Hypothesis Testing Problem using R

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Introduction

In elementary of statistic, we have learnt about hypothesis testing.A statistical hypothesis test is a method of statistical inference. Commonly, two statistical data sets are compared, or a data set obtained by sampling is compared against a synthetic data set from an idealized model(Wikipedia).We compare one alternative statement against a null hypothesis that is supposed to be true. In hypothesis testing, we determined if alternative claim is true by calculating whether the null hypothesis should be rejected or not.

In this process, we could introduce terms such as types of errors, significant level, p-value, and some graphs to make us easier to analyze the dataset. In this post, I am going to apply R into hypothesis testing problem by some example using the dataset "earn-of-collegemajors-all-ages"(Github). –import the dataset and packages to be used

```
dat <- read.csv("C:/Users/eriko/stat133/stat133-hws-fall17/post01/data/earn-of-collegemajors-all-ages.csv",strings
AsFactors=FALSE)
library(dplyr)
```

```
## Warning: package 'dplyr' was built under R version 3.4.2
```

```
##
## Attaching package: 'dplyr'
```

```
## The following objects are masked from 'package:stats':
##
##     filter, lag
```

```
## The following objects are masked from 'package:base':
##
##     intersect, setdiff, setequal, union
```

```
library(ggplot2)
```

```
## Warning: package 'ggplot2' was built under R version 3.4.2
```

```
library(BSDA)
```

```
## Warning: package 'BSDA' was built under R version 3.4.2
```

```
## Loading required package: lattice
```

```
##
## Attaching package: 'BSDA'
```

```
## The following object is masked from 'package:datasets':
##
##     Orange
```

```
setwd("/Users/eriko/stat133/stat133-hws-fall17/post01")
```

#Graphing and Analyze * Before we start doing a hypothesis testing problem, let's organize the data best fit to be worked in R studio, and do some analysis and graphing process to know more about the dataset.

* check the structure of the dataset.

```
str(dat)
```

```
## 'data.frame':    173 obs. of  11 variables:
##  $ Major_code                  : int  1100 1101 1102 1103 1104 1105 1106 1199 1301 1302 ...
##  $ Major                       : chr  "GENERAL AGRICULTURE" "AGRICULTURE PRODUCTION AND MANAGEMENT" "AGRICULTU
RAL ECONOMICS" "ANIMAL SCIENCES" ...
##  $ Major_category              : chr  "Agriculture & Natural Resources" "Agriculture & Natural Resources" "Agr
iculture & Natural Resources" "Agriculture & Natural Resources" ...
##  $ Total                       : int  128148 95326 33955 103549 24280 79409 6586 8549 106106 69447 ...
##  $ Employed                    : int  90245 76865 26321 81177 17281 63043 4926 6392 87602 48228 ...
##  $ Employed_full_time_year_round: int  74078 64240 22810 64937 12722 51077 4042 5074 65238 39613 ...
##  $ Unemployed                  : int  2423 2266 821 3619 894 2070 264 261 4736 2144 ...
##  $ Unemployment_rate           : num  0.0261 0.0286 0.0302 0.0427 0.0492 ...
##  $ Median                      : int  50000 54000 63000 46000 62000 50000 63000 52000 52000 58000 ...
##  $ P25th                       : int  34000 36000 40000 30000 38500 35000 39400 35000 38000 40500 ...
##  $ P75th                       : num  80000 80000 98000 72000 90000 75000 88000 75000 75000 80000 ...
```

* Rename the columns The name of columns in the dataset is too long and complicated, it is better to replace them by shorter abbreviation.

```
#replace the major_category's name and column name
colnames(dat) <- c("major_code","major","major_cat","total","employed","employed_fulltime","unemployed","unemploye
d_rate","median","q1","q3")
```

* Add column of employment rate

```
dat <- mutate(dat,employed_rate = dat$employed/dat$total)
```

* Picking data of “Computers & Mathematics”and “engineering”

```
#Create new dataframes of category of "Computers & Mathematics"and "engineering"
cs_math <- filter(dat,dat$major_cat=="Computers & Mathematics")
engin <- filter(dat,dat$major_cat=="Engineering")
#store to data file
write.csv(cs_math,file = "C:/Users/eriko/stat133/stat133-hws-fall17/post01/data/cs_math.csv")
write.csv(engin,file = "C:/Users/eriko/stat133/stat133-hws-fall17/post01/data/engin.csv")
```

* summary of data of “Computers & Mathematics”and “engineering”

```
#store the result in output file
sink(file = "/Users/eriko/stat133/stat133-hws-fall17/post01/output/cs_math-summary.txt")
summary(cs_math)
```

```
##    major_code      major             major_cat             total
##  Min.    :2001   Length:11          Length:11          Min.   :  7184
##  1st Qu.:2102   Class :character   Class :character   1st Qu.: 27062
##  Median :2106   Mode  :character   Mode  :character   Median : 51771
##  Mean    :2703                                         Mean   :161944
##  3rd Qu.:3700                                         3rd Qu.:165794
##  Max.    :4005                                         Max.   :783292
##     employed        employed_fulltime    unemployed     unemployed_rate
##  Min.   :  5874   Min.   :  5039    Min.   :  150   Min.   :0.02490
##  1st Qu.: 20818   1st Qu.: 16608    1st Qu.: 1702   1st Qu.:0.05237
##  Median : 44071   Median : 35954    Median : 2748   Median :0.05565
##  Mean   :128237   Mean   :106380    Mean   : 7270   Mean   :0.05944
##  3rd Qu.:142321   3rd Qu.:123777    3rd Qu.: 8277   3rd Qu.:0.06687
##  Max.   :656372   Max.   :561052    Max.   :34196   Max.   :0.09026
##      median             q1               q3          employed_rate
##  Min.   :50000   Min.   :34500   Min.   : 75000   Min.   :0.6490
##  1st Qu.:57500   1st Qu.:40000   1st Qu.: 82500   1st Qu.:0.7853
##  Median :66000   Median :43000   Median : 95000   Median :0.8177
##  Mean   :66273   Mean   :43427   Mean   : 95818   Mean   :0.8017
##  3rd Qu.:70000   3rd Qu.:46600   3rd Qu.:103500   3rd Qu.:0.8446
##  Max.   :92000   Max.   :53000   Max.   :136000   Max.   :0.8600
```

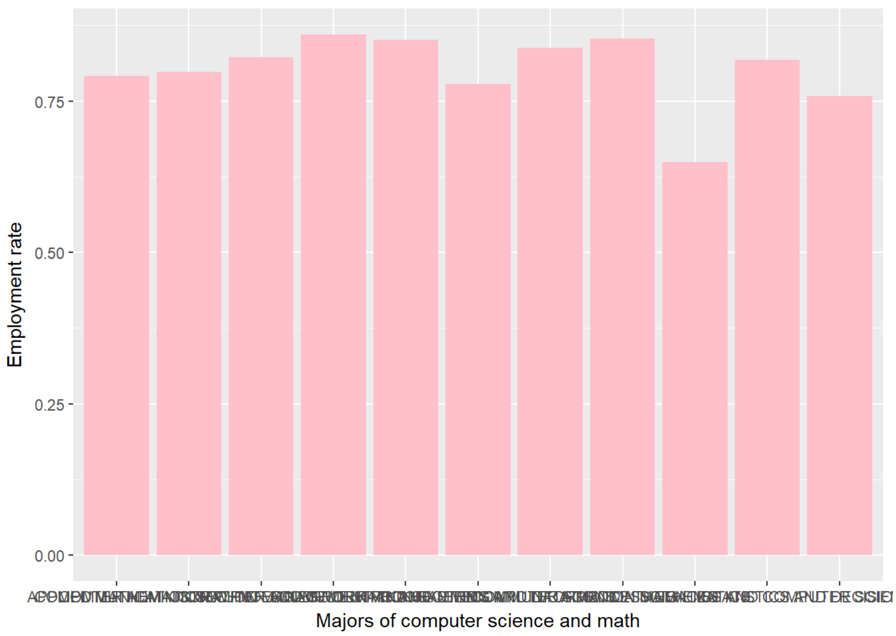
```
sink()
sink(file = "/Users/eriko/stat133/stat133-hws-fall17/post01/output/summary-engin.txt")
summary(engin)
```

```
##     major_code       major              major_cat              total       
##  Min.    :1401   Length:29          Length:29          Min.   :  6264  
##  1st Qu.:2406   Class :character   Class :character   1st Qu.: 18347  
##  Median :2413   Mode  :character   Mode  :character   Median : 37382  
##  Mean   :2490                                          Mean   :123311  
##  3rd Qu.:2499                                          3rd Qu.:138366  
##  Max.   :5008                                          Max.   :671647  
##     employed       employed_fulltime   unemployed     unemployed_rate  
##  Min.   :  4120   Min.   :  3350    Min.   :    0   Min.   :0.00000  
##  1st Qu.: 12876   1st Qu.:  9226    1st Qu.:  617   1st Qu.:0.04384  
##  Median : 27275   Median : 22104    Median : 1521   Median :0.04985  
##  Mean   : 90413   Mean   : 76414    Mean   : 5048   Mean   :0.05063  
##  3rd Qu.:101273   3rd Qu.: 85014    3rd Qu.: 5498   3rd Qu.:0.05882  
##  Max.   :489965   Max.   :422317    Max.   :26064   Max.   :0.08599  
##      median             q1              q3          employed_rate   
##  Min.   : 60000   Min.   :40000   Min.   : 82000   Min.   :0.5413  
##  1st Qu.: 67000   1st Qu.:46900   1st Qu.: 96000   1st Qu.:0.7001  
##  Median : 75000   Median :50000   Median :102000   Median :0.7295  
##  Mean   : 77759   Mean   :52459   Mean   :108534   Mean   :0.7278  
##  3rd Qu.: 85000   3rd Qu.:60000   3rd Qu.:116000   3rd Qu.:0.7702  
##  Max.   :125000   Max.   :75000   Max.   :210000   Max.   :0.8351  
```

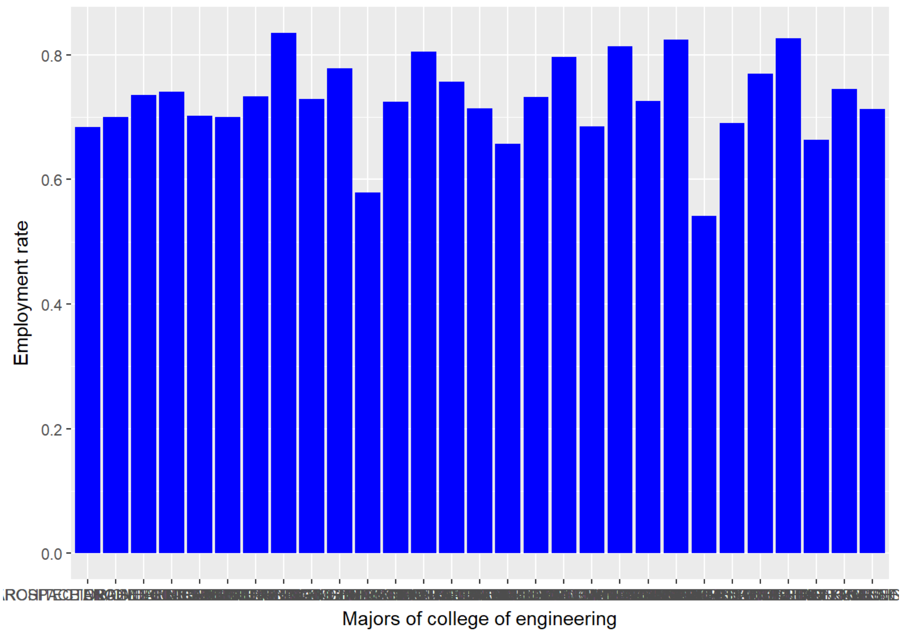
```r
sink()
```

* Plot and store employment rate of each dataframe

```r
ggplot(cs_math)+geom_col(aes(x=major,y=employed_rate),color=NA,fill="pink")+labs(x="Majors of computer science and math",y="Employment rate")
```




```r
ggplot(engin)+geom_col(aes(x=major,y=employed_rate),color=NA,fill="blue")+labs(x="Majors of college of engineering
",y="Employment rate")
```




```r
#save
pdf(file = "C:/Users/eriko/stat133/stat133-hws-fall17/post01/image/csmath-ggplot.pdf")
ggplot(cs_math)+geom_col(aes(x=major,y=employed_rate),color=NA,fill="pink")+labs(x="Majors of computer science and
math",y="Employment rate")
dev.off()
```

```
## png
##   2
```

```r
#save
pdf(file = "C:/Users/eriko/stat133/stat133-hws-fall17/post01/image/engin-ggplot.pdf")
ggplot(engin)+geom_col(aes(x=major,y=employed_rate),color=NA,fill="blue")+labs(x="Majors of college of engineering
",y="Employment rate")
dev.off()
```

```
## png
##   2
```

Hypothesis * To build up my own hypothesis testing problem, I would like to compare which one of “Computer science & math” and “Engineering” has higher income salary, since I was wondering for a long time if which of the field is paid more.

* But to compare the income salary by hypothesis test, I need the mean and standard deviation of the datasets.

* To get the mean and sd, here is the formula (Wan et al.(2014)),

$$\bar{x} = \frac{q1 + m + q3}{3}$$

$$S = \frac{q3???q1}{1.35}$$

where q1 is first quartile, m is the median, q3 is the third quartile + Add the mean and standard deviation to each datasets

```r
cs_math <- mutate(cs_math,mean=(q3+median+q1)/3,std=(q3-q1)/1.35)
engin <- mutate(engin,mean=(q3+median+q1)/3,std=(q3-q1)/1.35)
```

- Calculate the mean and the std of whole datasets

```r
Mean_cs_math <- sum(cs_math$mean * cs_math$total) / sum(cs_math$total)
Mean_engin <- sum(engin$mean * engin$total) / sum(engin$total)
std_cs_math <- mean(cs_math$std)
std_engin <- mean(engin$std)
```

Hypothesis: Computer science & math earn more money than the engineering major.

1. Claim
   H_0 (null): mean(cs_math income)-mean(engineering income) = 0
   H_1 (alternative claim): mean(cs_math income)-mean(engineering income) > 0

2. since the number of both independent sample are huge enough, suppose they are approximately normaly distributed. Standard deviation are known by calculation, we could use 2-sample Z-test.
3. Set the significant value as alpha=0.05, which means confidence level is 0.95
4. Program calculation

- Calculate using z.test(RDocumentation)

```
z.test(cs_math$mean,engin$mean, alternative = "greater", mu = 0, sigma.x = std_cs_math,sigma.y = std_engin, conf.level = 0.95)
```

```
##
##  Two-sample z-Test
##
## data:  cs_math$mean and engin$mean
## z = -0.79045, p-value = 0.7854
## alternative hypothesis: true difference in means is greater than 0
## 95 percent confidence interval:
##  -34129.93        NA
## sample estimates:
## mean of x mean of y
##  68506.06  79583.91
```

- Calculate using t.test(Phil Spector)

```
t.test(cs_math$mean,engin$mean,alternative = "greater",conf.level = 0.95)
```

```
##
##  Welch Two Sample t-test
##
## data:  cs_math$mean and engin$mean
## t = -2.5243, df = 23.49, p-value = 0.9906
## alternative hypothesis: true difference in means is greater than 0
## 95 percent confidence interval:
##  -18592.52       Inf
## sample estimates:
## mean of x mean of y
##  68506.06  79583.91
```

5. Conclusion: fail to reject null

- For the result of calculation using z-test, p-value=0.7854 is greater than the alpha=0.05, therefore fail to reject the null hypothesis, we don't have enough confidence to say that people who major in "Computer science & math" earn more than "Engineering" major.
- For the result of calculation using t-test, p-value=0.9906 is greater than the alpha=0.05, therefore fail to reject the null hypothesis, we don't have enough confidence to say that people who major in "Computer science & math" earn more than "Engineering" major.
  Therefore, we cannot conclude which of the major("CS & Math" and "Engineering") can earn more money after graduate.
- The difference between the Z-test and t-test is, when the mean of the sample can be known, the standard deviation is unknown, then we use the **t-test** to estimate the population. If the standard deviation is known or calculated, then use **z-test** to do the evaluation.

More about hypothesis test.

- Not only the problems like the example I give, there are still many kind of hypothesis tesing, such as:
- one-sample z-test(left-sided,right-sided,both-sided)
- one-sample t-test(left-sided,right-sided,both-sided)
- two-proportion z test(inference of two proportion)
- two-proportion t-test
- two-sample t/z-test(inference of two mean)
- chi-squre test(testinga claim about a standard deviation of population)
- Goodness-of-fit(test if sample data with k categories is "good fit"to an assumed distribution)
- One-way Analysis of Variance(ANOVA):test for equality of more than three sample data.
- And to do these in r, check (Rtutorial)
  For the concepts of hypothesis test, see (Pennstate).

Take Home Message!!

PLease try to make some function of t-test or z-test, for one-sample and two-sample.

And try to compare the employment rate and unemployment rate of the majors or the major categories you are interested in.

Thank you for reading my post!!!