

## Analyzing the NYC Subway Dataset

### ➤ (0) References

I used a wide variety of web sites, both during the lessons and while writing this document.

I used The Minitab Blog for a discussion how to interpret of R2 (<http://bit.ly/1lmfMOI> and <http://bit.ly/1FRmHwg>). Wikipedia also provided useful information on this topic (<http://bit.ly/1Jb3fLT>).

I found an excellent discussion of the pitfalls of using a linear regression model at <http://bit.ly/1JZWlKe>.

### ➤ (1) Statistical Test

1. Which statistical test did you use to analyze the NYC subway data? Did you use a one-tail or a two-tail P value? What is the null hypothesis? What is your p-critical value?

We used the Mann-Whitney U test with a one-sided critical P value of 0.025. The one-sided P value is what is returned by `scipy.stats.mannwhitneyu`. The null hypothesis was that there is no difference in ridership (`ENTRIESn_hourly`) on rainy days.

2. Why is this statistical test applicable to the dataset? In particular, consider the assumptions that the test is making about the distribution of ridership in the two samples.

We used the Mann-Whitney U test (rather than Welch's t-Test) because the distribution of `ENTRIESn_hourly` was non-normal. The Mann-Whitney U test is a non-parametric test, meaning that it doesn't assume that our data is drawn from any particular underlying probability distribution.

3. What results did you get from this statistical test? These should include the following numerical values: p-values, as well as the means for each of the two samples under test.

```
U, p = scipy.stats.mannwhitneyu(with_rain, without_rain)
```

produced the following:

```
(1105.4463767458733, 1090.278780151855, 1924409167.0,  
0.024999912793489721)
```

Here, the P value of  $<0.025$  allows us to reject the null hypothesis that there is no difference in ridership on days with rain.

4. What is the significance and interpretation of these results?

There is a statistically significant difference in ridership on rainy days. Average ridership is slightly higher on rainy days.

➤ (2) Linear Regression

1. What approach did you use to compute the coefficients theta and produce prediction for `ENTRIESn_hourly` in your regression model

I used the Ordinary Least Squares regression as implemented in `statsmodels.api`.

2. What features (input variables) did you use in your model? Did you use any dummy variables as part of your features?

The features in my model were `rain`, `meantempi`, `UNIT`, `Hour`, and `DATEn`.

I used dummy variables for these categorical features: `UNIT`, `Hour`, and `DATEn`. I converted `DATEn` to day of the week (0-6) as follows:

```
days_of_week = dataframe[['DATEn']].applymap(lambda x:
datetime.datetime.strptime(x, '%Y-%m-%d').strftime('%w'))
```

`rain` does not require dummy variables because, although it is categorical, it can take on only 2 different values.

3. Why did you select these features in your model? We are looking for specific reasons that lead you to believe that the selected features will contribute to the predictive power of your model.

`rain` - We already demonstrated in a previous lesson that ridership increases slightly when it's raining.

`meantempi` - More people may ride the subway when it's very cold or very hot outside. (However, this may be a non-linear feature, since people may be more likely to ride when it is either extremely hot or extremely cold.)

`Hour` - Ridership is probably higher during "rush hour," as people are going to or from work.

`DATEn` (after converting to day of the week) - There may be fewer riders on

weekends. (On a later visualization exercise, I found this to be true.)

4. What are the coefficients (or weights) of the non-dummy features in your linear regression model?

rain - -0.2358

meantempi - -10.4262

OLS Regression Results						
=====						
Dep. Variable:	y	R-squared:	0.534			
Model:	OLS	Adj. R-squared:	0.516			
Method:	Least Squares	F-statistic:	29.39			
Date:	Sun, 31 May 2015	Prob (F-statistic):	0.00			
Time:	01:46:58	Log-Likelihood:	-1.1600e+05			
No. Observations:	13195	AIC:	2.330e+05			
Df Residuals:	12699	BIC:	2.367e+05			
Df Model:	495					
Covariance Type:	nonrobust					
=====						
	coef	std err	t	P> t	[95.0% Conf. Int.]	
-----						
const	1752.8469	124.143	14.120	0.000	1509.508	1996.185
x1	-0.2358	32.624	-0.007	0.994	-64.184	63.712
x2	-10.4262	2.225	-4.687	0.000	-14.787	-6.066
x3	4188.5460	355.150	11.793	0.000	3482.381	4894.711

5. What is your model's R2 (coefficients of determination) value?

My model's R2 value was 0.534, as calculated both by the Udacity grader and by `statsmodels.api`.

6. What does this R2 value mean for the goodness of fit for your regression model? Do you think this linear model to predict ridership is appropriate for this dataset, given this R2 value?

R2 is a statistical measure of how close the data are to the fitted regression line. Its value ranges from 0 to 1, and in general, the higher the R2, the better the model fits the data.

R2 always increases as more features are added to a linear regression model. A

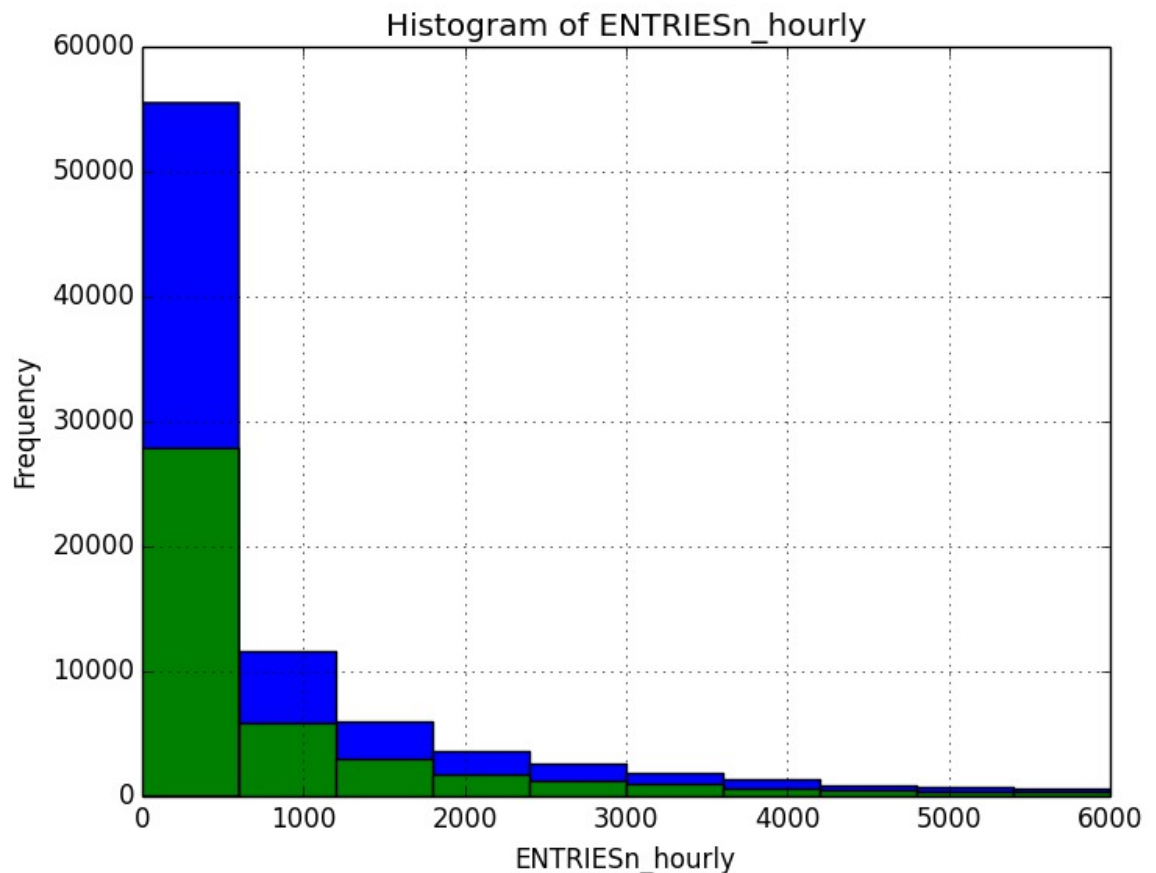
model can have a “good”  $R^2$  just by having a lot of variables, even if those variables hold no true predictive value.

In reality, most systems are not linear. As noted above, ridership may increase at both high and low extremes of temperature, as people choose to ride the subway rather than walk outside. A linear regression model cannot capture this non-linearity.

A linear regression model may lead to poor prediction when the features are significantly correlated with each other (e.g., rain and temperature).

### ➤ (3) Visualization

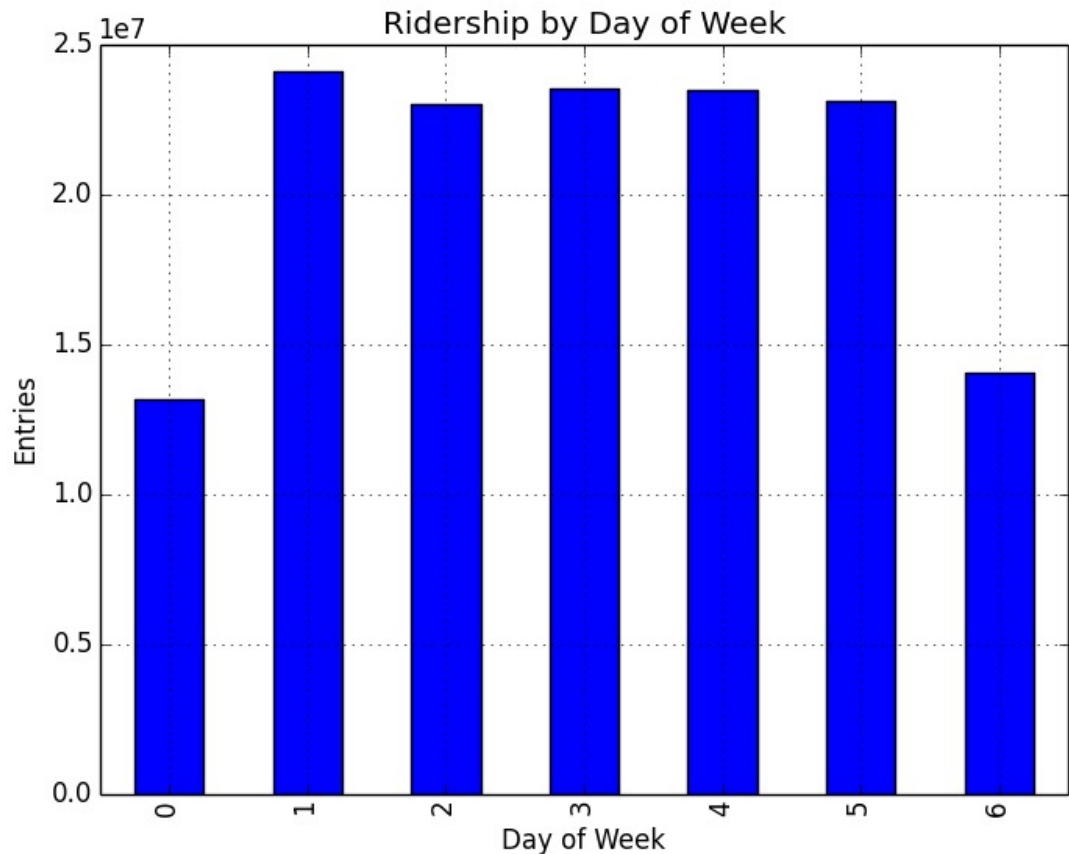
1. Histograms of `ENTRIESn_hourly` for rainy and non-rainy days:



The code used to generate this plot is as follows:

```
1 #!/usr/bin/python
2 import numpy as np
3 import pandas
4 import matplotlib.pyplot as plt
5
6 df = pandas.read_csv('/Users/jasonreaves/Desktop/turnstile_data_master_with_weather.csv')
7 plt.figure()
8 df[(df.rain == 0) & (df.ENTRIESn_hourly < 6000)]['ENTRIESn_hourly'].hist()
9 df[(df.rain == 1) & (df.ENTRIESn_hourly < 6000)]['ENTRIESn_hourly'].hist()
10 plt.ylabel('Frequency')
11 plt.xlabel('ENTRIESn_hourly')
12 plt.title('Histogram of ENTRIESn_hourly')
13 plt.show()
14
```

## 2. Freeform visualization: Ridership by day of week



As one might expect, ridership decreases on the weekend.

The code used to generate this plot is as follows:

```
1 #!/usr/bin/python
2 from pandas import *
3 import matplotlib.pyplot as plt
4 import pandasql
5
6 turnstile_weather = pandas.read_csv('/Users/jasonreaves/Desktop/turnstile_data_master_with_weather.csv')
7 turnstile_weather.rename(columns = lambda x: x.replace(' ', '_').lower(), inplace=True)
8 q = "SELECT STRFTIME('%w', daten) AS day, SUM(triesn_hourly) AS entries FROM turnstile_weather GROUP BY day"
9 df = pandasql.sqldf(q.lower(), locals())
10 plt.figure()
11 df.plot(kind='bar', x='day', y='entries', legend=False)
12 plt.xlabel('Day of Week')
13 plt.ylabel('Entries')
14 plt.title('Ridership by Day of Week')
15 plt.show()
16
```

#### ➤ (4) Conclusion

1. From your analysis and interpretation of the data, do more people ride the NYC subway when it is raining or when it is not raining?

Yes, average ridership increases slightly when it's raining.

2. What analyses lead you to this conclusion? You should use results from both your statistical tests and your linear regression to support your analysis.

As discussed above, the results of the Mann-Whitney U test show a small but statistically significant increase in ridership when it's raining. However, in my regression model, the coefficient of the rain variable was negative, suggesting an opposite trend. In fact, the absolute value of the rain coefficient was small (0.2358), its P value was high (0.994), and it's confidence interval was wide and included 0 (-64.184 63.712). From this, one can conclude that rain did not play a significant role in the linear regression model. Other variables, particularly UNIT (turnstile), played a larger role.

#### ➤ (5) Reflection

1. Please discuss potential shortcomings of the methods of your analysis.

- i. Dataset

The dataset covered only the month of May, so the model cannot reflect variations in ridership over the course of a year. One can imagine that over the course of a year, there would be greater fluctuations in temperature and other potentially significant weather phenomena such as snow and ice. There could also be changes in ridership as the population using the subway varies (e.g., more tourists during the summer months, and the holiday season).

ii. Analysis

The limitations of a linear regression model, some of which were discussed above, include outliers, non-linearities, and dependence among variables.

The statistical test showed slightly greater ridership when it's raining, but the practical significance of this finding depends on the reason the question is being asked in the first place.