IST772 Problem Set 5

Abhijith Anil Vamadev

The homework for week five is based on exercises 6 through 10 on pages 86 and 87, but with changes as noted in the text in this notebook (i.e., follow the problems as given in this document and not the textbook).

Attribution statement: (choose only one) 1. I did this homework by myself, with help from the book and the professor

Chapter 5, Exercise 6

The built-in warpbreaks data set (see "? warpbreaks" for documentation) contains data for the number of warp thread breaks per loom with different amounts of tension (we will not consider the type of wool). The tensions are labelled "L", "M" or "H" for low, medium and high tension. As a reminder, these subsetting statement accesses the breaks data for the low and medium tension:

```
lower <- warpbreaks$breaks[warpbreaks$tension=="L"] #low tension
med <- warpbreaks$breaks[warpbreaks$tension=="M"] #medium tension
high <- warpbreaks$breaks[warpbreaks$tension=="H"] #high tension
```

Run a t-test to compare the means of the breaks for medium tension ("M") and breaks for high tension ("H") in the warpbreaks data. Report the observed value of t, the degrees of freedom, and the p-value associated with the observed value (1 pt). Assuming an alpha threshold of .05, decide whether you should reject the null hypothesis that the means are equal or fail to reject the null hypothesis (1 pt). In addition, report the upper and lower bound of the confidence interval (1 pt).

```
t.test(warpbreaks$breaks[warpbreaks$tension=="M"], warpbreaks$breaks[warpbrea
ks$tension=="H"])# t-test

##
##  Welch Two Sample t-test
##
## data:  warpbreaks$breaks[warpbreaks$tension == "M"] and warpbreaks$breaks[
warpbreaks$tension == "H"]
## t = 1.6199, df = 33.74, p-value = 0.1146
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -1.203597 10.648042
## sample estimates:
## mean of x mean of y
##  26.38889  21.66667
```

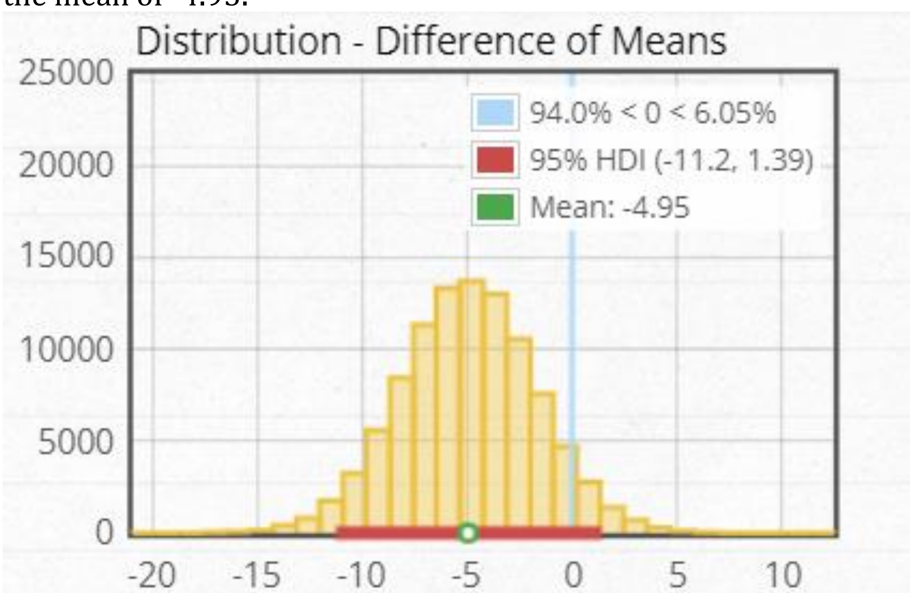
- The t value is 1.619 and the degrees of freedom is 33.74, with a p-value of 0.1146.
- As the p-value is greater than the alpha (0.05) we fail to reject the null hypothesis.
- The upper and lower bound of the confidence interval are 10.68 and -1.203. 95% interval indicates that, if the process was to repeat 100 times 95 of the test, would contain the mean difference..

Chapter 5, Exercise 7

Install and library() the BEST package. Note that you may need to install a program called JAGS onto your computer before you try to install the BEST package inside of R. Use BESTmcmc() to compare the warp breaks for medium tension ("M") to breaks for high tension ("H") (1 pt). Plot the result and document the boundary values that BESTmcmc() calculated for the HDI (1 pt). Write a brief definition of the meaning of the HDI and interpret the results from this comparison (1 pt).

```
#The BESTmcmc wasn't working so, I did it online.
```

- HDI is build from Markov chain with more than 100,000 simulations of mean difference between medium and high warp breaks data. HDI means that there is a 95% probability that the population mean difference between the two groups falls within this -11.2 and 1.39 range. The 95% HDI lies in the bell-curve.
- Medium tension has more breaks, than high tension, based on the interpretation of the mean of -4.95.



Chapter 5, Exercise 8

Compare and contrast the results of Exercise 6 and Exercise 7. You have three types of evidence: the results of the null hypothesis test, the confidence interval, and the HDI from the BESTmcmc() procedure. Each one adds something, in turn, to the understanding of the difference between tensions. Explain what information each test provides about the comparison of the breaks for medium tension and for high tension (1 pt for each report and interpretation).

- Means of Medium tension and high tension are equal - Null hypothesis. The NHSA states that there isn't enough evidence to suggest that null hypothesis can be accepted. Typically our null hypothesized value will be 0 (point of no difference), and if we find 0 in our confidence interval then that would mean we have a good chance of actually finding no difference in the means.
- Confidence intervals in the long run, not the particular one that we calculated.. The upper and lower bound of the confidence interval are 10.68 and -1.203. 95% interval indicates that, if the process was to repeat 100 times 95 of the test, would contain the mean difference. The confidence interval uses sample data to compute one and only one example of an upper and lower bound for the population mean.
- HDI is build from Markov chain with more than 100,000 simulations of mean difference between medium and high warp breaks data. HDI means that there is a 95% probability that the population mean difference between the two groups falls within this -11.2 and 1.39 range. The 95% HDI lies in the bell-curveIn contrast, the HDI is built up gradually from more than 100,000 steps in our Markov chain Monte Carlo process, with each step depicting a possible combination of the population parameters. The best HDI directly models the population parameters of interest and shows us probability distributions for those parameters.

Chapter 5, Exercise 9

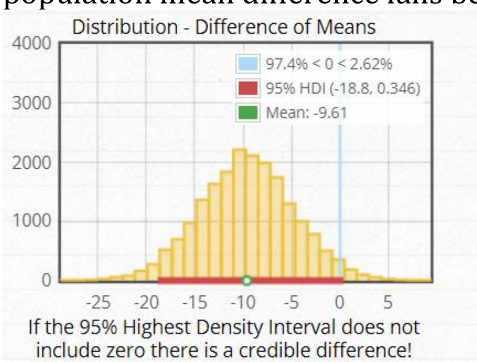
Using the same warpbreaks data set, compare the breaks for medium tension to the breaks for low tension ("L"). Use all of the methods described earlier (t-test, confidence interval, and Bayesian method) and explain all of the results (1 pt for each report and interpretation).

```
t.test(warpbreaks$breaks[warpbreaks$tension=="M"], warpbreaks$breaks[warpbrea
ks$tension=="L"]) #t-test for medium and low

##
##  Welch Two Sample t-test
##
## data:  warpbreaks$breaks[warpbreaks$tension == "M"] and warpbreaks$breaks[
```

```
warpbreaks$tension == "L"]
## t = -2.256, df = 26.554, p-value = 0.03252
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -19.1023204  -0.8976796
## sample estimates:
## mean of x mean of y
##  26.38889  36.38889
```

- Lower tension has more breaks compared to the medium tension based on the mean of -9.61 and the confidence interval.
- P-value is 0.0325, since it is lower than alpha, we reject the null-hypothesis. This suggests that the there is evidence to suggest that the two means of lower and medium are not equal.
- The confidence interval is -19.103 and -0.897, which does not include 0, meaning we have a good chance of finding a difference between the two means. If we were the process 100 times, then 95 times it would contain the mean difference.
- HDI is -18.8 and 0.346, with 97.4% < 0 < 2.62%, there is a 95% probability that the population mean difference falls between the HDI values.



Chapter 5, Exercise 10

Consider this t-test, which compares two datasets of n = 100,000 observations each:

```
t.test(rnorm(100000,mean=17.1,sd=3.8),rnorm(100000,mean=17.2,sd=3.8)) #t-test

##
##  Welch Two Sample t-test
##
## data:  rnorm(1e+05, mean = 17.1, sd = 3.8) and rnorm(1e+05, mean = 17.2, s
d = 3.8)
## t = -6.4981, df = 2e+05, p-value = 8.15e-11
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -0.14357363 -0.07703387
## sample estimates:
## mean of x mean of y
##  17.09272  17.20303
```

For rnorm() command was used to generate a random normal distribution of observations. The only difference between the two is that in the first rnorm() call, the mean is set to 17.1 and in the second it is set to 17.2. I think you would agree that this is a negligible difference, if we are discussing breaks. Run this line of code and comment on the results of the t-test (1 pt). What are the implications in terms of using the NHST on very large data sets (e.g., is it a good idea)? (1 pt)

- *The t-value is high and the p-value is a lot smaller than the alpha, hence we reject the null hypothesis. The Confidence interval at 95% are -0.15 and -0.09, 0 doesn't fall in the range of the confidence interval and there a chances of finding a difference between the two means.* Increasing sample size, decreases the p-value. The larger the size of the sample, larger the difference between the conditions and larger the t-statistic and smaller the p-value. The t-statistic will grow larger with more sample size, as computing the t-statistic involves using the number of samples, which will reduce the p-value. Hence, no it isn't a good idea to use NHST on large data sets.