ITEC 621 Exercise 2 - Foundations

Descriptive and Predictive Analytics

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2025-01-18

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General Instructions

In this exercise you will do quick descriptive and predictive analytics to evaluate if the Salaries data set (with professor salaries) supports the **gender pay gap hypothesis**.

First, download the R Markdown template for this exercise **Ex1_Foundations_YourLastName.Rmd** and save it with your own last name **exactly**. Then open it in R Studio and complete all the exercises and answer the questions below in the template. Run the code to ensure everything is working fine. When done, upload onto blackboard, knit your R Markdown file into a Word document and upload it into Blackboard. If for some reason you can't knit a Word file, knit an HTML file and save it as a PDF. Blackboard will not accept HTML files, but will take your PDF.

1. Descriptive Analytics

1.1 Examine the data

Is there a gender pay gap? Let's take a look

Load the library **{car}**, which contains the **Salaries** data set. Then, list the first few records with `head(Salaries)`. The display the `summmary()` for this dataset, which will show frequencies.

Then, load the library **{psych}** which contains the `describe()` function and use this function to list the descriptive statistics for the dataset.

Then display the median salary grouped by gender using the `aggregate()` function (feed grouping variables, dataset and aggregate function, i.e., `salary ~ sex, Salaries, mean`)

```
# libraries
library(car)
```

```r
library(psych)
head(Salaries) # data preview
```

```
##        rank discipline yrs.since.phd yrs.service  sex salary
## 1      Prof          B            19          18 Male 139750
## 2      Prof          B            20          16 Male 173200
## 3  AsstProf          B             4           3 Male  79750
## 4      Prof          B            45          39 Male 115000
## 5      Prof          B            40          41 Male 141500
## 6 AssocProf          B             6           6 Male  97000
```

```r
summary(Salaries) # summary statistics
```

```
##         rank     discipline yrs.since.phd    yrs.service        sex
##  AsstProf : 67   A:181      Min.   : 1.00   Min.   : 0.00   Female: 39
##  AssocProf: 64   B:216      1st Qu.:12.00   1st Qu.: 7.00   Male  :358
##  Prof     :266              Median :21.00   Median :16.00
##                             Mean   :22.31   Mean   :17.61
##                             3rd Qu.:32.00   3rd Qu.:27.00
##                             Max.   :56.00   Max.   :60.00
##      salary
##  Min.   : 57800
##  1st Qu.: 91000
##  Median :107300
##  Mean   :113706
##  3rd Qu.:134185
##  Max.   :231545
```

```r
describe(Salaries) # descriptive statistics
```

```
##                vars   n      mean       sd median   trimmed      mad   min
## rank*             1 397      2.50     0.77      3      2.62     0.00     1
## discipline*       2 397      1.54     0.50      2      1.55     0.00     1
## yrs.since.phd     3 397     22.31    12.89     21     21.83    14.83     1
## yrs.service       4 397     17.61    13.01     16     16.51    14.83     0
## sex*              5 397      1.90     0.30      2      2.00     0.00     1
## salary            6 397 113706.46 30289.04 107300 111401.61 29355.48 57800
##                   max  range  skew kurtosis      se
## rank*               3      2 -1.12    -0.38    0.04
## discipline*         2      1 -0.18    -1.97    0.03
## yrs.since.phd      56     55  0.30    -0.81    0.65
## yrs.service        60     60  0.65    -0.34    0.65
## sex*                2      1 -2.69     5.25    0.01
## salary         231545 173745  0.71     0.18 1520.16
```

```r
aggregate(salary ~ sex, Salaries, mean) # aggregate median salary
```

```
##      sex   salary
## 1 Female 101002.4
## 2   Male 115090.4
```

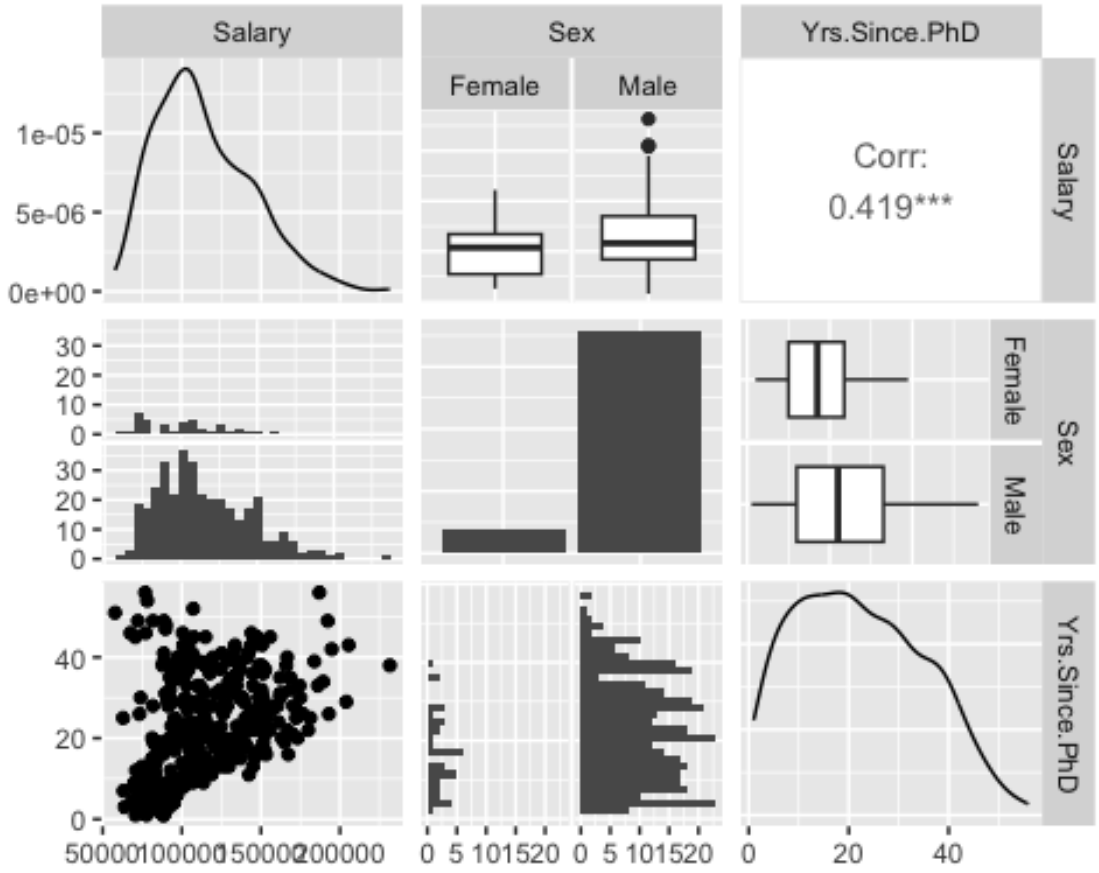
1.2 Correlation, Boxplots and ANOVA

Load the library **GGally** and run the **ggpairs()** function on the **salary** (notice that the dataset **Salary** is capitalized, whereas the variable **salary** is not), **sex** and **yrs.since.phd** variables (only) in the **Salaries** data set to display some basic descriptives and correlation visually. Please label your variables appropriately (see graph below).

Tips: `ggpairs()` requires a **data frame**. So you need to use the `data.frame()` function to bind the necessary column vectors into a data frame (e.g., `ggpairs(data.frame("Salary"=Salaries$salary, etc.)`. Notice the difference in the quality of the graphics and how categorical variables are labeled. Also, add the attribute `upper=list(combo='box')` at the end to get labels for the boxplot.

Finally, conduct an ANOVA test to evaluate if there is a significant difference between mean salaries for male and female faculty. Feed `Salaries$salary ~ Salaries$sex` into the `aov()` function. Embed the `aov()` function inside the `summary()` function to see the statistical test results.

```
library(GGally) # library
ggpairs(data.frame("Salary" = Salaries$salary, # pairwise comparisons
                   "Sex" = Salaries$sex,
                   "Yrs Since PhD" = Salaries$yrs.since.phd),
                    upper = list(combo = 'box'))
```




```
summary(aov(salary ~ sex, Salaries)) # summary statistics analysis
```

```
##              Df    Sum Sq   Mean Sq F value  Pr(>F)
## sex           1 6.980e+09 6.980e+09   7.738 0.00567 **
## Residuals   395 3.563e+11 9.021e+08
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

1.3 Preliminary Interpretation

Based on the output above, does it appear to be a gender pay gap? Why or why not. In your answer, please refer to as much of the data above to support your answer.

```
# Yes there is a gender pay gap. The mean salary for males is higher than
females, the variable 'sex' has statistical significance to the model -
suggesting the person's sex has an affect on their pay, and the bar chart
showing salaries for males and females shows a higher number of males towards
the top end of the distribution. The salary boxplots are inconclusive due to
their overlap and mean lines being very close together. The years since PhD
is much higher for males than for females, which may explain the salary
disparities.
```

2. Basic Predictive Modeling

2.1 Salary Gender Gap: Simple OLS Regression

Suppose that you hypothesize that there is a salary gender pay gap. Fit a linear model function `lm()` to test this hypothesis by predicting salary using only **sex** as a predictor. Store the results in an object called `lm.fit.1`, then inspect the results using the `summary()` function. Do these results support the salary gender gap hypothesis? Briefly explain why.

```
lm.fit.1 <- lm(salary ~ sex, Salaries) # OLS model
summary(lm.fit.1) # summary statistics

##
## Call:
## lm(formula = salary ~ sex, data = Salaries)
##
## Residuals:
##    Min     1Q Median     3Q    Max
## -57290 -23502  -6828  19710 116455
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)   101002       4809  21.001  < 2e-16 ***
## sexMale        14088       5065   2.782  0.00567 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 30030 on 395 degrees of freedom
## Multiple R-squared:  0.01921,    Adjusted R-squared:  0.01673
## F-statistic: 7.738 on 1 and 395 DF,  p-value: 0.005667
```

These results support the gender gap hypothesis. The dummy variable 'sexMale' is of statistical significance because p (0.00567) < 0.05, meaning that sex does have an affect on the model predicting salary. The coefficient of 'sexMale' is positive, meaning that a male would receive a higher salary, because a female would be attached a '0' value to the 'sexMale' variable, resulting in the intercept coefficient as their salary, whereas the male would be attached '1' value to the 'sexMale' variable, resulting in a higher salary.

2.2 Multivariate OLS Regression

Now fit a linear model with **sex** and **yrs.since.phd** as predictors and save it in an object named `lm.fit.2`. Then inspect the results using the `summary()` function. Do these results support the salary gender gap hypothesis? Briefly explain why.

```
lm.fit.2 <- lm(salary ~ sex + yrs.since.phd, Salaries) # multivariate model
summary(lm.fit.2) # summary statistics

##
## Call:
## lm(formula = salary ~ sex + yrs.since.phd, data = Salaries)
```

```
##
## Residuals:
##    Min     1Q Median     3Q    Max
## -84167 -19735  -2551  15427 102033
##
## Coefficients:
##               Estimate Std. Error t value Pr(>|t|)
## (Intercept)    85181.8     4748.3  17.939   <2e-16 ***
## sexMale         7923.6     4684.1   1.692   0.0915 .
## yrs.since.phd    958.1      108.3   8.845   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 27470 on 394 degrees of freedom
## Multiple R-squared:  0.1817, Adjusted R-squared:  0.1775
## F-statistic: 43.74 on 2 and 394 DF,  p-value: < 2.2e-16
```

These results alone do not suggest a gender pay gap, because the 'sexMale' variable is not of statistical significance to this model (p (.0915) > 0.05) and 'yrs.since.phd' is statistically significant, meaning that yrs.since.phd has a greater affect on salary.

2.3 Comparing Models with ANOVA F-Test

Run an ANOVA test using the `anova()` function to compare **lm.fit.1** to **lm.fit.2**.

```
# ANOVA
anova(lm.fit.1)

## Analysis of Variance Table
##
## Response: salary
##            Df     Sum Sq    Mean Sq F value   Pr(>F)
## sex         1 6.9800e+09 6980014930  7.7377 0.005667 **
## Residuals 395 3.5632e+11  902077538
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

anova(lm.fit.2)

## Analysis of Variance Table
##
## Response: salary
##                Df     Sum Sq    Mean Sq F value    Pr(>F)
## sex             1 6.9800e+09 6.9800e+09  9.2507  0.002512 **
## yrs.since.phd   1 5.9031e+10 5.9031e+10 78.2341 < 2.2e-16 ***
## Residuals     394 2.9729e+11 7.5454e+08
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

2.4 Interpretation

Provide your brief conclusions (in no **more than 3 lines**) about whether you think there is a gender pay gap based on this analysis (you will expand this analysis much further in HW2). First, which `lm()` model is better and why? Then, compare the best predictive model of the two against the descriptive analytics results you obtained in section 1 above. If the null hypothesis is that there is no gender pay gap, is this hypothesis supported? Why or why not?

lm.fit.2 is a better model because both variables are statistically significant to the model and the residuals SSE is less than that of lm.fit.1. The models support the descriptive analytics because we see both sex and years since phd are significant visually and statistically.The hypothesis is not supported because both the models and analytics show that males make more money than females on average.