Assignment 2

pavan

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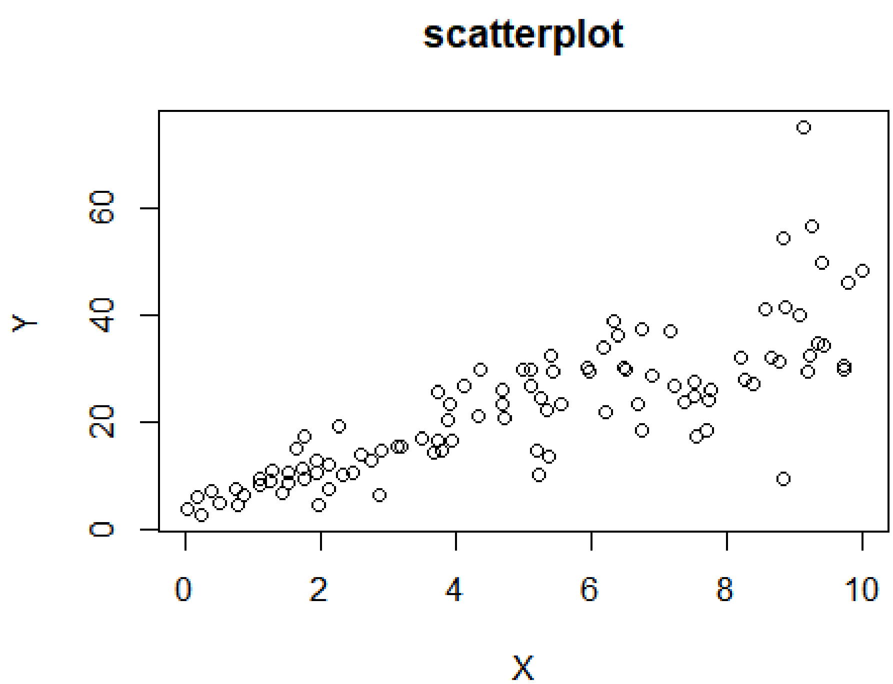
##1. Run the following code in R-studio to create two variables X and Y.

```
set.seed(2017)
X=runif(100)*10
Y=X*4+3.45
Y=rnorm(100)*0.29*Y+Y
```

a) Plot Y against X. Include a screenshot of the plot in your submission. Using the File menu you can save the graph as a picture on your computer. Based on the plot do you think we can fit a linear model to explain Y based on X? (5 Marks)

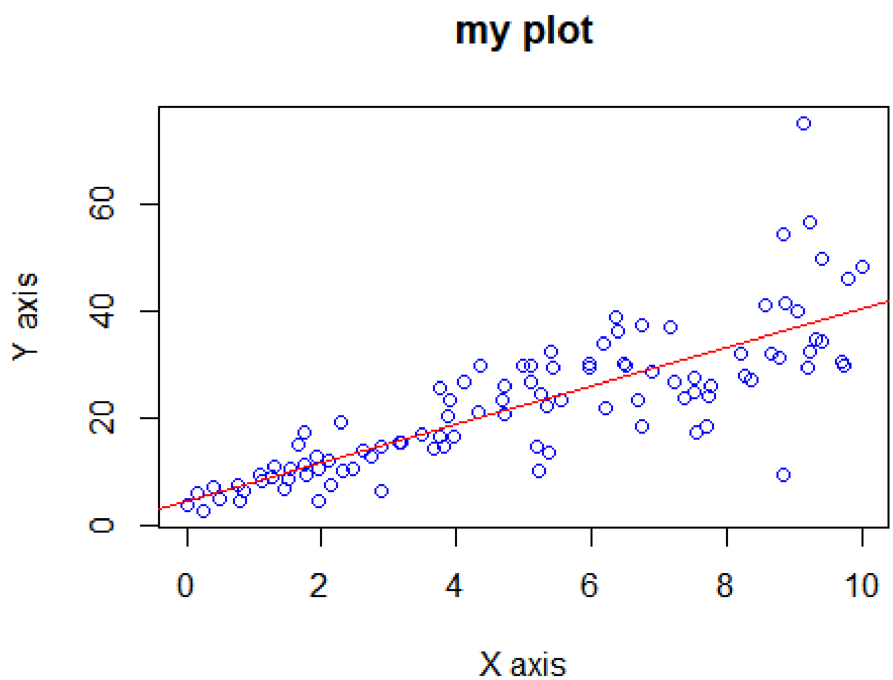
```
 # scatterplot
plot(X,Y, main="scatterplot")
```



Ans: Yes, based on the scatterplot we can fit a linear model to explain Y based on X.

b) Construct a simple linear model of Y based on X. Write the equation that explains Y based on X. What is the accuracy of this model? (5 Marks)

```
## lm() is the function to create linear model of Y from X
plot(X,Y,xlim=c(0, 10),xlab="X axis", ylab="Y axis", main="my plot",
col="blue")
abline(lsfit(X, Y),col = "red")
```




```
Model=lm(Y ~X)
summary(Model)

##
## Call:
## lm(formula = Y ~ X)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -26.755  -3.846  -0.387   4.318  37.503
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)   4.4655     1.5537   2.874  0.00497 **
## X             3.6108     0.2666  13.542  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 7.756 on 98 degrees of freedom
```

```
## Multiple R-squared:  0.6517, Adjusted R-squared:  0.6482
## F-statistic: 183.4 on 1 and 98 DF,  p-value: < 2.2e-16
```

Ans:

Y = B0 + B1X + E the regression coefficient B0 represent the intercept while B1 represents the slope and E is the error term that the regression model could not explain. The accuracy of the model R square is 65%. That is the extent to which the explainatory variable X predicts Y is 65%.

#c) How the Coefficient of Determination, R^2, of the model above is related to the correlation coefficient of X and Y? (5 marks)

```
Coefficient_Determination <- cor(X,Y)^2
Coefficient_Determination

## [1] 0.6517187

r <- (cor(X,Y)^2)/2
r

## [1] 0.3258593
```

#Ans: Coefficient of determination R^2 is equal (r)^2, that is, Correlation Coefficient squared.R^2 or coefficient of determination shows percentage variation in y that is explained by the independent variable x. R^2 is usually between 0 and 1. It is obtained by getting the square value of the Coefficient of correlation,“r” value. In other words Coefficient of Determination is the square of Coefficient of Correlation (r)^2.The Coefficient of Correlation is the degree of relationship between two variables say x and y. Its value is between -1 and 1. +1 indicates that the two variables are perfectly increasing together, while -1 indicates that the two variables are perfectly decreasing together.

question 2

a) James wants to buy a car. He and his friend, Chris, have different opinions about the Horse Power (hp) of cars. James think the weight of a car (wt) can be used to estimate the Horse Power of the car while Chris thinks the fuel consumption expressed in Mile Per Gallon (mpg), is a better estimator of the (hp). Who do you think is right? Construct simple linear models using mtcars data to answer the question. (10 marks)

```
head(mtcars)

##                    mpg cyl disp  hp drat    wt  qsec vs am gear carb
## Mazda RX4         21.0   6  160 110 3.90 2.620 16.46  0  1    4    4
```

```
## Mazda RX4 Wag     21.0   6  160 110 3.90 2.875 17.02  0  1    4    4
## Datsun 710        22.8   4  108  93 3.85 2.320 18.61  1  1    4    1
## Hornet 4 Drive    21.4   6  258 110 3.08 3.215 19.44  1  0    3    1
## Hornet Sportabout 18.7   8  360 175 3.15 3.440 17.02  0  0    3    2
## Valiant           18.1   6  225 105 2.76 3.460 20.22  1  0    3    1

# James' opinion about the HorsePower (hp) of cars
model <- lm(hp ~ wt,  data = mtcars)
summary(model)

## 
## Call:
## lm(formula = hp ~ wt, data = mtcars)
## 
## Residuals:
##     Min      1Q  Median      3Q     Max 
## -83.430 -33.596 -13.587   7.913 172.030 
## 
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)    
## (Intercept)   -1.821     32.325  -0.056    0.955    
## wt            46.160      9.625   4.796 4.15e-05 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## 
## Residual standard error: 52.44 on 30 degrees of freedom
## Multiple R-squared:  0.4339, Adjusted R-squared:  0.4151 
## F-statistic:    23 on 1 and 30 DF,  p-value: 4.146e-05

# Chris' opinion about the Horse Power (hp) of cars
model <- lm(hp ~ mpg,  data = mtcars)
summary(model)

## 
## Call:
## lm(formula = hp ~ mpg, data = mtcars)
## 
## Residuals:
##    Min     1Q Median     3Q    Max 
## -59.26 -28.93 -13.45  25.65 143.36 
## 
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)    
## (Intercept)   324.08      27.43  11.813 8.25e-13 ***
## mpg            -8.83       1.31  -6.742 1.79e-07 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## 
## Residual standard error: 43.95 on 30 degrees of freedom
## Multiple R-squared:  0.6024, Adjusted R-squared:  0.5892 
## F-statistic: 45.46 on 1 and 30 DF,  p-value: 1.788e-07
```

Ans:

The linear model below shows that Chris is right becuse the R-squared values show that fuel consumption (MPG) explains 60% of the variance in horse power, while Jame's opinion does not count because the vehicles weight(wt) only explains 43% of the variation in horsepower.

Therefore, mpg is a better predictor of the car's horsepower

b) Build a model that uses the number of cylinders (cyl) and the mile per gallon (mpg) values of a car to predict the car Horse Power (hp). Using this model, what is the estimated Horse Power of a car with 4 calendar and mpg of 22? (10 mark)

```
model <- lm(hp ~ cyl + mpg,  data = mtcars)
summary(model)
```

```
##
## Call:
## lm(formula = hp ~ cyl + mpg, data = mtcars)
##
## Residuals:
##    Min     1Q Median     3Q    Max
## -53.72 -22.18 -10.13  14.47 130.73
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)   54.067     86.093   0.628  0.53492
## cyl           23.979      7.346   3.264  0.00281 **
## mpg           -2.775      2.177  -1.275  0.21253
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 38.22 on 29 degrees of freedom
## Multiple R-squared:  0.7093, Adjusted R-squared:  0.6892
## F-statistic: 35.37 on 2 and 29 DF,  p-value: 1.663e-08
```

```
predict(model, data.frame(cyl=4, mpg=22))
```

```
##        1
## 88.93618
```

Answer: the estimated horsepower = 89.

##3. For this question, we are going to use BostonHousing dataset. The dataset is in 'mlbench' package, so we first need to instal the package, call the library and the load the dataset using the following commands install.packages('mlbench'),library(mlbench),data(BostonHousing).You should have a dataframe with the name of BostonHousing in your Global environment now

#a) Build a model to estimate the median value of owner-occupied homes (medv)based on the following variables: crime crate (crim), proportion of residential land zoned for lots over 25,000 sq.ft (zn), the local pupil-teacher ratio (ptratio) and weather the whether the tract bounds Chas River(chas). Is this an accurate model? (Hint check R2) (5 marks)

```
library('mlbench')
data(BostonHousing)
model <- lm(medv~crim+zn+ptratio+chas, data=BostonHousing)
summary(model)

##
## Call:
## lm(formula = medv ~ crim + zn + ptratio + chas, data = BostonHousing)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -18.282  -4.505  -0.986   2.650  32.656
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept) 49.91868    3.23497  15.431  < 2e-16 ***
## crim        -0.26018    0.04015  -6.480 2.20e-10 ***
## zn           0.07073    0.01548   4.570 6.14e-06 ***
## ptratio     -1.49367    0.17144  -8.712  < 2e-16 ***
## chas1        4.58393    1.31108   3.496 0.000514 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 7.388 on 501 degrees of freedom
## Multiple R-squared:  0.3599, Adjusted R-squared:  0.3547
## F-statistic: 70.41 on 4 and 501 DF,  p-value: < 2.2e-16
```

Answer: The Coefficient of Determination (R^2) = 36%. This is a weak prediction on the median value of owner-occupied homes (medv) based on the given variables. The accuracy of thus model is not reliable.

#b) Use the estimated coefficient to answer these questions?

#I. Imagine two houses that are identical in all aspects but one bounds the Chas River and the other does not. Which one is more expensive and by how much? (5 marks)

```
summary(model)
```

```
##
## Call:
## lm(formula = medv ~ crim + zn + ptratio + chas, data = BostonHousing)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -18.282  -4.505  -0.986   2.650  32.656
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept) 49.91868    3.23497  15.431  < 2e-16 ***
## crim        -0.26018    0.04015  -6.480 2.20e-10 ***
## zn           0.07073    0.01548   4.570 6.14e-06 ***
## ptratio     -1.49367    0.17144  -8.712  < 2e-16 ***
## chas1        4.58393    1.31108   3.496 0.000514 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 7.388 on 501 degrees of freedom
## Multiple R-squared:  0.3599, Adjusted R-squared:  0.3547
## F-statistic: 70.41 on 4 and 501 DF,  p-value: < 2.2e-16
```

#answer: Estimated coefficients show that the house by Chas River will be more expensive because the price will increase by $4584 relative to any house not by the rive.

#II. Imagine two houses that are identical in all aspects but in the neighborhood of one of them the pupil-teacher ratio is 15 and in the other one is 18. Which one is more expensive and by how much? (Golden Question: 10 extra marks if you answer)

```
a <- 1494 *3
a

## [1] 4482
```

#Answer: If the coefficient of pupil to teacher ratio = -1.49367 then there will be a decrease of approximately $1,494 to every unit change in the ptratio. Therefore, if the pupil-teacher ratio is raised by 3 units (yielding pupil-teacher ratio of 15 and 18 for the two houses). The estimated values indicates that the pupil-teacher ratio of 18 will be less expensive compared to that of pupil-teacher ratio of 15 ($1,494 *3) it'll be $4,482.

#c) Which of the variables are statistically important (i.e. related to the house price)? Hint: use the p-values of the coefficients to answer.(5 mark)

```
summary(model)

##
## Call:
## lm(formula = medv ~ crim + zn + ptratio + chas, data = BostonHousing)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
```

```
## -18.282  -4.505  -0.986   2.650  32.656
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept) 49.91868    3.23497  15.431  < 2e-16 ***
## crim        -0.26018    0.04015  -6.480 2.20e-10 ***
## zn           0.07073    0.01548   4.570 6.14e-06 ***
## ptratio     -1.49367    0.17144  -8.712  < 2e-16 ***
## chas1        4.58393    1.31108   3.496 0.000514 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 7.388 on 501 degrees of freedom
## Multiple R-squared:  0.3599, Adjusted R-squared:  0.3547
## F-statistic: 70.41 on 4 and 501 DF,  p-value: < 2.2e-16
```

#Answer: All four variables are statistically important given that their p-values are less or equal to 0.05 of significance.

#d) Use the anova analysis and determine the order of importance of these four variables. (10 marks)

```
print(anova(model))
```

```
## Analysis of Variance Table
##
## Response: medv
##            Df  Sum Sq Mean Sq F value    Pr(>F)
## crim        1  6440.8  6440.8 118.007 < 2.2e-16 ***
## zn          1  3554.3  3554.3  65.122 5.253e-15 ***
## ptratio     1  4709.5  4709.5  86.287 < 2.2e-16 ***
## chas        1   667.2   667.2  12.224 0.0005137 ***
## Residuals 501 27344.5    54.6
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

#Answer: Using the sum square, the order of importance will be;: 1. Crim =6440.8 2. Ptratio = 4709.5 3. Zn = 3554.3 4. Chas = 667.2