Assignment 03- Business Analytics

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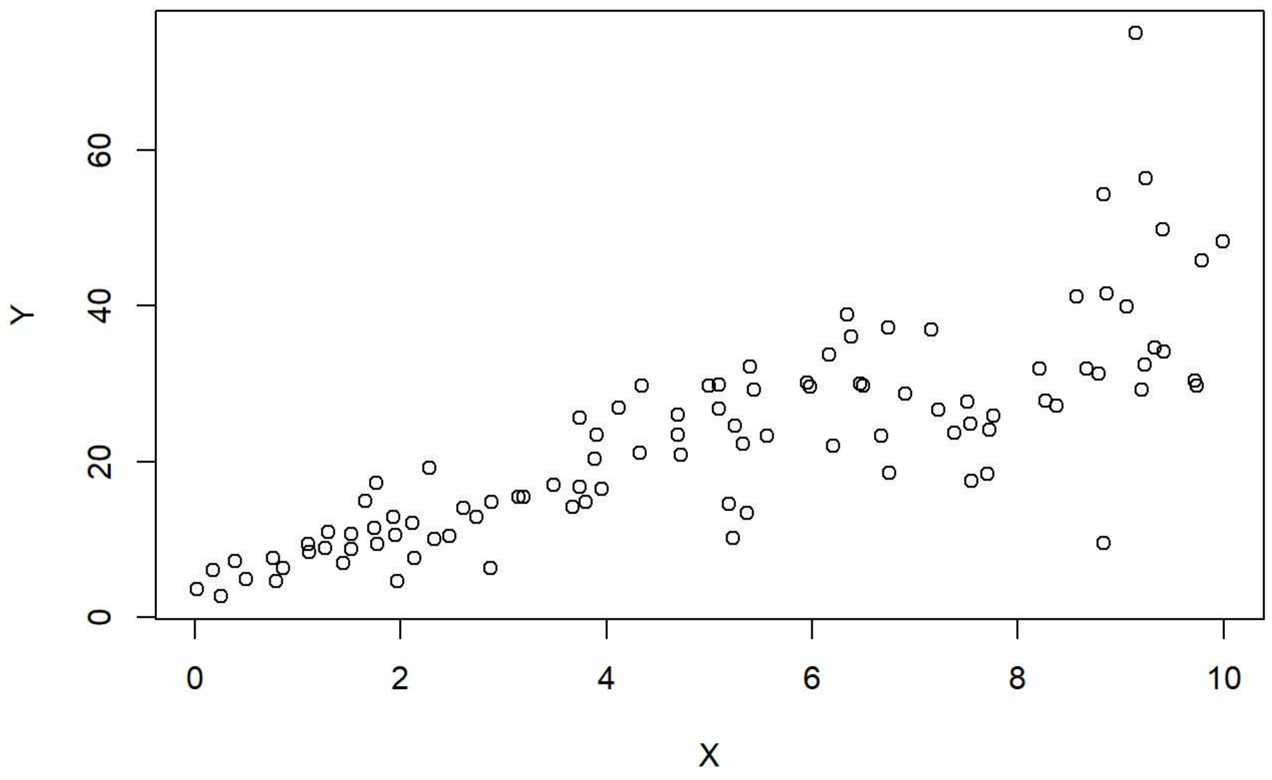
```
# 01.Run the following code in R-studio to create two variables X and Y.

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?
plot(X,Y)
```



```
# Answer:
# According to the plot, it seems that a linear model can be used to show the relationshi
p between X and Y.It seems to be a positive linear relationship between X and Y and some
scatter around the line. There are some points which seem to be outliers and may affect t
he fit of the model.
```

```
# 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?
model <- lm(Y~X)
model
```

```
##
## Call:
## lm(formula = Y ~ X)
##
## Coefficients:
## (Intercept)            X
##       4.465        3.611
```

```
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
```

```
# Y Equation
# Y = 4.4655 + 3.6108*X
# Based on the R-squared and the residual standard error value the model accuracy can be
explained. According to the model summary, the R squared value is 0.6517, which means tha
t model explains 65.17% of the variability in the data. The residual standard error is 7.
756 which means the average distance that the data points fall from the regression line.
The overall model appears to be a good fit for the data, as evidenced by the R-squared va
lue and the low residual standard error.
```

```
# C) How the Coefficient of Determination, R2, of the model above is related to the corre
lation coefficient of X and Y?
# Answer:
# The coefficient of determination(R squared) measures how well the linear regression mod
el fits the data.It measures the proportion of the variance in the dependent variable (Y)
according to the independent variable (X) in the linear regression model.The correlation
coefficient measures the strength and direction of linear relationship between X and Y va
riable. Generally, the correlation coefficient value should be a value in between -1 and
+1. According to the above summary, the R-squared value is 0.6482 means 64.82% of varianc
e in Y is explained by the linear relationship with X. It shows somewhat good fit of the
model to data. The correlation between X and Y can be calculated as the square root of R-
squared value. In here it is approximately 0.807
cor(X,Y)
```

```
## [1] 0.807291
```

```
sqrt(summary(model)$r.squared)
```

```
## [1] 0.807291
```

```
# 02. We will use the ‘mtcars’ dataset for this question. The dataset is already included
in your R distribution. The dataset shows some of the characteristics of different cars.
# 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 th
e Horse Power of the car while Chris thinks the fuel consumption expressed in Mile Per Ga
llon (mpg), is a better estimator of the (hp). Who do you think is right? Construct simpl
e linear models using mtcars data to answer the question.
data("mtcars")

# Model1 - Horsepower(hp) and weight(wt)
model_wt <- lm(hp~wt, data=mtcars)

# Model2 - Horsepower(hp) and Miles Per Gallon (mpg)
model_mpg <- lm(hp~mpg, data=mtcars)

summary(model_wt)
```

```
## 
## 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
```

```
summary(model_mpg)
```

```
##
## 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
```

```
# According to the summary statistics, both models are significant because the significan
t coefficients (p< 0.05). The multiple R-squared value of model_wt 0.4339 and adjusted R
squared value is 0.4151.The multiple R-squared value of model_mpg 0.6024 and adjusted R s
quared value is 0.5892. Based on the R-squared and adjusted R-squared values the model_mp
g can be identified as the better model. Hence that, as Chris says to estimate horse powe
r, Miles per Gallon is better variable than wight of a car.
```

```
# 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 estima
ted Horse Power of a car with 4 calendar and mpg of 22?
#Build linear regression model
model3 <- lm(hp~ cyl + mpg, data= mtcars)

# predict the Horse Power (hp) of a car with 4 cylinders and mpg 22
new_data <- data.frame(cyl=4,mpg=22)
predicated_hp <- predict(model3, newdata = new_data)
predicated_hp
```

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

```
# Answer:
# According to the above calculation the estimated Horse Power of a car with 4 cylinders
and 22mpg is 88.93618.
```

```
# 03. For this question, we are going to use BostonHousing dataset. The dataset is in ‘ml
bench’ package, so we first need to instal the package, call the library and the load the
dataset using the following commands

library(mlbench)
```

```
## Warning: package 'mlbench' was built under R version 4.2.3
```

```
data("BostonHousing")

# A) Build a model to estimate the median value of owner-occupied homes (medv) based on t
he 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 t
he tract bounds Chas River(chas). Is this an accurate model? (Hint check R2 )
model4 <- lm(medv ~ crim + zn + ptratio + chas, data= BostonHousing)
summary(model4)
```

```
##
## 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
```

```
summary(model4)$r.squared
```

```
## [1] 0.359859
```

```
# According to the above summary the R-Squared value is 0.3599. Therefore, this model ind
icates relatively low R-squared value. It means the model is not accurately predicting th
e median value of owner-occupied homes based on the predictor variables.
```

```
# 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?
coefs <- coef(model4)

difference <- coefs["chas1"] * (1 - 0) # this is based on the assumption that  if a house
bounds Chas river (chas=1), if a house dooes not bounds Chas river (chas=0)
difference
```

```
##    chas1
## 4.583926
```

```
# Answer:
# According to the above explanation the difference is 4.583926. Because the difference i
s positive, a house that bounds the Charles river is expected to be $4,583.93 approximate
ly than a house that does not.
```

```
## II) Imagine two houses that are identical in all aspects but in the neighborhood of on
e of them the pupil-teacher ratio is 15 and in the other one is 18. Which one is more exp
ensive and by how much?
diff_ptratio <- 15-18
coefs <- coef(model4)
diff_medv <- coefs["ptratio"]*diff_ptratio
diff_medv
```

```
##  ptratio
## 4.481018
```

```
# Answer:
# Due to the above difference value is positive, the house with ptratio of 15 is expected
to be more expensive than the  house with ptratio of 18. Approximately $ 4,4810.18.
```

```
# C) Which of the variables are statistically important (i.e. related to the house pric
e)? Hint: use the p-values of the coefficients to answer.
summary(model4)
```

```
## 
## 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
```

```
# To decide which variables are important, we have to consider the P-values of the coefficients in the coefficient table. A small P-value (generally less than 0.05) implies a strong evidence against the null hypothesis of no relationship and suggests that the predictor is statistically significant. In the given model P-values of,intercept: < 2e-16 ***, crim: 2.20e-10 ***, zn:6.14e-06 ***, ptratio: < 2e-16 ***,chas1: 0.000514 ***. All of the predictors have p-values less than 0.05 which indicates that all variables in the model are important in explaining the variation in the house prices.
```

```
# D) Use the anova analysis and determine the order of importance of these four variables
# fit the linear regression models
model5 <- lm(medv ~ crim + zn + ptratio + chas, data = BostonHousing)
model6 <- lm(medv ~ crim + zn + ptratio, data = BostonHousing)
model7 <- lm(medv ~ crim + zn + chas, data = BostonHousing)
model8 <- lm(medv ~ zn + ptratio + chas, data = BostonHousing)
model9 <- lm(medv ~ crim + ptratio + chas, data= BostonHousing)

# perform anova analysis to compare the models
anova(model6, model5)
```

```
## Analysis of Variance Table
## 
## Model 1: medv ~ crim + zn + ptratio
## Model 2: medv ~ crim + zn + ptratio + chas
##   Res.Df   RSS Df Sum of Sq      F    Pr(>F)    
## 1    502 28012                                  
## 2    501 27345  1    667.19 12.224 0.0005137 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
anova(model7, model5)
```

```
## Analysis of Variance Table
## 
## Model 1: medv ~ crim + zn + chas
## Model 2: medv ~ crim + zn + ptratio + chas
##   Res.Df   RSS Df Sum of Sq      F    Pr(>F)    
## 1    502 31487                                  
## 2    501 27345  1    4142.9 75.906 < 2.2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
anova(model8, model5)
```

```
## Analysis of Variance Table
## 
## Model 1: medv ~ zn + ptratio + chas
## Model 2: medv ~ crim + zn + ptratio + chas
##   Res.Df   RSS Df Sum of Sq      F  Pr(>F)    
## 1    502 29636                                
## 2    501 27345  1    2291.7 41.987 2.2e-10 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
anova(model9, model5)
```

```
## Analysis of Variance Table
##
## Model 1: medv ~ crim + ptratio + chas
## Model 2: medv ~ crim + zn + ptratio + chas
##   Res.Df   RSS Df Sum of Sq      F    Pr(>F)
## 1    502 28485
## 2    501 27345  1    1140.1 20.889 6.138e-06 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
# Answer:
# According to the ANOVA explanation,  by comparing the P-value we can identify the impor
tance of four variables. The smaller value is the most significant variable in explaining
the variation in the responsible variable. When compare the model 6 and 5, the difference
of the variable is chas. After adding chas the p value is 0.0005137 ***. When compare the
model7 and 5 the difference is ptratio. After adding ptratio the p value is < 2.2e-16 **
*. When compare the model 8 and 5, the difference of the variable is crim. After adding c
rim the p value is  2.2e-10 ***. When compare the model 9 and 5, the difference of the va
riable is zn. After adding zn the p value is 6.138e-06 ***. According to that to find the
order of importance of each variable we can arrange the P-values of each from lowest to t
he highest. Ptratio = 2.2e-16 ***, crim= 2.2e-10 ***, zn = 6.138e-06 ***, chas = 0.000513
7 *** likewise we can order the most important variable to the least important variable a
ccording to the ANOVA analysis.
```