Cold Storage Case Study

Muthu Pandian G

July 26, 2019

Cold Storage Case Study

About Cold Storage

```
     Cold    Storage    started    its    operations    in    Jan    2016.
They are in the business of storing Pasteurized Fresh Whole or Skimmed Milk,
Sweet Cream, Flavored Milk Drinks.

     To  ensure  that  there  is  no  change  of  texture,  body  appearance,
separation of fats the optimal temperature to be maintained is between 2 deg
- 4 deg C.
```

Problem 1 Statement

```
     In  the  first  year  of  business  they  outsourced  the  plant  maintenance
work    to    a    professional    company    with    stiff    penalty    clauses.

     It was agreed that if it was statistically proven that probability of
temperature   going outside the 2 degrees - 4 degrees C during the one-year
contract was above 2.5% and less than 5% then the penalty would be 10% of AMC
Fee. In case it exceeded 5% then the penalty would be 25% of the AMC fee
```

Importing Data Set

```
setwd("D:/Great Lakes/Projects/First Project - Cold Storage Case Study")
cold_storage_data <- read.csv("K2_Cold_Storage_Temp_Data.csv",header= TRUE)
attach(cold_storage_data)
```

Descriptive Statistics

Dimension of Cold Storage Temperature Data

```
dim(cold_storage_data)

## [1] 365   4
```

Structure of Cold Storage Tempertaure Data

```
str(cold_storage_data)

## 'data.frame':    365 obs. of  4 variables:
##  $ Season     : Factor w/ 3 levels "Rainy","Summer",..: 3 3 3 3 3 3 3 3 3
3 ...
##  $ Month      : Factor w/ 12 levels "Apr","Aug","Dec",..: 5 5 5 5 5 5 5 5
5 5 ...
##  $ Date       : int  1 2 3 4 5 6 7 8 9 10 ...
##  $ Temperature: num  2.4 2.3 2.4 2.8 2.5 2.4 2.8 2.3 2.4 2.8 ...
```

Summary of Cold Storage Temperature Data

```
summary(cold_storage_data)

##     Season          Month          Date        Temperature
##  Rainy :122   Aug    : 31   Min.   : 1.00   Min.   :1.700
##  Summer:120   Dec    : 31   1st Qu.: 8.00   1st Qu.:2.500
##  Winter:123   Jan    : 31   Median :16.00   Median :2.900
##               Jul    : 31   Mean   :15.72   Mean   :2.963
##               Mar    : 31   3rd Qu.:23.00   3rd Qu.:3.300
##               May    : 31   Max.   :31.00   Max.   :5.000
##               (Other):179
```

Mean cold storage temperature for Summer, Winter and Rainy Season

```
season_mean <- aggregate(Temperature~Season,FUN = mean)
print(season_mean)

##   Season Temperature
## 1  Rainy    3.039344
## 2 Summer    3.153333
## 3 Winter    2.700813
```

Overall mean for the full year

```
mean<- mean(Temperature)
print(mean)

## [1] 2.96274
```

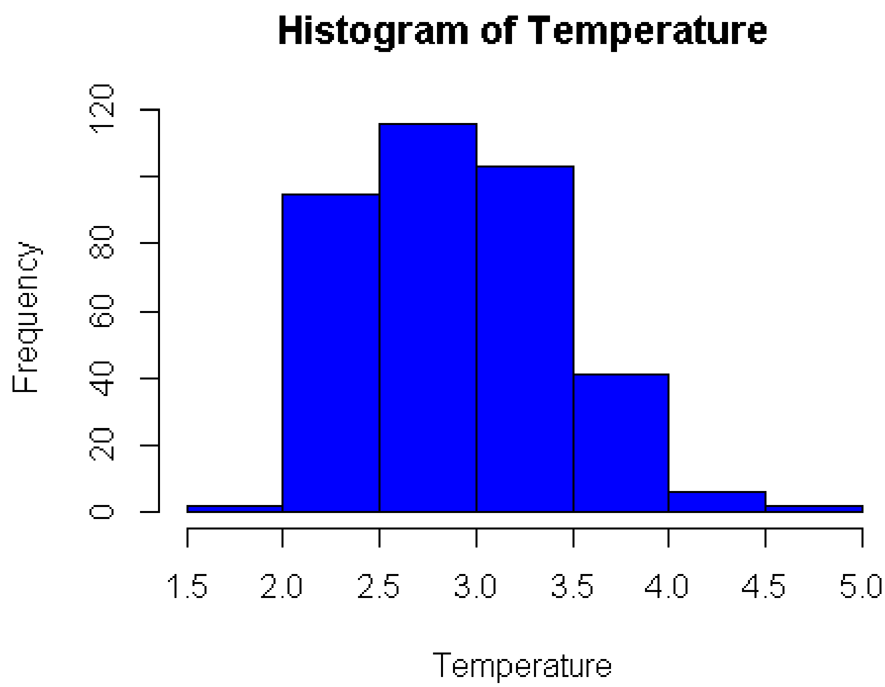
Standard Deviation for the full year

```
sd <- sd(Temperature)
print(sd)

## [1] 0.508589
```

Frequency Plot of Temperature

```
hist(Temperature,col = "Blue")
```



From the plot we can Assume it as Normal distribution, As per Quality Control range given by Cold Storage (2 deg - 4 deg)

Lets see the probability of temperature having fallen below 2 deg C

```
pnorm(2,2.96274,0.508589)

## [1] 0.02918142
```

Lets see the probability of temperature having gone above 4 deg C

```
(1-pnorm(4,2.96274,0.508589))*100

## [1] 2.070079
```

From the above values its clear that,

2.9181416% chances of temperature having fallen below 2 deg C

2.0700788% chances of temperature having gone above 4 deg C

Hence, we can statistically **prove that** there is **2.9 % chance of temperature falling below 2 deg C and 2.07 % chance of temperature falling above 4 deg C**

So as per penalty clauses our probablity lies between 2.5 % to 5%. So there would be **10% Penalty For the AMC Company**.

Problem 2 Statement

In Mar 2018, Cold Storage started getting complaints from their Clients that they have been getting complaints from end consumers of the dairy products going sour and often smelling. On getting these complaints, the supervisor pulls out data of last 35 days temperatures. As a safety measure, the Supervisor has been vigilant to maintain the temperature below 3.9 deg C.

Assume 3.9 deg C as upper acceptable temperature range and at alpha = 0.1 do you feel that there is need for some corrective action in the Cold Storage Plant or is it that the problem is from procurement side from where Cold Storage is getting the Dairy Products.

Importing Data Set

```
setwd("D:/Great Lakes/Projects/First Project - Cold Storage Case Study")
Cold_Storage <- read.csv("Cold_Storage_Mar2018.csv")
attach(Cold_Storage)

## The following objects are masked from cold_storage_data:
##
##     Date, Month, Season, Temperature
```

Descriptive Statistics

Dimension of Cold Storage

```
dim(Cold_Storage)

## [1] 35  4
```

Total number of rows or sample size

```
n <- nrow(Cold_Storage)
print(n)

## [1] 35
```

Mean of Temperature

```
sample_mean <- mean(Temperature)
print(sample_mean)

## [1] 3.974286

Mu<- 3.9

# as per our problem statement Assume 3.9 deg C as upper acceptable
temperature range
```

Standard Deviation of Temperature

we take **Population Standard Deviation** for **z test** as per Formula,

```
sd<- 0.508589
print(sd)

## [1] 0.508589
```

From **Problem statement we take alpha = 0.1** which means 90% significance level

Hypothesis Statement

As Per our Problem statement,

- Our Null Hypothesis will be H_0: mu>= 3.9 which means there is Need for corrective action in Cold Storage Plant
- Our Alternate Hypothesis will be H_1: mu < 3.9 No need for corrective action in Cold Storage Plant
- Based on our Hypothesis statement we can be sure that it is One Tailed Test

Z-Statistics

```
sample_error <- sample_mean - Mu
standard_error <- sd/(sqrt(n))
z <- sample_error/standard_error
print(z)

## [1] 0.8641166
```

Probabaility / chances of our Z Value to occur in the Critical Region

```
pnorm(-abs(z))

## [1] 0.1937619
```

Z-Test Inference

- Since our Probability value (0.1937619) is greater than our significance level (0.1) i.e., p>alpha
- It means that we doesn’t have enough evidence in rejecting null hypothesis at 0.1 level of significance.
- So we are unable to reject Null Hypothesis which is H_0 : mu>= 3.9

- Based on our Ztest results, we can arrive to the conclusion that our mean value is greater than our Sample Mean (3.9) and there is a **corrective action required in Cold Storage Plant**

T-Statistics

For **T- Test** we need to take **Sample Standard Deviation** as per Formula,

```
sd1 <- sd(Temperature)
print(sd1)

## [1] 0.159674

t.test(Temperature,mu=3.9,conf.level = 0.90)

##
##  One Sample t-test
##
## data:  Temperature
## t = 2.7524, df = 34, p-value = 0.009422
## alternative hypothesis: true mean is not equal to 3.9
## 90 percent confidence interval:
##  3.928648 4.019923
## sample estimates:
## mean of x
##  3.974286
```

T-Test Inference

- We Can Clearly see that our P-value (0.009422) is way less than our significance level (alpha=.1) i.e., p< alpha.
- From this it is safe to say that we have enough evidence to reject the null Hypothesis and accept the alternate hypothesis
- As per T- Test Results we can arrive to the conclusion that there is NO need for corrective action in the Cold Storage Plant

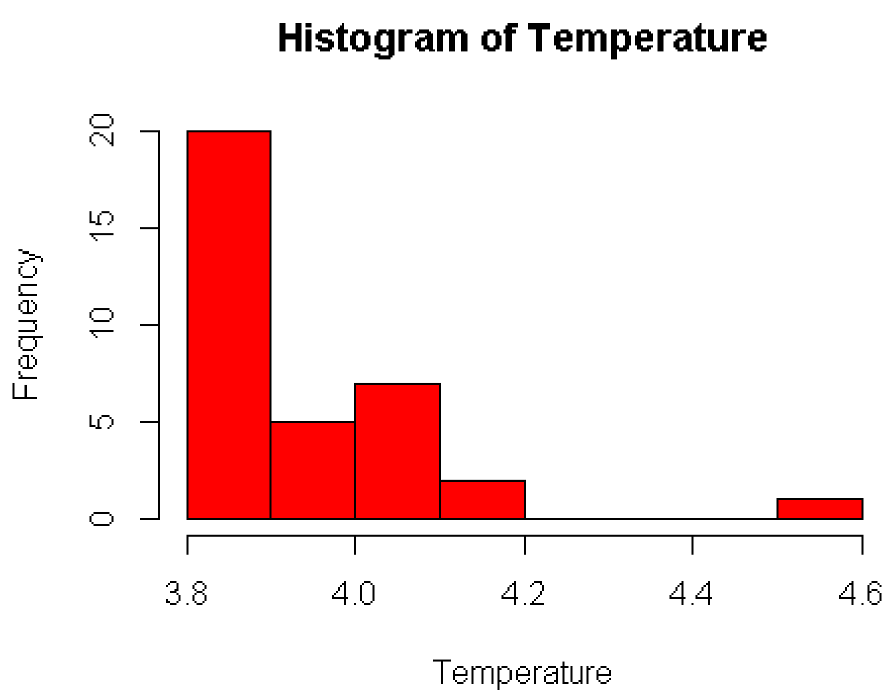
Inference from Both Tests

1. It's Pretty clear that both tests give us different results.
2. In Z test we concluded that **there is need for some corrective action in the Cold Storage Plant**

3. In T test we concluded that there is **no need for corrective action in the Cold Storage Plant** and the problem is from procurement side from where Cold Storage is getting the Dairy Products
4. Now we are in a dilemma, which test to rely on and make a decision. This is when our conditions to choose test statistics using **Central Limit Theorem** comes handy.
5. It says that t-test is necessary for small samples (n<30) because their distributions are not normal
6. If the sample is large (n>=30) then statistical theory says that the sample mean is normally distributed and a z test for a single mean can be used. which is clearly proven here
7. Hence, we need to rely on z test as our n = 35 and make decision based on Z-test Inference. ie., there is need for some corrective action in the Cold Storage Plant

Frequency Plot of Temperature

```
hist(Temperature,col="red")
```



From the above plot we can clearly see that somedays the Temperature values went above our upper acceptable temperature range of 3.9 deg C.

SO, it is clear that we need to take some corrective action in the Cold Storage Plant.