SPM 5708 Homework 5 (Standardization, Normalization, & Paired Sample T-Tests)

Standardization means taking a value for a certain observation (e.g., a seasonal performance statistic for a certain player) and converting it into a ***z-score***. A z-score shows how many standard deviations above or below the population (group, league, etc.) average that specific value was. Z-scores are calculated as:

$$z = \frac{x - group\ mean}{group\ s.d.}$$

However, because z-scores aren't always the easiest thing to conceptualize or communicate, it can be helpful to take it one step further and ***normalize*** them so that they are presented on a scale that ranges from 0-100. Normally, we would have to do this by referencing our z-score in a z-table, but with the help of the *pnorm* function, we can normalize values with a few keystrokes. After normalizing a z-score, we see the percentage of observations that a specific value would be higher than in a normal group/population (i.e., the percentile it ranks at).

5.1 Comparing Mahomes to Hall of Famers

A lot of publicity surrounded Patrick Mahomes' second season in 2018 as he cruised to an NFL regular-season MVP title while leading a high-powered Chiefs' offense to the AFC Championship. Some have said his statistics were the best for a year-two player in NFL history, but making this comparison can be hard since the style of play in the NFL has dramatically shifted in recent years from a more run-oriented league to one dominated by the passing game.

Keeping in mind the shifts in play that have occurred over the decades, how do Mahomes' second-season stats compare to the second-season stats of NFL Hall of Famers Dan Marino and Kurt Warner? That is, which QB appeared to have the best second season, *given the era he played in*? By standardizing and normalizing the data found in the worksheets of the *Mahomes* file, we can compare these QBs across certain statistical categories.

1. The *Mahomes* Excel file contains three worksheets (*Mahomes, Warner,* and *Marino*) that you will need to import separately into R Studio. These sheets contain the passing statistics for every player who threw a pass in the 2018 (*Mahomes*), 1999 (*Warner*), and 1984 (*Marino*) seasons. We will need to subset the sheets appropriately before conducting our analyses. To do this, ***filter*** all three datasets so that they only contain players who are officially listed as quarterbacks (*Pos=="QB"*) ***and*** attempted at least 100 passes (*Att>=100*) in the observed season. This way, non-quarterbacks and backups are largely removed.

2. Standardize, and then normalize, the three players' values for completion percentage (*CmpPct*), adjusted net yards per attempt (*AdjNYPA*), and total passing touchdowns (*TD*) *relative to the QBs in their respective dataset*. To standardize, we run the raw values through the ***scale*** command. Once we get the standardized values (z-scores), we then use the *pnorm* function to get the normalized percentages (just like we did in class). **Report the normalized values for the three quarterbacks across these three statistics in a table**

below (you can create the table in Word if needed).

	Player	CmpPct_Norm	AdjNYPA_Norm	TD_Norm
1	Patrick Mahomes	0.6295893	0.9814836	0.9964723
2	Kurt Warner	0.9848153	0.9944321	0.9995395
3	Dan Marino	0.9409438	0.9964318	0.9998268

3. **Interpret (discuss)** your results as they relate to deciphering which QB (of the three) had the best second season, and which of the three statistical categories they were best in relative to each other and the QBs from their time period.

   Answer: Of the 3 isolated statistics, it appears that Patrick Mahomes performed the worst of the 3, relative to their competition. Despite being in the 98th and 99th percentile for Adjusted Net Yards per Attempt and Passing Touchdowns, he was only in the 63rd percentile for Completion Percentage. This alludes to the idea that Mahomes' cumulative success came from an extremely pass-heavy play style. I would argue that the next most dominant QB comparative to their competition was Dan Marino; although, he is hardly behind Kurt Warner. Marino found himself in the 94th, 99th, and 99th percentiles for Completion Percentage, Adjusted Net Yards per Attempt, and Passing Touchdowns respectively. As for the superior dominator, Kurt Warner showcased an outstanding 98th, 99th, and 99th percentile for Completion Percentage, Adjusted Net Yards per Attempt, and Passing Touchdowns respectively. His edge of 4 percentile points in Completion Percentage gave him the boost over Dan Marino, with Adjusted Net Yards per Pass Attempt and Passing Touchdowns only differing by tenths of a percentage point.

5.2 Do Transfer Football Players Improve?

Paired-sample t-tests are hypothesis tests designed to compare whether *means* from two observations of the same entity (e.g., player or team) significantly differ. It is represented by the following hypothesis statements examining whether the mean difference is significantly different from zero:

$H_0: \mu_d = 0$

$H_1: \mu_d \neq 0$

Using the t-test, a ***p*-value** is calculated. If below our preferred alpha (α) of .05, we reject the null hypothesis (H_0) in favor of the alternative (H_1) hypothesis, which implies that the difference between the two means from the same subject is significantly different from 0. If the *p*-value is above .05, we fail to reject the null hypothesis and assume that the mean difference is not significantly different from 0.

1. Import the *fbs_portal.csv* file from Canvas that some of you used in *Homework 1*. Using R, apply a wide receivers' (*WR*) average pre-transfer (*PFF_Grade_Pre_WT*) and post-transfer (*PFF_Grade_Post_WT*) Pro Football Focus (PFF) grades is significantly different from 0 ($p <$ .05). **Below, report and interpret your results in relation to your conclusions about this hypothesis test.**

   Answer: From a paired-sample two-sided t-test, we got a p-value = .0399 which is less than alpha = .05, so we reject the null hypothesis. We have significant evidence that the WR's pre-transfer PFF grade does not equal their post-transfer PFF grades on average, at the 5% significance level.

2. Now, conduct the same test for tight end transfers (*TE*). **Report and interpret your results below as they relate to your conclusions about this test.**

   Answer: From a paired-sample two-sided t-test, we got a p-value = .05785 which is greater than alpha = .05, so we fail to reject the null hypothesis. We do not have significant evidence that the TE's pre-transfer PFF grade differs from their post-transfer PFF grades on average, at the 5% significance level.

In the previous two examples, we were simply testing whether there was a significant difference in the average PFF grades of these FBS players before and after transferring. By not specifying a "direction" in our test (i.e., that the mean difference would be *positive* or *negative*), we were defaulting to what is called a ***two-tailed*** test. If our hypothesis is that PFF grades (performance) will significantly and positively *improve* following a transfer, we would need to utilize a ***one-tailed*** test to better account for the probability of detecting an effect in that direction. Note this initiates a slight shift in our underlying alternative hypothesis statement (H_1: $\mu_d > 0$).

3. For both the prior position groups (*WR* and *TE*), conduct one-tailed, paired sample t-tests that specifically examine whether the transfers' average PFF grades improve from pre- to post-transfer. This is where you will need to incorporate *alternative="less"* or *alternative="greater"* functions within the *t.test()* code, depending on whether you typed the pre-transfer (less) or post-transfer (greater) column first. **Report the results and your conclusions from both tests below.**

Answer WR: From a paired-sample one-sided t-test, we got a p-value = .01995 which is less than alpha = .05, so we reject the null hypothesis. We have significant evidence that the WR's pre-transfer PFF grade are less than their post-transfer PFF grades on average, at the 5% significance level.

Answer TE: From a paired-sample one-sided t-test, we got a p-value = .9711 which is greater than alpha = .05, so we fail to reject the null hypothesis. We do not have significant evidence that the TE's pre-transfer PFF grade are less than their post-transfer PFF grades on average, at the 5% significance level.

4. Someone asks you to see whether FBS transfers who were 3-star recruits (*Star_Rating* column) average significantly **more** snaps per season after transferring. Using values in the *Snap_Count_Pre_per_Season* and *Snap_Count_Post_per_Season* columns, **provide an answer. Then, conduct the same test and provide the same answer for 5-star recruits.**
   Answer 3 Stars: From a paired-sample one-sided t-test, we got a p-value = 1 which is greater than alpha = .05, so we fail to reject the null hypothesis. We do not have significant evidence that the 3-Stars snap count per game is more than their post-transfer snap count per game on average, at the 5% significance level.

   Answer 5 Stars: From a paired-sample one-sided t-test, we got a p-value = .1392 which is greater than alpha = .05, so we fail to reject the null hypothesis. We do not have significant evidence that the 5-Stars snap count per game is more than their post-transfer snap count per game on average, at the 5% significance level

SUBMIT THIS COMPLETED WORD DOC AND YOUR R SCRIPT TO THE ASSIGNMENT DROP BOX ON CANVAS WHEN FINISHED.