IDS 702: Module 1.1

Motivating example

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Introduction

- By now, you should already be familiar with t-tests and simple linear regression (SLR).
- At the very least, you should know the basics.
- Specifically, you should know how to fit a SLR model and assess whether or not the model assumptions are violated.
- We will use those ideas as building blocks for the models we will explore throughout this course.

Motivating example

- In the 1970's, Harris Trust and Savings Bank was sued for discrimination on the basis of sex.
- As evidence, the defense presented analysis of salaries of employees of one type (skilled, entry level clerical).
- The data is in the file `wagediscrim.txt` on Sakai.
- We are interested in answering the question: **did female employees tend to receive lower base/starting salaries than similarly qualified and experienced male employees?**

  Which statistical tests can we use to probe the question above?

IDS 702

Data

93 employees on data file (61 female, 32 male).

Variable	Description
bsal	Annual salary at time of hire
sal77	Annual salary in 1977.
educ	years of education.
exper	months previous work prior to hire at bank.
fsex	1 if female, 0 if male
senior	months worked at bank since hired
age	months

Since we care about inference on bsal, as our response variable, we will exclude sal77 for all analysis.

Is this reasonable? Why or why not?

Data

How many rows? How many columns?

```
wages <- read.csv("data/wagediscrim.txt", header= T)
dim(wages)
```

```
## [1] 93  8
```

Take a look at the first few rows of the data.

```
head(wages)
```

```
##   bsal sal77  sex senior age educ exper fsex
## 1 5040 12420 Male     96 329   15  14.0    0
## 2 6300 12060 Male     82 357   15  72.0    0
## 3 6000 15120 Male     67 315   15  35.5    0
## 4 6000 16320 Male     97 354   12  24.0    0
## 5 6000 12300 Male     66 351   12  56.0    0
## 6 6840 10380 Male     92 374   15  41.5    0
```

Data

Check variable types.

```
wages$sex <- factor(wages$sex,levels=c("Male","Female"))
wages$fsex <- factor(wages$fsex)
str(wages)
```

```
## 'data.frame':    93 obs. of  8 variables:
##  $ bsal  : int  5040 6300 6000 6000 6000 6840 8100 6000 6000 6900 ...
##  $ sal77 : int  12420 12060 15120 16320 12300 10380 13980 10140 12360 10920 ...
##  $ sex   : Factor w/ 2 levels "Male","Female": 1 1 1 1 1 1 1 1 1 1 ...
##  $ senior: int  96 82 67 97 66 92 66 82 88 75 ...
##  $ age   : int  329 357 315 354 351 374 369 363 555 416 ...
##  $ educ  : int  15 15 15 12 12 15 16 12 12 15 ...
##  $ exper : num  14 72 35.5 24 56 41.5 54.5 32 252 132 ...
##  $ fsex  : Factor w/ 2 levels "0","1": 1 1 1 1 1 1 1 1 1 1 ...
```

Exploratory data analysis (EDA)

Next, quick summaries of each variable.

```
summary(wages)
```

```
##       bsal           sal77              sex         senior           age       
##  Min.   :3900   Min.   : 7860   Male  :32   Min.   :65.00   Min.   :280.0  
##  1st Qu.:4980   1st Qu.: 9000   Female:61   1st Qu.:74.00   1st Qu.:349.0  
##  Median :5400   Median :10020               Median :84.00   Median :468.0  
##  Mean   :5420   Mean   :10393               Mean   :82.28   Mean   :474.4  
##  3rd Qu.:6000   3rd Qu.:11220               3rd Qu.:90.00   3rd Qu.:590.0  
##  Max.   :8100   Max.   :16320               Max.   :98.00   Max.   :774.0  
##       educ           exper        fsex  
##  Min.   : 8.00   Min.   :  0.0   0:32  
##  1st Qu.:12.00   1st Qu.: 35.5   1:61  
##  Median :12.00   Median : 70.0         
##  Mean   :12.51   Mean   :100.9         
##  3rd Qu.:15.00   3rd Qu.:144.0         
##  Max.   :16.00   Max.   :381.0         
```

IDS 702

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Since we only care about comparing starting salaries for male and female employees for now, let's look at boxplots of bsal by sex.

```
ggplot(wages,aes(x=sex, y=bsal, fill=sex)) +
  geom_boxplot() + coord_flip() +
  scale_fill_brewer(palette="Blues") +
  labs(title="Baseline Salary vs Sex",y="Base Salary",x="Sex") +
   theme_classic() + theme(legend.position="none")
```

What do you think? What can you infer from this plot?

T-TEST?

We could go further and try a t-test for the hypotheses.

$$H_0 : \mu_{\text{male}} - \mu_{\text{female}} \leq 0 \text{ vs. } H_A : \mu_{\text{male}} - \mu_{\text{female}} > 0$$

```
t.test(bsal~sex,data=wages,alternative="greater")
```

```
##
##      Welch Two Sample t-test
##
## data:  bsal by sex
## t = 5.83, df = 51.329, p-value = 1.855e-07
## alternative hypothesis: true difference in means is greater than 0
## 95 percent confidence interval:
##  582.9857      Inf
## sample estimates:
##   mean in group Male mean in group Female
##             5956.875             5138.852
```

Is a t-test sufficient here? Any concerns?

IDS 702

SLR?

How about fitting a SLR model to the two variables.

$$\text{bsal}_i = \beta_0 + \beta_1 \text{sex}_i + \epsilon_i; \quad \epsilon_i \overset{iid}{\sim} \mathcal{N}(0, \sigma^2), \quad i = 1, \ldots, n.$$

```
model1 <- lm(bsal~sex,data=wages); summary(model1)
```

```
##
## Call:
## lm(formula = bsal ~ sex, data = wages)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -1336.88  -338.85    43.12   261.15  2143.12
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)   5956.9      105.3  56.580  < 2e-16
## sexFemale     -818.0      130.0  -6.293 1.08e-08
##
## Residual standard error: 595.6 on 91 degrees of freedom
## Multiple R-squared:  0.3032,    Adjusted R-squared:  0.2955
## F-statistic:  39.6 on 1 and 91 DF,  p-value: 1.076e-08
```

What can we infer from these results?

EDA

- T-test shows men started at higher salaries than women $(t = 5.83, p < .0001)$; same conclusion from the regression.
- But one could argue this is so because both methods **do not** control for other characteristics. Indeed, we have ignored the other variables.
- There are other variables that are correlated with bsal. Here's the correlation matrix of all numerical variables using the corr function in R.

	bsal	sal77	senior	age	educ	exper
bsal	1.00	0.42	-0.29	0.03	0.41	0.17
sal77	0.42	1.00	0.13	-0.55	0.42	-0.37
senior	-0.29	0.13	1.00	-0.18	0.06	-0.07
age	0.03	-0.55	-0.18	1.00	-0.23	0.80
educ	0.41	0.42	0.06	-0.23	1.00	-0.10
exper	0.17	-0.37	-0.07	0.80	-0.10	1.00

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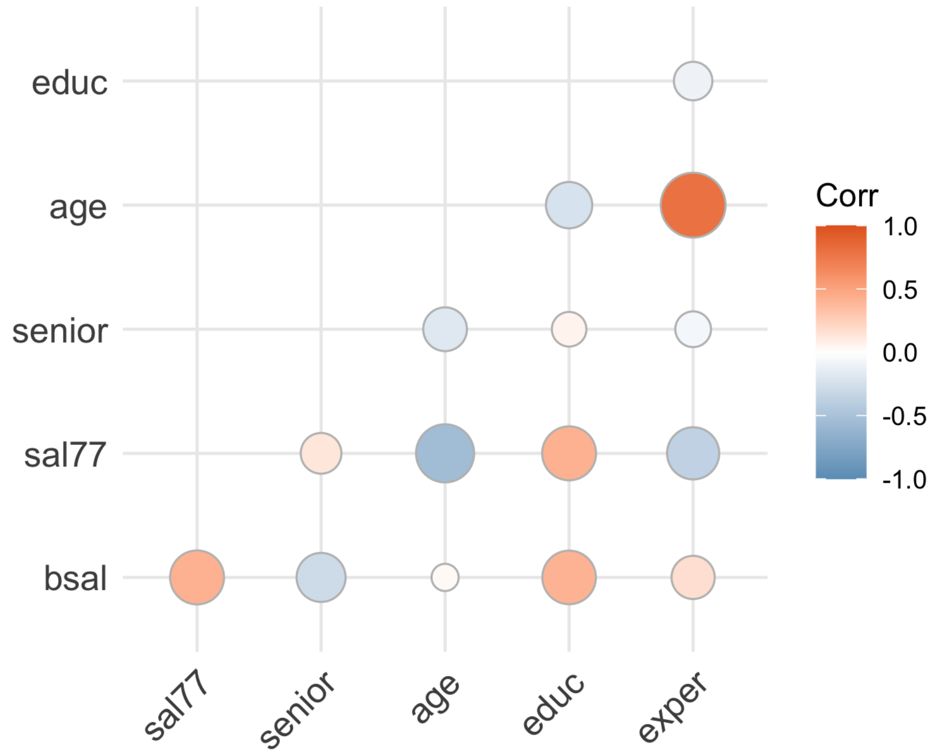
Or visually (using the `ggcorrplot` package),

```
wages_corr <- round(cor(wages[,!is.element(colnames(wages),c("sex","fsex"))]),
ggcorrplot(wages_corr, method = "circle",type = "lower",
           colors = c("#6D9EC1", "white", "#E46726"))
```



EDA

- So, let's take a look at scatter plots of all variables

- First, recall the description of all the variables.

Variable	Description
bsal	Annual salary at time of hire
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educ	years of education.
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IDS 702

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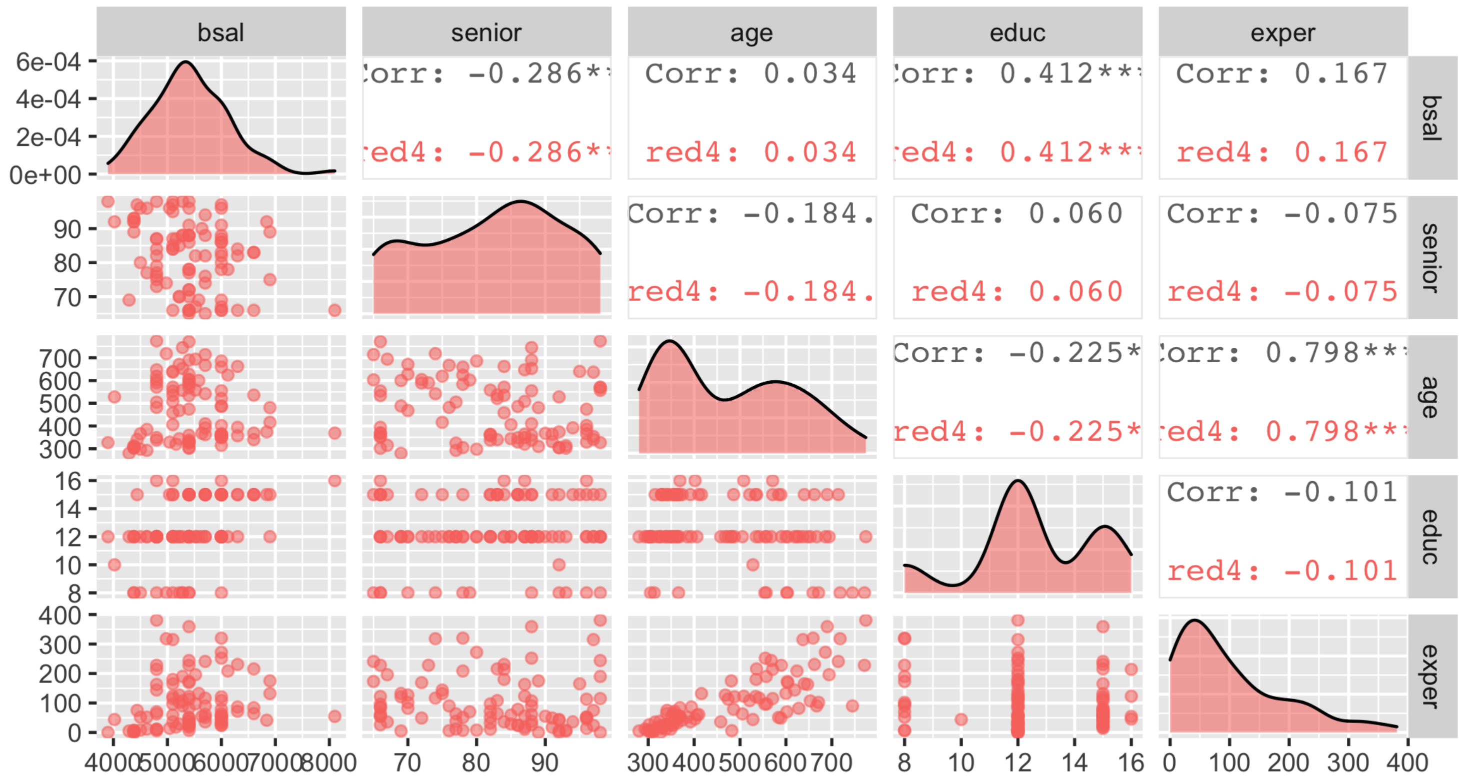
```
ggpairs(wages[,!is.element(colnames(wages),c("sal77","sex","fsex"))],
        mapping=ggplot2::aes(colour = "red4",alpha=0.6)) #GGally package
```

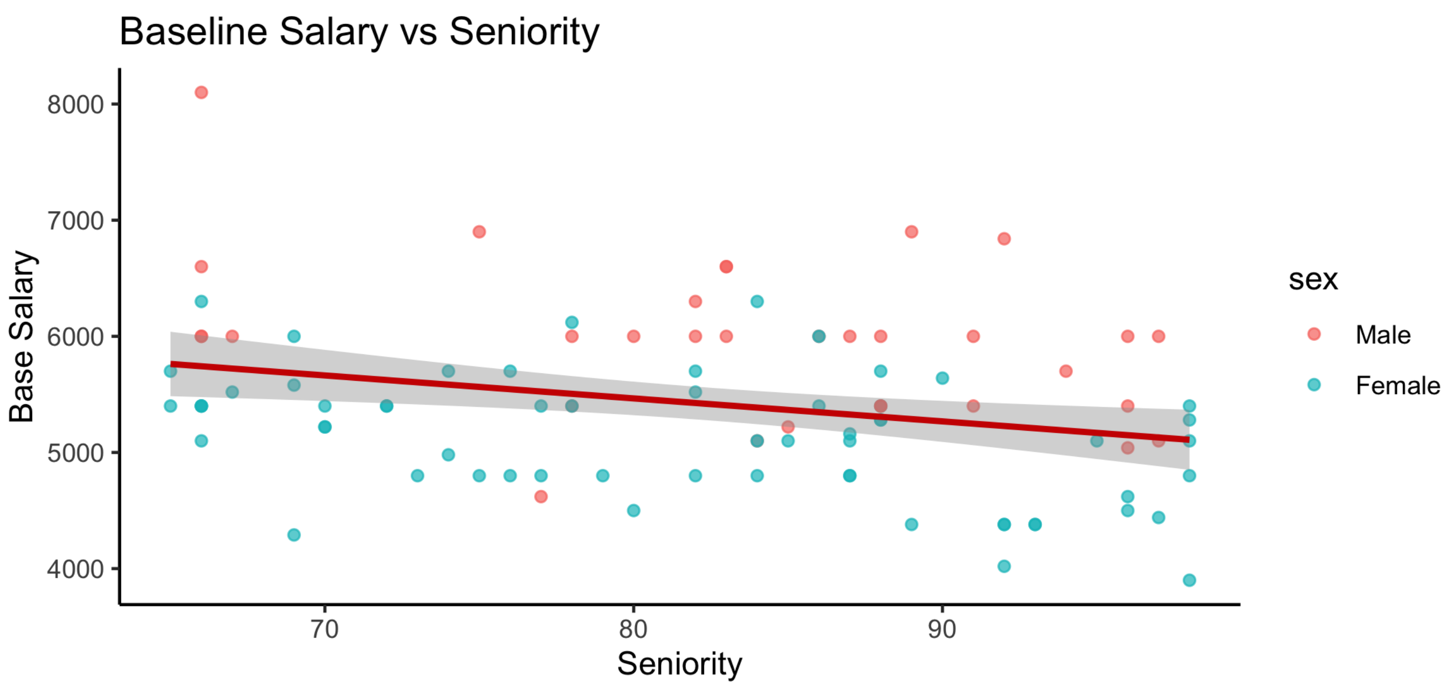


This plot looks very busy!

EDA

Let's take a closer look one variable at a time. First, bsal vs. senior.

```
ggplot(wages,aes(x=senior, y=bsal)) +
  geom_point(alpha = .7,aes(color=sex)) +
  geom_smooth(method="lm",col="red3") + theme_classic() +
  labs(title="Baseline Salary vs Seniority",x="Seniority",y="Base Salary")
```



IDS 702

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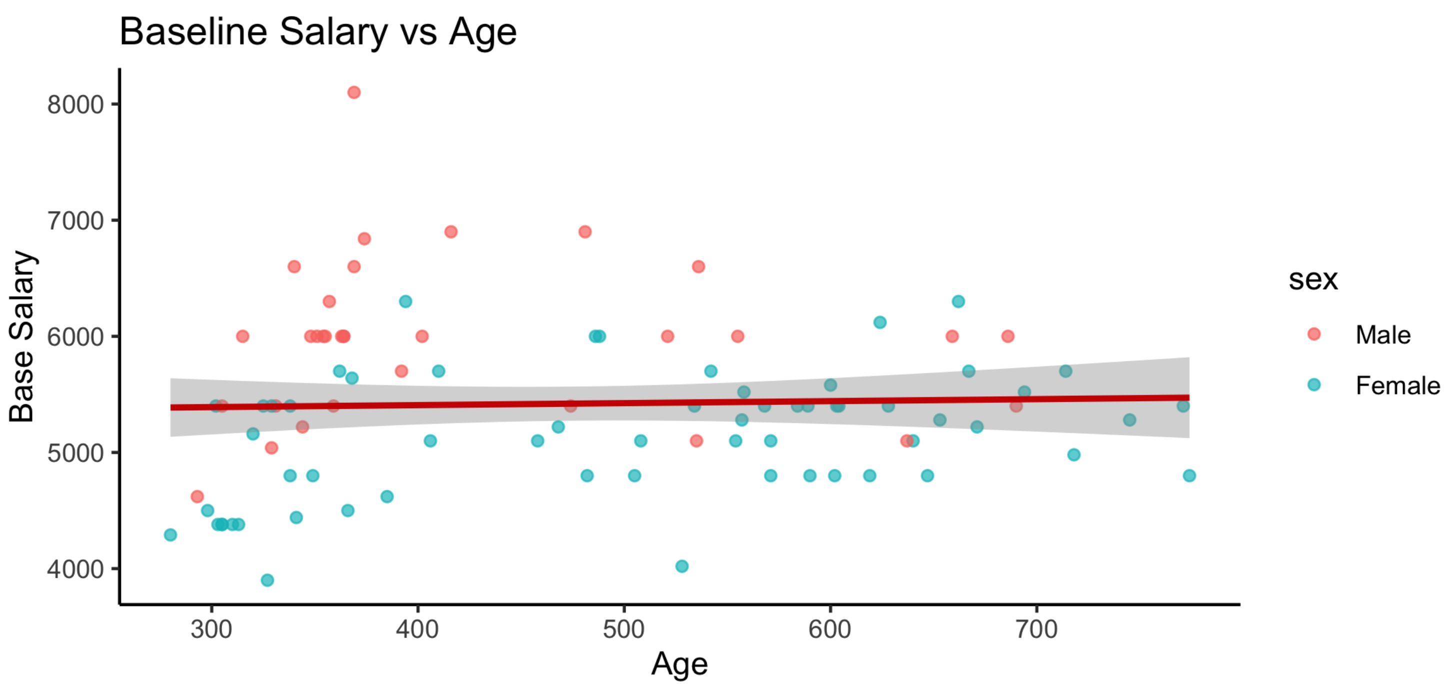
Next, bsal vs. age

```
ggplot(wages,aes(x=age, y=bsal)) +
  geom_point(alpha = .7,aes(color=sex)) +
  geom_smooth(method="lm",col="red3") + theme_classic() +
  labs(title="Baseline Salary vs Age",x="Age",y="Base Salary")
```



IDS 702

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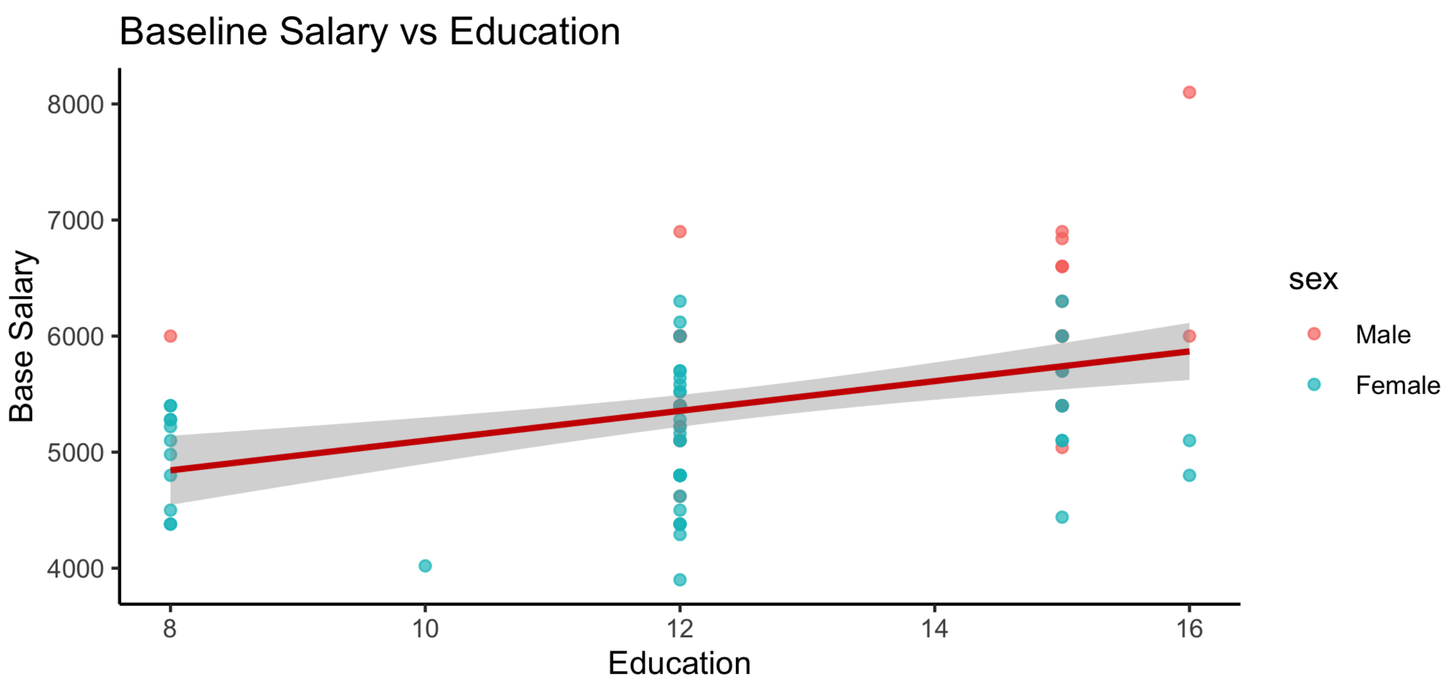
bsal vs. educ

```
ggplot(wages,aes(x=educ, y=bsal)) +
  geom_point(alpha = .7,aes(color=sex)) +
  geom_smooth(method="lm",col="red3") + theme_classic() +
  labs(title="Baseline Salary vs Education",x="Education",y="Base Salary")
```



IDS 702

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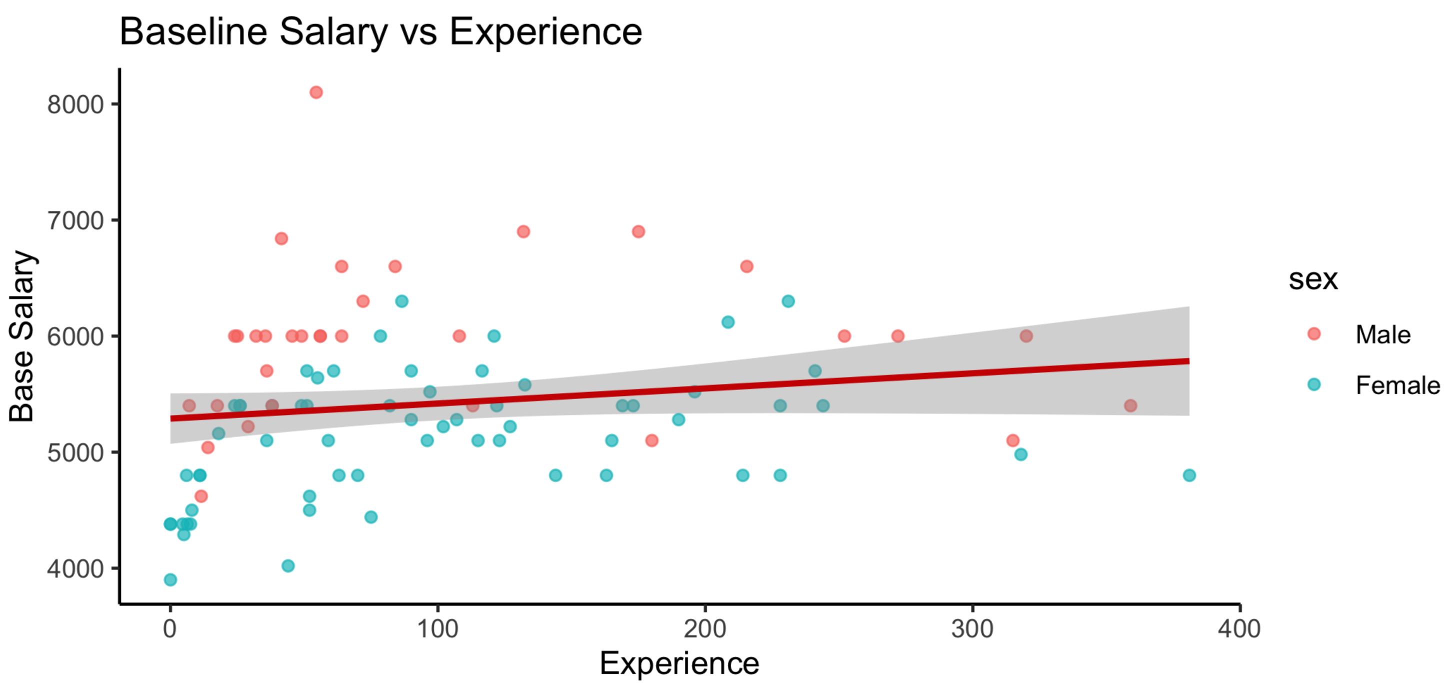
Finally, bsal vs. exper

```
ggplot(wages,aes(x=exper, y=bsal)) +
  geom_point(alpha = .7,aes(color=sex)) +
  geom_smooth(method="lm",col="red3") + theme_classic() +
  labs(title="Baseline Salary vs Experience",x="Experience",y="Base Salary")
```



IDS 702

Takeaways

- Clearly, they are other variables that may be relevant in explaining baseline salary.
- We need to explore other statistical methods than the t-test and simple linear regression.
- We need methods that can explore the relationship between baseline salary and sex while also controlling for the other variables that clearly may be relevant.
- This brings us to multiple linear regression (MLR).
- Something to keep in mind, the overall conclusions may not change after using a better model for this data.

  In general, this should never stop you from exploring and reporting the results from better models; you should always be rigorous when doing analyses and be honest when reporting the results!

IDS 702

What's next?

Move on to the readings for the next module!

IDS 702