ECON 8310

Business Forecasting

Instructor:
Dustin White
Mammel Hall 332M

Office Hours:
Mondays, Thursdays from 4:45-5:45 PM

Contact Info:
drwhite@unomaha.edu

Quick Note

This class does not require that you **already** know how to program, but you will be expected to program in class every week.

- Spend time outside class practicing (by time I mean hours)
- Udacity.com is an excellent learning resource
- Datacamp.com is another great resource to get you started

Quick Note

Your ability to use code to solve problems will be the basis for your grade in this course, so if you cannot commit the time to practice coding, you are not likely to pass this class.

Grade Details

Score	Grade	Score	Grade
>94%	A	62.5-69.9	D
90-93.9	A-	60-62.5	D-
87.5-89.9	B+	<60	F
82.5-87.4	B		
80-82.4	B-		
77.5-79.9	C+		
72.5-77.4	C		
70-72.4	C-		

Grade Details

Assignment	Percent of Grade
Lab Work	480 points
Midterm Exam	250 points
Final Exam	270 points

My Expectations

- You will be expected to learn to program during this course if you do not already know how
- Plan on spending all of our time in lab working on projects and refining your predictions
- Take charge of your assignments; they will be open-ended

Expectations of Me

- I will work through examples of code in class
- I will be available during office hours to help you with assignments
- I will revise the course material as needed to suit your interests

Lecture 1: Intro and OLS Review

What is Forecasting?

Forecast: "to predict or estimate (a future event or trend)" -- Google Dictionary

- Predict stock market movements
- Estimate the quantity of stock required during a certain time-span
- Determine the most likely outcome of a stochastic process based on previous events
- **Learn from patterns**

Quick Forecast

```
import numpy as np
from bokeh.plotting import figure, show

x = np.linspace(-1, 1, 101)
y = 2 * (x + np.random.rand(101))

p = figure(plot_width = 800, plot_height=500)
p.scatter(x,y, color='green', size = 10, alpha=0.5)
show(p)
```

What just happened??

```
import numpy as np
from bokeh.plotting import figure, show
```

These are our import statements

- We import "libraries" into Python that enable us to do tons of cool things
- In this case, we import numeric functions and the ability to render plots

What just happened??

```
x = np.linspace(-1, 1, 101)
y = 2 * (x + np.random.rand(101))
```

Next, we generate all our x values, and our y values (a random process based on those x values)

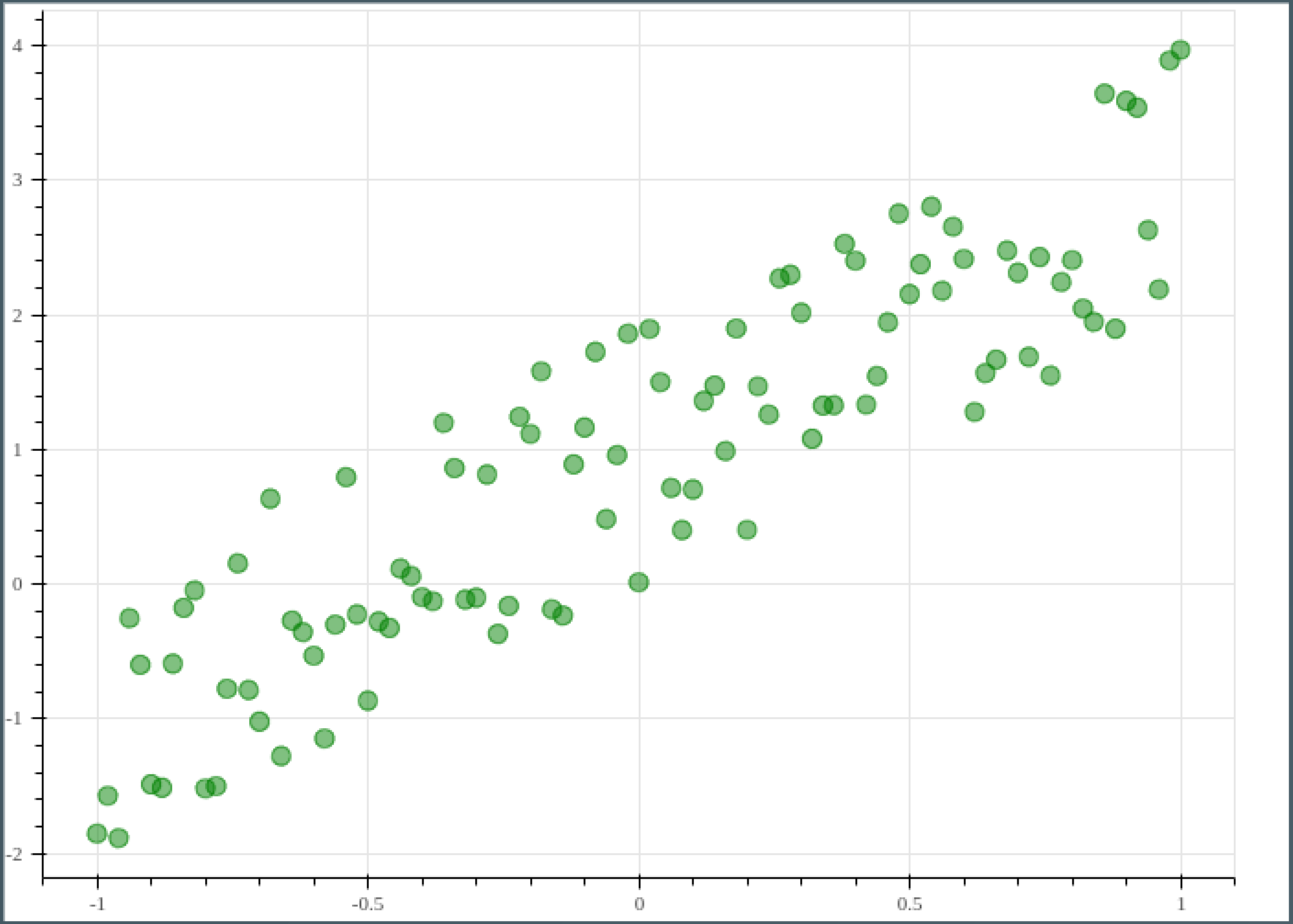
- There are 101 elements in both the x and y vectors

What just happened??

```
p = figure(plot_width = 800, plot_height=500)
p.scatter(x,y, color='green', size = 10, alpha=0.5)
show(p)
```

Finally, we generate a plot using the x and y vectors as coordinates, and tell Python to show us the plot

Should look like:



Quick Forecast

```
xs = np.concatenate((np.ones(101).reshape(101,1),
                     x.reshape(101,1)), axis=1)

beta = np.linalg.solve(np.dot(xs.T, xs), np.dot(xs.T, y))

yhat = beta[0] + beta[1]*x

p = figure(plot_width = 800, plot_height=500)
p.scatter(x,y, color='green', size = 10, alpha=0.5)
p.line(x, yhat, color='red', line_width=3, alpha=0.5)
show(p)
```

Now What?

```
xs = np.concatenate((np.ones(101).reshape(101,1),
                     x.reshape(101,1)), axis=1)
```

We create a matrix with a column of ones (to generate an intercept), and our x values.

Now What?

```
beta = np.linalg.solve(np.dot(xs.T, xs), np.dot(xs.T, y))
```

Then we solve the equation

$$\hat{\beta} = (x'x)^{-1}x'y$$

- Note that we do NOT explicitly calculate the inverse of the $(x'x)$ matrix!

Now What?

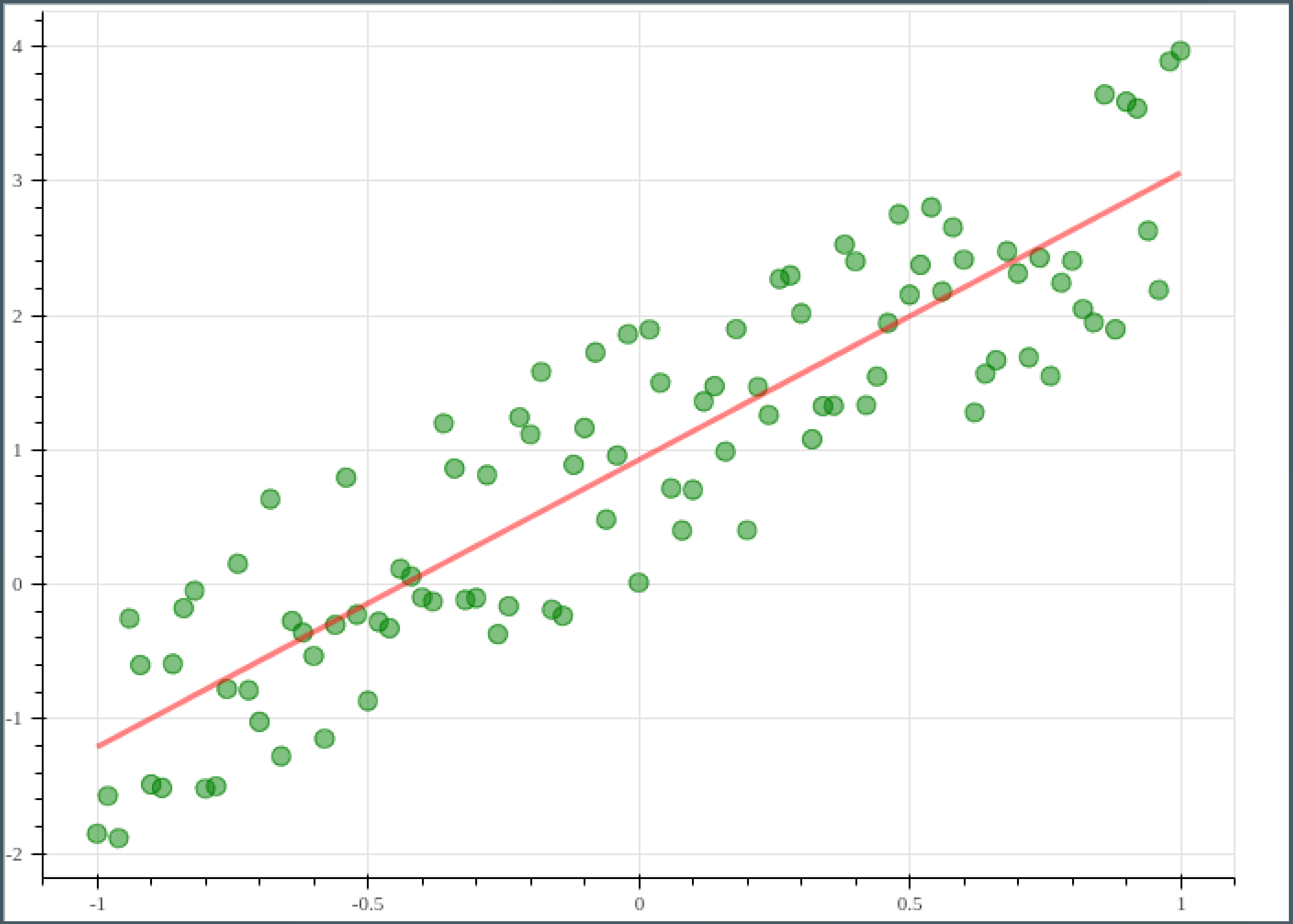
```
yhat = beta[0] + beta[1]*x

p = figure(plot_width = 800, plot_height=500)
p.scatter(x,y, color='green', size = 10, alpha=0.5)
p.line(x, yhat, color='red', line_width=3, alpha=0.5)
show(p)
```

And then we calculate our *estimate* of y using the first element (beta[0]) as an intercept, and the second element (beta[1]) as the slope of our function

After, we use a for loop to plot both the output variable (y) as well as our prediction (yhat)

Now we see...



Our Goal

In this course, we want to learn how to predict outcomes based on the information that we already possess.

Forecasting

- Time Series forecasts
- Probility models
- Forecasting using machine learning
- Using ensemble methods to strengthen our understanding
- Choosing the best tool for the job

Remembering OLS...

- Ordinary Least Squares (OLS) is the foundation of regression analysis, and an excellent starting point for this course
- Estimates the expected outcome ($\hat{y}$) given the inputs (x)

Remembering OLS...

- Ordinary Least Squares (OLS) is the foundation of regression analysis, and an excellent starting point for this course
- Estimates the expected outcome ($\hat{y}$) given the inputs (x)
- Calculating coefficient standard errors informs us about the level of noise in the data
- R^2 and Adjusted R^2 tell us how much of the total variation our model accounts for

Calculating the Least Squares Estimator

$$y = x\beta + \epsilon$$

$$\Downarrow$$

$$\epsilon = y - x\beta$$

So that we seek to minimize the squared error

$$min\ (y - x\beta)'(y - x\beta)$$

Calculating the Least Squares Estimator

$$min_{\hat{\beta}}\ (y - x\hat{\beta})'(y - x\hat{\beta})$$

$$\Downarrow$$

$$x'y = x'x\hat{\beta}$$

$$\Downarrow$$

$$\hat{\beta} = (x'x)^{-1}x'y$$

Variance Estimators

Our unbiased estimate of the variance matrix is $\hat{s}^2$:

$$\hat{s}^2 = \frac{(y - x\hat{\beta})'(y - x\hat{\beta})}{(n-k)}$$

or

$$\hat{s}^2 = \frac{y'y - y'x(x'x)^{-1}x'y}{(n-k)}$$

Covariance of $\hat{\beta}$

Under standard assumptions (specifically with normally distributed errors),

$$\hat{\beta} \sim N(\beta, \sigma^2 (x'x)^{-1})$$

Therefore, our estimate of the covariance of $\hat{\beta}$ is

$$Cov(\hat{\beta}) = \hat{s}^2 (x'x)^{-1}$$

Note: The main diagonal of the covariance matrix is the variance of each $\hat{\beta}$ coefficient.

Calculating t-statistics and significance

The t-statistic of an OLS regression coefficient can be calculated as

$$t_j = \frac{\hat{\beta}_j}{\hat{\sigma}_j}$$

Where $\hat{\sigma}_j$ is the square root of the j-th element on the main diagonal of $Cov(\hat{\beta})$.

Generating an OLS Results Table

We now have enough information to create a results table after performing OLS estimation:

Coefficient	Std. Error	t-stat	P-value
$\hat{\beta}_j$	$\hat{\sigma}_j$	t_j	$P(\mid \hat{\beta}_j \mid > 0 \mid t_j)$
...	...	...	...

Python and Distribution Functions

```
from scipy.stats import t

pval = t.sf(tstat, df)
```

We use the sf (denoting *survival function*) method of the t-distribution object to return 1-CDF of the t-distribution given our calculated t-statistic and our degrees of freedom $(n - k)$.

Functions in Python

Sometimes, we want to make a prepackaged function to repeatedly generate results of a certain kind.

```
def myFunction(input1, input2, ...):
    line1
    line2
    ...
    return results # can be one object, or a list of them
```

Functions in Python

A simple example:

```
def sayHello(n):
    for i in list(range(n_times)):
        print("Hello!")

    return None
```

Will print "Hello!" n times.

Import Data

```python
import pandas as pd

# Read data from excel files
data = pd.read_excel("filename.xlsx")

# Read data from csv files
data = pd.read_csv("filename.csv")
```

We use the pandas library to import a table of data that we can use for calculations.

Break apart Data

```
import patsy as pt

# Create x and y matrices from a Data Frame

y, x = pt.dmatrices("y ~ x1 + x2 + ...", data=data)
```

We use the patsy library to generate the x and y matrices that are necessary for OLS estimation

Size of the Data

We can go back to numpy to find the shape of our data (important for degrees of freedom calculations):

```
import numpy as np

np.shape(data) # Returns (number_rows, number_columns)
```

Getting Help

```
help(pd.read_excel)
```

We use the help function to get information about an object or function.

```
dir(pd.read_excel)
```

The dir function will allow you to view all methods associated with a given object or function.

For lab today

Form a group (of 3-4 people). Work together to write a function that can take an arbitrary Data Frame (imported via pandas), and print an OLS Regression table.

hint:

```
def myOLS(data, regression_equation):
    ...
```

Links: [t-stats in Scipy]