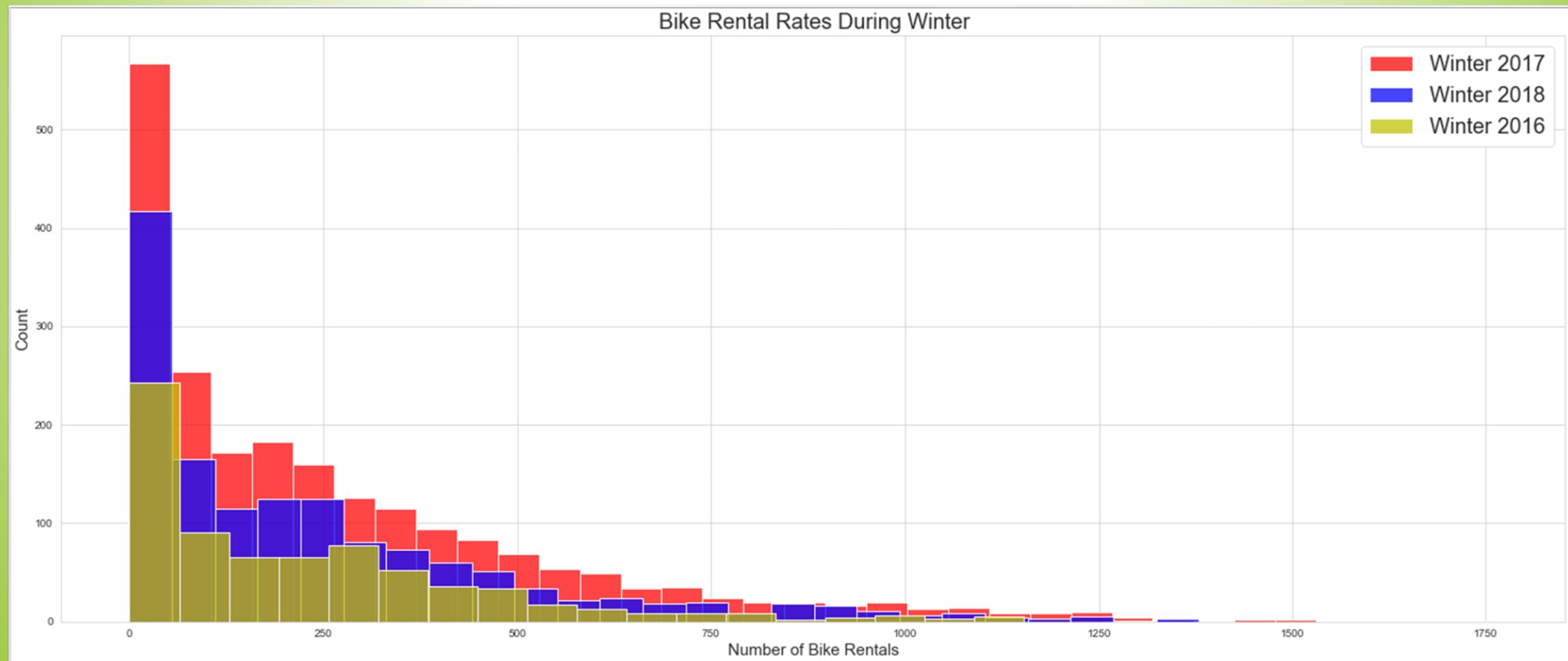
Analysis of data

- *Total Number of Rented Bike for each season during 3 years of study.*
- *During summers, the number of rented bikes is the most 2,390,450 as oppose to the winters with 1,0985,580.*



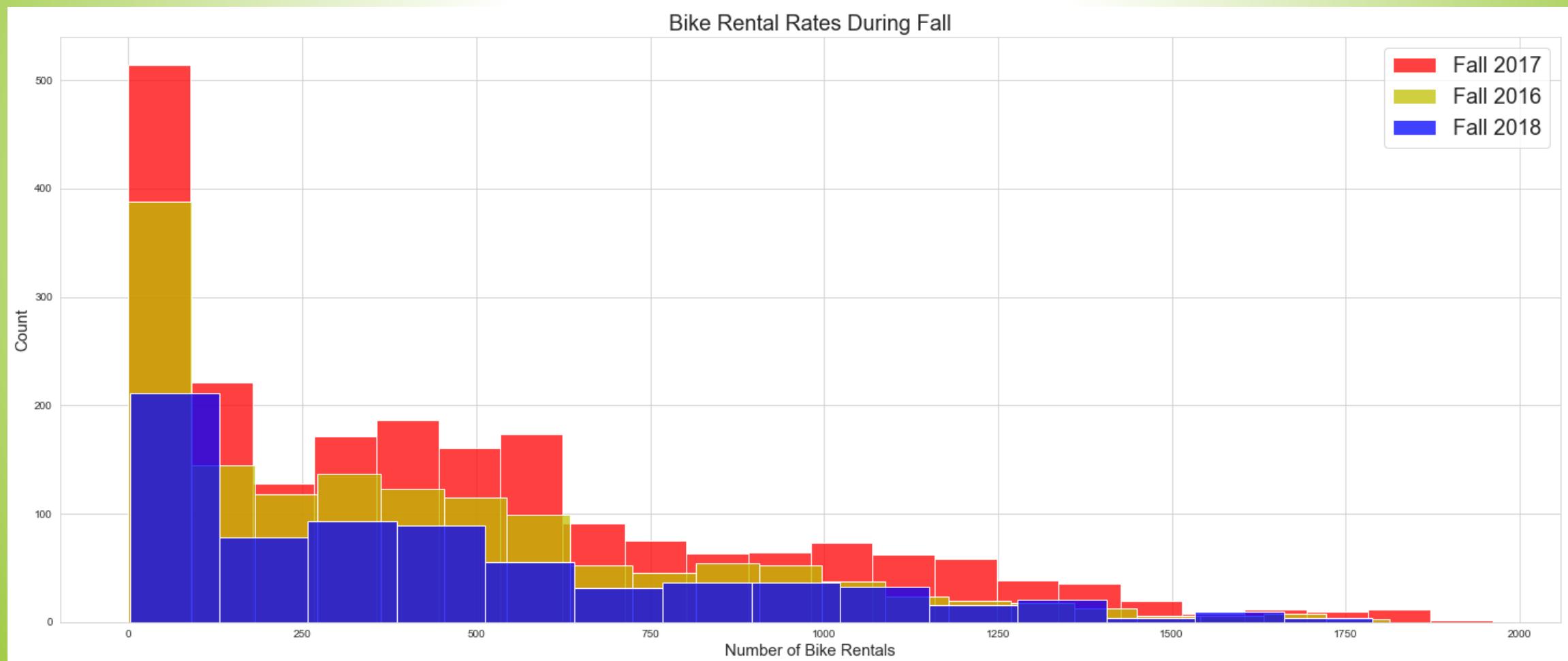
Analysis of data

- Seasonal rate of bike rental (winters)
- Year of 2017 is ranked the top



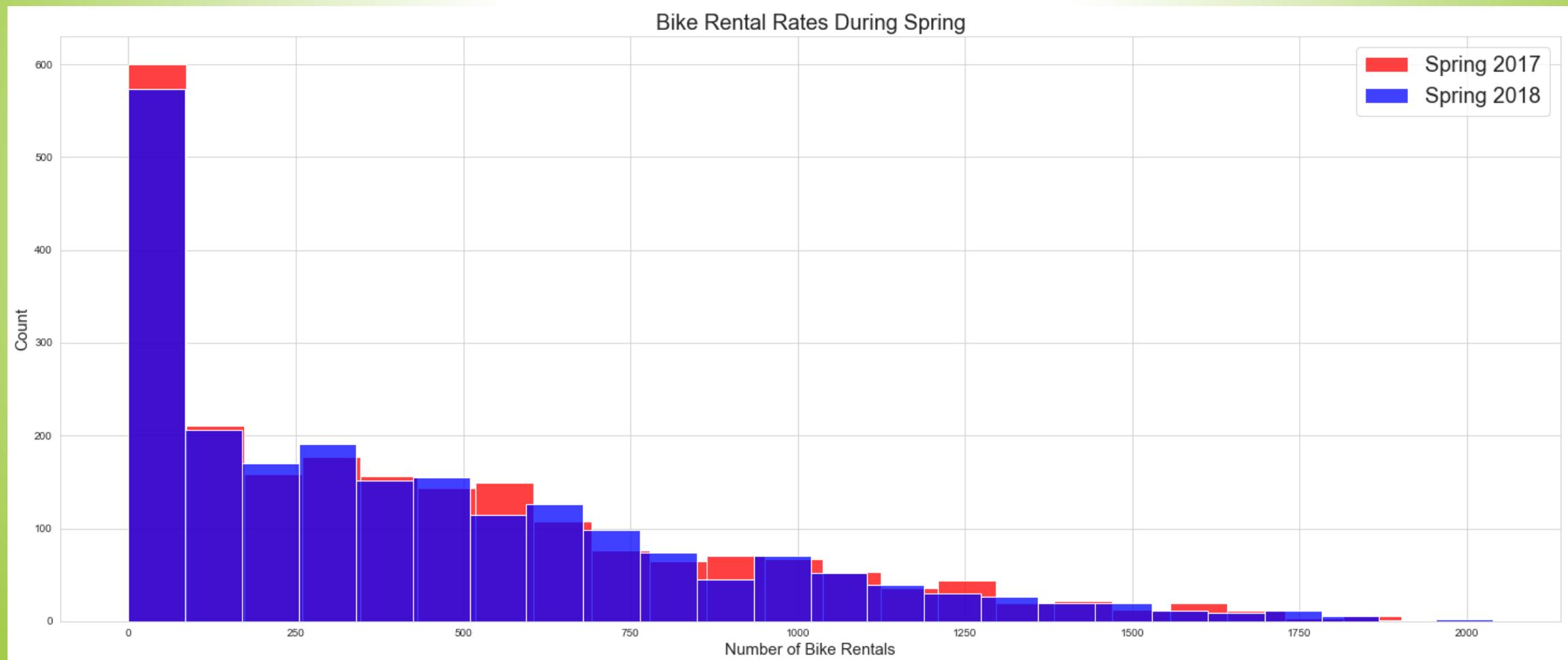
Analysis of data

- Seasonal rate of bike rental (*falls*)
- Year of 2017 is ranked the top



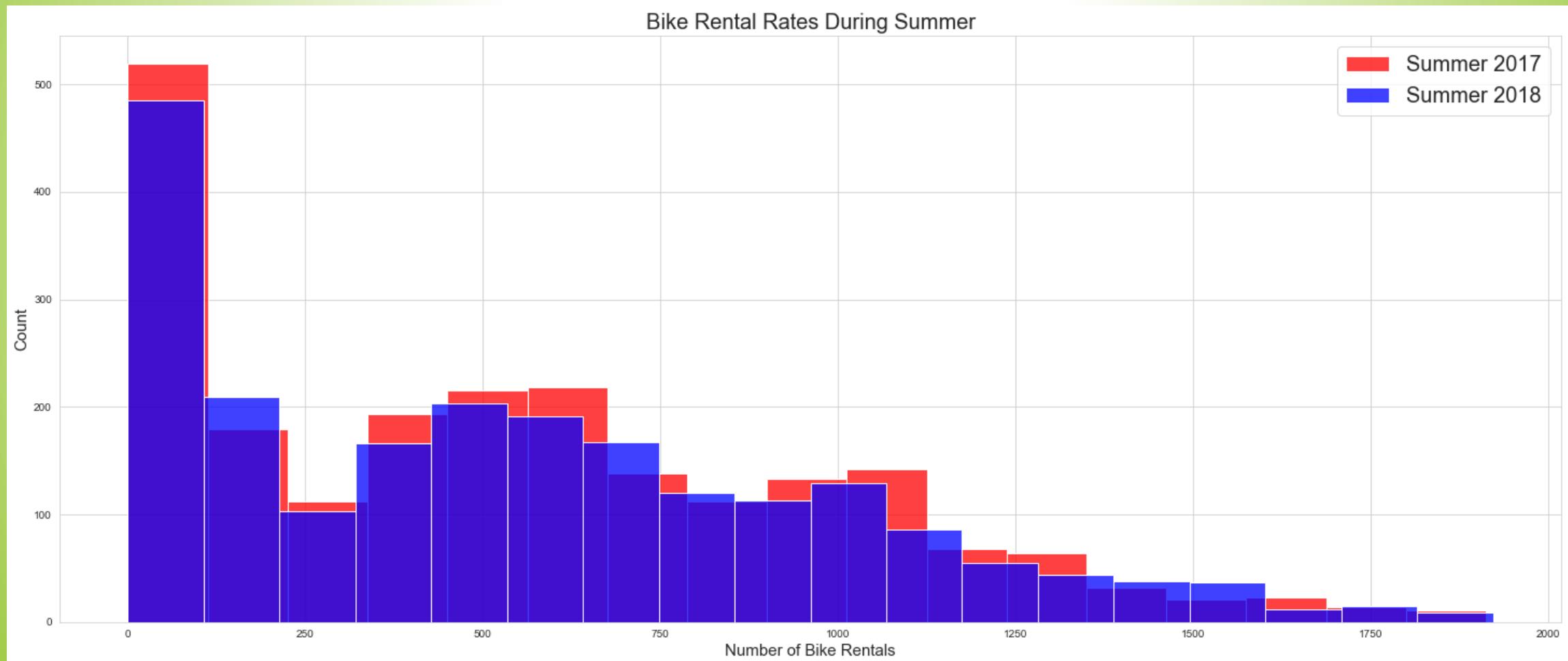
Analysis of data

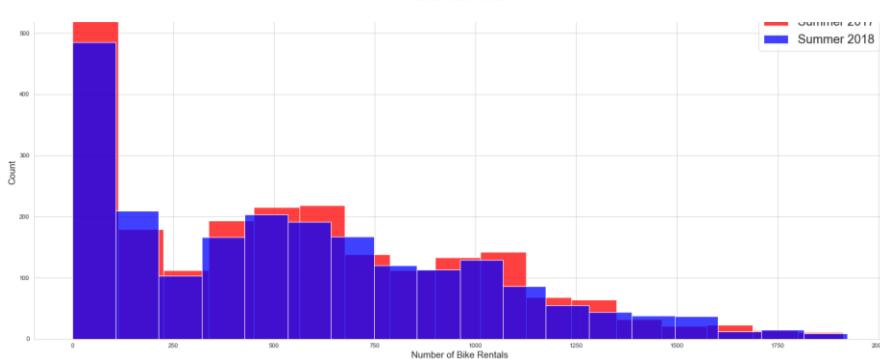
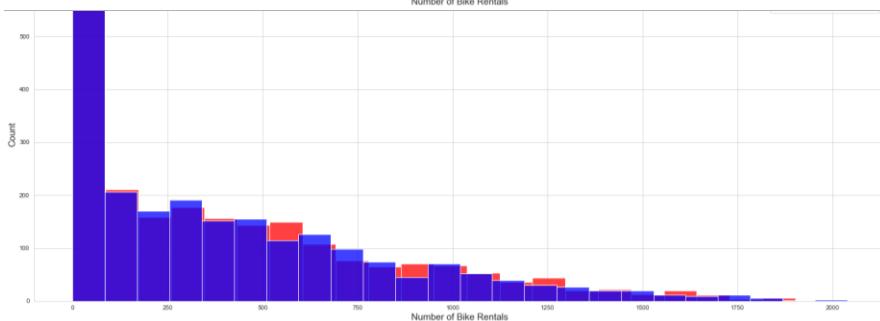
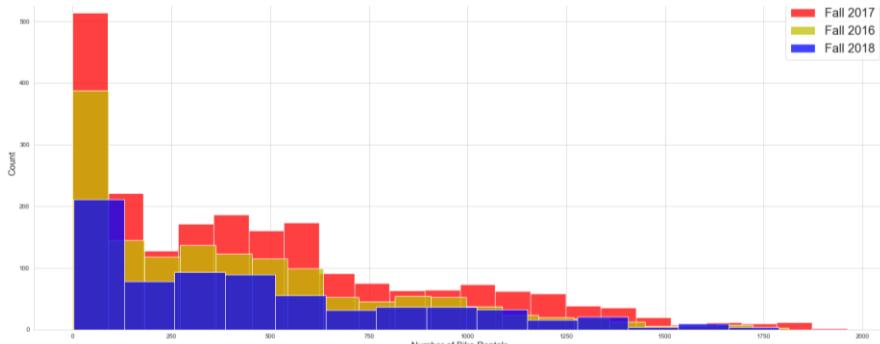
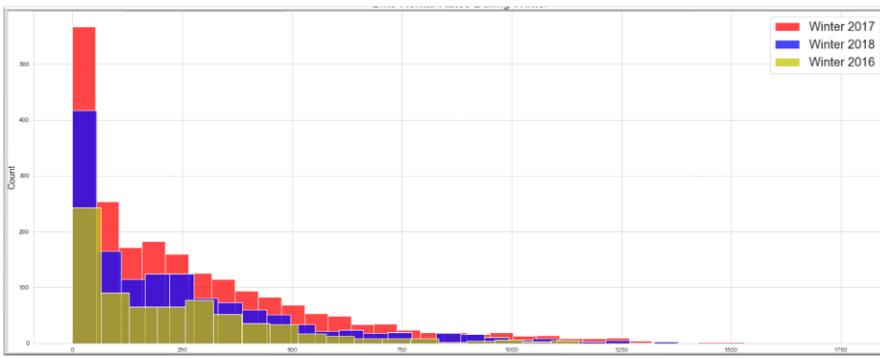
- Seasonal rate of bike rental (*Springs*)
- Only between 2017 and 2018.



Analysis of data

- Seasonal rate of bike rental (*Summers*)
- Only between 2017 and 2017.



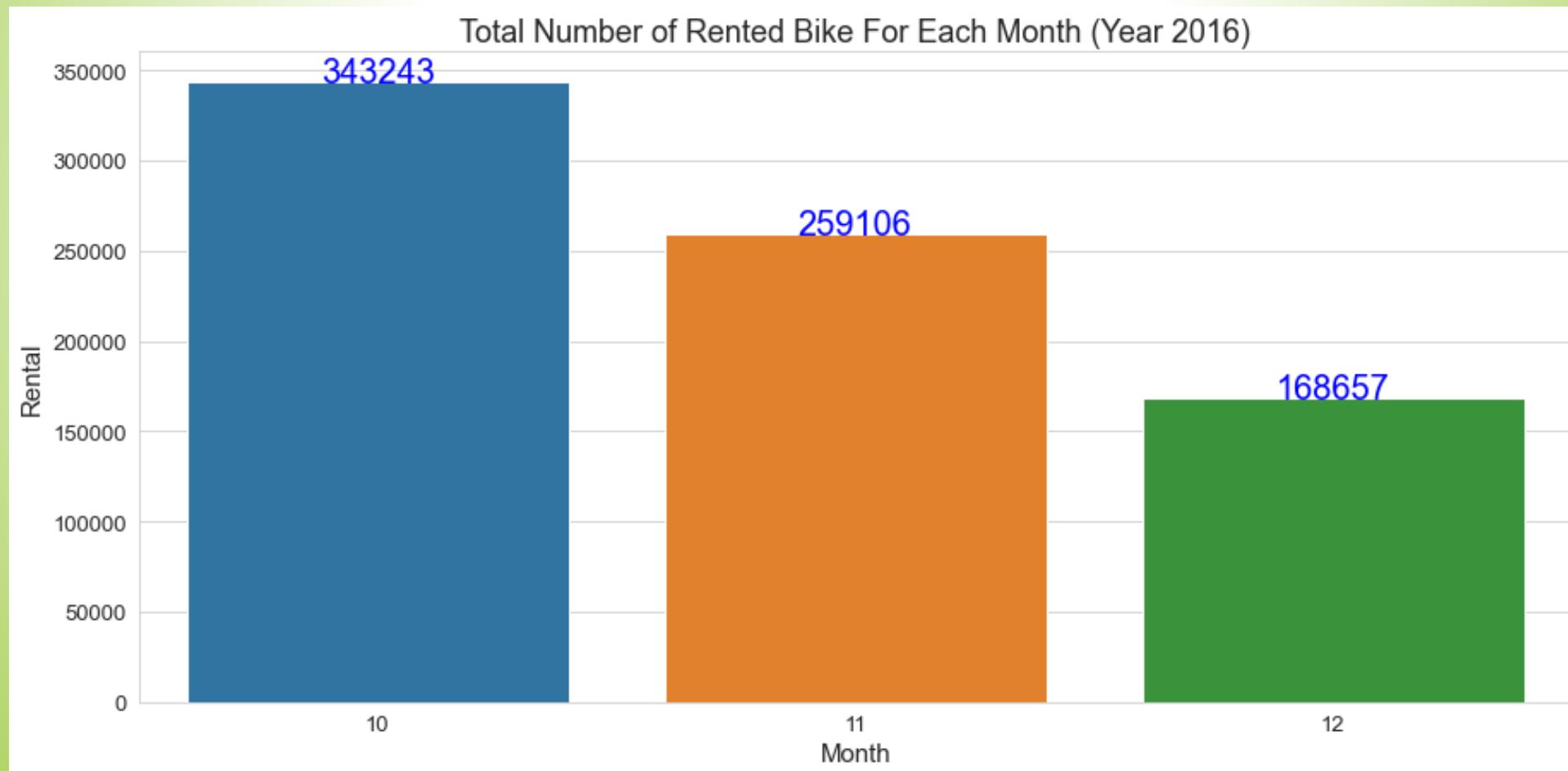


Conclusion

- ▶ Therefore; base on the dataset, because we have the whole year data for 2017, for all seasons, year of 2017 is ranked the top for Bike Rental Rate.
- ▶ Bike Rental Rate during 2017 and 2018 is almost the same for summer and spring.

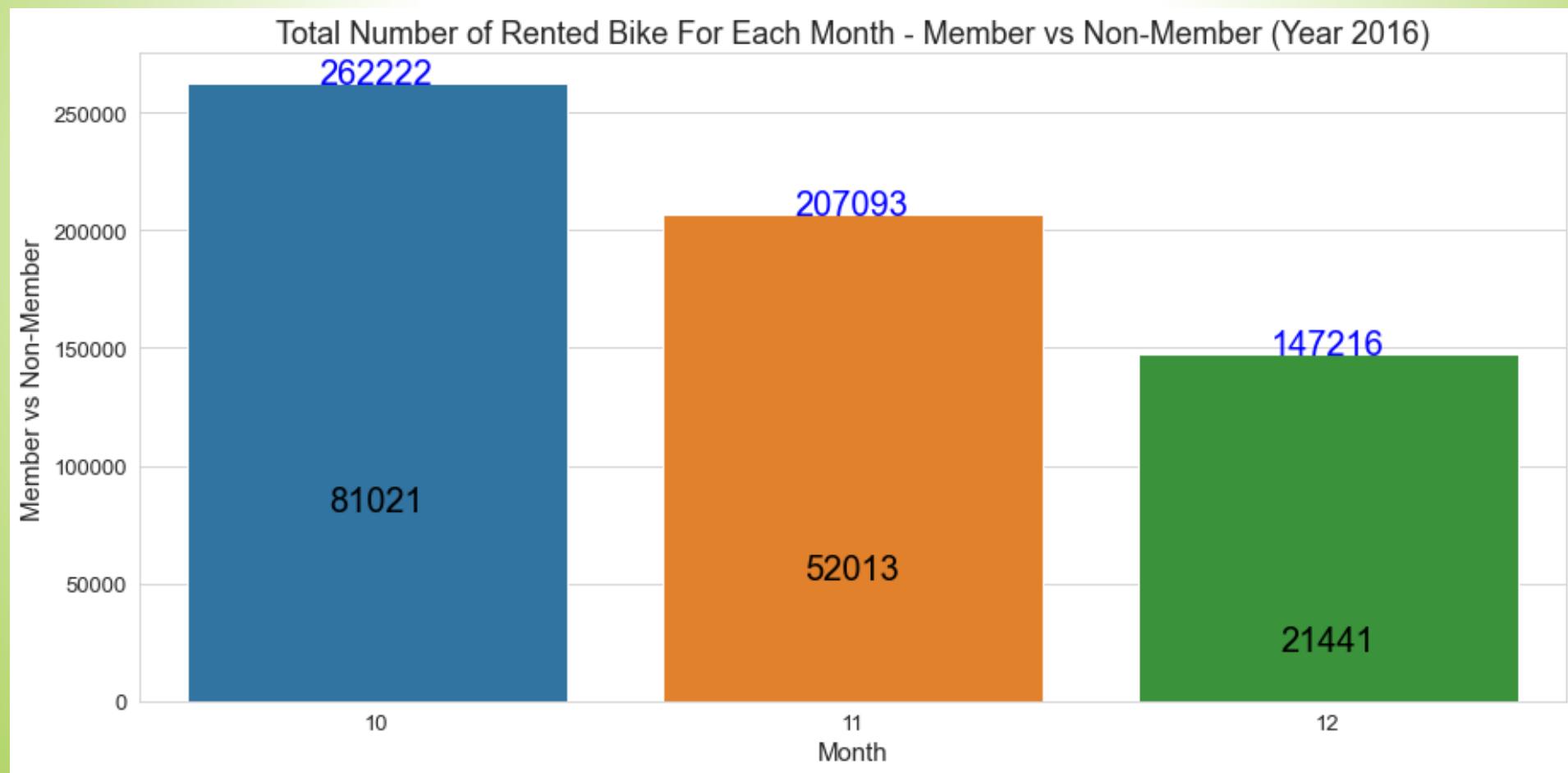
Analysis of data

- *Total Number of Rented Bike for each month during year of 2016.*
- *During October, more bikes are rented*
- *As we go further, this rate is decreasing*



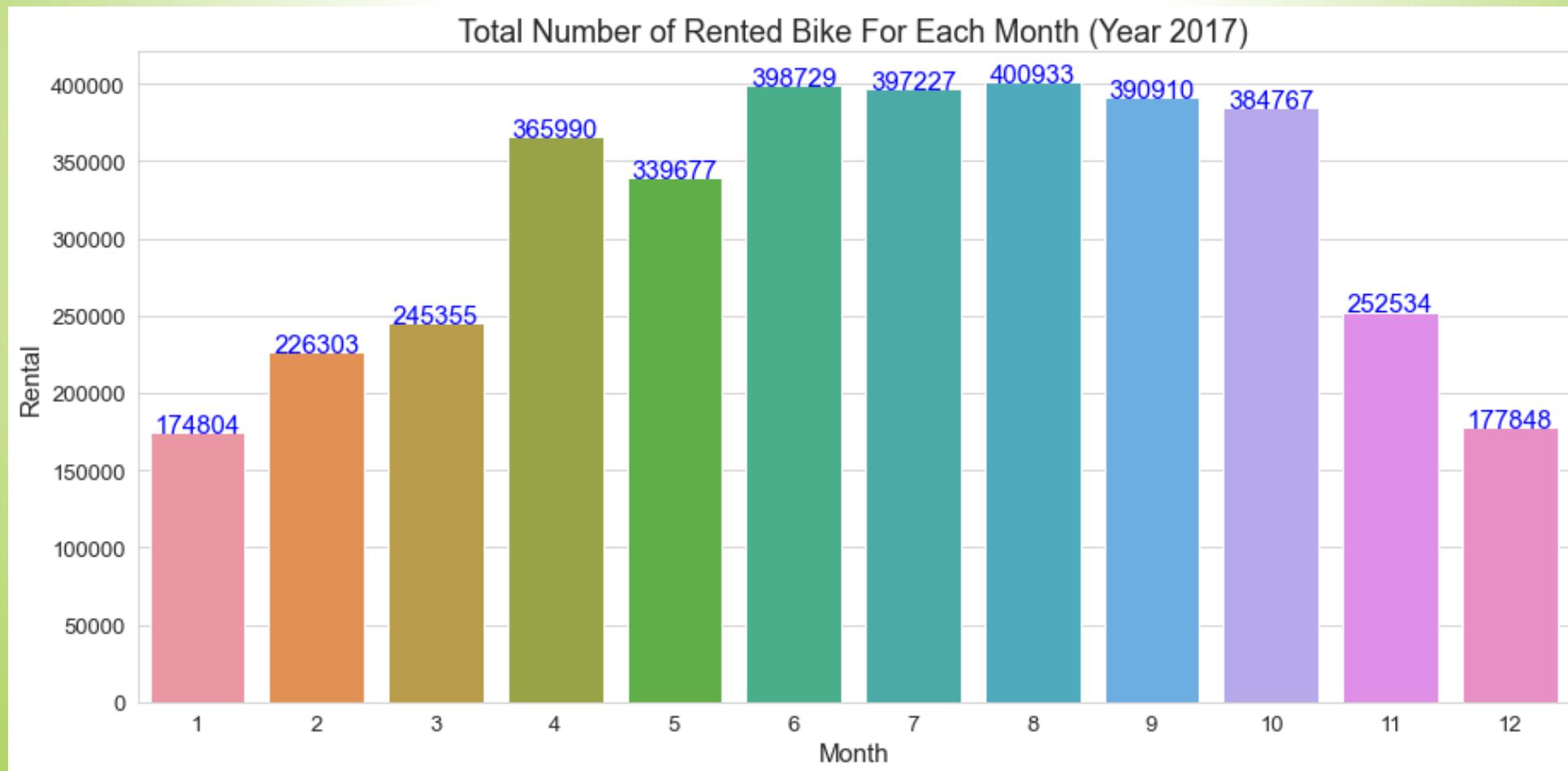
Analysis of data

- *Total Number of Rented Bike by (Members and Non-members) for each month during year of 2016.*



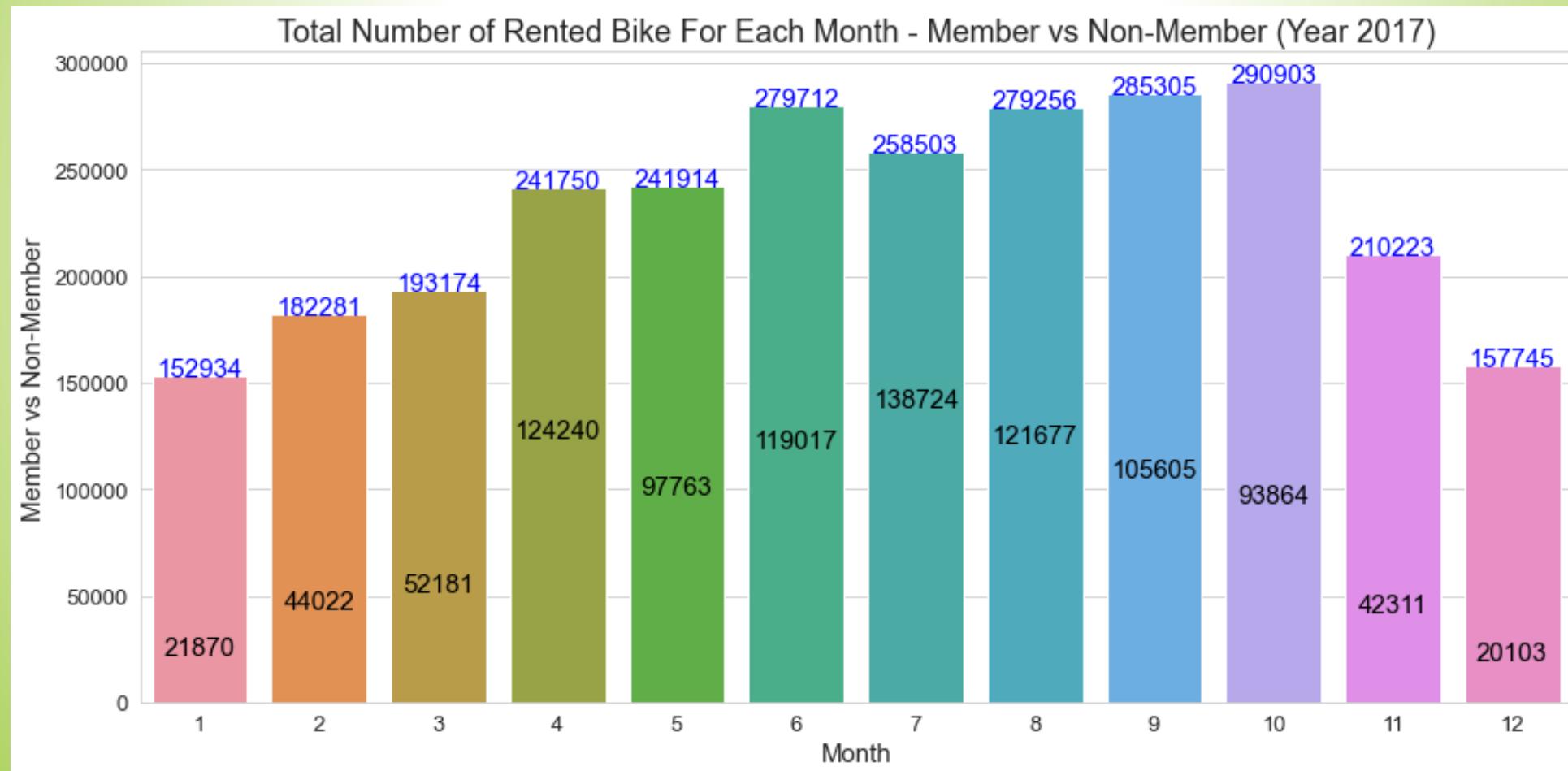
Analysis of data

- *Total Number of Rented Bike for each month during year of 2017.*
- *From June to October, rental rate is almost the same and on top of the rest of the year (around 400K)*
- *Less bikes were rented during January, November and December*



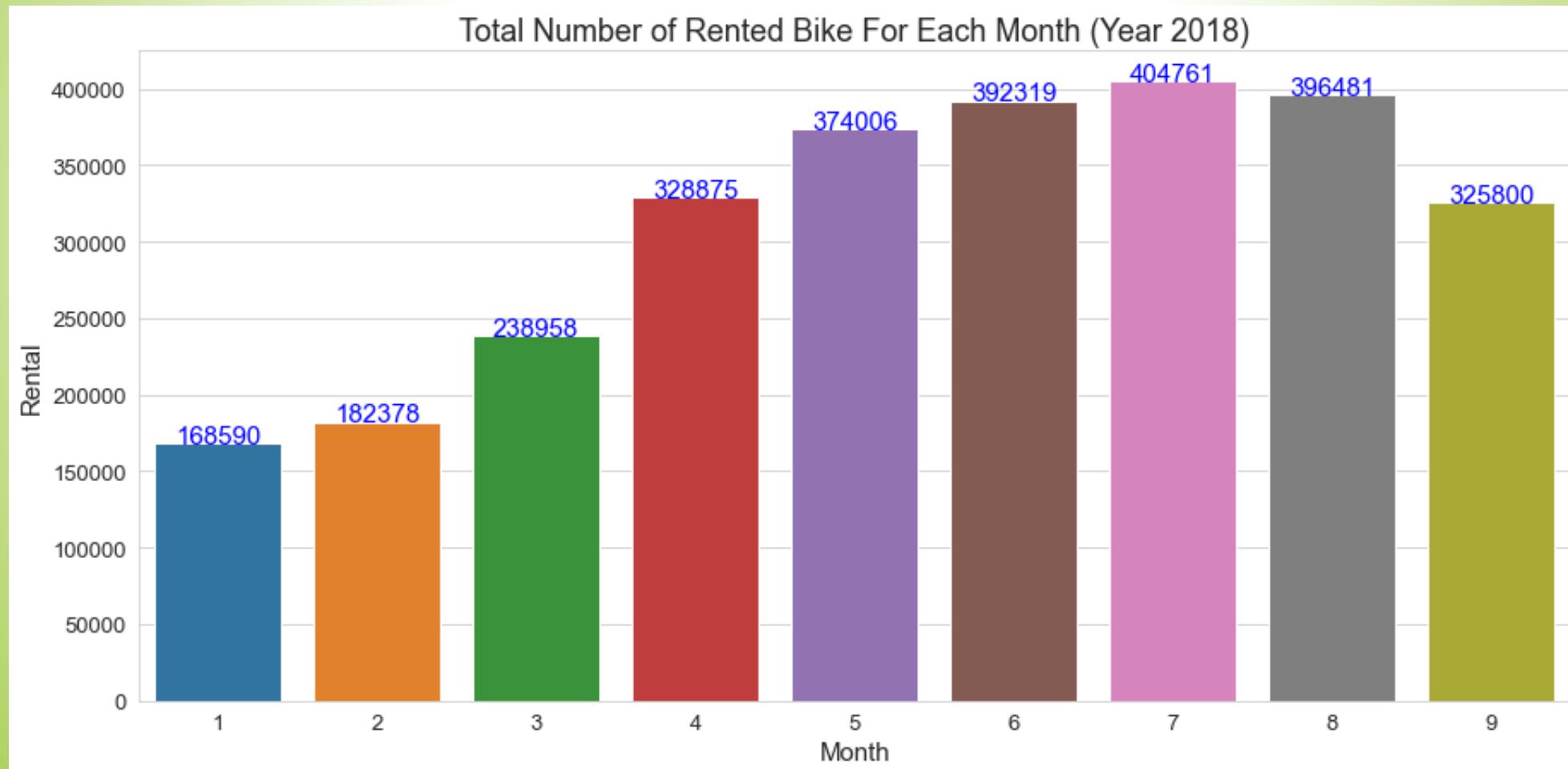
Analysis of data

- *Total Number of Rented Bike by (Members and Non-members) for each month during year of 2016*



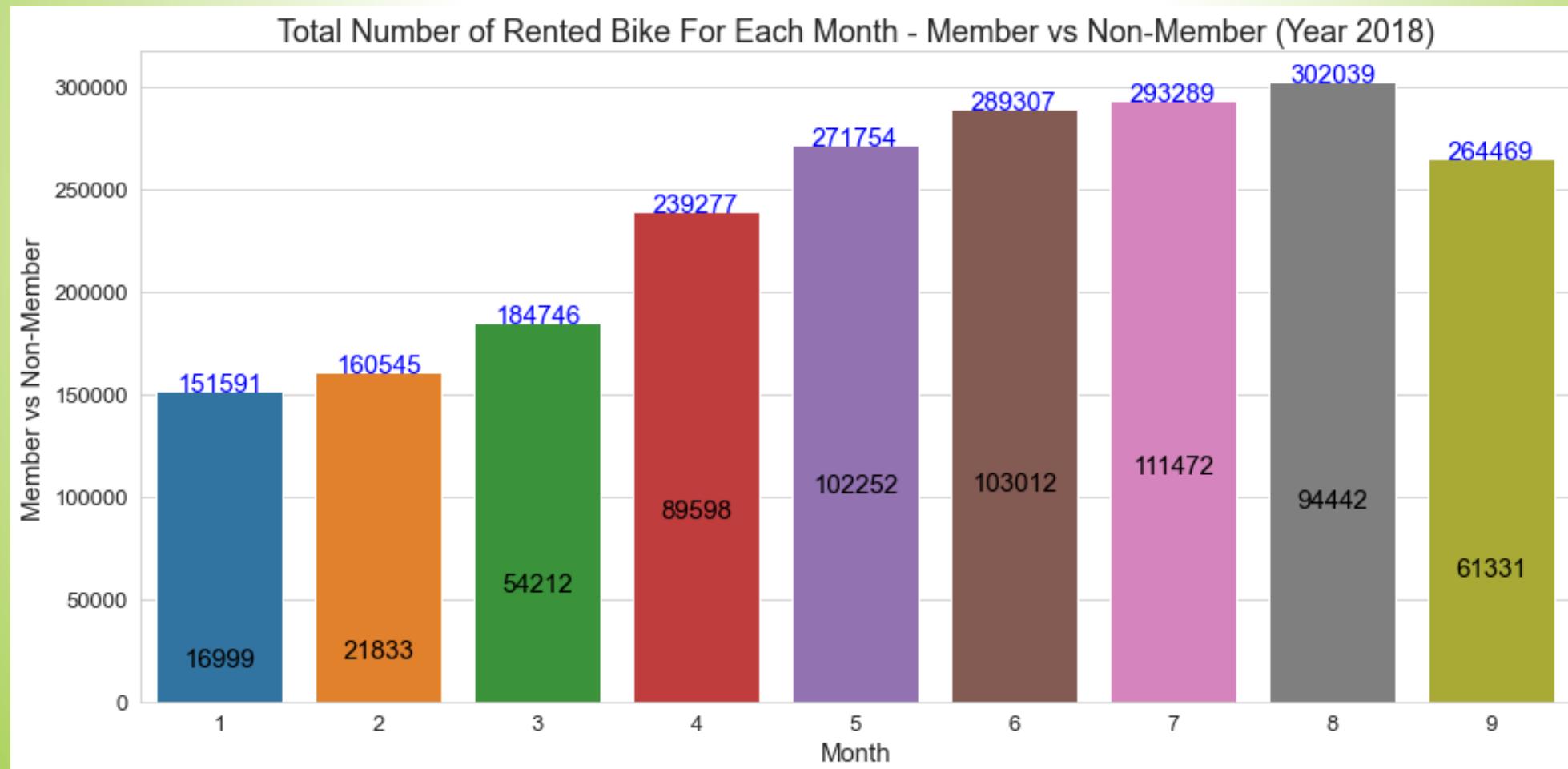
Analysis of data

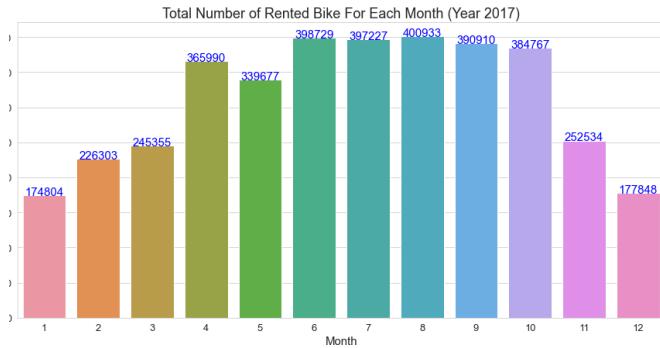
- *Total Number of Rented Bike for each month during year of 2018.*
- *From May to August, rental rate is almost the same and on top of the rest of the year (around 400K)*
- *Rental rates saw a decrease in September comparing with 2017*



Analysis of data

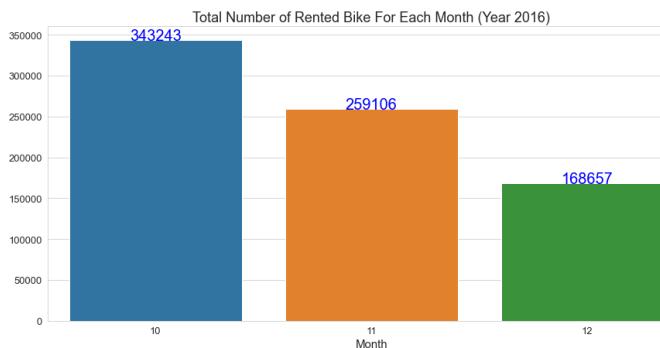
- *Total Number of Rented Bike by (Members and Non-members) for each month during year of 2018*

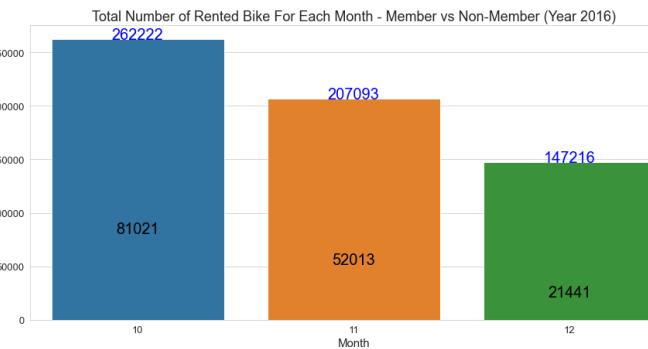
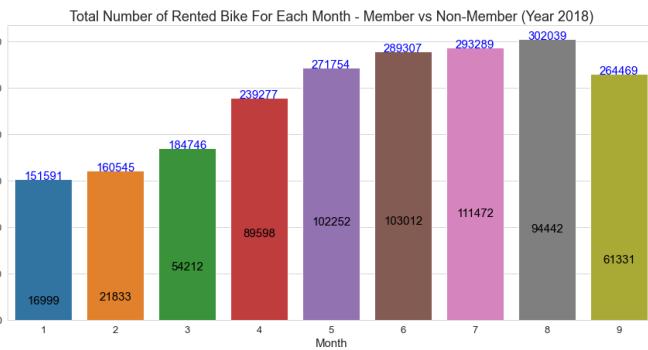
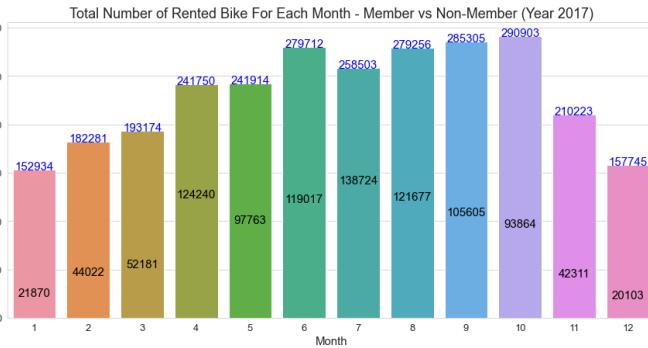




Conclusion

- ▶ During the whole period of study, more bikes were rented in July 2018 followed by June 2017 and August 2017 by 404.761K , 398.729K and 396.481K, respectively.





Conclusion

- ▶ During the whole period of study, non-members rental rates almost follows the same pattern as the members.
- ▶ Least number of bikes were rented in January 2018 by both group of users with 151.591K and 16.999K for members and non-members respectively.

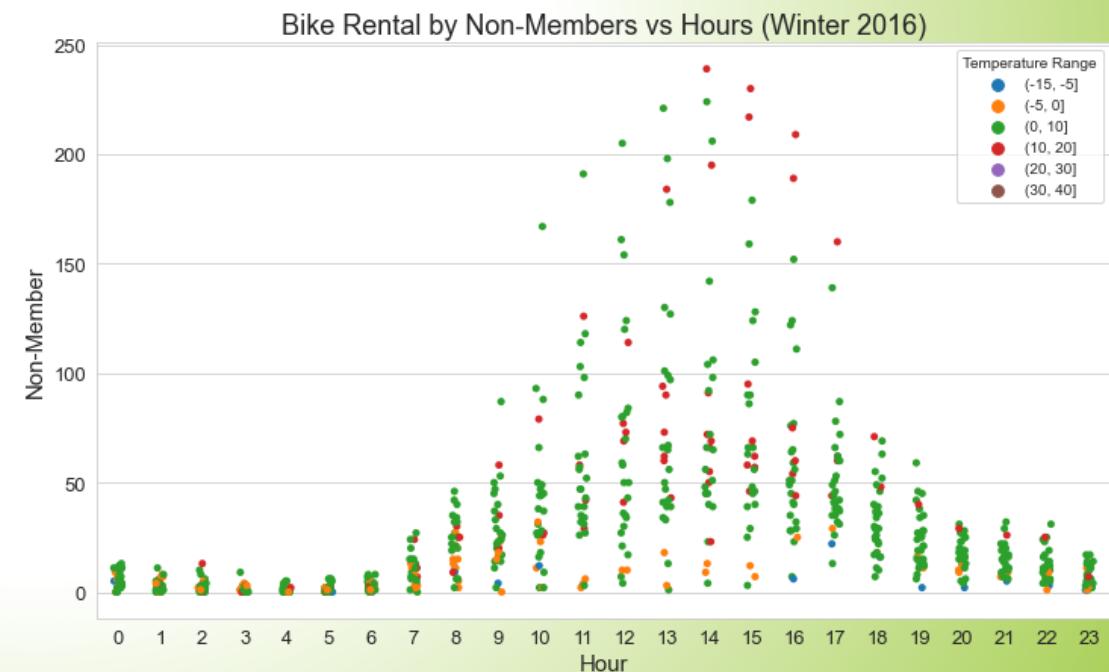
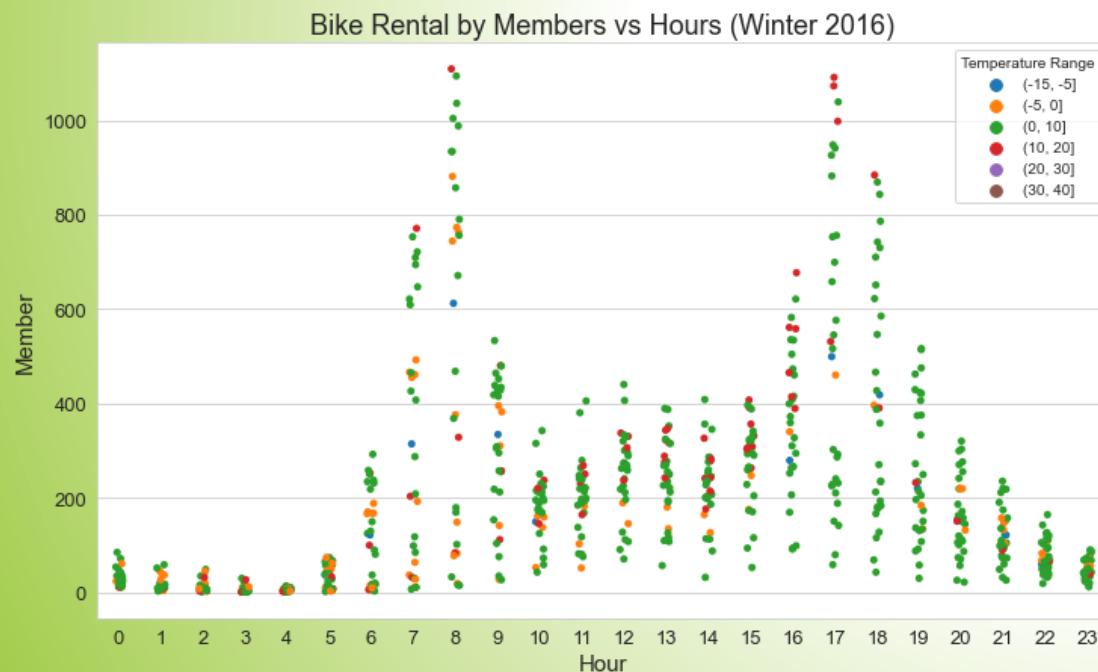
Seasonal and Temperature Changes

In the next slides we can observe that :

- For each season, how was the temperature (in Celsius) during 24 hours and how many were the rentals for both members and nonmembers
- How bike rental rates is affected by the temperature and humidly level (0 to 100)

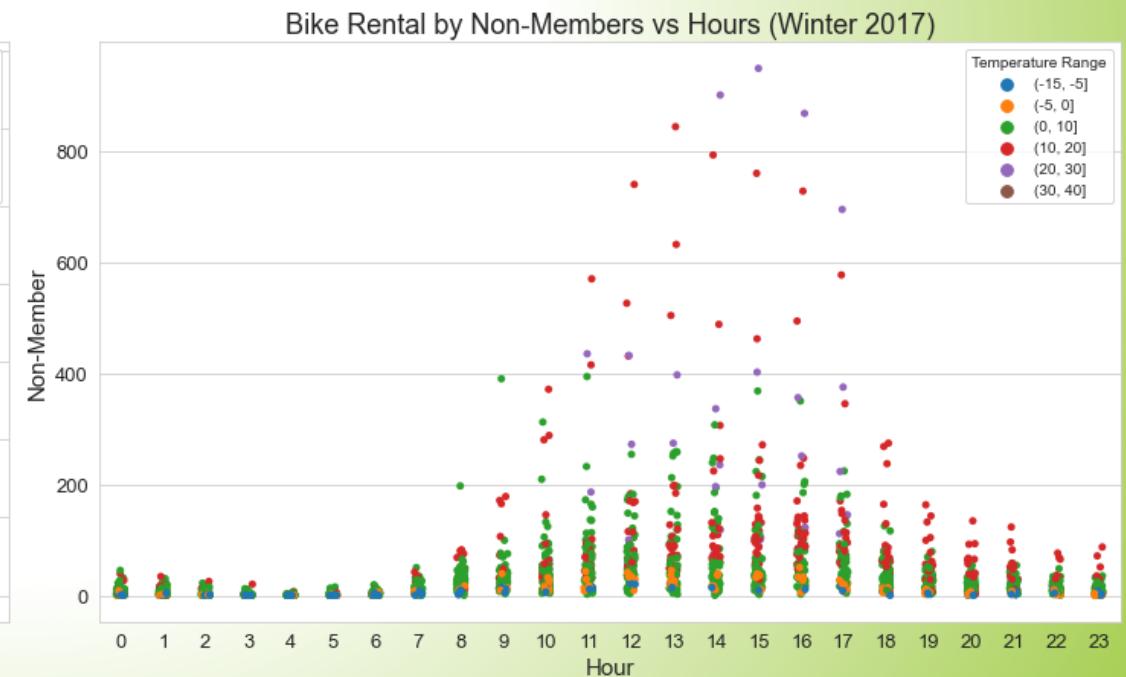
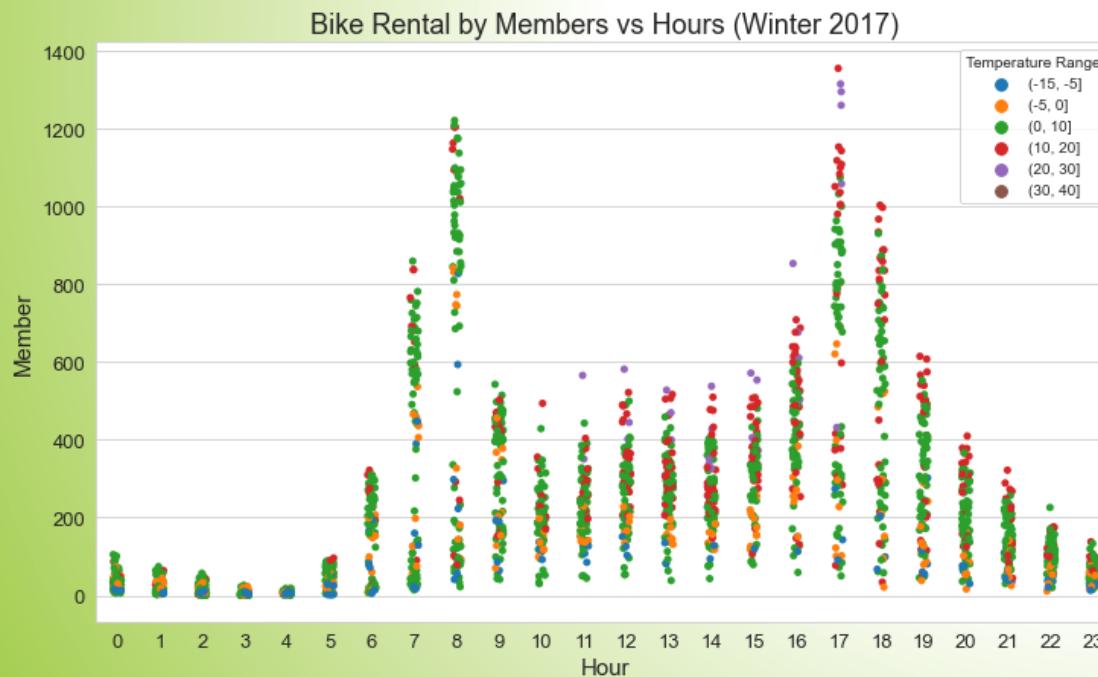
Winter 2016

- Data provided only for January and February
- The temperature mostly was between 0 to 10
Bike rentals were rare during colder days (-15 to -5 Celsius)
- Rental by members was higher among (7am to 8am) and (16 to 18) compare to rest of the day
- Nonmembers rented more around (10am to 16)



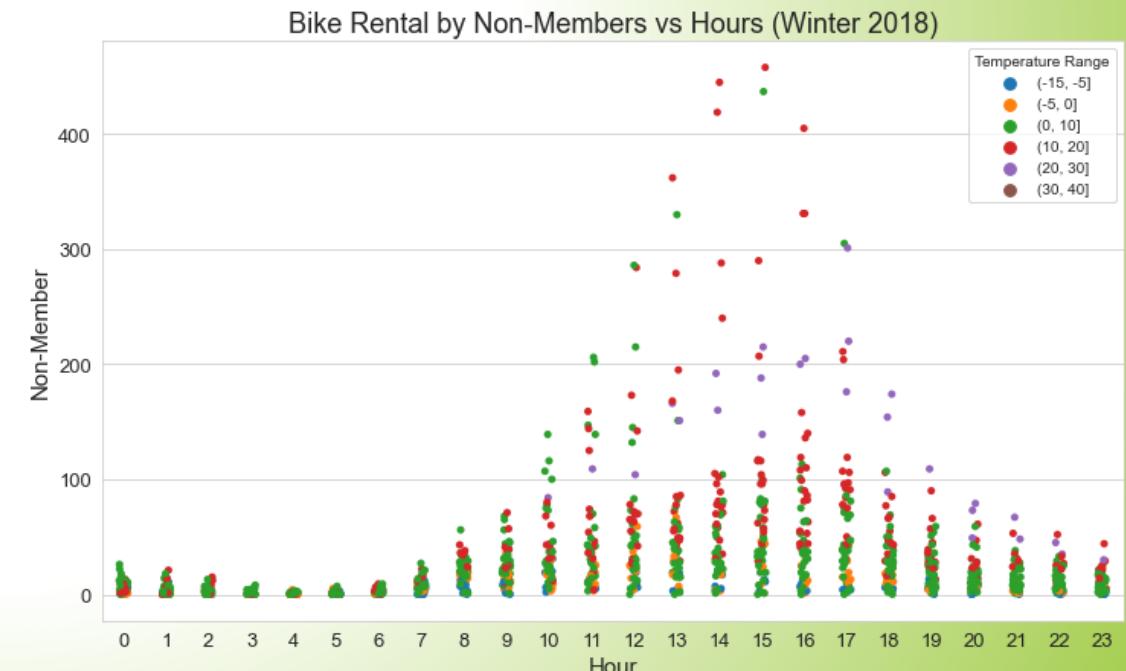
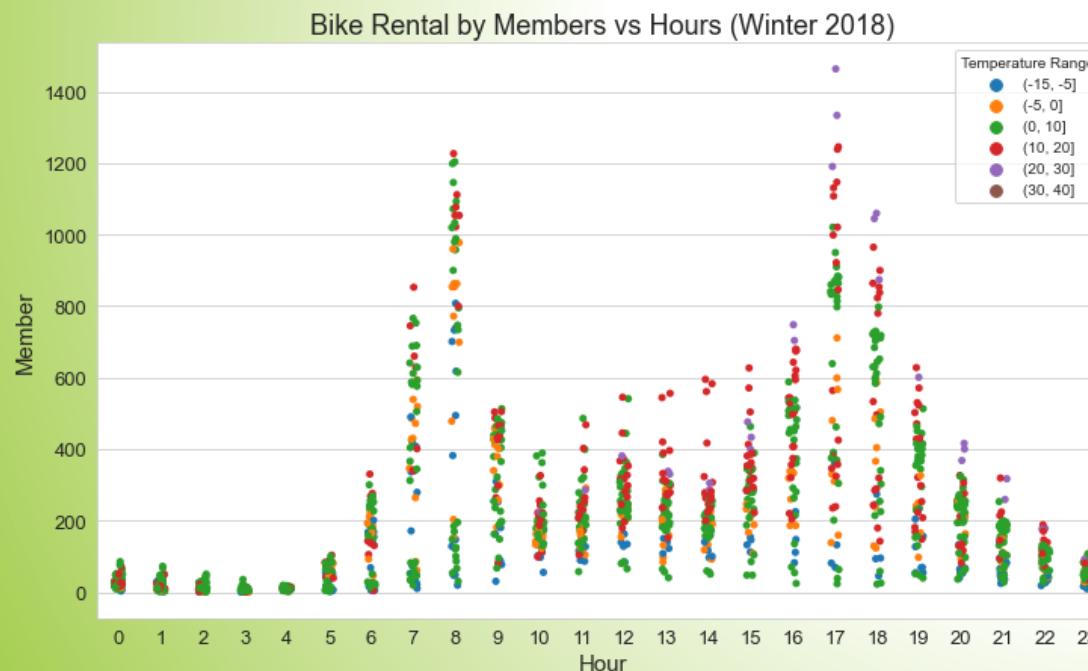
Winter 2017

- The temperature mostly was between 0 to 10
Bike rentals were rare during colder days (-15 to -5 Celsius)
- In this year base on dataset, more number of cold days are recorded compare to 2016
- Rental by members was higher among (7am to 8am) and (16 to 18) compare to rest of the day
- Nonmembers rented more around (10am to 16)



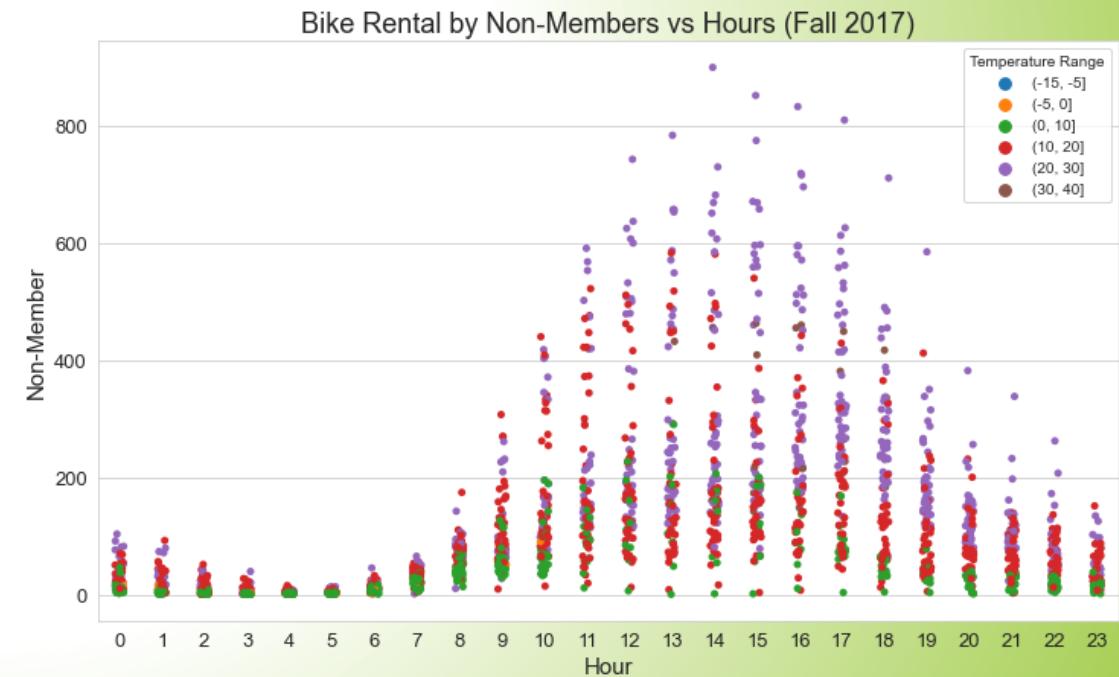
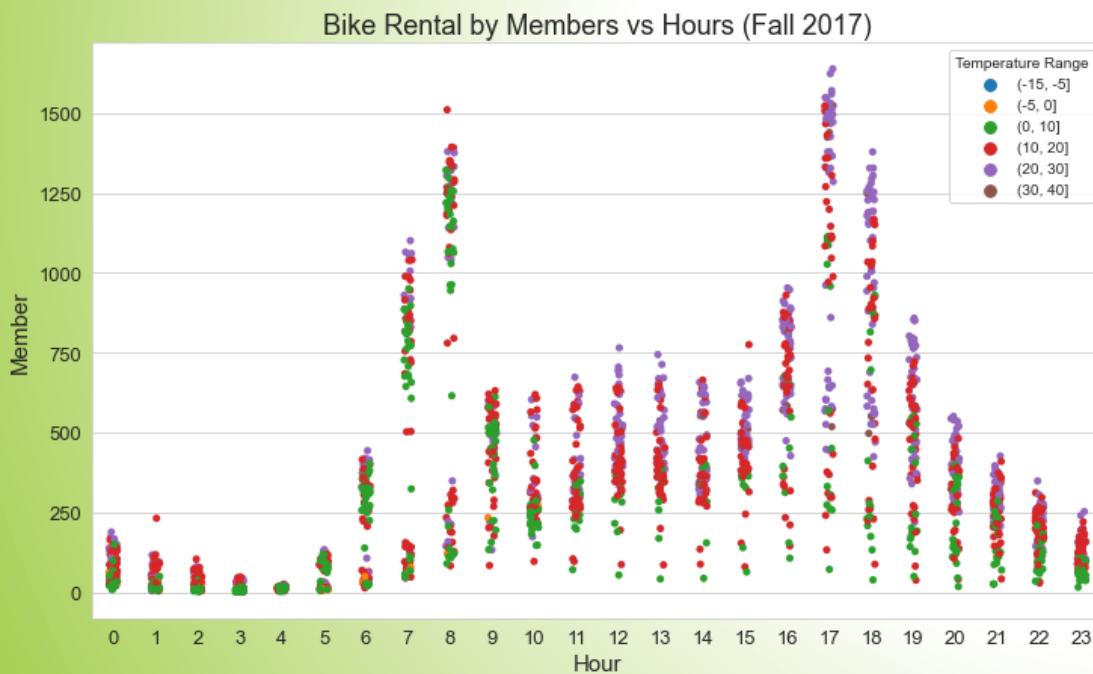
Winter 2018

- Warmer days were recorder compare to the previous years (more red points)
Bike rentals were rare during colder days (-15 to -5 Celsius)
- In this year base on dataset, more number of cold days are recorded compare to 2016
- Rental by members was higher among (7am to 8am) and (16 to 18) compare to rest of the day
- Nonmembers rented more around (15am to 17)



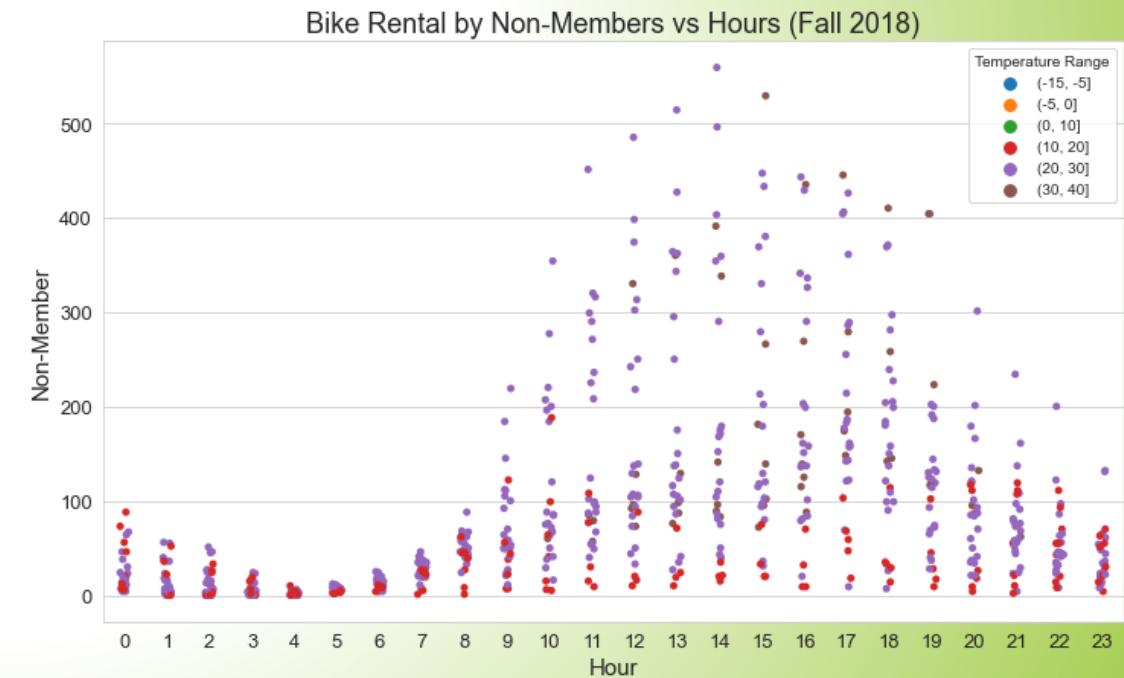
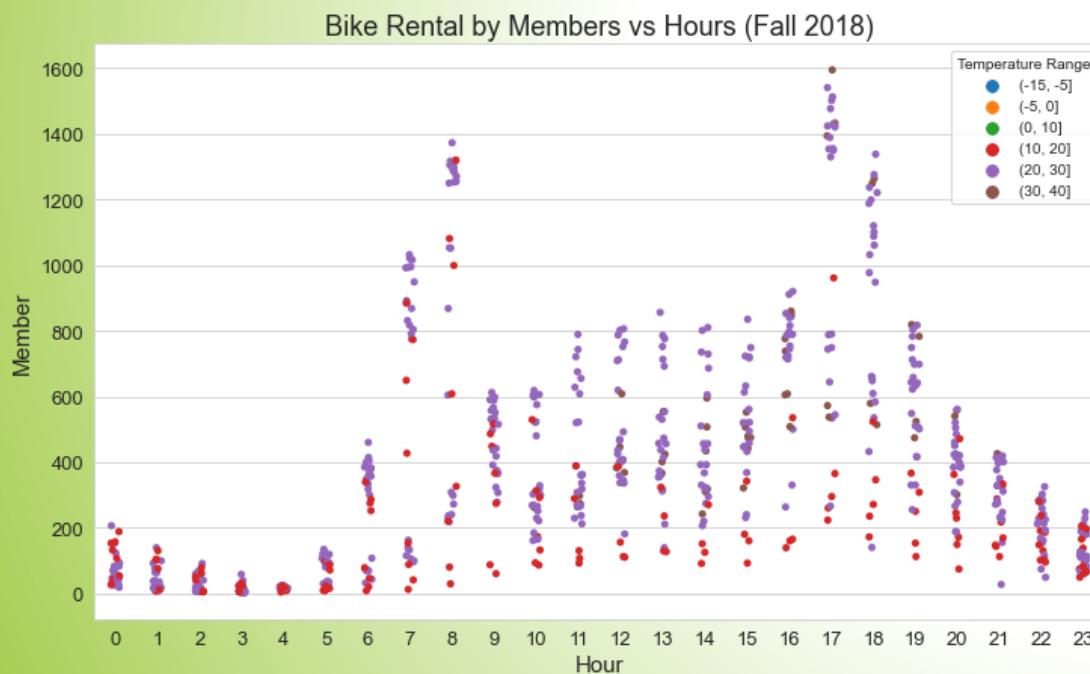
Fall 2017

- Rentals increased compare to winter
- The temperature mostly was between 10 to 20
- Rental by members was higher among (7am to 8am) and (16 to 19) compare to rest of the day
- Nonmembers rented more around (13am to 17)



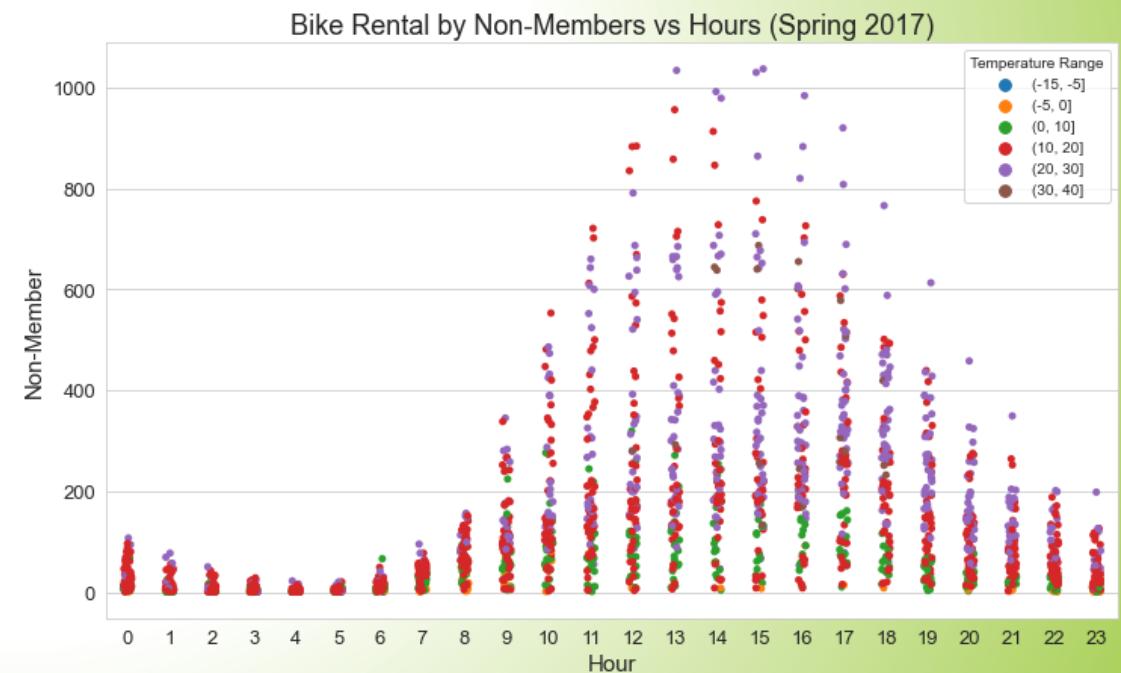
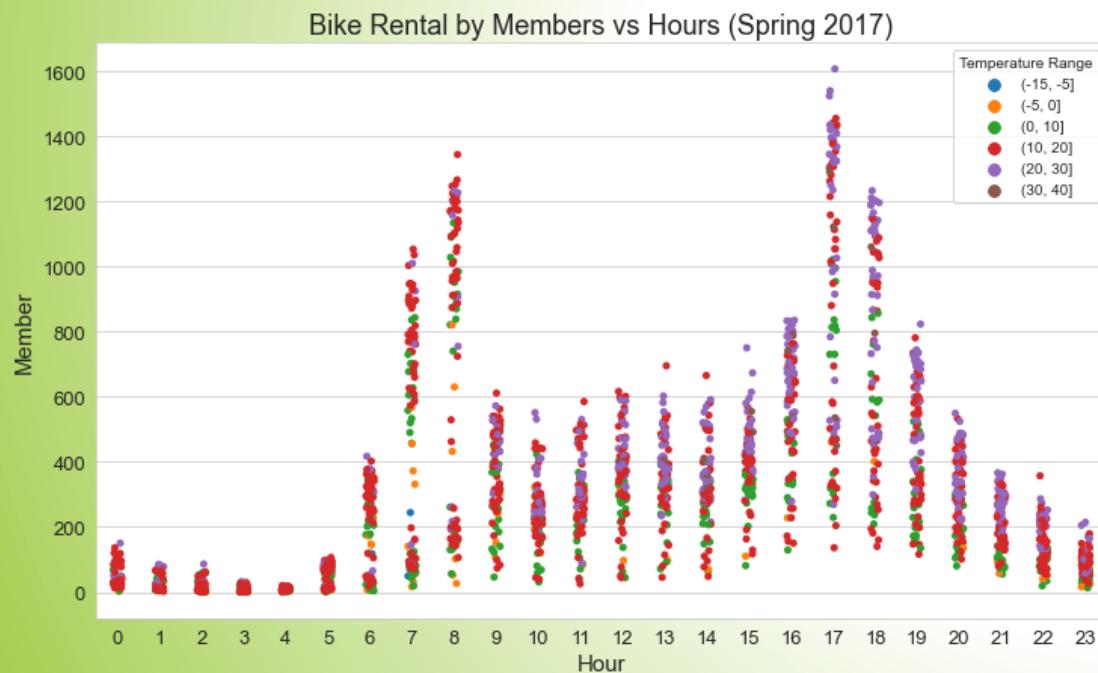
Fall 2018

- Data provided only for September
- Rentals increased compare to winter
- The temperature mostly was between 20 to 30
- Rental by members was higher among (7am to 8am) and (16 to 19)



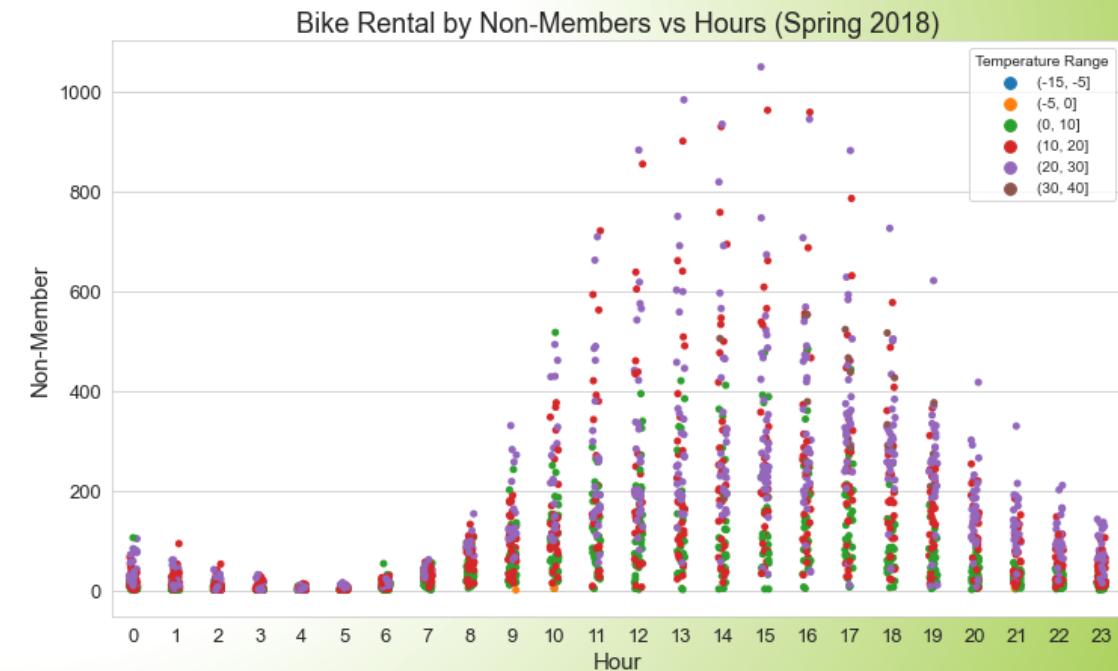
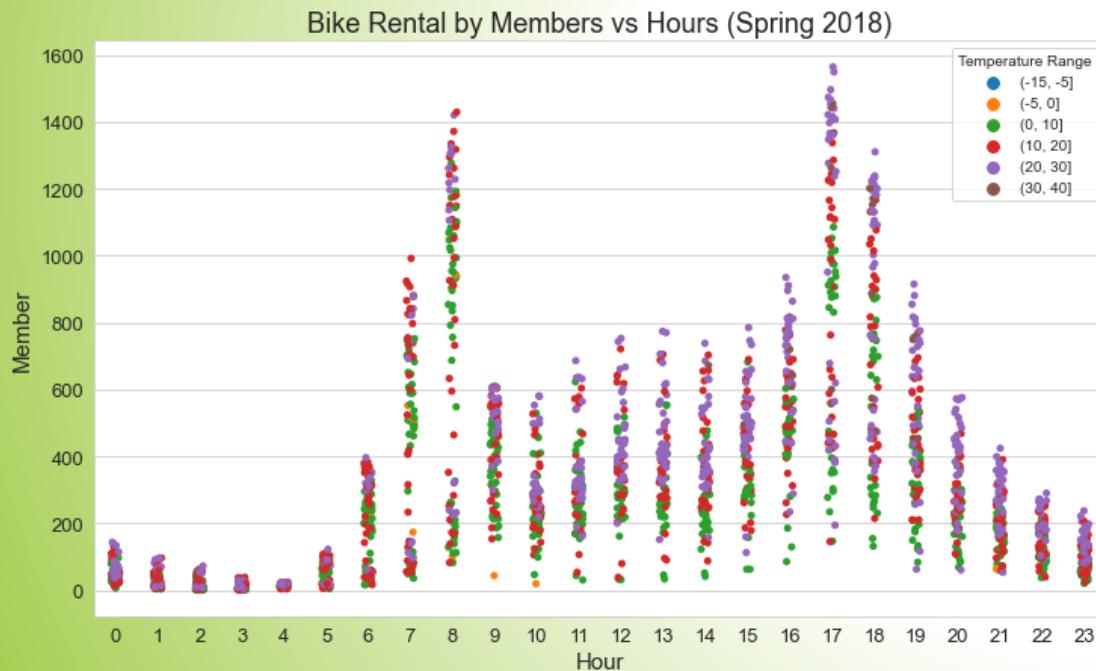
Spring 2017

- Rentals increased compare to fall and winter
- The temperature mostly was between 10 to 20. Warmer days is recorded (20 to 30)
- Rental by members was higher among (7am to 8am) and (17 to 18) compare to rest of the day
- Nonmembers rented more around (11am to 17)



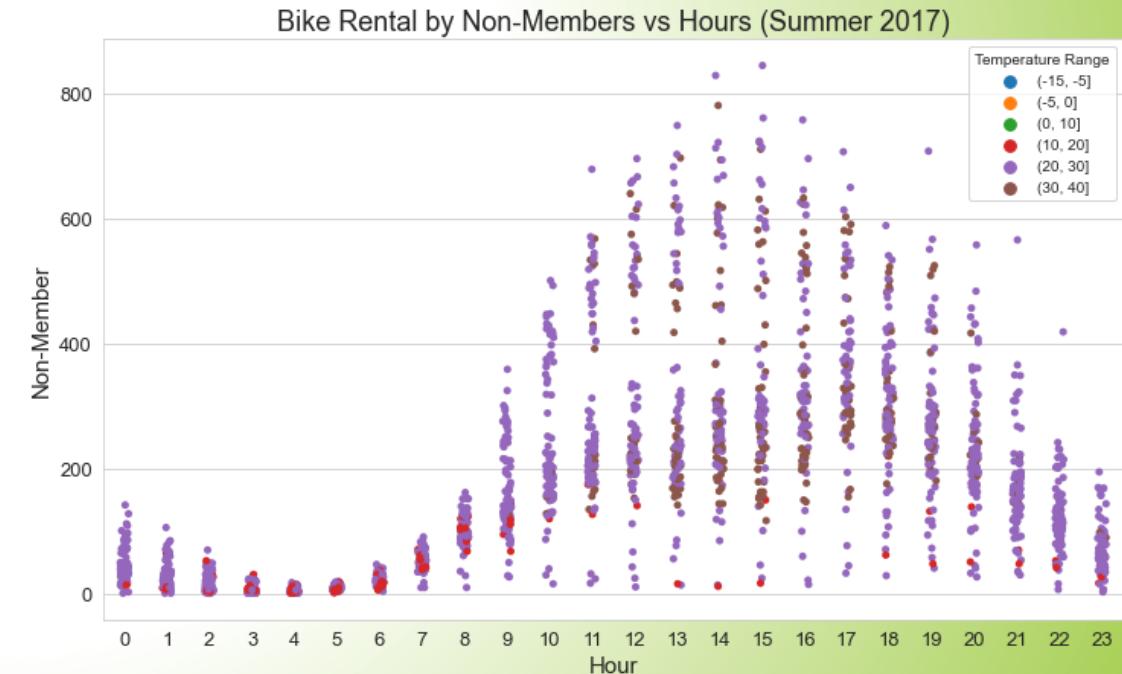
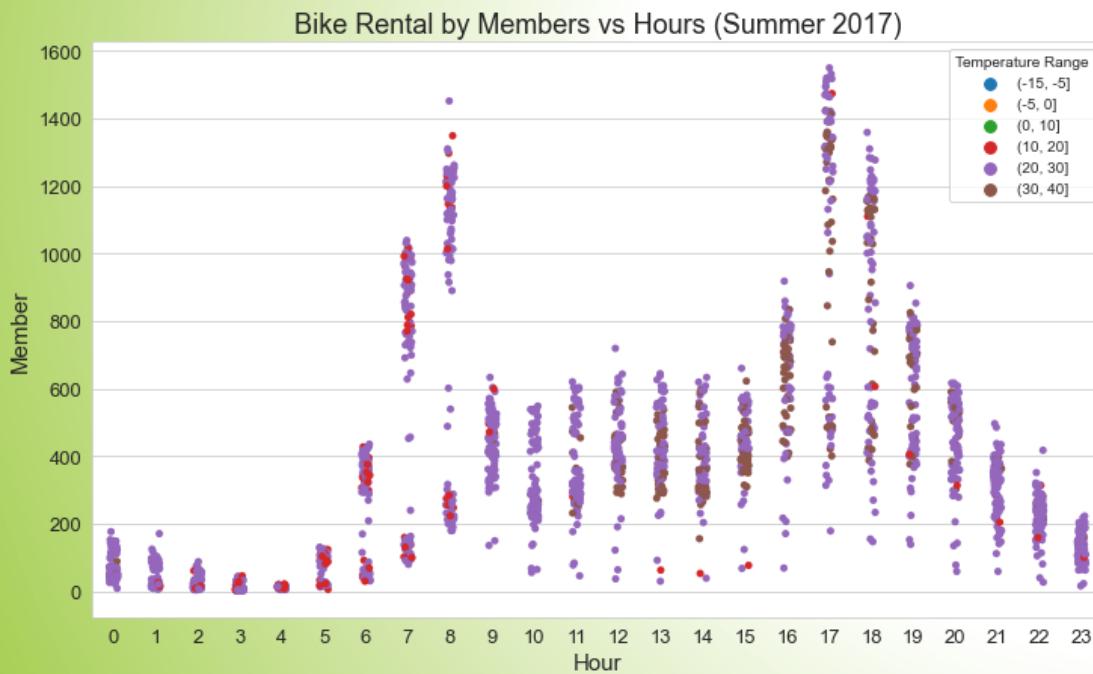
Spring 2018

- Rentals increased compare to fall and winter
- The temperature mostly was between 10 to 20. Warmer days is recorded (20 to 30)
- Rental by members was higher among (7am to 8am) and (17 to 18) compare to rest of the day
- Nonmembers rented more around (11am to 17)



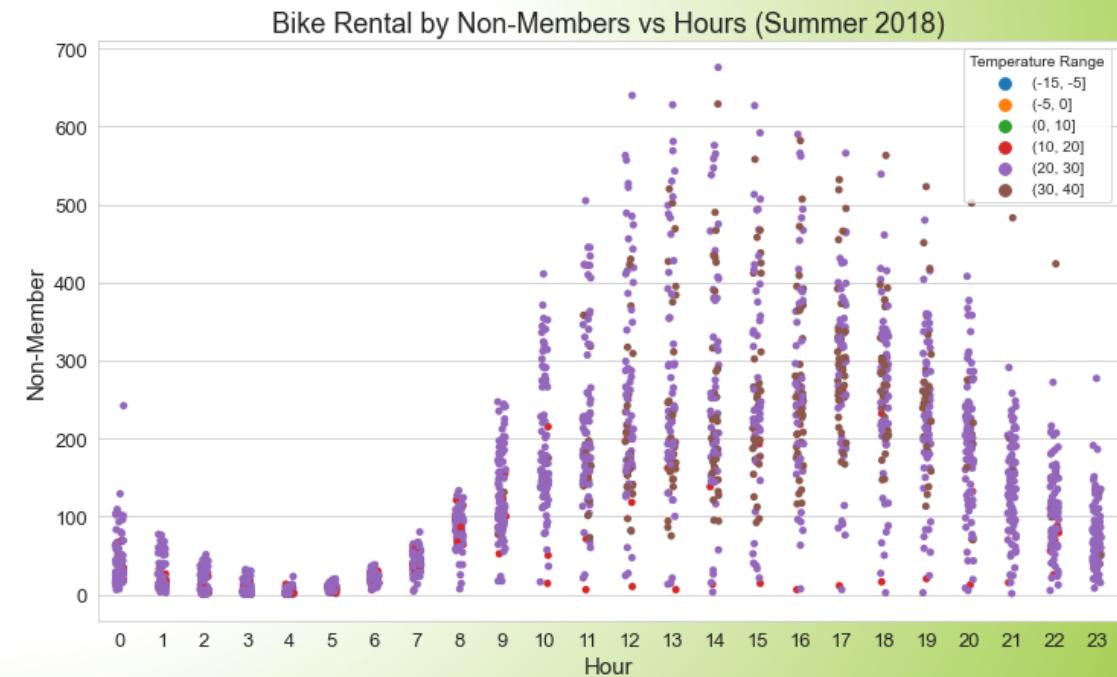
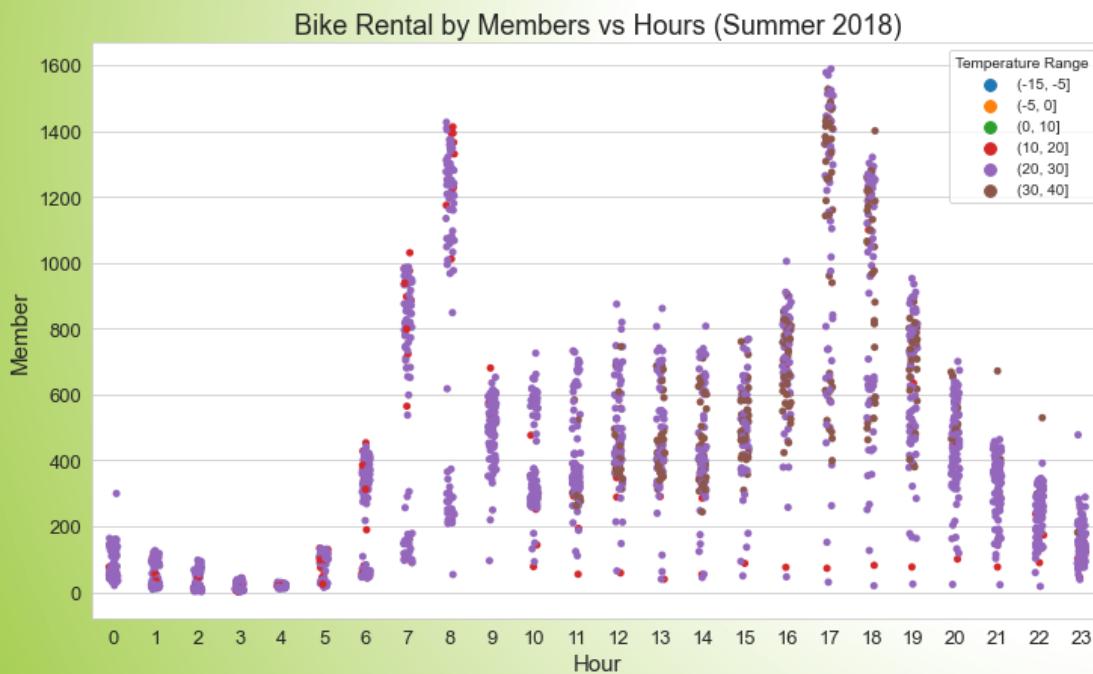
Summer 2017

- Rentals increased compare to other seasons
- The temperature mostly was between 20 to 30. Warmer days is recorded
- Rental by members was higher among (7am to 8am) and (16 to 19) compare to rest of the day
- Nonmembers rented more around (12am to 18)



Summer 2018

- Rentals increased compare to other seasons
- The temperature mostly was between 20 to 30. Warmer days is recorded
- Rental by members was higher among (7am to 8am) and (16 to 19) compare to rest of the day
- Nonmembers rented more around (12am to 19)

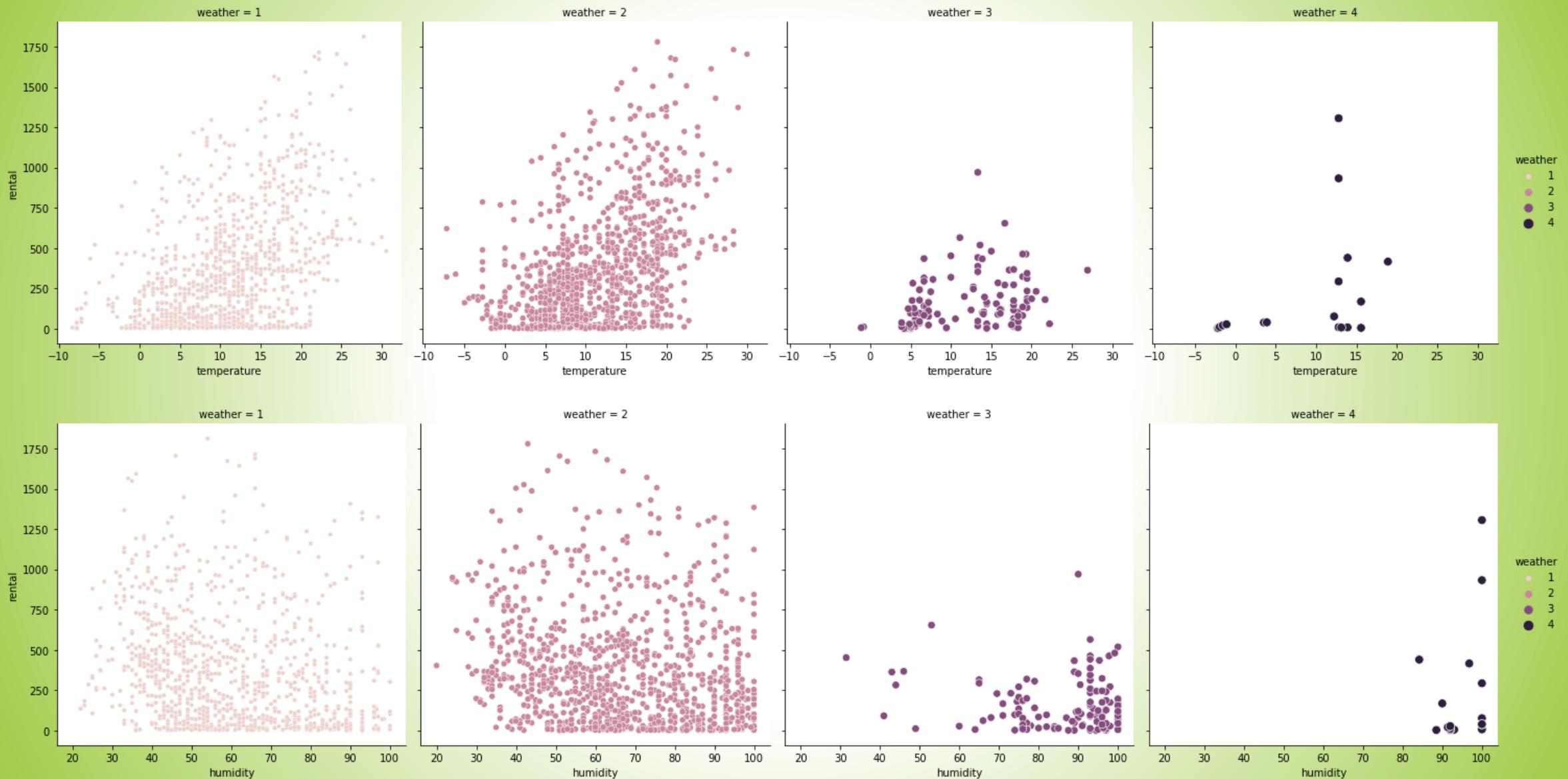


Weather Condition, Temperature and Humidity Changes

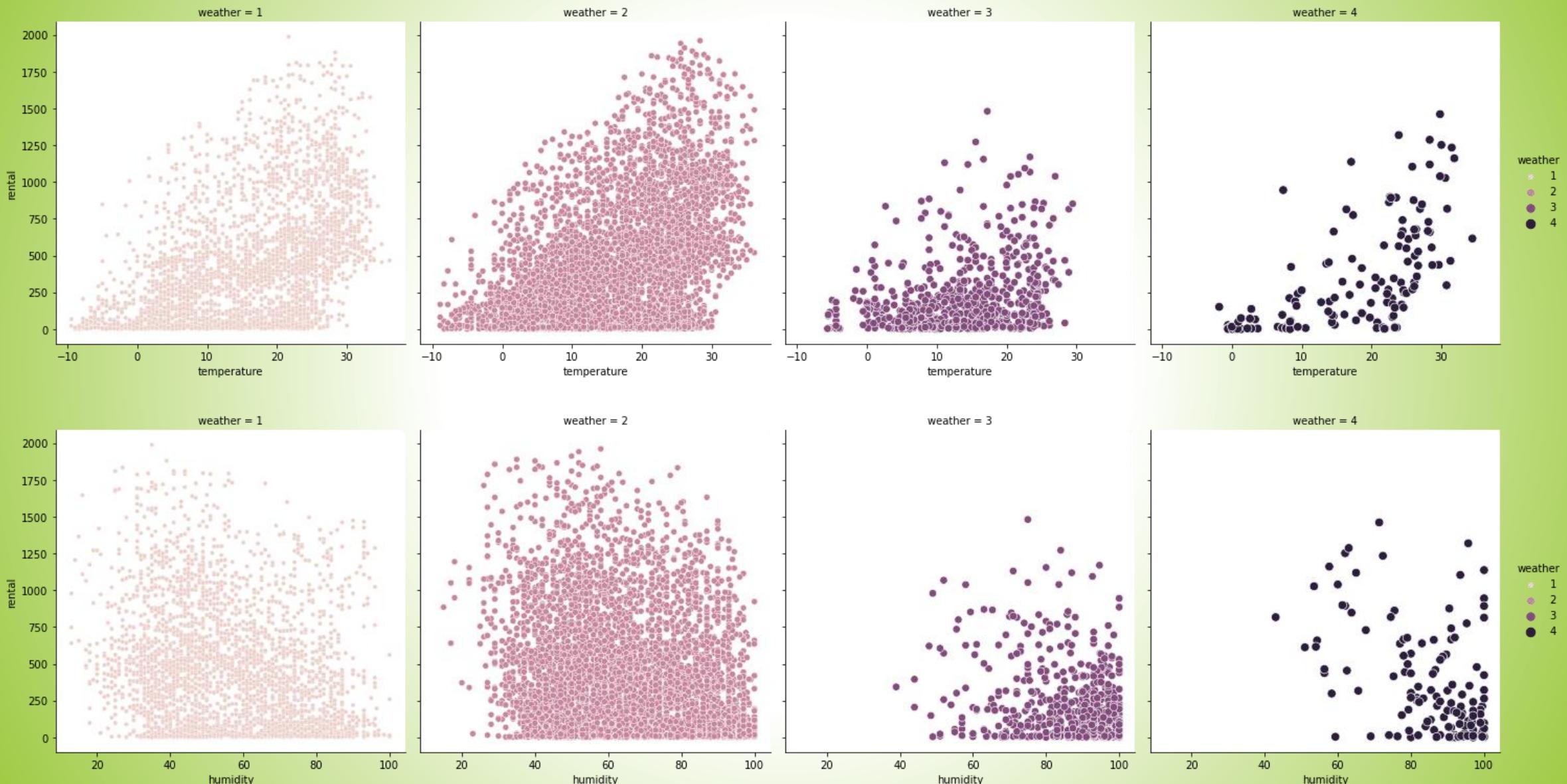
In the next slides we can observe that :

- How bike rental rates is affected by the temperature and humidly level (0 to 100)
 - How bike rental rates is affected in different weather condition and how was the temperature:
-
- 1:Fair/Windy 2:Mostly Cloudy 3:Light Rain 4: Heavy Rain/Snow

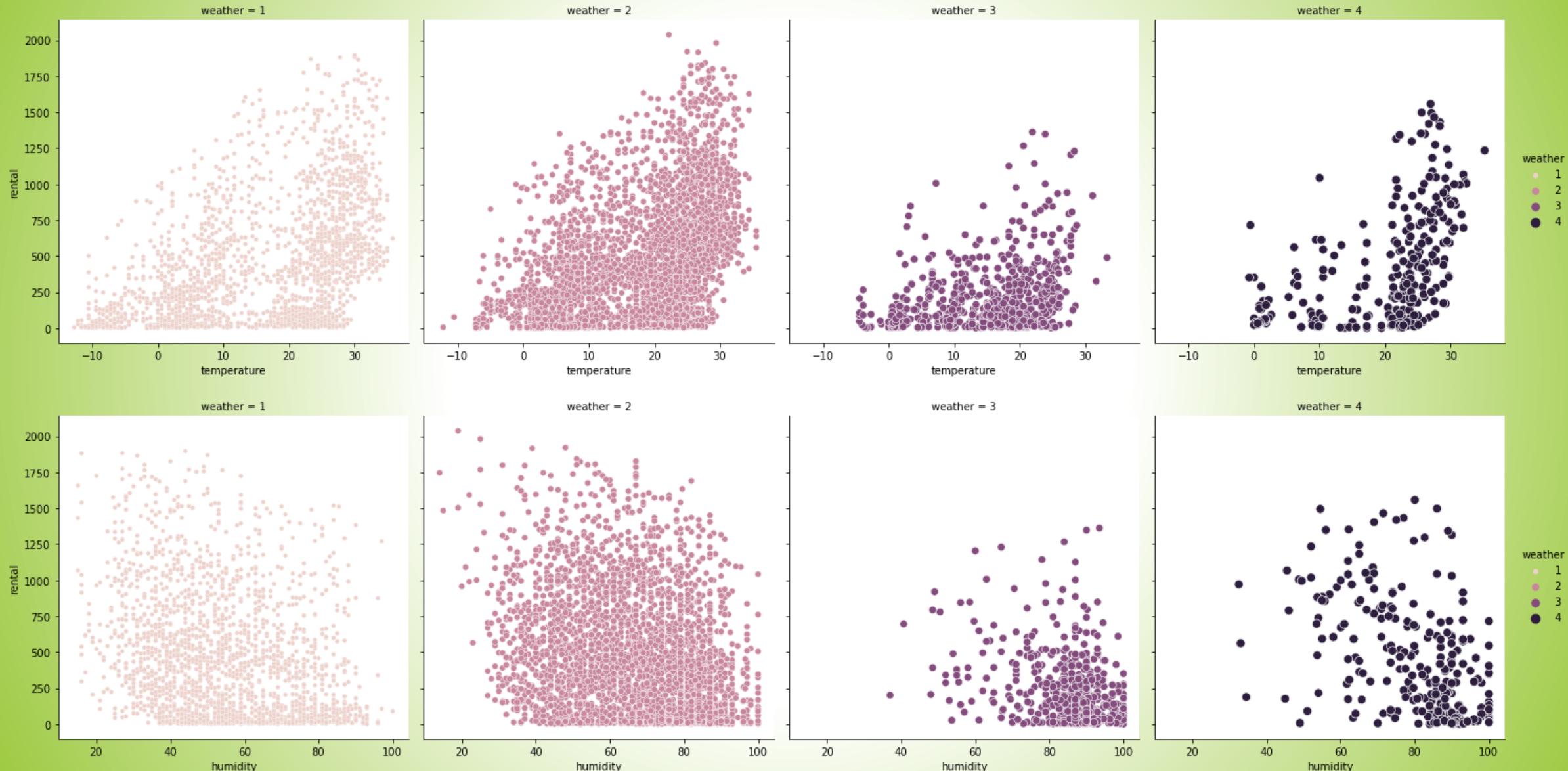
Rental vs Temperature and Humidity (2016) Weather condition is highlighted by color of points (the lighter color the milder the weather)



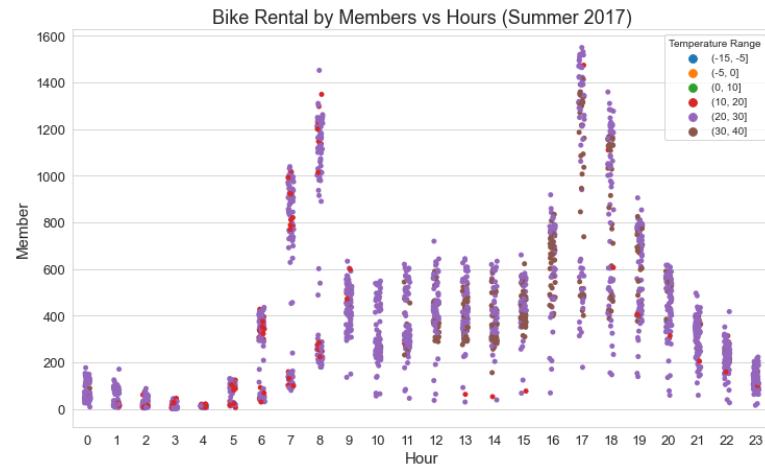
Rental vs Temperature and Humidity (2017)



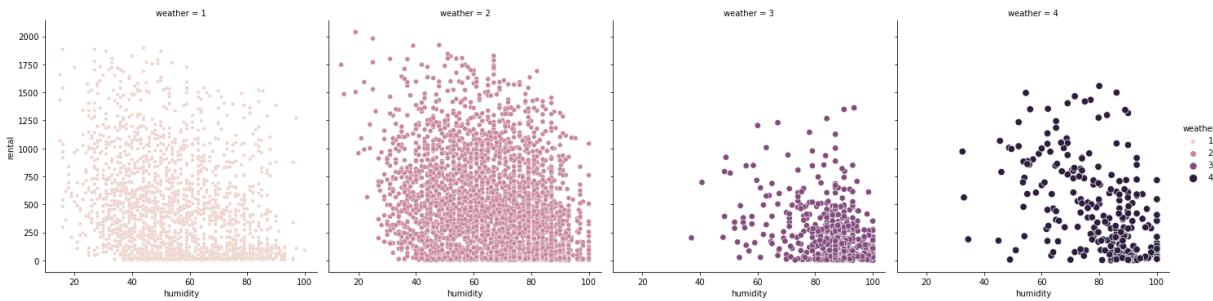
Rental vs Temperature and Humidity (2018)



Conclusion



- ▶ In general, members rent bikes early in the morning (7am to 8 am) and during the evening (16 to 19)
- ▶ Non-members tended to rent around noon to the evening (11am to 18pm)
- ▶ As the temperature increased, the number of rentals increased but the rental pattern remained mostly the same
- ▶ Temperature and Number of Rentals had positive correlation
- ▶ Humidity and Number of Rentals were negatively correlated.
- ▶ Temperature and Humidity were negatively correlated. This was more evident when it was mostly cloudy and windy



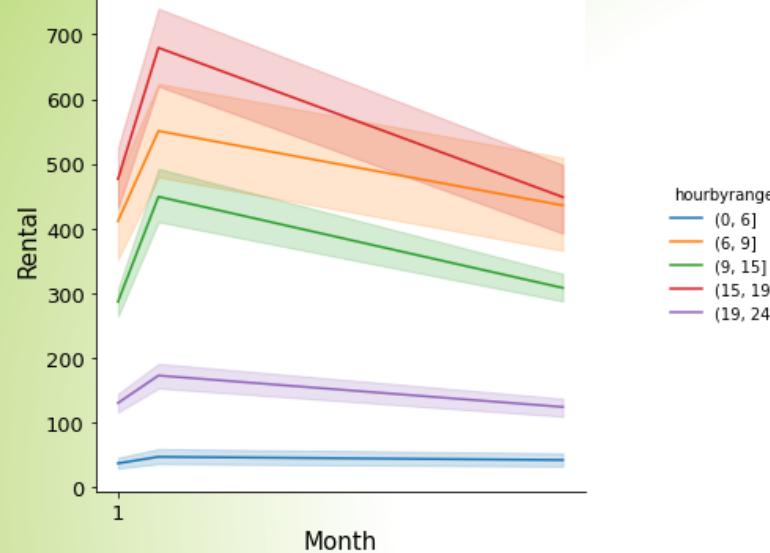
Bike Rental during different periods of days for 4 seasons

In the next slides we can observe that :

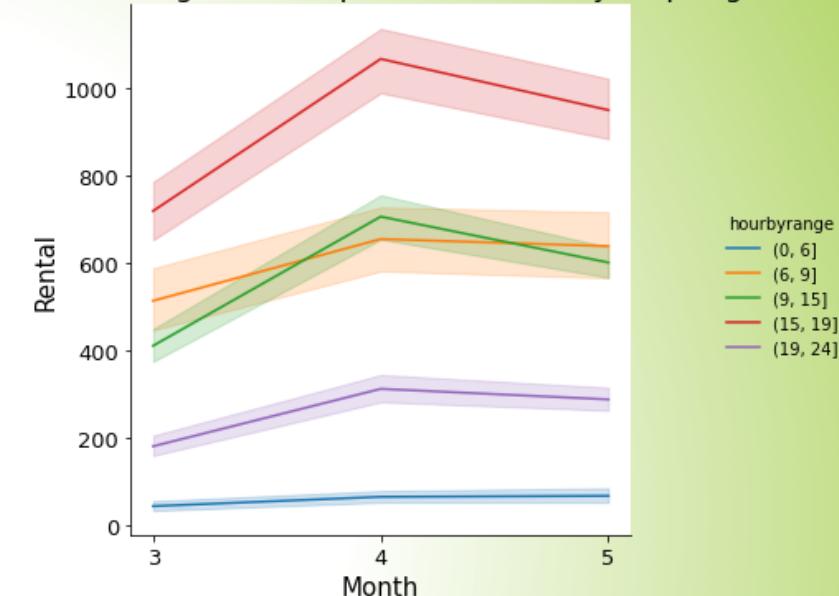
- For each season of the years how rental rates had been changed during different periods.
- Each 24 hour day, is separated in to 5 intervals:
 - (0 to 6am] (6am to 9am] (9am to 15pm] (15pm to 19pm] (19pm to 24pm]

Year 2017

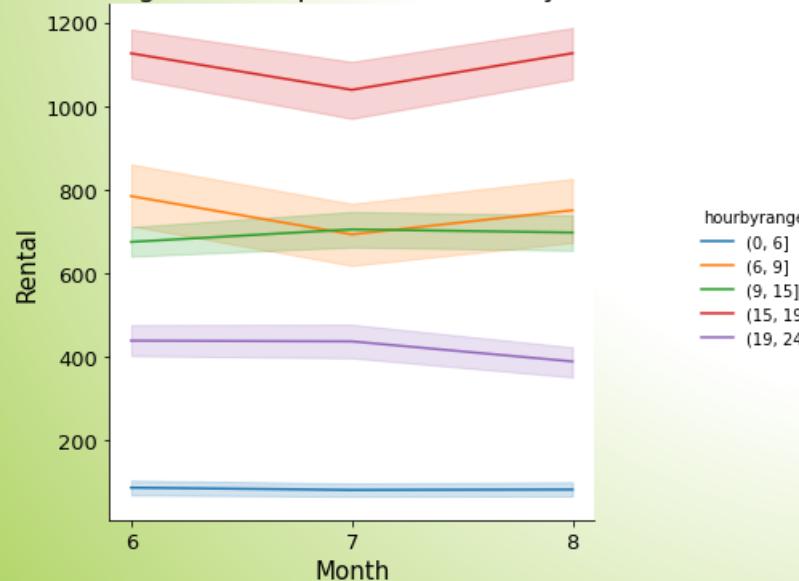
Bike Rental during different periods of the days (Winter 2017)



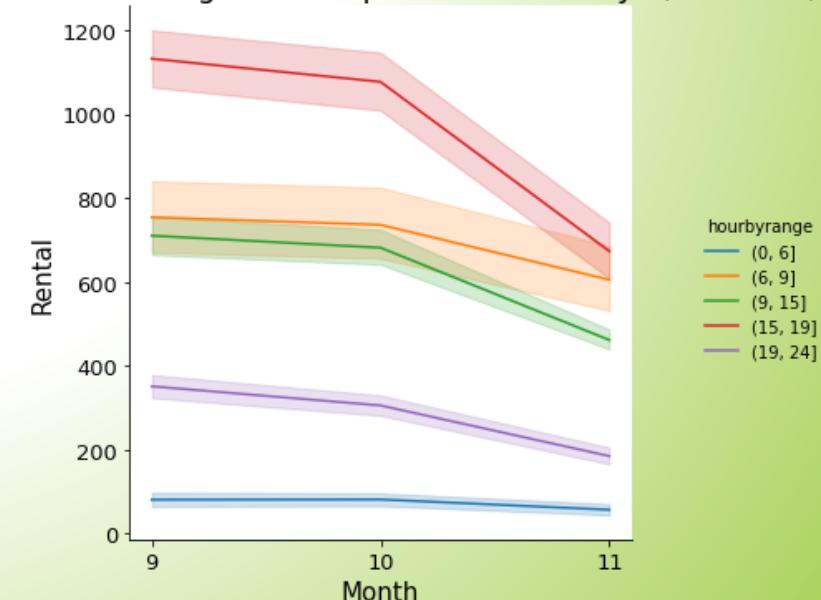
Bike Rental during different periods of the days (Spring 2017)



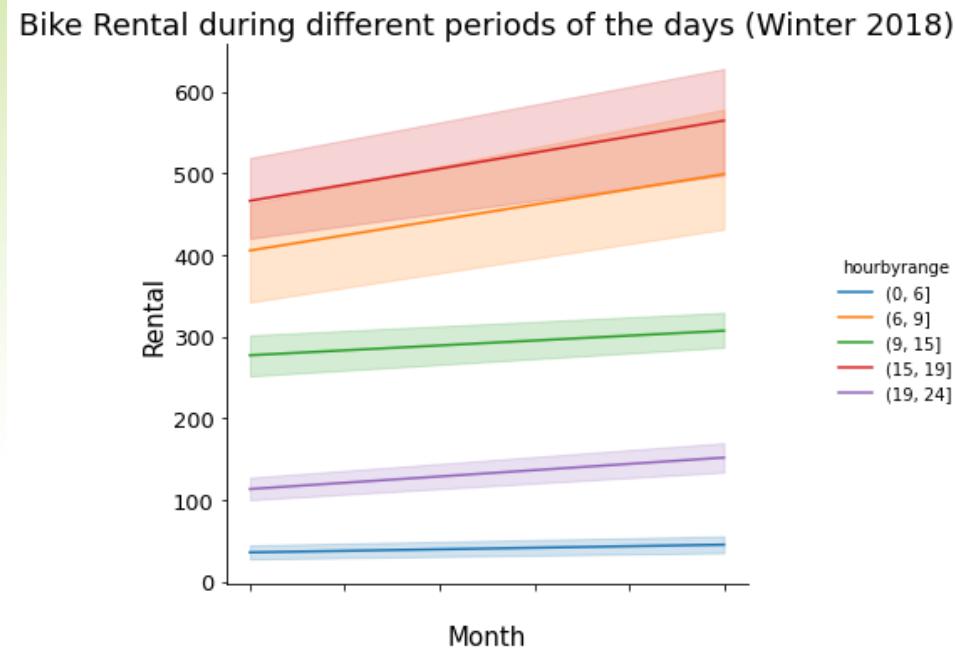
Bike Rental during different periods of the days (Summer 2017)



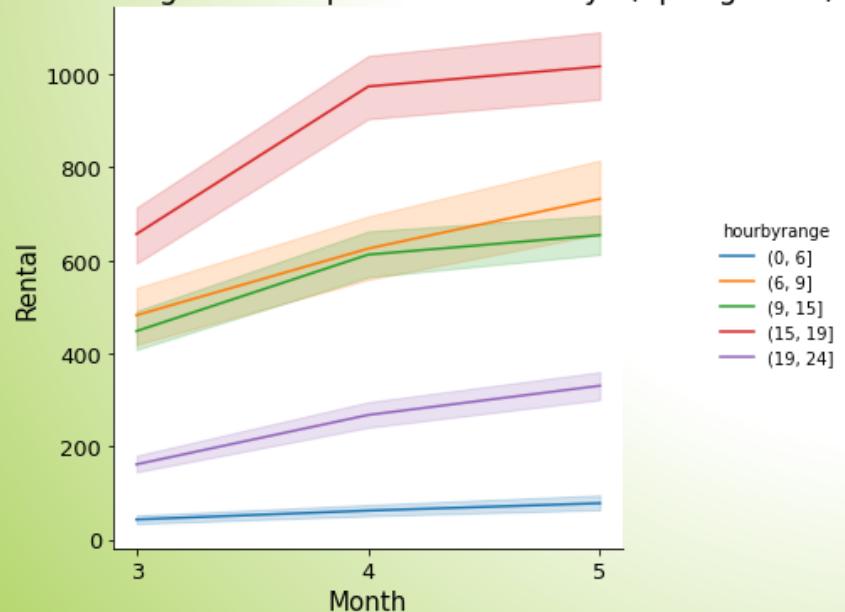
Bike Rental during different periods of the days (Fall 2017)



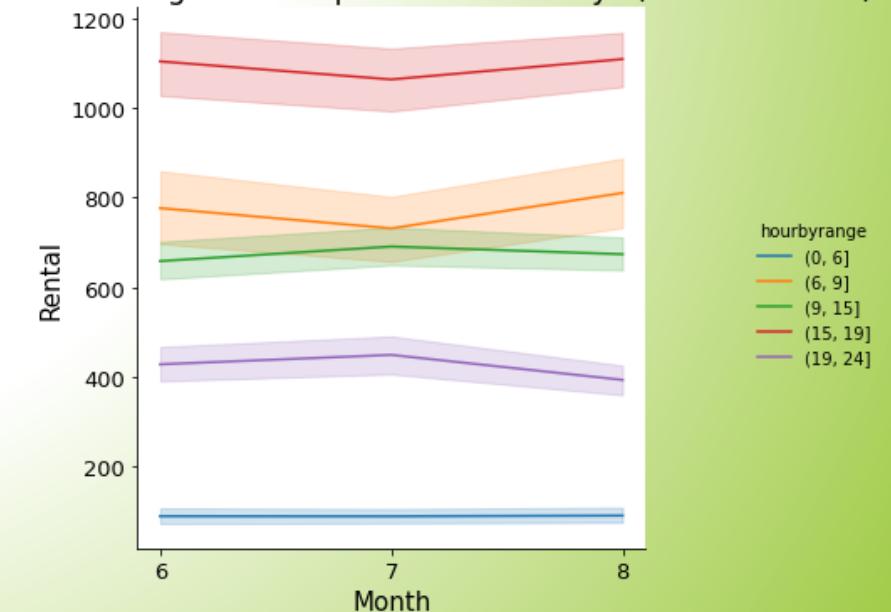
Year 2018



Bike Rental during different periods of the days (Spring 2018)

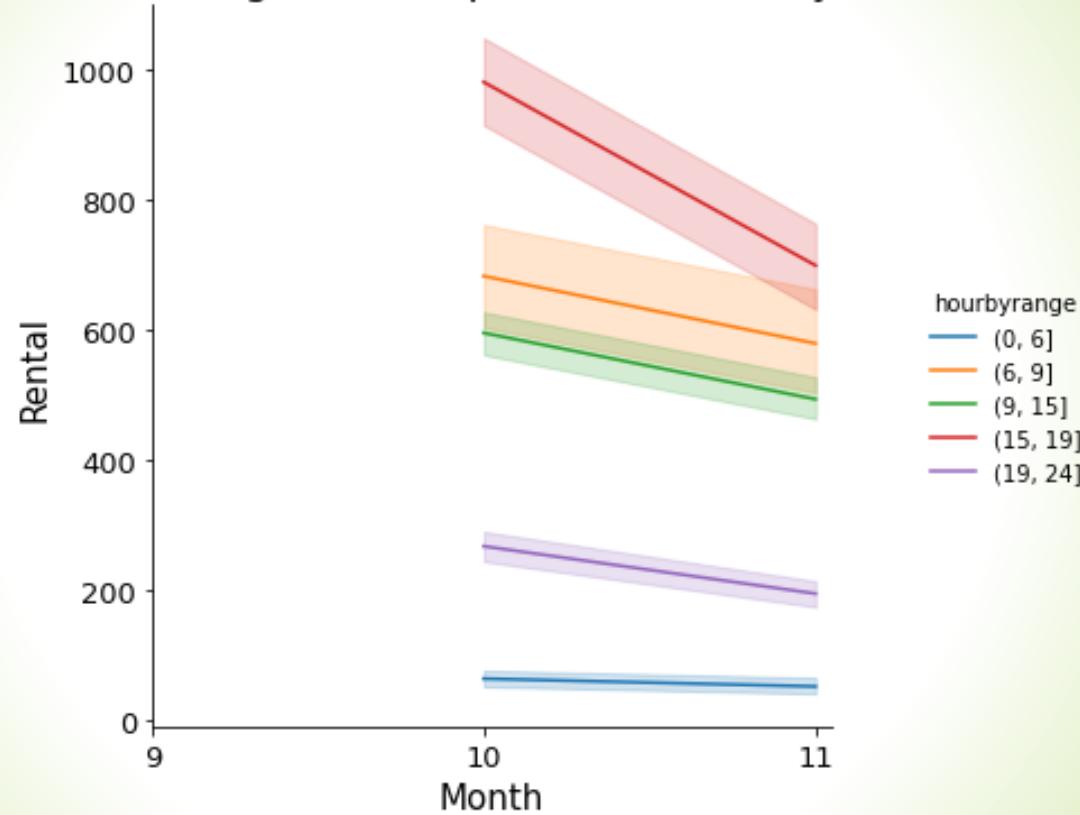


Bike Rental during different periods of the days (Summer 2018)

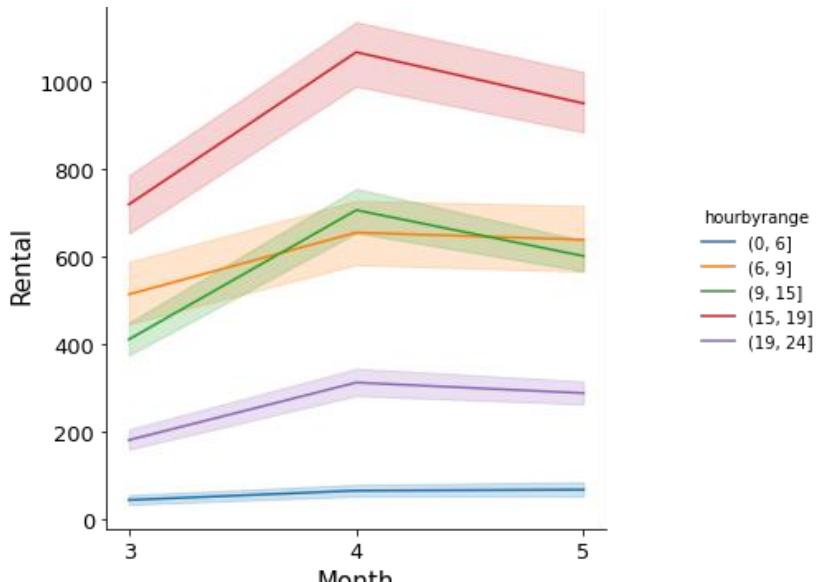


Year 2016

Bike Rental during different periods of the days (Fall 2016)



Conclusion



- ▶ In general, most of the bike rentals were between 15pm to 19pm
- ▶ The 6am to 9am interval ranked the second. However, in April 2017 people preferred to rent bike between 9am to 15pm compared to [6am to 9am]
- ▶ From 19pm to midnight people tend to rent less bike
- ▶ least number of bikes were rented from midnight to 6am

Prediction and Regression Analysis

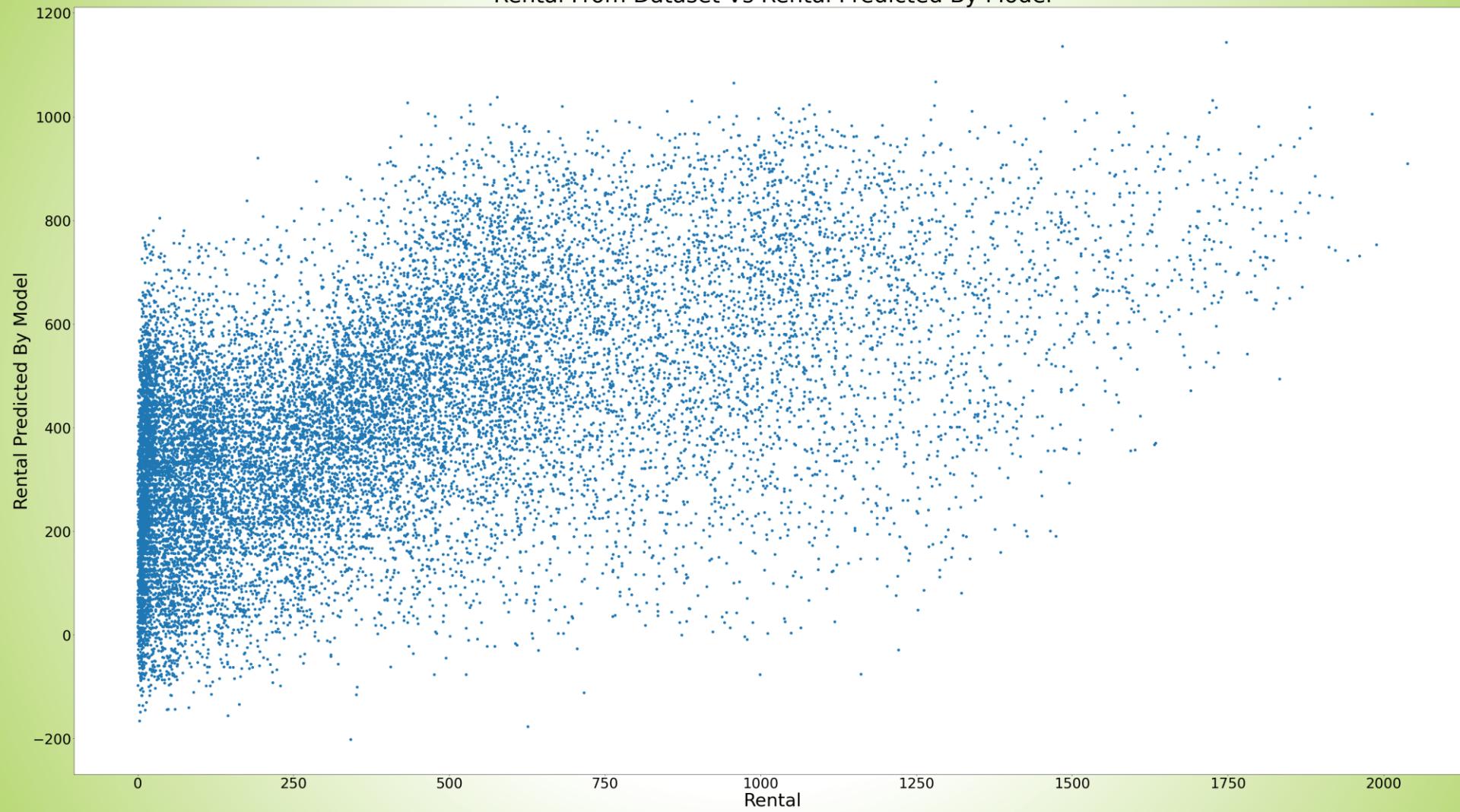
As we see so far, many climatic factors contribute to bike rental rates.('temperature,humidity level,windspeed,weather condition,dewpoint,windgust' etc).

For the analyse of regression only 'temperature, humidity, wind speed, pressure and weather condition' is being considered.

```
regdata= pd.read_csv("Bikeshare.csv", usecols = ['temperature','humidity','windspeed','pressure','weather','rental'])
```

| | temperature | humidity | windspeed | pressure | weather | rental |
|---|-------------|----------|-----------|----------|---------|--------|
| 0 | 18.33 | 100.0 | 6.0 | 30.1 | 3 | 103 |
| 1 | 17.78 | 100.0 | 10.0 | 30.1 | 3 | 63 |
| 2 | 17.78 | 100.0 | 10.0 | 30.1 | 3 | 33 |
| 3 | 17.78 | 100.0 | 10.0 | 30.1 | 3 | 23 |
| 4 | 17.78 | 100.0 | 9.0 | 30.1 | 3 | 11 |

Rental From Dataset Vs Rental Predicted By Model



Testing the Model

Estimate the rental rate when:

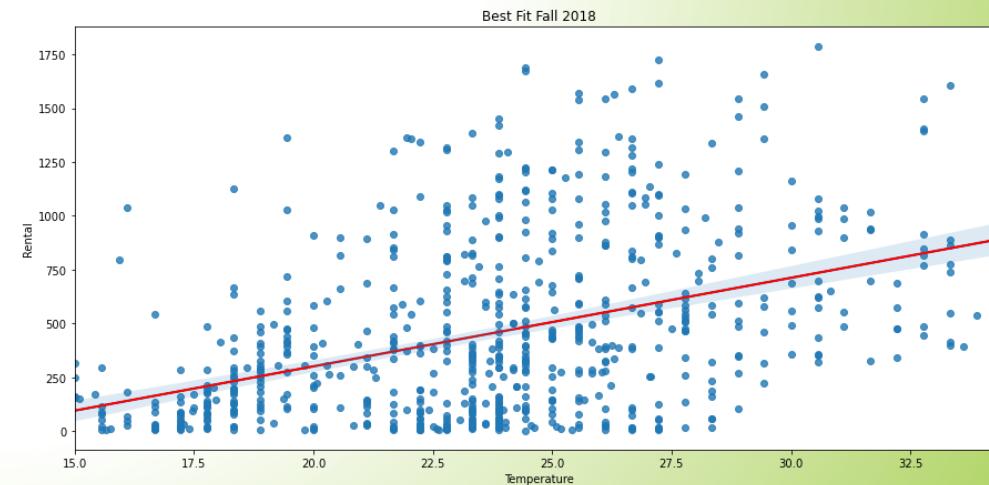
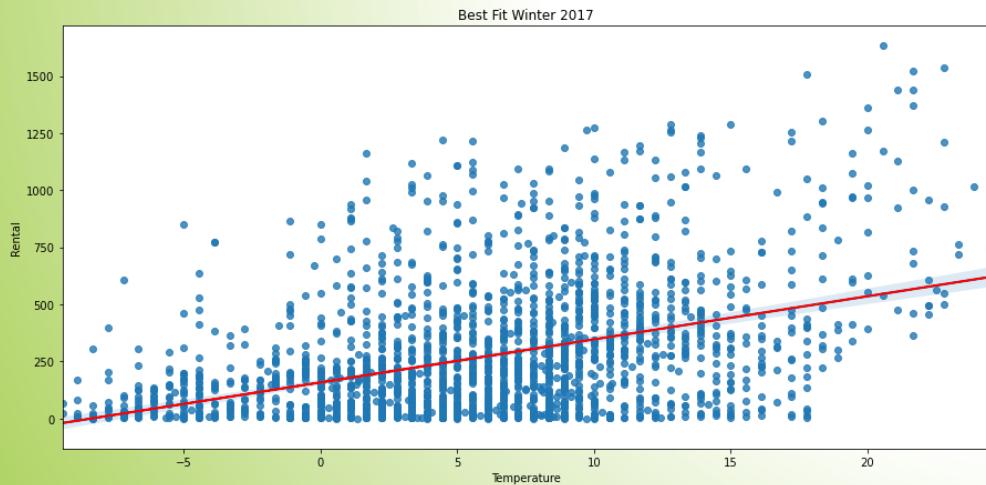
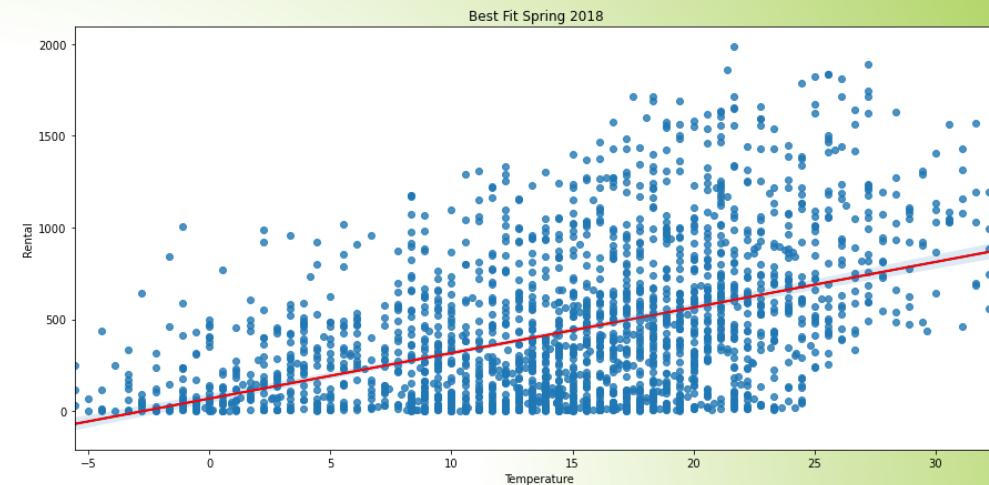
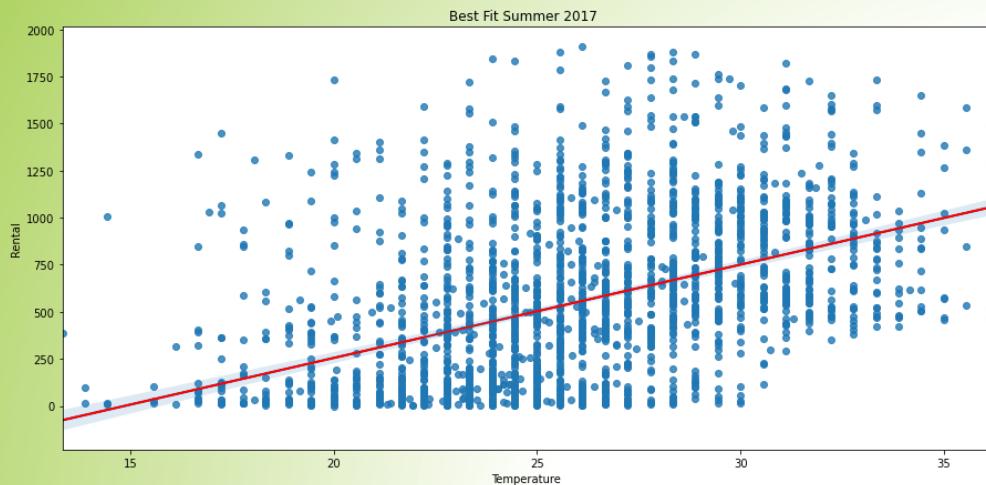
Temperature=20 , Humidity=100 , Windspeed=6 , Pressure=30 and Weather condition=2

```
rental = model_ols.predict([[20,100,6,30,2]])
print('Predicted Rental :', rental)
```

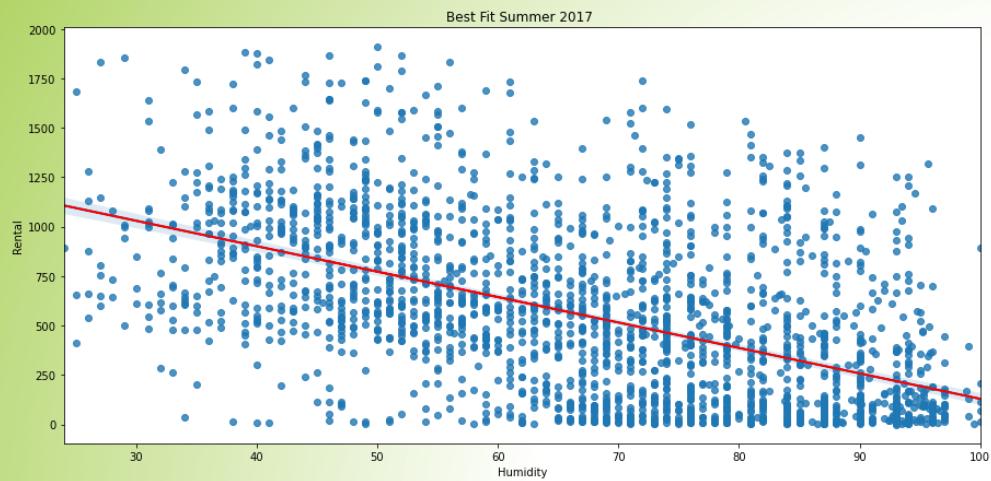
```
Predicted Rental : [247.6257419]
```

In the next pages, a scatter plot of linear regression is done for ‘temperature and humidity’ vs rental during different seasons for 2017 and 2018

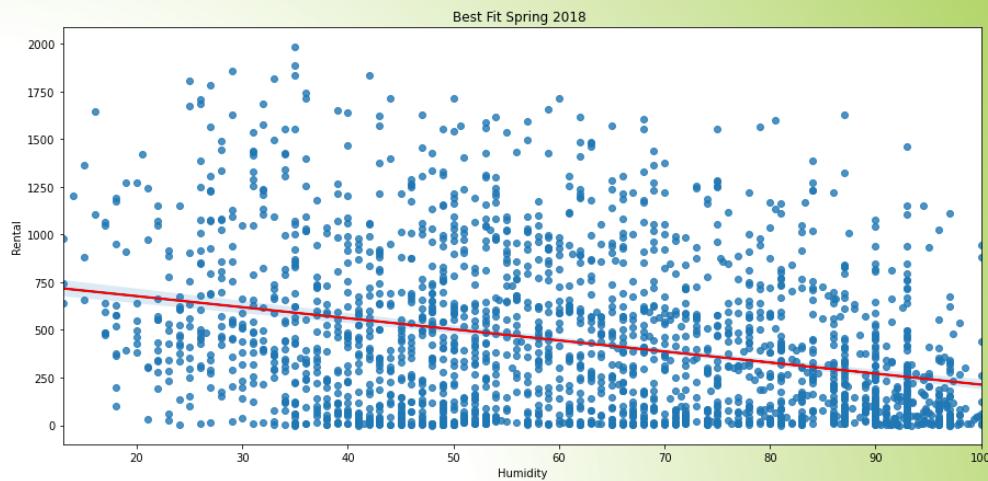
Rental vs Temperature



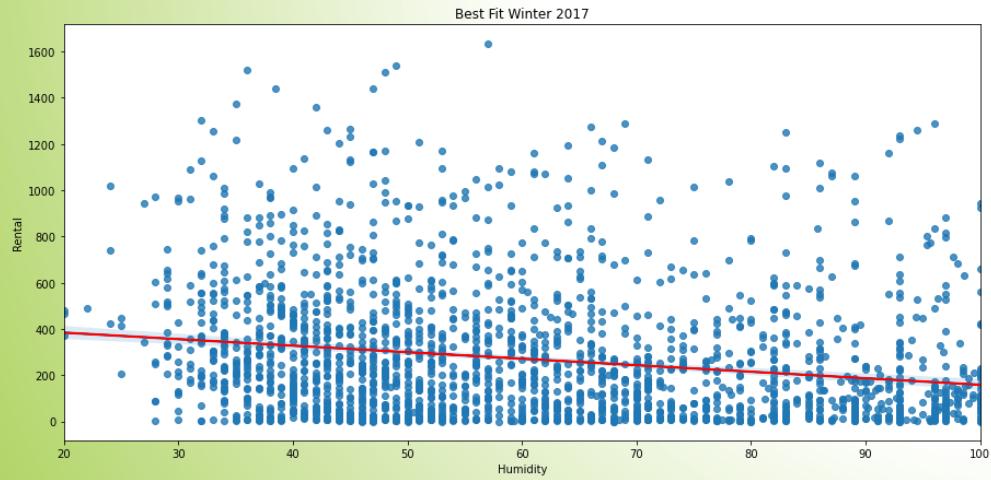
Rental vs Humidity



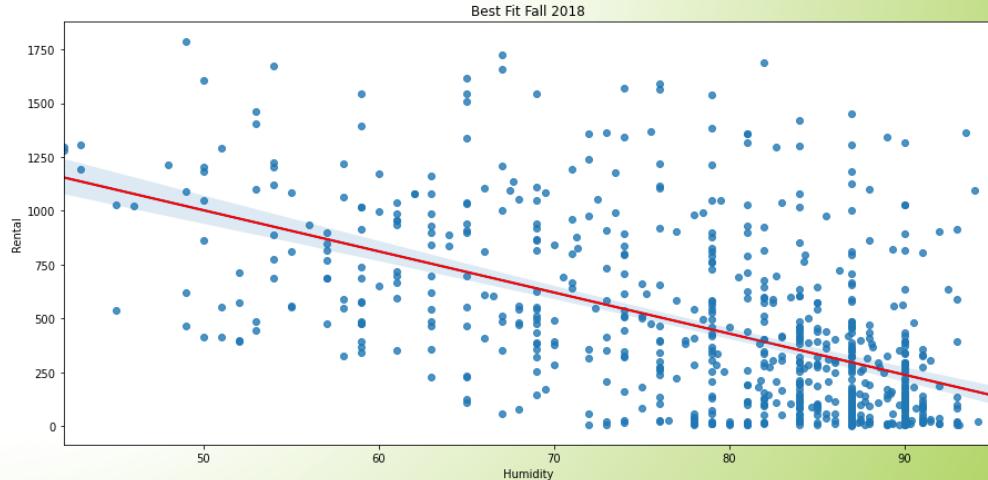
R-square=0.274



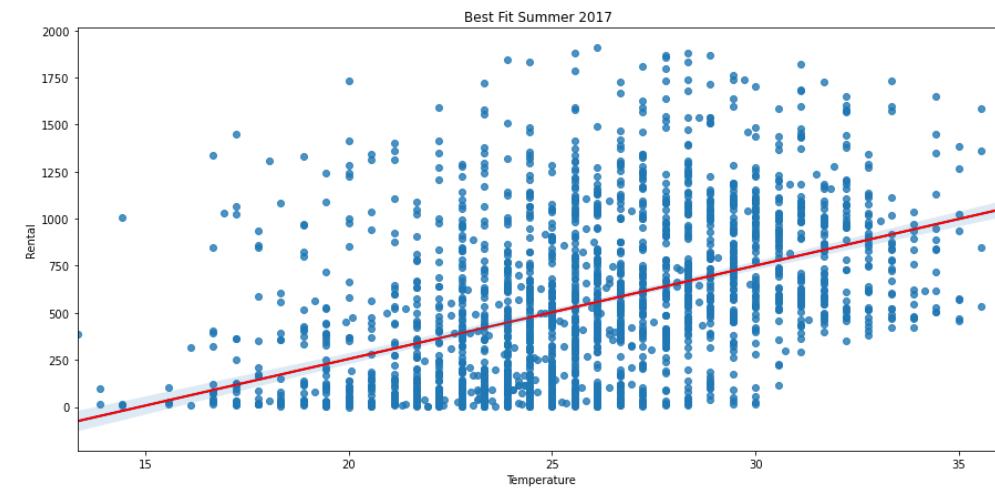
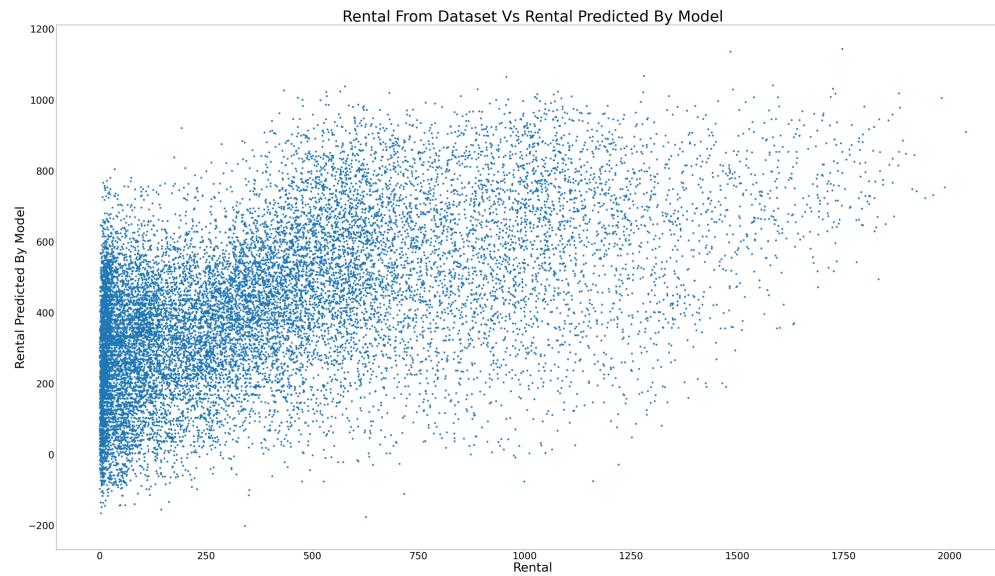
R-square=0.096



R-square=0.04



R-square=0.285



Conclusion

- ▶ *Different factors overall make a positive correlation with rental rate*
- ▶ *when focus was on only one factor, the R square was below 0.3 which was not significant to make a proper prediction*

Recommendation to decision maker

- ▶ Increase number of bike or station because of high demand regardless of the season (from 15pm to 19pm)
- ▶ Provide promotion for all users to use the service more during warmer months (from 19pm to midnight)
- ▶ Provide non-members with a promotion so they use the service more in the morning(6am to 9am)



References

<https://www.capitalbikeshare.com/>

<https://www.flickr.com/photos/bikeportland/7001381113>