

## **2015-2016 NBA Season Final Project**

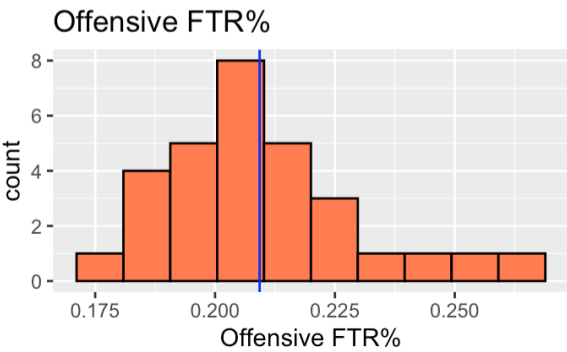
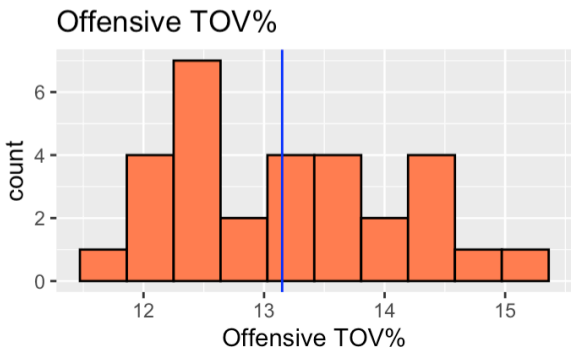
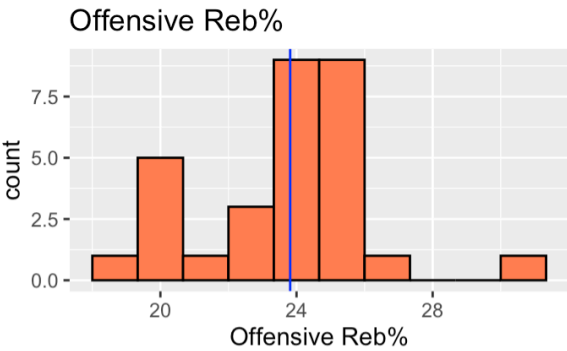
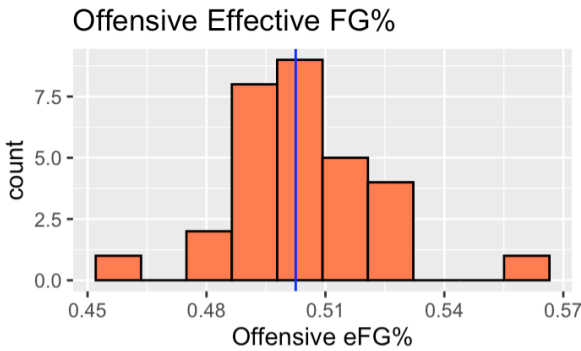
### **Season Overview and Format:**

The 2015-2016 NBA season contained the first NBA playoffs series that I ever watched, and got me into the NBA. The obvious unique characteristic about this season was that the Golden State Warriors finished with the best ever NBA record of 73-9, but fell in the finals to LeBron James and the Cleveland Cavaliers in a dramatic comeback. Additionally, although GSW received most of the applause from the regular season, the San Antonio Spurs also finished with an impressive 67-15 record. To put this in perspective, the East winners (also the Cavaliers) topped their conference with a 57-25 record, 10 games behind the Spurs. This season, there were 30 teams, with 15 teams in the Eastern conference, and 15 teams in the Western conference. Within each conference, there are also 3 divisions containing 5 teams each. For the East, it is split up into the Central, Atlantic, and Southeast divisions. For the West, it is split up into the Pacific, Southwest, and Northwest divisions.

Statistical Summary of Relevant Statistics:

Mean: 0.5025 , Std Dev: 0.019

Mean: 23.813 , Std Dev: 2.494

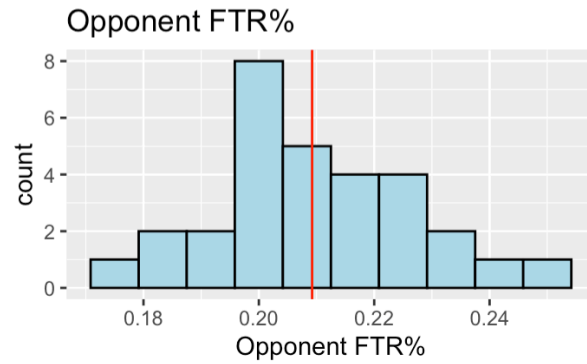
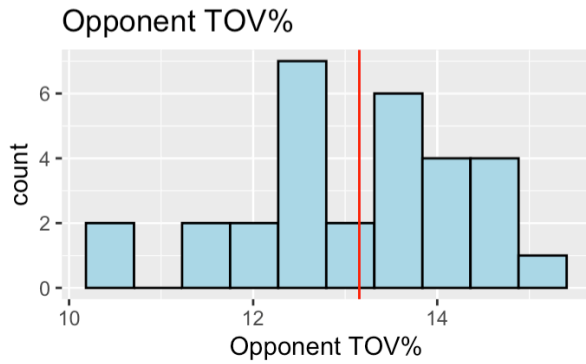
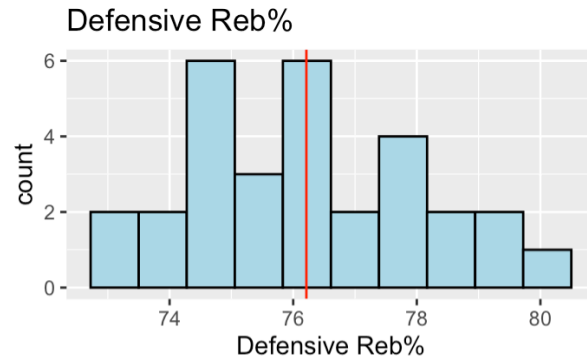
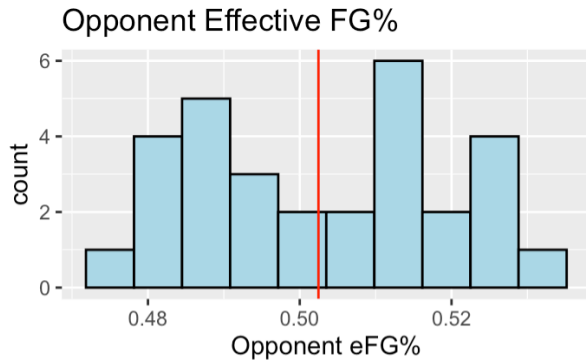


Mean: 13.15 , Std Dev: 0.9123

Mean: 0.2093 , Std Dev: 0.0206

Mean: 0.5025 , Std Dev: 0.0166

Mean: 76.2133 , Std Dev: 1.8658



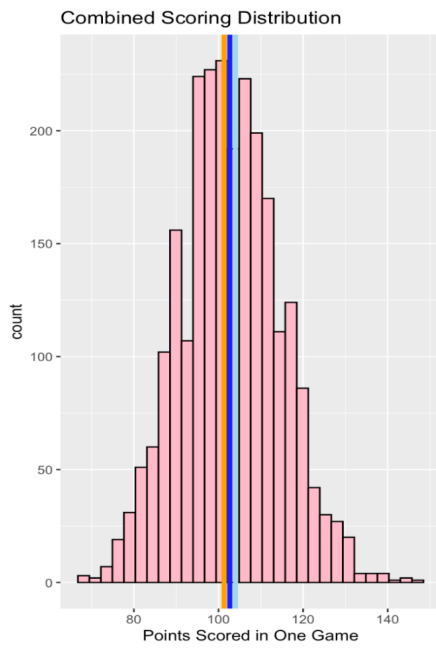
Mean: 13.153 , Std Dev: 1.172

Mean: 0.2092 , Std Dev: 0.0176

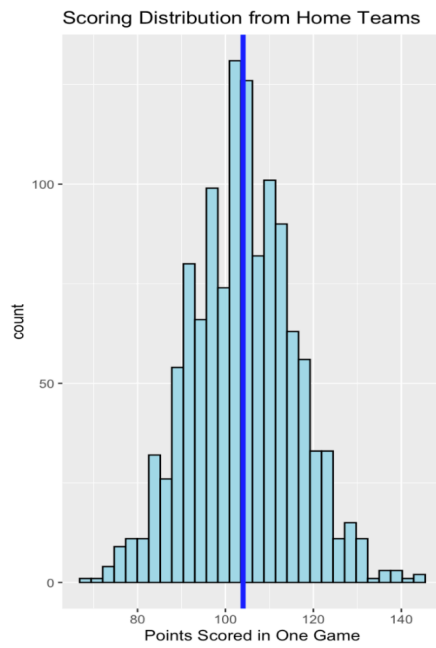
## **Discussion of Relevant Statistics:**

Firstly taking a look at the offensive four factors, the Offensive eFG% is roughly symmetric with a mean of 0.5025 and a standard deviation of 0.019. Here we can also see a low outlier belonging to the Lakers, and a high outlier corresponding to the Warriors. For Offensive Rebound Percentage, it has a strange distribution with a mean of 23.8 and a standard deviation of 2.50. It also contains a large outlier corresponding to the OKC Thunder. For Offensive TOV%, we see a more right skewed distribution, with a mean of 13.15 and standard deviation of 0.91. For Offensive FT Ratio, it is also right skewed, with a mean of 0.21 and standard deviation of 0.02, with high outliers corresponding to the Timberwolves, Rockets, and Raptors. Now for the defensive four factors, Opponent eFG% is also roughly symmetric with a mean of 0.5025 and standard deviation of 0.02. Defensive Rebound Percentage is also roughly symmetric, with a mean of 76.21 and standard deviation of 1.87. For Opponent TOV%, it appears to be left skewed with a mean of 13.15 and standard deviation of 1.1, with a low outlier corresponding to the Knicks. Finally, for Opponent FT Ratio, it is fairly symmetric with a mean of 0.21 and standard deviation of 0.02.

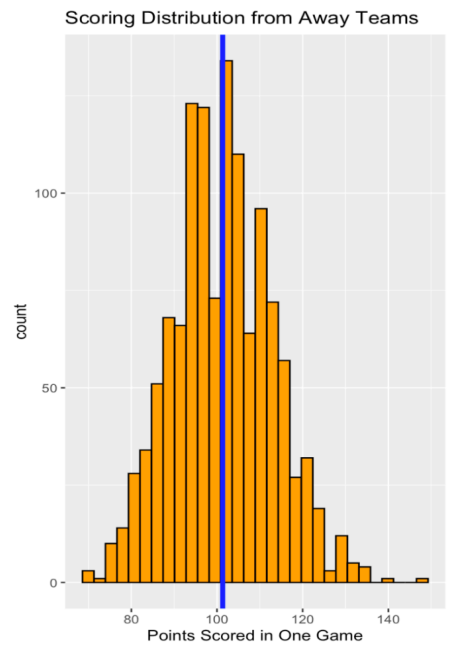
## Creation of Scoring Distribution:



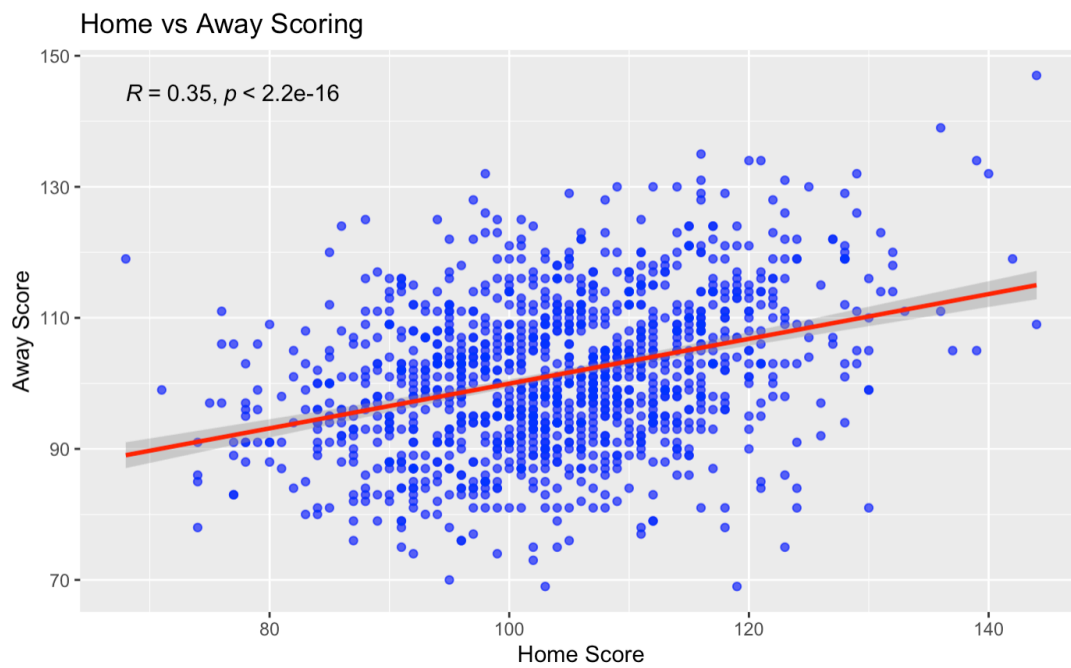
Mean: 102.67 , Std Dev: 11.74



Mean: 104.01 , Std Dev: 11.75



Mean: 101.33 , Std Dev: 11.58

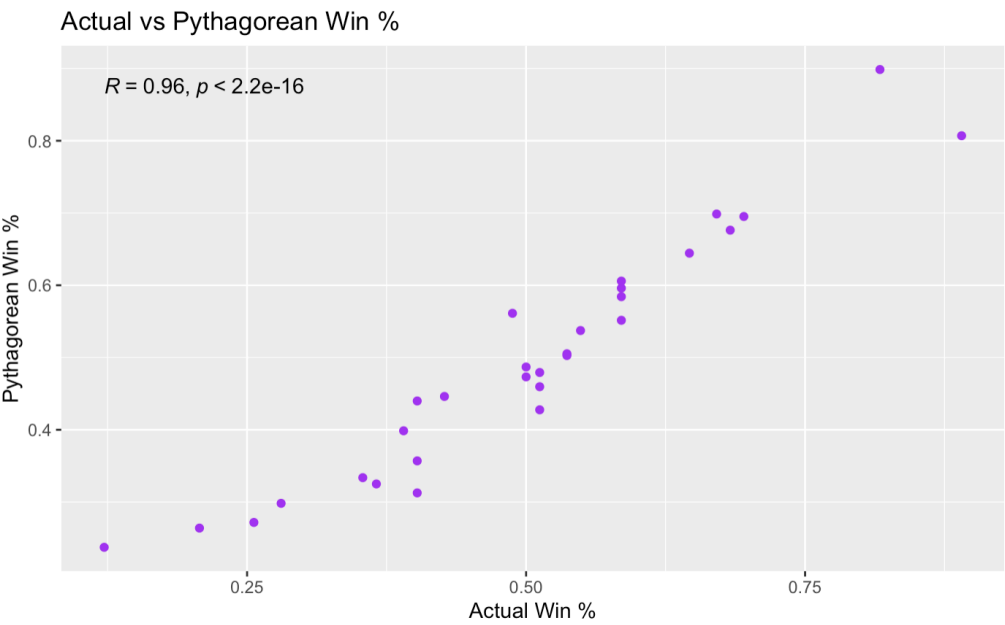


## **Discussion of Scoring Distribution:**

The first 3 graphs are the scoring distributions for the combined scores (home and away are included), home team, and away team. All three histograms seem to be roughly symmetric around the mean, which is shown by the blue vertical line. The mean score for the combined data is 102.67 points in a game, with a standard deviation of 11.74 points. The home team has a greater mean of 104.01 points and a similar standard deviation of 11.75, while the away team score has a lower mean of 101.33 points and a standard deviation of 11.58. This indicates that on average, the home team generally scores more points than the away team, although with a greater variance. This can be seen with the three vertical lines on the combined plot, where it has the overall mean in dark blue, the home mean in light blue, and the away mean in orange. We can see that the home mean is greater than the away mean. This idea can be transferred to the phenomenon of “home court advantage”, which explains that the home team has some sort of advantage when playing in their own backyard. Next, the scatterplot shows the relationship between the home team’s points and the away team’s points. There is a correlation of 0.35, which indicates a moderately weak positive relationship between the two variables. This suggests that if one team is scoring more, the other team is also likely to score more as well.

Calculation of Pythagorean Win Percentage:

Team	Actual Pyth Error			Team	Actual Pyth Error		
San Antonio Spurs	0.817	0.899	-0.082	Dallas Mavericks	0.512	0.479	0.033
Golden State Warriors	0.890	0.807	0.083	Washington Wizards	0.500	0.473	0.027
Oklahoma City Thunder	0.671	0.699	-0.028	Chicago Bulls	0.512	0.460	0.053
Cleveland Cavaliers	0.695	0.695	0.000	Orlando Magic	0.427	0.446	-0.019
Toronto Raptors	0.683	0.676	0.007	Sacramento Kings	0.402	0.440	-0.037
Los Angeles Clippers	0.646	0.644	0.002	Memphis Grizzlies	0.512	0.428	0.085
Atlanta Hawks	0.585	0.606	-0.020	New York Knicks	0.390	0.399	-0.008
Boston Celtics	0.585	0.596	-0.011	Denver Nuggets	0.402	0.357	0.045
Charlotte Hornets	0.585	0.584	0.001	Minnesota Timberwolves	0.354	0.334	0.020
Utah Jazz	0.488	0.561	-0.073	New Orleans Pelicans	0.366	0.325	0.041
Miami Heat	0.585	0.552	0.034	Milwaukee Bucks	0.402	0.313	0.090
Indiana Pacers	0.549	0.537	0.011	Phoenix Suns	0.280	0.298	-0.018
Portland Trail Blazers	0.537	0.505	0.031	Brooklyn Nets	0.256	0.272	-0.016
Detroit Pistons	0.537	0.503	0.034	Los Angeles Lakers	0.207	0.264	-0.057
Houston Rockets	0.500	0.487	0.013	Philadelphia 76ers	0.122	0.237	-0.115



## Discussion of Pythagorean Win Percentage:

The tables above display each NBA team's 2015-2016 actual win percentage, pythagorean win percentage, and error. We can see that the error column has very low values that are close to zero, indicating that our pythagorean win model did a pretty good job in predicting each team's actual win percentage. In fact, the mean absolute error (MAE) for the error came to be 0.036, or 3.60%, indicating that on average, the pythagorean win model was off by roughly 3 and a half percent. Taking a look at the scatter plot between the two win percentages, we can see a very positive linear relationship, indicating that once again, the model was pretty spot on with its predictions. Additionally, there is a 0.96 correlation between the two variables, reinforcing our previous observations.

Now looking at individual teams, the Milwaukee Bucks, Golden State Warriors, and Memphis Grizzlies overperformed the most, with errors of 0.090, 0.083, and 0.085, respectively. The Bucks actually won 40.2% of their games, when they were expected to win only 31.3% of them. The Warriors won 89% of their games, when they were expected to win 80.7%. The Grizzlies won 51.2% of their games, with expectations of winning 42.8%. The 3 teams that underperformed the most were the Philadelphia 76ers (-0.115), San Antonio Spurs (-0.082), and the Utah Jazz (-0.073). The 76ers were expected to win 23.7% of their games, but only won 12.2%. The Spurs were expected to win 89.9% of their games, but won 81.7% of their games instead. Finally, the Jazz were expected to win 56.1% of their games, but won 48.8%.



## Calculation of Bradley-Terry Ratings:

	Bradley-Terry Rating		Bradley-Terry Rating
Location	2.6866554	Miami Heat	1.5040896
Atlanta Hawks	3.4915174	Milwaukee Bucks	-3.9796854
Boston Celtics	2.8043353	Minnesota Timberwolves	-3.3813413
Brooklyn Nets	-7.1144518	New Orleans Pelicans	-3.5518802
Charlotte Hornets	2.3582076	New York Knicks	-2.7348033
Chicago Bulls	-1.4631895	Oklahoma City Thunder	7.0919656
Cleveland Cavaliers	5.4518478	Orlando Magic	-1.6498032
Dallas Mavericks	-0.0151564	Philadelphia 76ers	-9.9177625
Denver Nuggets	-2.8063752	Phoenix Suns	-6.3152208
Detroit Pistons	0.4265727	Portland Trailblazers	0.9797475
Golden State Warriors	10.3812653	Sacramento Kings	-2.2814545
Houston Rockets	0.3419910	San Antonio Spurs	10.2772493
Indiana Pacers	1.6220947	Toronto Raptors	4.0515926
Los Angeles Clippers	4.1291658	Utah Jazz	1.8440774
Los Angeles Lakers	-8.9156025	Washington Wizards	-0.4953396
Memphis Grizzlies	-2.1336535		

## Discussion of Bradley-Terry Ratings:

From this table, we can see that the Golden State Warriors have the highest rating of 10.38, followed closely by the San Antonio Spurs, with a rating of 10.28. From the East, the Cleveland Cavaliers have the highest Bradley-Terry rating of only 5.45, which is essentially half the rating of the Western conference winners. This could suggest that based on the ratings, the top Western teams (Warriors, Spurs, etc.) are stronger than the top Eastern teams (Cavaliers, Raptors, etc.). The worst teams from the Eastern conference include the Philadelphia 76ers and the Brooklyn Nets, with ratings of -9.92 and -7.11 respectively. From the West, the Los Angeles Lakers (rating of -8.92) and Phoenix Suns (rating of -6.31) bottom the charts. The most average teams

based on their ratings were the Dallas Mavericks (-0.02), Houston Rockets (0.34), Washington Wizards (-0.50), and the Detroit Pistons (0.43).

### Preseason and Postseason Elo Ratings:

Team	Starting Elo	Ending Elo	Change	Team	Starting Elo	Ending Elo	Change
Golden State Warriors	1710.609	1828.265	117.655	Washington Wizards	1530.816	1520.459	-10.357
San Antonio Spurs	1641.568	1772.246	130.678	Detroit Pistons	1453.135	1511.434	58.299
Oklahoma City Thunder	1559.539	1668.354	108.816	Memphis Grizzlies	1579.607	1467.486	-112.120
Cleveland Cavaliers	1619.220	1651.042	31.822	Chicago Bulls	1548.795	1459.711	-89.084
Toronto Raptors	1502.918	1637.105	134.187	Orlando Magic	1368.695	1423.589	54.894
Los Angeles Clippers	1629.398	1636.510	7.112	Denver Nuggets	1442.695	1415.289	-27.406
Atlanta Hawks	1564.236	1598.693	34.458	Sacramento Kings	1425.045	1409.837	-15.208
Portland Trailblazers	1537.759	1587.667	49.908	Milwaukee Bucks	1461.134	1394.435	-66.699
Boston Celtics	1490.327	1571.275	80.948	New Orleans Pelicans	1514.335	1385.331	-129.004
Miami Heat	1477.671	1569.935	92.264	Minnesota Timberwolves	1337.277	1373.935	36.658
Charlotte Hornets	1435.442	1567.329	131.887	New York Knicks	1336.752	1370.702	33.949
Houston Rockets	1610.903	1540.599	-70.304	Phoenix Suns	1485.983	1332.224	-153.759
Dallas Mavericks	1541.799	1529.471	-12.328	Brooklyn Nets	1477.380	1279.867	-197.513
Indiana Pacers	1503.357	1529.383	26.027	Los Angeles Lakers	1352.086	1256.175	-95.911
Utah Jazz	1523.501	1524.487	0.986	Philadelphia 76ers	1338.044	1187.190	-150.853

### Discussion of Preseason and Postseason Elo Ratings:

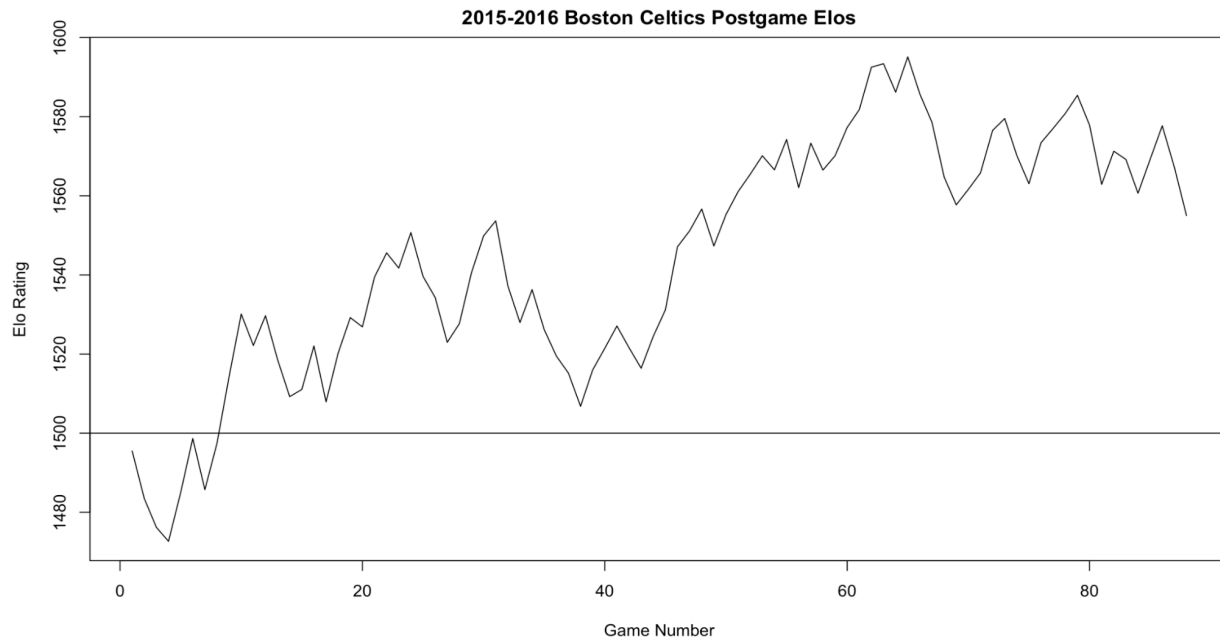
The tables above display the starting and ending elos for all teams in the NBA from the 2015-2016 season. The top 3 best teams in the entire league belonged to the Western Conference, with the Golden State Warriors, the San Antonio Spurs, and the OKC Thunder. The worst 3 performing teams were the Philadelphia 76ers, the LA Lakers, and the Brooklyn Nets. 8 teams from each conference qualify for the playoffs, so from the West, the Warriors, Spurs, Thunder, Clippers, Trailblazers, Rockets, Mavericks, and the Jazz are expected to qualify. From the East, the Cavaliers, Raptors,

Celtics, Heat, Hornets, Pacers, Wizards, and Pistons are expected to qualify.

Interestingly, in the West, an elo of at least 1523.501 was required to make the playoffs, while an elo of only 1453.135 was required from the East. This supports the idea that in general, the West is theoretically “better” and more competitive than the East.

The team that improved the most was the Toronto Raptors, who started at 1502.918, ended at 1637.105, and an improvement of +134.19. Next, the Charlotte Hornets started at 1435.442 and ended at 1567.329, with an improvement of +131.89. The third most improved team was the San Antonio Spurs, who started at 1641.568 and ended with 1772.246, which is an improvement of +130.68. The team that regressed the most was the Brooklyn Nets, who started with an elo of 1477.380 and ended at 1279.867, which was a decline of -197.51. Next, the Phoenix Suns started at 1485.983 and ended at 1332.224, which is a decline of -153.76. Finally, the Philadelphia 76ers started at 1338.044 and ended at 1186.190, which is a decline of -150.85. Overall, elos seem to reflect teams’ regular season performances relatively well.

## Elo Ratings for One Team:



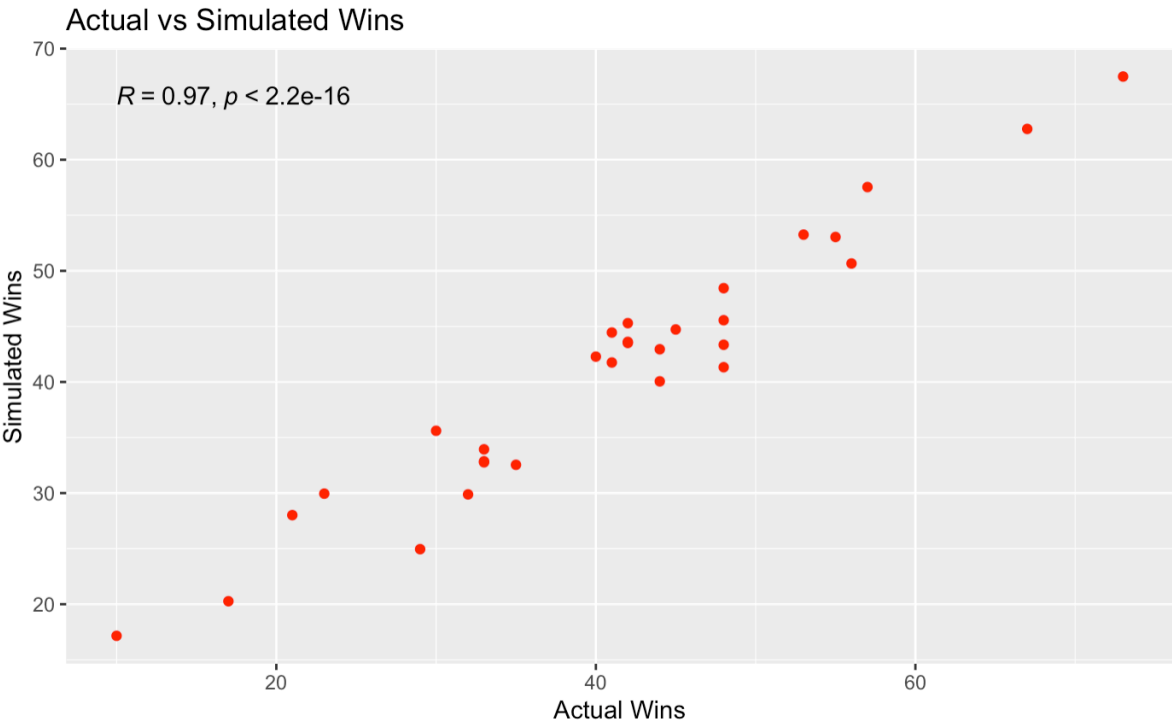
## Analysis of Elo Ratings for One Team:

The above line graph displays the Boston Celtic's postgame elos throughout the 2015-2016 season. Overall, the Celtics had a pretty successful season, as their elo climbed from 1490.34 to 1571.28, which is an 80.95 improvement from their preseason elo. That being said, their season consisted of many streaks, where they were on constant 3-4 game winning streaks, followed by a 3-4 game losing streak. On the graph, we can see this through the many peaks and valleys that occur over the course of the season. However, this pattern was broken in games 40-60, where the Celtics ended the 20 game run with 14 wins and only 6 losses, improving their elo from about 1520 all the way to their season high of around 1590. During this stint, the Celtics overcame the likes of future champions in Cleveland, and other strong teams such as the Clippers and Heat. Additionally, after breaching the 1500 elo mark after around game 10, the Celtics

never dipped below that benchmark, indicating a successful season. They ended up as the 5th seed from the East with a 48-34 record, but a first round exit in the playoffs to the Atlanta Hawks. Star players included Avery Bradley, who averaged 15 points a game, as well as Isaiah Thomas, who averaged 22 points and 6 helpers a game.

Simulated Regular Season Results:

Team	Actual Wins	Average Wins	Division Titles	Team	Actual Wins	Average Wins	Division Titles
Brooklyn Nets	21	28.017	0.000	Orlando Magic	35	32.546	0.000
Charlotte Hornets	48	41.328	0.065	Phoenix Suns	23	29.951	0.000
Chicago Bulls	42	43.510	0.006	Portland Trailblazers	44	42.943	0.036
Cleveland Cavaliers	57	57.539	0.975	San Antonio Spurs	67	62.771	0.999
Dallas Mavericks	42	43.607	0.000	Toronto Raptors	56	50.662	0.802
Denver Nuggets	33	32.769	0.000	Utah Jazz	40	42.281	0.039
Houston Rockets	41	44.450	0.001	Washington Wizards	41	41.752	0.096
Indiana Pacers	45	44.725	0.017	Boston Celtics	48	45.554	0.198
Los Angeles Clippers	53	53.258	0.003	Golden State Warriors	73	67.485	0.997
Memphis Grizzlies	42	45.292	0.000	New York Knicks	32	29.883	0.000
Miami Heat	48	43.349	0.154	Philadelphia 76ers	10	17.156	0.000
Milwaukee Bucks	33	33.939	0.000	Atlanta Hawks	48	48.441	0.685
Minnesota Timberwolves	29	24.954	0.000	Detroit Pistons	44	40.055	0.002
New Orleans Pelicans	30	35.608	0.000	Los Angeles Lakers	17	20.267	0.000
Oklahoma City Thunder	55	53.047	0.925	Sacramento Kings	33	32.861	0.000



### **Comparison of Simulation and Actual Regular Season:**

The tables above display the results from the Monte Carlo simulation, with each team's actual wins, average wins from the simulation, and their division titles. From the 30 teams, the 3 teams that were the closest to their expected win totals were the Denver Nuggets (0.231 game difference), the Sacramento Kings (0.139 game difference), and the Los Angeles Clippers (0.258 game difference). A potential reason for these teams to be close to their expected numbers could be that these teams were very consistent in their seasons, so the simulations essentially picked the same results for every iteration. In other words, these teams beat who they were supposed to beat and lost to the teams that they were meant to lose to, so the simulation had an easier time running through the process. Looking at the division titles, the simulated winners turned out to be the Cavaliers from the Central division, the Thunder from the Northwest division, the Spurs from the Southwest division, Raptors from the Atlantic division, Warriors from the Pacific division, and finally Hawks from the Southeast division. In reality, all teams except for the Hawks topped their division (the Heat took the Southeast). The three teams that overperformed their simulated number of wins were the Hornets (overachieved by 6.68 games), Warriors (5.52), and the Raptors (5.33). In contrast, the teams that underachieved were the 76ers (7.20 games under), Nets (7.20 games), and the Suns (7.00 games). The scatterplot shows that there is a very strong positive correlation (0.97) between actual and simulated wins, indicating that the Monte Carlo simulation did very well in predicting the number of games won by each team. This figure is similar to the scatterplot for actual vs pythagorean win percentage, which indicates that both methods of predicting wins do a fairly nice job.

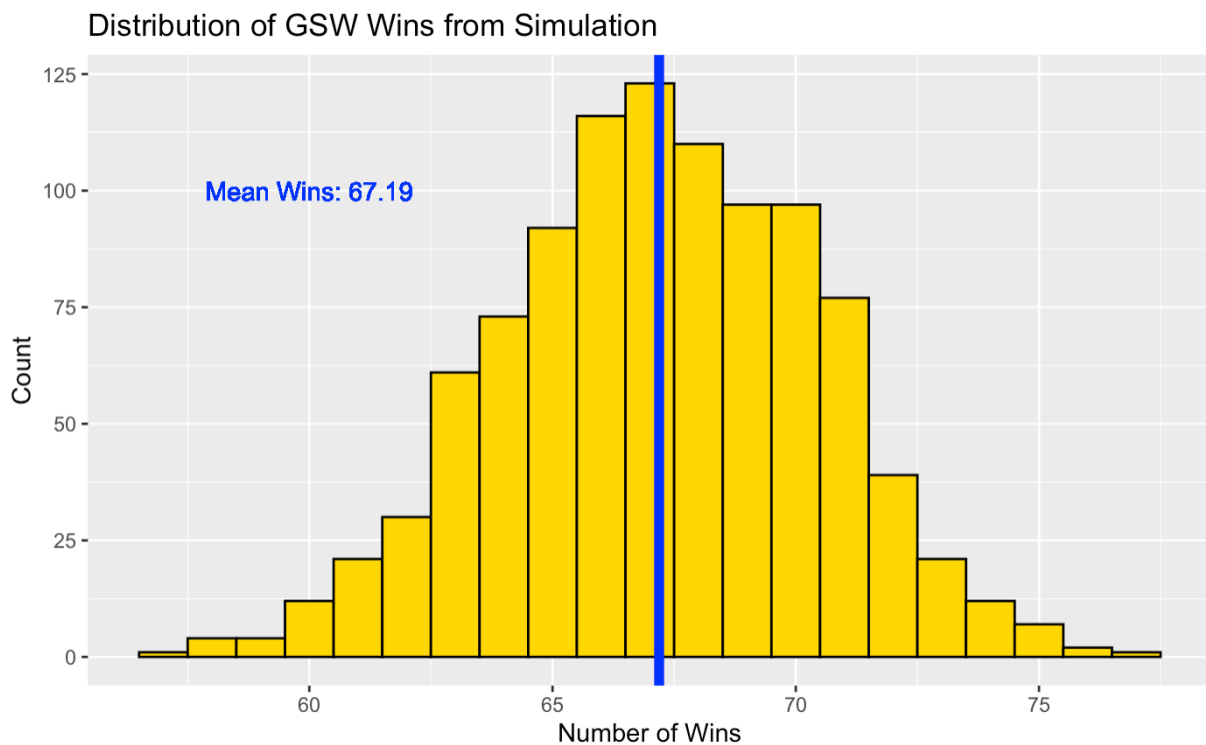
### **Analysis of Overachieving Team:**

The Golden State Warriors were overachievers during the season, according to both the Pythagorean win model and Monte Carlo simulation. This makes sense, as they had a record of 73-9 during the regular season. According to the simulation, the Warriors had an average wins of 67.19 games (shown in histogram below), so they overachieved by about 6 games.

Let's take a look at the four factors mentioned in a previous section. The Warriors led the league in offensive eFG%, was 56.30%. To accompany this, one of the defining characteristics of the Warriors was that they embodied the idea of "small ball", which involves a ton of three point shooting from their sharpshooters Stephen Curry and Klay Thompson. Looking at the Warrior's 3 point shooting, they made 1,077 of their 2,592 threes, indicating a 3 point FG% of 41.60%. To put this into perspective, the Rockets were the second most willing to shoot threes, and they made 878 of their 2,533 shots, which is a FG% of only 34.70%. Additionally, the Warriors were efficient in scoring 2 point field goals as well, making 52.80% of their 2 pointers (this also leads the league). That being said, because of their offensive nature, they also had a good amount of offensive turnovers. They had an offensive turnover rate of 13.50%, indicating that almost 14% of their offensive possessions ended in a turnover. This makes sense, because the Warriors love to use their guards to find creative looks to the basket, and this naturally leads to more turnovers, but the high risk is usually worth the high rewards. Moreover, the Warriors were 19th in the league when it came to offensive rebound percentage, which again is logical to their 3 point shooting rate and smaller size overall in the team. They were also 25th in the league when it came to offensive

free throw to field goal rate, which also makes sense, as shooting threes results in less fouls, and the majority of fouls occur when players drive to the hoop.

Now moving on to the defensive statistics, the Warriors were 2nd in opponent eFG% (47.90%), meaning they held their opponents to a relatively low success rate on their shots. A large reason why this was the case was due to the elite defense displayed by Draymond Green, who was an all around threat on both sides of the court this season. That being said, they were also only 20th in forcing opponent turnovers, with a rate of 12.60%. Moving on to defensive boards, they were pretty average, placing 16th in the league with 76%. Finally, they were also average with opponent FT/FG rate, with 20.8%.



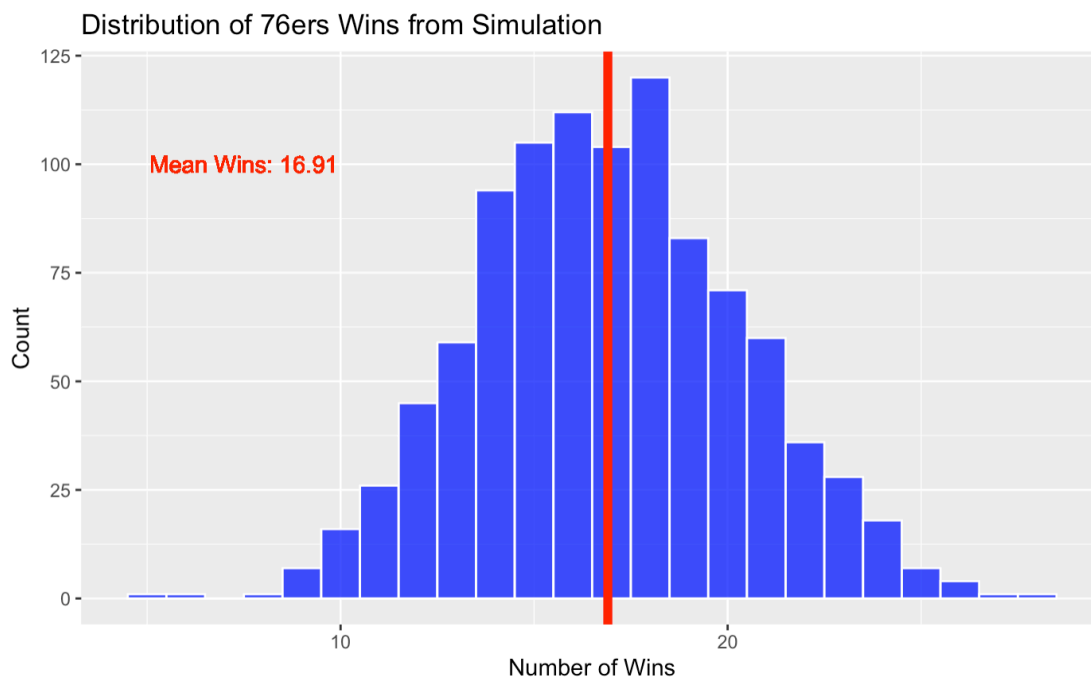


## **Analysis of Underachieving Team:**

Now, let's examine the worst team from the 2015-2016 season, the Philadelphia 76ers. The 76ers ended the season with a record of 10-72, finishing at the bottom of their conference, and with the worst record across the league. According to the simulation, the 76ers had an average wins of 16.91, which was about 7 wins better than how they actually performed. A large factor in this was also due to the fact that their draft pick from 2014 Joel Embiid was out until the 2016-2017 season with foot injuries. Essentially, they were setting themselves up for a better draft pick in the future (trust the process). Philadelphia were the 25th team in offensive eFG% with a rate of 48.70%. They actually took a good amount of threes, but only ended up scoring on 33.90% of their attempts, which drives this eFG% down a good bit. The 76ers were also the second worst team when it came to offensive turnovers. They turned the ball over on 14.80% of their offensive possessions, which allows the other team to get more scoring opportunities for themselves. Additionally, even if they got a shot off, they couldn't get the offensive board, as they had an offensive rebound rate of 20.60%, which ranks 25th across the league. As for their offensive FT/FG rate, they ranked 27th, with a rate of 18.60%. Looking at these offensive statistics, it becomes obvious why they only registered 7,988 points over the stretch of the season, which converts to an average of around 97 points a game. In comparison, the Warriors averaged around 115 points a game, which is 9,421 total points during the season.

Now for defensive stats, the Sixers were ranked 18th when it came to opponent eFG%, as they allowed 51% of their opponent's attempts. Next, they ranked 13th when it came to causing opponent turnovers at 13.50%. However, the caveat to this is that

they were the 2nd worst team at opponent FT/FG ratio. These statistics indicate that the 76ers were most likely a very aggressive team on defense, which allows to cause turnovers, but also causes more fouls, which allows the opponent to go to the free throw line. Finally, the 76ers ranked 27th in defensive rebounds, which could be because the center that they drafted previously was not able to play, so their center position was not as strong as they hoped.



### Conclusion/Takeaways:

After running the Pythagorean Win Percentage model, the Bradley-Terry Ratings, and Monte Carlo Simulation, it is clear that all 3 methods were very successful in predicting the NBA season for 2015-2016. Using outside and background knowledge of what actually happened during the season, we are able to support our observations with the statistical evidence displayed in this report. As we saw with Monte Carlo and Pythagorean Win Percentage, the correlations between what actually happened and

what the simulation predicted would happen was almost 1, indicating that they did a pretty decent job. From these models, we can also determine who overachieved or underachieved compared to how we thought they would do during the season. For example, we were able to confirm our beliefs that the Golden State Warriors overachieved their expectations by an incredible amount, displaying offensive production that almost won them the championship. On the flip side, we also observed how events not shown in the data (Joel Embiid getting injured), can greatly negatively affect a team's performance during the season.

Additionally, we saw how important having a strong offense is, especially in the modern game. Now that the importance of three point shooting has been realized, it becomes such an important asset to the game. 3-and-D players that can both shoot the three ball very well and defend at a high level are crucial to success, even if they aren't the most athletic or creative. A prime example of this is Klay Thompson, who is one of the greatest shooters of all time, and an elite defender. Another aspect of this season that could be further studied is the performance of the Cavaliers during the postseason. They defied all odds by coming back from a 3-1 deficit in the finals, but somehow found the willpower to overtake the best offensive team of all time.

In addition, it would be interesting to examine the likes of individual players, such as the impact that LeBron James, Kyrie Irving, and Kevin Love had in the regular season compared to crunch time during the later playoff games. Using these models, we can, for example, investigate the Cavalier's elo fluctuations during losses when one of their star players are injured. Overall, this report gives us a glimpse into the season, and how we can extract conclusions by looking at various ranking models.