Empirical software engineering

Lab 1: Descriptive statistics, regression and hypothesis testing
Group 9

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Exercise 1 - Time to Develop

a) Descriptive data:

Mean = 244.625
Median = 231
Standard deviation = 83.4672591
Variance = 6966.7833333

b) What is being calculated?

What is being calculated is the **sample** standard deviation, since the company has provided the time spent only for 16 features chosen at random. The population would be if we had the time for all the features developed.

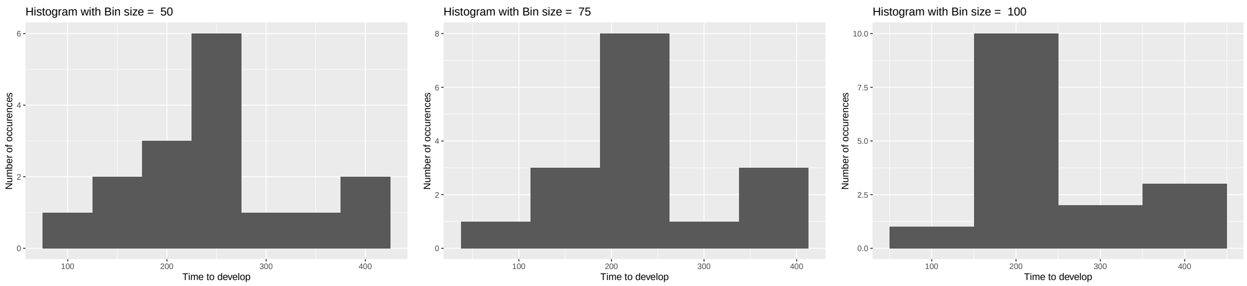
c) Hypothesis

The hypothesis is one tailed because we are only looking in one direction.

h0: mean(Time) <= 225 Hours
h1: mean(Time) > 225 Hours

d) Histogram

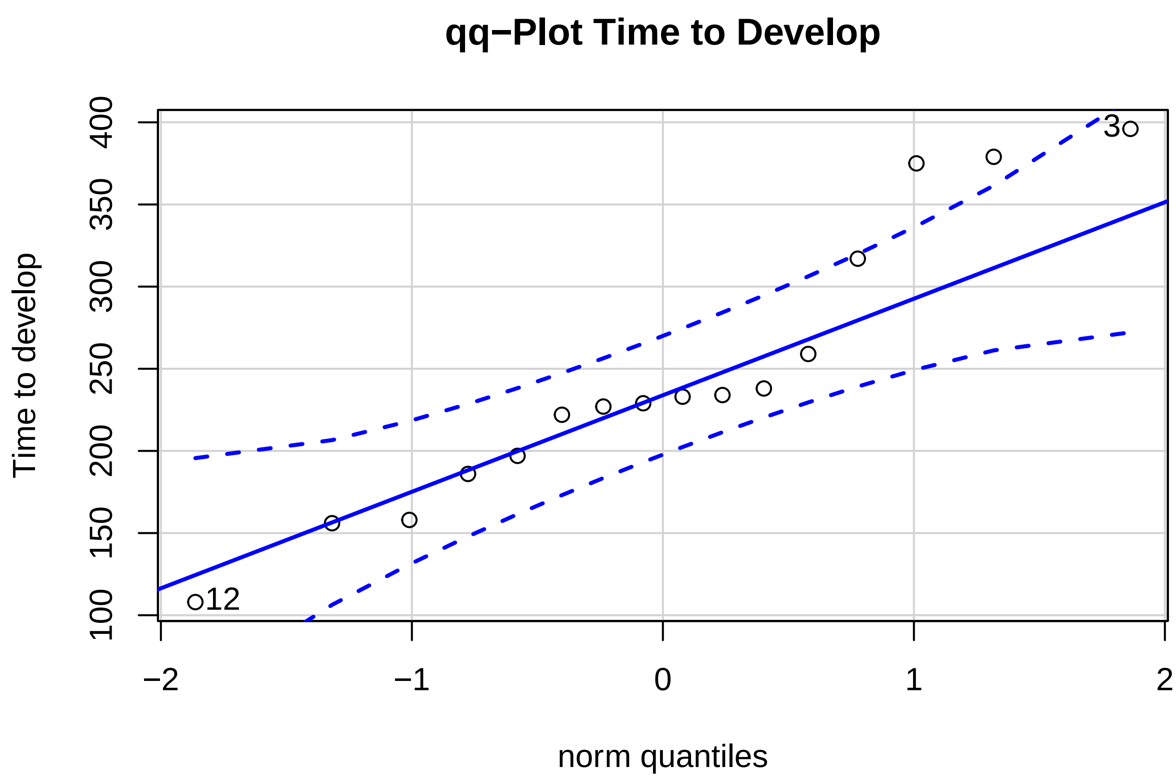
```
dbin<-data.frame(d1)
histogram_with_bin <- function(bin_size) {
  title<- paste("Histogram with Bin size = ", bin_size)
  ggplot(data = dbin, aes(x=d1))+
  geom_histogram(binwidth = bin_size)+
  labs(title=title, x='Time to develop', y='Number of occurences')
}

histogram_with_bin(50)
histogram_with_bin(75)
histogram_with_bin(100)
```



Changing the amount of bins doesn't change the perspective drastically, but we can observe that most of the values are concentrated between 200 and 250, using the bin size of 50. When we used bigger values we would assume that most values were between 100 and 300 which gives us much less precision on that.

e) qq-Plot

```
car::qqPlot(d1,main = 'qq-Plot Time to Develop', ylab= 'Time to develop')
```




```
## [1]  3 12
```

f) Shapiro-Wilk test

```r
shapiro.test(d1)
```

```
##
##  Shapiro-Wilk normality test
##
## data:  d1
## W = 0.92033, p-value = 0.1708
```

Observing the QQ-plot of the data we can see that it doesn't seem to follow a normal distribution since the residuals are not independent and there are points out of the 95% confidence interval that we are using in the plot.

The Shapiro-Wilk would also reinforce this non-normality of the data since it's W value is below 1, but the p-value is larger than alpha so we can't reject that the data is normally distributed based on this test.

g) One sample T-Test

We are using a T-Test instead of a Z-Test because we have a sample size smaller than 30 and we don't know the standard deviation of the population. We used a one sample T-Test since we have only one sample group in this experiment.

The data follows the assumptions of a T-Tests since:

- It follows a continuous scale
- We assumed that the data was collected randomly from the population
- We assumed that the data is approximately normally distributed since we couldn't reject it using the Shapiro-Wilk test.

```r
t.test(d1, mu=225 , alternative = 'greater' ,conf.level=0.95)
```

```
##
##  One Sample t-test
##
## data:  d1
## t = 0.94049, df = 15, p-value = 0.1809
## alternative hypothesis: true mean is greater than 225
## 95 percent confidence interval:
##  208.0444      Inf
## sample estimates:
## mean of x
##   244.625
```

As seen in the test output the confidence interval is between 208 to infinity.

Based on the T-Test we can't reject the null hypothesis that the time to develop is less than 225 because the p-value is larger than the alpha value.

Exercise 2 - Performance

a) Descriptive Statistics

```
psych::describeBy(df2$Time,df2$Group)
```

```
##
##  Descriptive statistics by group
## group: timeOptimized
##    vars  n mean   sd median trimmed  mad   min   max range  skew kurtosis   se
## X1    1 10   16 0.03  16.01   16.01 0.02 15.96 16.04  0.08 -0.43    -1.19 0.01
## ------------------------------------------------------------------------------------
## group: timeOriginal
##    vars  n  mean   sd median trimmed  mad   min   max range  skew kurtosis   se
## X1    1 10 16.02 0.03  16.02   16.02 0.04 15.96 16.05  0.09 -0.43    -1.28 0.01
```

b) Type of data

```
str(defaultDf2)
```

```
## tibble [20 x 2] (S3: tbl_df/tbl/data.frame)
##  $ Group: chr [1:20] "timeOriginal" "timeOptimized" "timeOriginal" "timeOptimized" ...
##  $ Time : num [1:20] 16 16 16 16 16 ...
```

```
df2$Group <- as.factor(df2$Group)
df2$Time <- as.numeric(df2$Time)

str(df2)
```

```
## tibble [20 x 2] (S3: tbl_df/tbl/data.frame)
##  $ Group: Factor w/ 2 levels "timeOptimized",..: 2 1 2 1 2 1 2 1 2 1 ...
##  $ Time : num [1:20] 16 16 16 16 16 ...
```

Explanation for each data type:

- The numeric type is a number that measures a value.
- The categorical is a integer value connected to a set of characters.
- The ordinal type is a number that represents the natural order of the elements without the indication of the relative size difference.

c) Linear Model

```
lm(Time ~ Group,df2)
```

```
##
## Call:
## lm(formula = Time ~ Group, data = df2)
##
## Coefficients:
##       (Intercept)  GrouptimeOriginal
##             16.00               0.01
```

The values observed in the linear model function were:

- The value for the intercept (a) is 16 according to the function.
- The value of b is 0.01.
- The value of X is 1 for the group original and 0 for group optimized.

d) Is the factory "Group" statistically significant for this model?

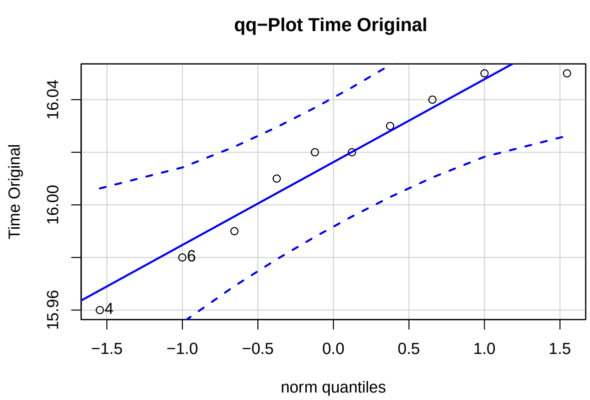
```r
t.test(formula = Time~Group, data=df2, var.equal=T)
```

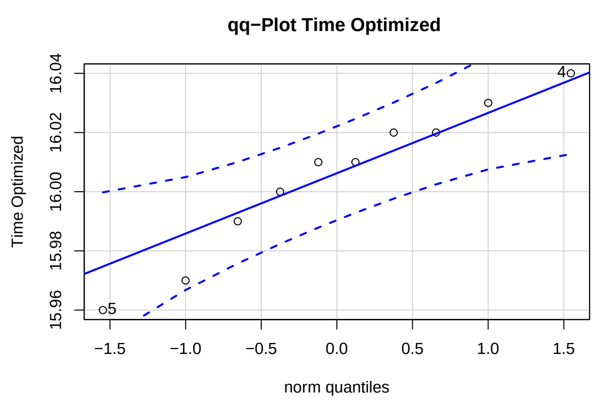
```
##
##  Two Sample t-test
##
## data:  Time by Group
## t = -0.79894, df = 18, p-value = 0.4347
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -0.03629652  0.01629652
## sample estimates:
## mean in group timeOptimized  mean in group timeOriginal
##                      16.005                      16.015
```

The factor group is not statistically significant since the p value is larger than the alpha value.

We can't say that time optimized is better than the original one based on our tests.

```
## [1] 4 6

## [1] 5 4
```





Based on the qq-plots the data fulfills the assumptions for the linear regression model.