Portfolio on Permutation Test

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# Background

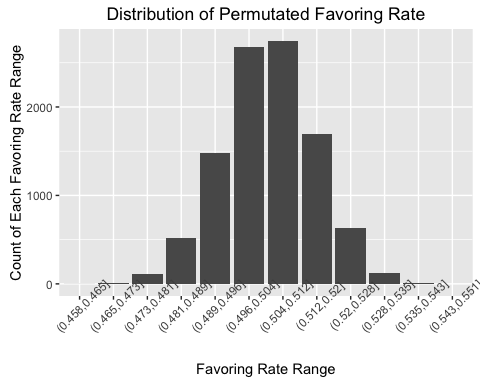
The task of this portfolio is to determine if a passed proposal is overturned because the voting process is tampered. In the specific case, among 8059 ballots returned, 1672 are not signed and therefore, disqualifed. The proposal is passed based on very slight higher favoring rate amond signed votes: 3208 voted in favor and 3143 voted oppose. However, among the discounted votes, 730 were in favor and 942 were against which suggests, if those discounted votes are counted, the result would went the other way. A jounalist suspect the voting result is tampered or the result is influenced by some external factors. The specific challenge of this project is to determine if the unproportional ratio between favor and oppose of the discounted votes are caused by randomness.

# Approach

Assuming the counted portion of the votes are truely reflectory outcomes of people's opinion, the null hypothesis is that the favoring rate of the counted votes is equal to the favoring rate of the discounted votes. A permutation test on favoring rate is conducted to test this hypothesis. The idea of the permutation test is to sample the size of discounted votes (idealy all possible combinations) from the counted votes; in this particular case, 1672 out of 6351 and examine the favor rate of the sample. After numbers of repeatition such process, a distribution of possible favor rate can be fored and induce the p-value of the observed discounted favor rate.

# Analysis & Result

After performing the procedure discussed in the "Approach" section, number of possible favor ratio is ploted as the following histogram.



Considering the discounted favoring rate being 43.66%, the distribution plot indicates that, assuming discounted votes reflect people's true opinions and share similar distribution with the counted votes, it is very unlikely for the discounted favoring rate being smaller than 0.452. In fact, after trying randomly drawing 1672 (number of discounted votes) out of 6351 (number of counted votes) for 10,000 times, none of those permutation records has a favoring rate smaller than the observed discounted favoring rate.

### Conclusion

The permutation test shows that statistically, it is very unlikely for the counted pool and the discounted pool both reflecting opinions of one population. This conclusion implies, it is very possible the result of the voting is tampered or there is some underlying causation between the lower favoring rate and higher discounted rate. Based on the testing result, I suggest the voting result should be disqualified and the proposal should be revoted.

# Full Code

library(ggplot2)  
  
voted\_favor = 3208  
voted\_oppose = 3143  
  
  
test\_favor = 730  
test\_oppose = 942  
test\_total = test\_favor+test\_oppose  
test\_favor\_ratio = test\_favor/test\_total  
  
  
n=10000 # set number of permutations  
data = c(rep(1,voted\_favor),rep(0,voted\_oppose))  
  
ratio\_distrib = c()  
for (i in 1:n){  
 perm = sample(data,test\_total) # sample from counted votes  
 perm\_favor = sum(perm)   
 perm\_favor\_ratio = perm\_favor/test\_total # calculate simulated favor rate  
 ratio\_distrib <- c(ratio\_distrib,perm\_favor\_ratio)  
}  
  
# get the range of permutated favoring rate and construct a factor vector for plotting  
ratio\_min = min(ratio\_distrib)  
ratio\_max = max(ratio\_distrib)  
step = (ratio\_max-ratio\_min)/10  
  
range\_distrib = cut(ratio\_distrib,breaks=seq(ratio\_min-step,ratio\_max+step,step))  
df <- as.data.frame(table(range\_distrib))  
names(df) <- c("range","count")  
  
# construct distribution plot  
g <- ggplot(data=df,aes(x=range,y=count))+geom\_bar(stat = "identity")+  
 theme(axis.text.x = element\_text(angle=45))  
g <- g+ggtitle("Distribution of Permutated Favoring Rate")+  
 xlab("Favoring Rate Range") + ylab("Count of Each Favoring Rate Range")  
g  
  
# count number of permutated favoring rate lower than observed discounted favoring rate  
sum(ratio\_distrib<test\_favor\_ratio)