

SEIS-631 Final Project

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Introduction

What

This project is looking at the relationship between this season's National Hockey League scoring average statistics and that of years' past. It will also be taking a look at relationships between teams and specifically determining if the Western conference teams score lower, on average, compared to the Eastern conference teams.

Why

There has been much discussion this year within the media and throughout fans of the NHL that scoring is up, comparatively speaking, to past years. To the naked eye, and those following the league on a nightly basis, this seems to be true. Therefore, I want to determine statistical significance of this observation, in order to verify if the league is having an outstandingly high scoring average season.

The second topic I want to cover is one of the relationship of goal scoring between conferences. In the past, the Western conference has been seen as a much more tight-checking, heavy brand of hockey compared to the Eastern conference, therefore creating lower scoring games. This put up the reputation of there being less of an emphasis on defense in the East, causing the average goals scored to be higher. I want to prove if this theory holds true for this years goal-scoring statistics, meaning if the Western conference is indeed still lower-scoring than the Eastern conference.

How

I have collected data and split them into two separate CSV files initially created in Excel workbooks. One file consists the seasons information, columns including the years, goals for average, and games played (all teams combined) in each season. In the second file columns such as Team name, games played (as of 4/7/22) goals for per game average per team, and the conference of each team are accumulated named Teams. I will then load these files in to RStudio, using the readr package. I will then create plots and basic summary statistics in order to describe the data, visualize trends, and help understand what we will be looking at. From there I will perform relationship tests, first between the seasons, and then between conferences. I will perform these tests against hypotheses which I will later describe as we proceed with the project.

Body

The Stats

In order to use the statistics for my project, I created two separate excel files labeled "631PDseasons" and "631PDteams". In order to get these files into R I needed to change them to be csv files. Once done, in R I checked to make sure my working directory was the location in which these files were saved. From there I used the library, readr, to assign my files to variables.

```
library(readr)
Seasons <- read_csv("C:\\Users\\njsaw\\OneDrive\\Documents\\631PDseasons.csv")
```

```
##
## -- Column specification -----
## cols(
##   Season = col_character(),
##   `Gf avg.` = col_double(),
##   `Games Played` = col_double()
## )
```

```
Teams <- read_csv("C:\\Users\\njsaw\\OneDrive\\Documents\\631PDteams.csv")
```

```
##
## -- Column specification -----
## cols(
##   Team = col_character(),
##   `GP (4/7/22)` = col_double(),
##   `GF/GP` = col_double(),
##   Conference = col_character()
## )
```

The datasets were then created:

Teams

```
## # A tibble: 32 x 4
##   Team          `GP (4/7/22)` `GF/GP` Conference
##   <chr>          <dbl>     <dbl> <chr>
## 1 Arizona Coyotes          70     2.51 west
## 2 Montréal Canadiens      70     2.54 east
## 3 Philadelphia Flyers      70     2.57 east
## 4 Seattle Kraken           70     2.59 west
## 5 San Jose Sharks          69     2.61 west
## 6 Chicago Blackhawks       70     2.63 west
## 7 Ottawa Senators          69     2.7  east
## 8 Buffalo Sabres           71     2.73 east
## 9 Anaheim Ducks           72     2.74 west
## 10 New York Islanders       69     2.77 east
## # ... with 22 more rows
```

head(Teams)

```
## # A tibble: 6 x 4
##   Team          `GP (4/7/22)` `GF/GP` Conference
##   <chr>          <dbl>     <dbl> <chr>
## 1 Arizona Coyotes          70     2.51 west
## 2 Montréal Canadiens      70     2.54 east
## 3 Philadelphia Flyers      70     2.57 east
## 4 Seattle Kraken           70     2.59 west
## 5 San Jose Sharks          69     2.61 west
## 6 Chicago Blackhawks       70     2.63 west
```

Seasons

```
## # A tibble: 20 x 3
##   Season `Gf avg.` `Games Played`
##   <chr>     <dbl>     <dbl>
```

```
## 1 (20-21)      2.94      868
## 2 (19-20)      3.02     1082
## 3 (18-19)      3.01     1271
## 4 (17-18)      2.97     1271
## 5 (16-17)      2.77     1230
## 6 (15-16)      2.71     1230
## 7 (14-15)      2.73     1230
## 8 (13-14)      2.74     1230
## 9 (12-13)      2.72      720
## 10 (11-12)     2.73     1230
## 11 (10-11)     2.79     1230
## 12 (09-10)     2.84     1230
## 13 (08-09)     2.91     1230
## 14 (07-08)     2.78     1230
## 15 (06-07)     2.95     1230
## 16 (05-06)     3.08     1230
## 17 (03-04)     2.57     1230
## 18 (02-03)     2.65     1230
## 19 (01-02)     2.62     1230
## 20 (00-01)     2.76     1230
```

```
head(Seasons)
```

```
## # A tibble: 6 x 3
##   Season `Gf avg.` `Games Played`
##   <chr>    <dbl>         <dbl>
## 1 (20-21)  2.94           868
## 2 (19-20)  3.02          1082
## 3 (18-19)  3.01          1271
## 4 (17-18)  2.97          1271
## 5 (16-17)  2.77          1230
## 6 (15-16)  2.71          1230
```

You can see the different columns within each dataset that I collected. In the seasons there are the Season, the GF average (Goals for average) for that season per team, and the number of total games played in the season. It is worth noting that when we are discussing goals for, the data is looking at one team in the game, so if we looked at on a game-per-game basis we would have to double it. Within the Teams dataset are the Team names, their goals for per game (“GP (4/7/22)”) as of April 7th of 2022, the number of games each team has played, and their designated conference (west or east). A summary of the data collected:

```
summary(Seasons)
```

```
##      Season      Gf avg.    Games Played
## Length:20      Min.   :2.570      Min.   : 720
## Class :character 1st Qu.:2.728      1st Qu.:1230
## Mode  :character Median :2.775      Median :1230
##              Mean  :2.814      Mean  :1183
##              3rd Qu.:2.942      3rd Qu.:1230
##              Max.   :3.080      Max.   :1271
```

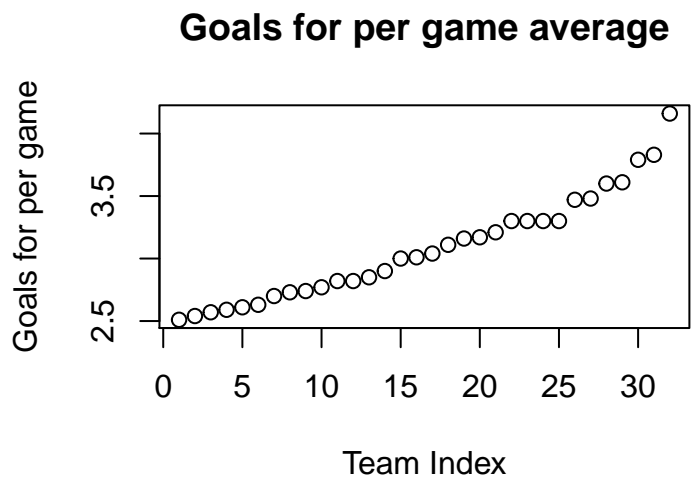
```
summary(Teams)
```

```
##      Team      GP (4/7/22)    GF/GP    Conference
## Length:32      Min.   :69.00      Min.   :2.510      Length:32
## Class :character 1st Qu.:70.00      1st Qu.:2.737      Class :character
## Mode  :character Median :70.00      Median :3.025      Mode  :character
##              Mean  :70.25      Mean  :3.082
```

```
##          3rd Qu.:71.00    3rd Qu.:3.300
##          Max.      :72.00    Max.      :4.160
```

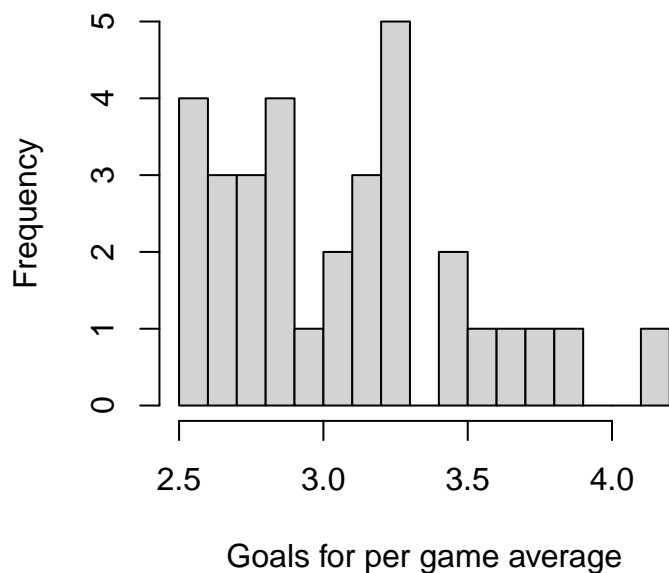
For the categorical variables the summary simply shows the length and that they are characters. For the numerical variables, a variety of basic statistics are shown, however the most important one the Mean of each as that what we will be using when running our tests. A look at the distributions:

```
plot(Teams$`GF/GP`, main = "Goals for per game average", xlab = "Team Index", ylab = "Goals for per game average")
```

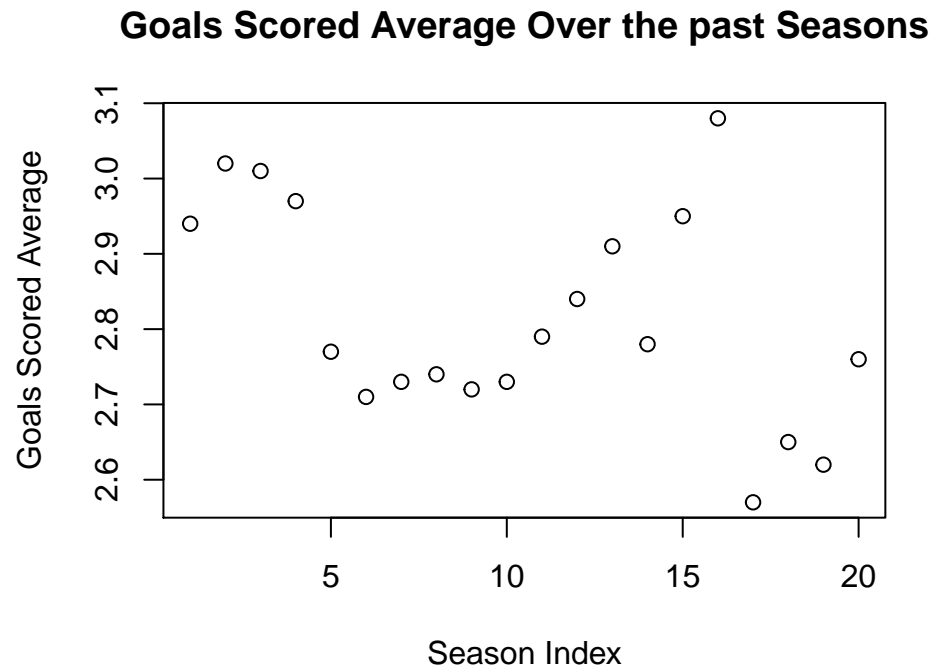


```
hist(Teams$`GF/GP`, main = "Histogram of Teams Average Goals Scored Per Game", xlab = "Goals for per game average", ylab = "Frequency")
```

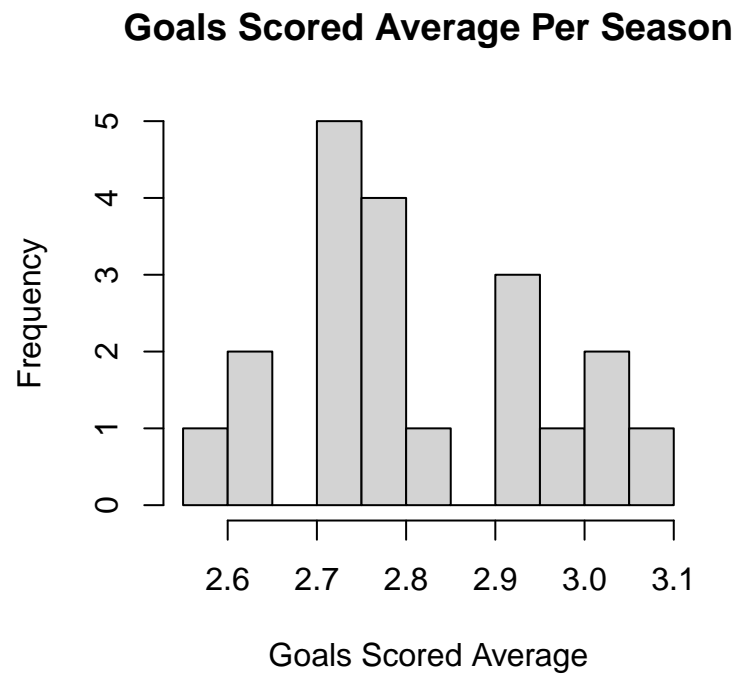
Histogram of Teams Average Goals Scored Per Game



```
plot(Seasons$`Gf avg.` , main = "Goals Scored Average Over the past Seasons", xlab = "Season Index", ylab = "Goals Scored Average")
```



```
hist(Seasons$`Gf avg.` , main = "Goals Scored Average Per Season", xlab = "Goals Scored Average", breaks = 10)
```



The first chart is a scatter plot of the goals for average between each team. The teams are indexed, going from lowest average to highest average. The highest average, from the summary statistics, is 4.160, which is important to note as slightly above the typical range, but not significant enough to exclude from the data. The second is a histogram with the distribution of the frequency of the average goals scored per team. I would say this distribution could constitute as relatively normal, however a slight skew to the right. The third chart is a scatter plot of the goals for averages throughout the years, the indexes are going from the year 2020-2021 down. There looks to have been some variation throughout the years, and, reading from right to left as that would be starting in 2000-2001, it is dipping until around the 03-04 lockout, and out of the lockout the scoring was up until it slowly started decreasing again, before going back up for a time. The final chart is a histogram showing the distribution of the frequency of the goals for average. This distribution is unimodal and relatively normal with no outliers.

Variables

In order to make the data a little easier to use in the coming tests, I assigned the columns and other measures to variables. For the Teams:

```
Team <- Teams$Team
GPTeam <- Teams$`GP (4/7/22)`
GFavgperteam <- Teams$`GF/GP`
```

So now, each column is separated (we will get to conference in a bit).

Team

```
## [1] "Arizona Coyotes"      "Montréal Canadiens"   "Philadelphia Flyers"
## [4] "Seattle Kraken"      "San Jose Sharks"      "Chicago Blackhawks"
## [7] "Ottawa Senators"     "Buffalo Sabres"       "Anaheim Ducks"
## [10] "New York Islanders"  "Vancouver Canucks"   "Los Angeles Kings"
## [13] "Detroit Red Wings"   "Dallas Stars"         "New York Rangers"
## [16] "New Jersey Devils"   "Winnipeg Jets"        "Vegas Golden Knights"
## [19] "Boston Bruins"       "Columbus Blue Jackets" "Washington Capitals"
## [22] "Pittsburgh Penguins" "Carolina Hurricanes"  "Tampa Bay Lightning"
## [25] "Nashville Predators" "Calgary Flames"       "Edmonton Oilers"
## [28] "St. Louis Blues"     "Minnesota Wild"       "Colorado Avalanche"
## [31] "Toronto Maple Leafs" "Florida Panthers"
```

GFavgperteam

```
## [1] 2.51 2.54 2.57 2.59 2.61 2.63 2.70 2.73 2.74 2.77 2.82 2.82 2.85 2.90 3.00
## [16] 3.01 3.04 3.11 3.16 3.17 3.21 3.30 3.30 3.30 3.30 3.47 3.48 3.60 3.61 3.79
## [31] 3.83 4.16
```

The same can be done for the seasons:

```
Season <- Seasons$Season
GFavgperyear <- Seasons$`Gf avg.`
GPSeason <- Seasons$`Games Played`
```

We can further break down our variables with what we will need in further tests.

```
AVGcurrent <- mean(GFavgperteam)
AVGPast <- mean(GFavgperyear)
SDCurrent <- sd(GFavgperteam)
SDpast <- sd(GFavgperyear)
```

This gives us the mean and standard deviation for both the average goals scored per year and per team. We can make a couple of subsets to divide our Teams dataset into the appropriate conference.

```
western <- subset(Teams, Teams$Conference == "west")
eastern <- subset(Teams, Teams$Conference == "east")
```

These subsets will make it easier to find the mean and standard deviations of the eastern and western conference goal scoring.

```
avgwest <- mean(western$`GF/GP`)
avgeast <- mean(eastern$`GF/GP`)
sdwest <- sd(western$`GF/GP`)
sdeast <- sd(eastern$`GF/GP`)
```

With our variables now assigned and broken down, we can proceed with the tests to determine if this current season is higher in scoring than years past and if there is a difference in average scoring between conferences.

Is this year's goal scoring higher?

While the goal scoring averages seem to be relatively normal, a sample size of 20 seasons creates the opportunity to determine if the average goals scored in the season 2021-2022 is higher than that of years past by using the one-sample T-Test. To begin, there is an assumption of independence, which in this case is true as each year is unique. There is also a normality assumption in which there appears to be no outliers between the years and the total number of years is 20, which is less than 30, meeting this condition. In order to properly test, we will form hypotheses.

$H_o :$

The average goals scored per game in 21-22 is the same as in the past 20 years.

$H_a :$

The average goals scored per game in 21-22 is greater than the past 20 years.

Now I will conduct a one-sided (only want to know if this years scoring is higher) T-test with the degrees of freedom being

20-1

```
## [1] 19
```

at a confidence of 99% (significance level of .01). The average and standard deviation for the past 20 seasons is:

```
AVGPast
```

```
## [1] 2.8145
```

```
SDpast
```

```
## [1] 0.1432875
```

In order to use this test we must find the standard error as this is just a sample of the population:

```
SEPast <- SDpast/sqrt(20)
SEPast
```

```
## [1] 0.03204007
```

Now we are able to proceed with our T-Test against the current average goals scored per game:

```
AVGcurrent
```

```
## [1] 3.081875
```

Thus:

```
Tvalue1 <- (AVGcurrent - AVGPast)/SEPast
Tvalue1
```

```
## [1] 8.34502
```

This seems to be a significantly high T value, in order to determine the true significance we need to find the p-value of this:

```
pt(Tvalue1, df = 19, lower.tail = FALSE)
```

```
## [1] 4.450688e-08
```

With such a low p-value (lower than .01) we reject the null hypothesis, and conclude that this year's goal scoring is, indeed, significantly higher than what we have seen in the past.

Is goal scoring different between conferences?

To answer this question I will strictly look at the Teams dataset. The two conferences are already split into subsets to make them easier to use. The test that will be performed to determine if there is a difference between conferences is the two-sample T-test, testing the difference between two means. We can proceed with this test, as there is independence between the two groups, no team is a part of both conferences, and within each group, all teams are unique. Also, as was stated before, there does not appear to be any outliers in the data. The hypotheses to be tested are:

$$H_0 : \mu_w - \mu_e = 0$$

There is no difference in average goals scored between conferences.

$$H_a : \mu_w - \mu_e \neq 0$$

There is a difference in the average goals scored between conferences.

We have already found the mean and standard deviations of the two conferences.

```
avgwest
```

```
## [1] 3.06375
```

```
avgeast
```

```
## [1] 3.1
```

```
sdwest
```

```
## [1] 0.423145
```

```
sdeast
```

```
## [1] 0.4380259
```

Each conference contains 16 teams, so with degrees of freedom being the minimum of the two populations minus one, the degrees of freedom is 15. The standard error for the two samples will be:

```
SEC <- sqrt(((sdwest^2)/16)+((sdeast^2)/16))
SEC
```

```
## [1] 0.1522577
```

We want to run on a confidence of 99% (significance level of .01). To find the T-value:

```
Tvalue2 <- ((avgeast - avgwest)-0)/SEC
Tvalue2
```

```
## [1] 0.2380833
```


This appears to be a low T-value. The p-value for this T statistic is:

```
pcon <- pt(Tvalue2, df = 15, lower.tail = FALSE)
pcon * 2
```

```
## [1] 0.8150382
```

We need to multiply it by two because we are looking at the comparison as a not-equal-to, so both sides of the distribution. With this high of a p-value, we fail to reject the null hypothesis, and conclude there is no significant difference in scoring between the two conferences. In fact we can create a 99% confidence interval:

```
specT <- qt(.01, df = 15, lower.tail = FALSE)
specT
```

```
## [1] 2.60248
```

Using the special T-statistic for 15 degrees of freedom:

```
Lowbound <- (avgeast - avgwest) - specT*SEC
Upbound <- (avgeast - avgwest) + specT*SEC
Lowbound
```

```
## [1] -0.3599976
```

```
Upbound
```

```
## [1] 0.4324976
```

We can predict with 99% confidence that the average difference in goal scoring between the two conferences this year will be:

$$-0.36 \leq \mu \leq 0.43$$

Topics from class

R Markdown

R Markdown was used for the development of this project. R Markdown allowed for R chunks, Latex equations, and general writing. Within R markdown, I learned how to format R chunks, specifically to make the graphs smaller, so they don't take up the entire page. I also learned how to format Latex mathematical equations into the document to show hypothesis testing and interval creation. I struggled a little bit at the beginning with R Markdown not being able to find variables that I created in the console, so I had to assign everything again, added a little more work but it worked.

GitHub

Using GitHub was a bit of a process. I had a GitHub account, but I had created one repository previously, so I am much less than an expert on the matter. However, after doing this project, creating a repository, and getting my working files from RStudio into GitHub, the idea behind it makes a lot more sense. I was getting an error message when I initially tried to commit my work, saying that the system needed a valid name. I was unsure what that meant, however I came to find out that I needed to use my GitHub credentials to associate RStudio and GitHub. So, I had to go into the terminal window and run two commands: "git config --global user.email"my GitHub email"" and "git config --global user.name"my GitHub username"". I learned that within RStudio, after initially creating a project based with my Git repository, all commits and pushes can be done through the upper right-hand environment window, where there is a "Git" tab and simple buttons that direct you to the desired outcomes.

One-Sample T-test

The one-sample T-test was used in determining whether this years goal scoring is higher than in the past 20 years. The assumptions that each year was distinct and the total number of years was less than 3, to meet normality. The test uses the mean of a sample, and tests it against a point, which in the case of this project was this year's goal scoring average. I created hypotheses relevant to performing the test, found the proper standard error, and found the T-value associated to this year's scoring when compared against the past 20 year's average. Finally, I compared it against the significant T-value and rejected the null hypothesis.

Two-Sample T-test, difference between means

This test was used to determine if there was a difference between the two conferences' average goal scoring this season. The assumptions of independence within and between groups was confirmed as well as there being less than 30 samples per conference as well. The hypotheses tested were that there is no difference between average goal scoring and there is a difference between means. The standard error was collected, a T-value was found, and the corresponding p-value was found. I struggled a little bit trying to figure out which distribution function to run in order to find the p-value, however after some trial and error I was able to figure it out. The p-value needed to be multiplied by two because we were looking at a not-equal-to alternative hypothesis instead of one-sided, so the distribution could fall on either side. Once done, it was compared against the significant p-value and the test confirmed the null hypothesis, showing no difference between the two conferences. To conclude I created a confidence interval at 99% confidence to show the average difference in goal scoring between the two conferences.

Observational study

The study I conducted here was an observational study. There was no experiment done, meaning no treatment was applied to either of the groups, nor withheld. I collected my data from NHL data link and Hockey Reference data link. The tests I performed did not manipulate the data in any way, rather were comparison tests, therefore I can make casual conclusions based on the data results from the tests. This was also a retrospective study, as I am taking the information from past events as opposed to gathering the data as it comes in. In both cases the response variable was the goal scored averages, however in the one-sample T-test, I used the season as the explanatory variable, and in the two-sample T-test, I used the conference as the explanatory variable.

Conclusion

I enjoyed this project because it allowed me to use topics we covered in class, and apply them to real-world scenarios. I was able to look into something I was interested in and determine if there was any significant evidence to the typical hockey talk within the media. I don't know if I learned anything new from a standpoint of theoretical topics in class, as the tests I ran were what we learned and were fairly easy for me to apply, I do believe I gained knowledge about R and how to use it properly. I learned that there are a variety of ways one can import data in to R, depending on where it is coming from and which programs they have installed, I was able to create smaller charts, which I had no knowledge of prior, in order to format them better within my paper. I used a variation of functions that we talked about in class to analyze the data I was interested in. I ultimately succeeded in coming up with conclusions to my hypotheses and gained experience with R.