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STAT 1341 - Sports Analytics

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2016-2017 NHL Season Analysis

Season Overview and Format

The 2016-2017 NHL season marks the NHL's 100th year in the league's history. Heading into the season the Pittsburgh Penguins are the current Stanley Cup champions who are looking to become the first team to win back-to-back championships in the NHL's salary cap era. This feat will be challenging given the NHL's parody and trend towards young players, such as Connor McDavid who was announced before the start of the season as the youngest captain in the NHL's history for the Edmonton Oilers at the age of only 19. The offseason also featured the first American-born player since Patrick Kane to be drafted first overall as Auston Matthews was selected by the Toronto Maple Leafs. Additionally, the NHL salary cap had a boost for the 2016-17 season from $71.4 million to $73.1 million. There was only one minor rule change regarding nuances related to the penalty for delay of game for the upcoming season, otherwise, the NHL was running as status quo as a high-paced, high-skill league. As a lifelong Pittsburgh Penguins fan, I decided to explore this NHL season as it was the second of back-to-back Stanley Cups for the team and the first time this feat has been accomplished in nearly 20 years since the Detroit Red Wings in 1997-1998. With such high talent amongst all NHL teams and a physically demanding 82-game schedule, I anticipate this season to be largely associated with the Penguins outperforming expectations. I am also interested in exploring if the Penguins "got hot" at the right time or were consistently a powerhouse throughout the entirety of the season. I am eager to embark more into exploring these hypotheses.

For the 2016-2017 NHL season there were 30 teams in four divisions, further divided into East and West (See Figure 1 below).

East		***West***	
Atlantic Division	**Metropolitan Division**	**Central Division**	**Pacific Division**
Buffalo Sabres	Carolina Hurricanes	Chicago Blackhawks	Anaheim Ducks
Boston Bruins	Columbus Blue Jackets	Minnesota Wild	Edmonton Oilers
Tampa Bay Lightning	New Jersey Devils	St. Louis Blues	San Jose Sharks
Florida Panthers	New York Islanders	Nashville Predators	Calgary Flames
Toronto Maple Leafs	New York Rangers	Winnipeg Jets	Los Angeles Kings
Detroit Red Wings	Philadelphia Flyers	Dallas Stars	Arizona Coyotes
Ottawa Senators	Pittsburgh Penguins	Colorado Avalanche	Vancouver Canucks
Montreal Canadiens	Washington Capitals		

Figure 1: 2016-2017 NHL Division Set Up

Teams will compete in an 82-game regular season in which the top 3 teams from each division will make the playoffs along with 2 additional wild-card teams from both the East and the West.

Statistical Summary of Relevant Statistics

Looking at the season in further detail, I began to explore some advanced statistics in hockey such as Expected Goals and PDO. Expected goals for are defined as the statistical chance of an unblocked shot to become a goal. PDO is defined as shooting percentage plus save percentage. These two metrics can begin to give us a glimpse at the strength of teams relative to expectations. This can begin to show us if teams

were favored by luck throughout the season. One way to see if teams outperformed expectations is by comparing a team's Actual Goals for versus Expected Goals for as shown in Figure 2.

Here we see teams such as the Washington Capitals, Minnesota Wild, and St. Louis Blues outperformed expectations substantially scoring 46, 40, and 31 more goals than expected, respectively. This can give us insight into these teams being luckier, i.e. shots that typically would not go in, went in for these teams. Conversely, we see that the Los Angeles Kings and Colorado Avalanche are on the other end of the spectrum, in which many of their shots should have gone in but didn't. This can be caused by a combination of things such as playing against a hot goalie, lower-skilled talent not being able to capitalize on scoring opportunities, or simply bad bounces.

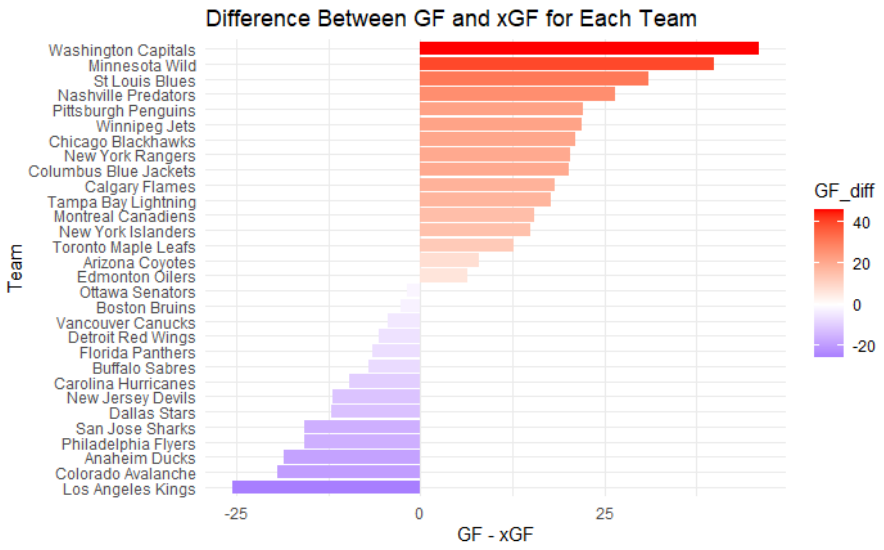

Figure 2: Comparing NHL Team's Actual Goals for Goals Against Expected For

Looking further into expected goals for, I was interested in seeing if there were any outliers for our data. To do this I took the Expected Goals for percentage variable ((Expected Goals for - Expected Goals against) / Total Expected Goals). Figure 3 shows a distribution of Expected Goals for Percentage that is slightly left skewed and that is further confirmed by the median being greater than the mean (Figure 5). Displayed in Figure 4 are all teams' Expected Goals for Percentage.

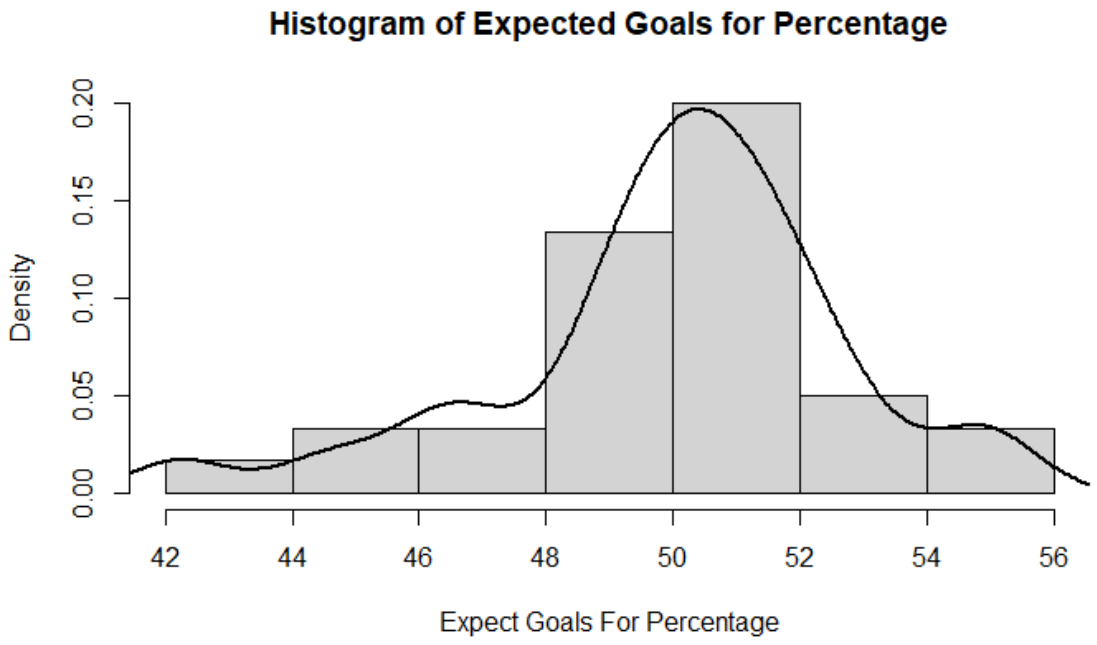

Figure 3: Distribution of Expected Goals for Percentage Variable

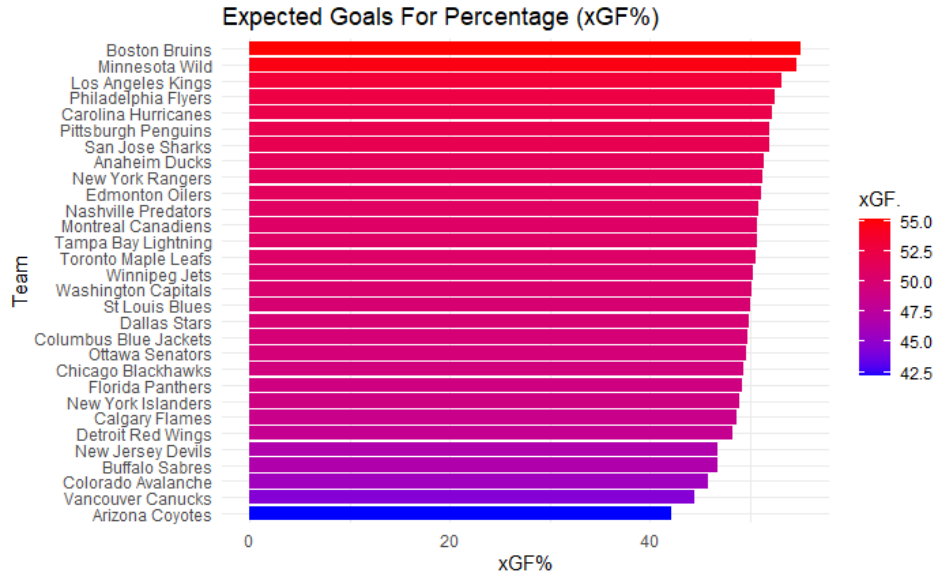

Figure 4: Expected Goals for Percentage for each team.

Mean	***Median***	***Standard Deviation***
49.974	50.25	2.764

Figure 5: Descriptive Statistics of Expected Goals for Percentage,

Testing for outliers, we found that the Boston Bruins were an outlier on the high end and the Vancouver Canucks were an outlier on the low end. This represents the team being statistically good (or bad) at

controlling the play, i.e. generating high-quality offensive shots while limiting high-quality shots on defense, and vice versa.

Next, I took a dive into PDO for each team. Generally, PDO is a good representative of luck and outperforming expectations as teams with high shooting and save percentages can be expected to regress toward the mean over time. Figure 5 shows the PDO of each team for the 2016-17 NHL season. Here we see similar results to those shown in Figure 2 where teams such as the Washington Capitals and Minnesota Wild performed strongly in the PDO metric, meanwhile, the Colorado Avalanche once again are shown at the bottom. This is a good start in understanding individual team strength and the impact of luck during the 2016-17.

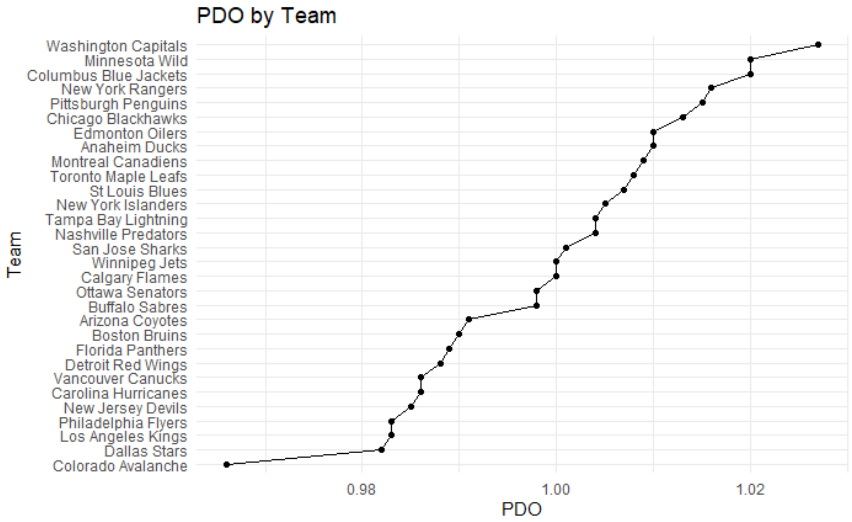

Figure 5: PDO of each team during the 2016-17 NHL Season

Team Scoring Distributions

Next, I decided to look at team scoring distribution for the 2016-17 NHL season. This will help us better understand home ice advantage and any relevant trends in scoring.

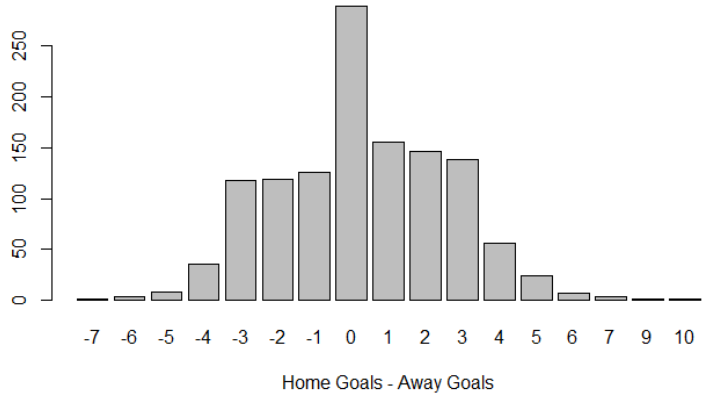

Figure 6: Home-Aways Bar Plot representing Home Ice Advantage

Here we see a generally normal-looking plot with a slight left skew, representing home ice advantage as most of the data represents a positive outcome for the home team. One interesting point about this season is the large number of games that ended with a 0-goal differential, meaning the games ended in a tie, causing the need for overtime. Additionally, we found essentially no correlation between home and away scores (r = -0.0085). Next, I was interested in exploring overall goal-scoring trends to see how many goals were scored per game. Figure 6 above displays goals scored this season without shootouts. Here we see a right-skewed graph that shows on average most teams tend to score 2 or 3 goals each per game, which seems on par given our background knowledge of the NHL being a relatively low-scoring league. This is further confirmed when looking at the mean and standard deviations of goal scoring for the home in away teams. Home teams averaged 2.80 goals per game with a standard deviation of 1.68, meanwhile, away teams averaged just 2.50 goals per game with a standard deviation of 1.57. This analysis shows that there is certainly a slight home-ice advantage throughout the regular season.

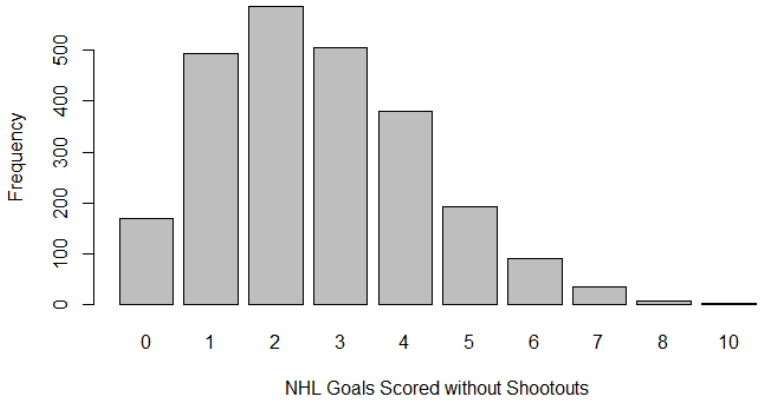

Figure 7: NHL Goals Per game without shootouts.

Pythagorean Win Percentage

Moving forward, I decided to look at Pythagorean Win Percentage which attempts to estimate a team's win percentage based on how many goals for and goals against that occurred during an NHL season.. Below are two graphs that show the strong correlation between an NHL team goal scoring ratio and win percentage. This is the basis of the Pythagorean win percentage. Our analysis showed a 0.962 correlation between Pythagorean win percentage and Actual Winning Percentage.

Looking at teams from the 2016-17 NHL season we see that, once again the Colorado Avalanche underachieved, continuing the theme that they were unlucky throughout the season.
Additionally, the Chicago Blackhawks and the Pittsburgh Penguins were the two biggest overachievers.
Looking deeper into our team of interest, the Pittsburgh Penguins, we see that they achieved 111 points during the regular season, meanwhile, the Pythagorean win percentage predicted them to only achieve 89 points. This can be shown as an overachievement, but also it can be interpreted as the ability to win close games since the Pythagorean win percentage is based on the goal-scoring ratio. This can be insightful when we think about what makes a championship-caliber team. Oftentimes NHL playoff games are low-scoring, close, tight-checking games, and the ability to win these types of games is what separates

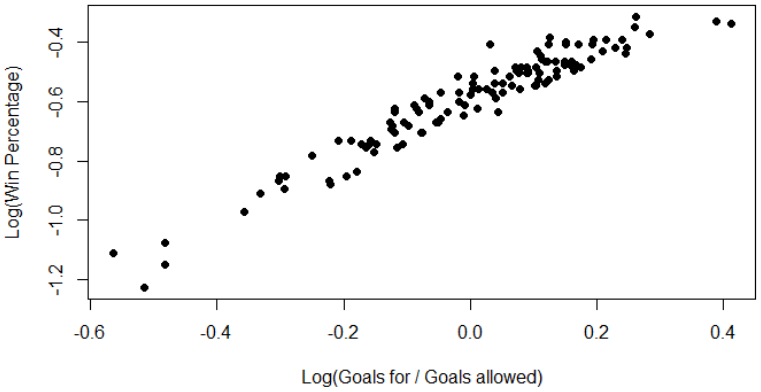

Figure 8: Comparing Log(Goals Ratio) and Log(Win

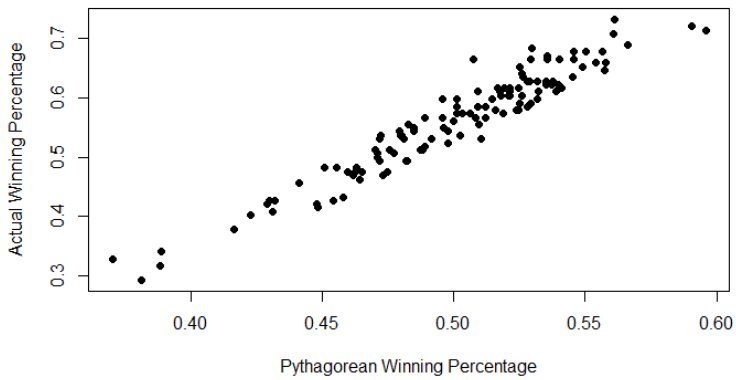

Figure 9: Comparing Pythagorean Win Percentage with Actual Win Percentage.

Champions from the rest of the league. It seems the Pittsburgh Penguins did this well.

Figure 10 below shows every team's win percentage compared to their Pythagorean win percentage.

Teams	*Actual Win Percentage*	*Pythagorean Win Percentage*	*Actual - Pythagorean*	*Actual Points*	*Pythagorean Points*
Anaheim Ducks	0.640	0.5260366	0.113963393	105	86.27000
Arizona Coyotes	0.427	0.4295103	-0.002510285	70	70.43969
Boston Bruins	0.579	0.5246194	0.054380639	95	86.03758
Buffalo Sabres	0.476	0.4648671	0.011132863	78	76.23821
Calgary Flames	0.573	0.5032109	0.069789091	94	82.52659
Carolina Hurricanes	0.530	0.4807770	0.049222993	87	78.84743
Chicago Blackhawks	0.665	0.5292432	***0.135756809 ****	109	86.79588
Colorado Avalanche	***0.293 *****	***0.3809191 *****	***-0.087919125 *****	***48 *****	***62.47074 *****
Columbus Blue Jackets	0.659	0.5579594	0.101040600	108	91.50534
Dallas Stars	0.482	0.4627798	0.019220249	79	75.89588
Detroit Red Wings	0.482	0.4508582	0.031141826	79	73.94074
Edmonton Oilers	0.628	0.5377690	0.090230988	103	88.19412
Florida Panthers	0.494	0.4718494	0.022150595	81	77.38330
Los Angeles Kings	0.524	0.4976400	0.026360016	86	81.61296
Minnesota Wild	0.646	0.5573958	0.088604190	106	91.41291
Montreal Canadiens	0.628	0.5280323	0.099967737	103	86.59729
Nashville Predators	0.573	0.5185514	0.054448629	94	85.04242
New Jersey Devils	0.427	0.4315577	-0.004557671	70	70.77546
New York Islanders	0.573	0.5009895	0.072010476	94	82.16228
New York Rangers	0.622	0.5372453	0.084754678	102	88.10823
Ottawa Senators	0.598	0.4954615	0.102538504	98	81.25569
Philadelphia Flyers	0.537	0.4797547	0.057245267	88	78.67978
Pittsburgh	0.677	0.5456331	0.131366870	111	89.48383

Penguins					
San Jose Sharks	0.604	0.5214051	0.082594931	99	85.51043
St Louis Blues	0.604	0.5178719	0.086128138	99	84.93099
Tampa Bay Lightning	0.573	0.5062380	0.066762037	94	83.02303
Toronto Maple Leafs	0.579	0.5156040	0.063395981	95	84.55906
Vancouver Canucks	0.421	0.4289721	-0.007972055	69	70.35142
Washington Capitals	***0.720 ****	***0.5906430 ****	0.129356999	***118 ****	***96.86545 ****
Winnipeg Jets	0.530	0.4915208	0.038479193	87	80.60941

*Figure 10: Comparing Actual Results vs Pythagorean Expectations. * denotes highest, ** denotes lowest.*

Poisson Ratings

Team Offensive Poisson Ratings:

Team	***Rating***	***Team***	***Rating***
Anaheim Ducks	-0.0906	**Arizona Coyotes**	-0.2438
Boston Bruins	-0.0671	**Buffalo Sabres**	-0.2048
Calgary Flames	-0.1069	**Carolina Hurricanes**	-0.1416
Chicago Blackhawks	-0.0692	**Colorado Avalanche**	-0.3961
Columbus Blue Jackets	0.0028	**Dallas Stars**	-0.1021
Detroit Red Wings	-0.2057	**Edmonton Oilers**	-0.0102
Florida Panthers	-0.1753	**Los Angeles Kings**	-0.2163
Minnesota Wild	0.0278	**Nashville Predators**	-0.0437
Montreal Canadiens	-0.1182	**New Jersey Devils**	-0.3019
New York Islanders	-0.0158	**New York Rangers**	0.0374
Ottawa Senators	-0.1696	**Philadelphia Flyers**	-0.1410
Pittsburgh Penguins	0.1325	**San Jose Sharks**	-0.1247
St. Louis Blues	-0.0909	**Tampa Bay Lightning**	-0.0616
Toronto Maple Leafs	0.0285	**Vancouver Canucks**	-0.3193

Washington Capitals	0.0380	**Winnipeg Jets**	0 (Baseline Team)

Figure 11: Offensive Poisson Ratings.

Team Defensive Poisson Ratings:

Team	***Rating***	***Team***	***Rating***
Anaheim Ducks	0.2211	**Arizona Coyotes**	-0.0065
Boston Bruins	0.2054	**Buffalo Sabres**	0.1157
Calgary Flames	0.1351	**Carolina Hurricanes**	0.1249
Chicago Blackhawks	0.1802	**Colorado Avalanche**	-0.0555
Columbus Blue Jackets	0.2671	**Dallas Stars**	-0.0113
Detroit Red Wings	0.0610	**Edmonton Oilers**	0.1927
Florida Panthers	0.1165	**Los Angeles Kings**	0.2438
Minnesota Wild	0.2203	**Nashville Predators**	0.2089
Montreal Canadiens	0.2754	**New Jersey Devils**	0.0874
New York Islanders	0.0850	**New York Rangers**	0.1826
Ottawa Senators	0.2303	**Philadelphia Flyers**	0.1175
Pittsburgh Penguins	0.1713	**San Jose Sharks**	0.2633
St. Louis Blues	0.2094	**Tampa Bay Lightning**	0.1389
Toronto Maple Leafs	0.0954	**Vancouver Canucks**	0.0663
Washington Capitals	0.3676	**Winnipeg Jets**	0 (Baseline Team)

Figure 12: Team Defensive Poisson Ratings for the 2016-17 NHL season.

Above are the team Offensive and Defensive rating coefficients based on the Poisson distribution. A Poisson distribution is a discrete probability distribution that shows a certain number of events that will occur in a specific period, i.e. goals during a hockey game. Here we calculated all of our coefficients relative to the baseline team of the Winnipeg Jets (chosen as they were last alphabetically). One interesting insight shown is that the Pittsburgh Penguins were the best-performing offensive team this season. On the other end of the spectrum, we see that the Washington Capitals are the best defensive team. This is a fascinating insight as the Washington Capitals were the Presidents Trophy champions

(most points in the regular season) with the Pittsburgh Penguins coming in second place. Additionally, if we tie this back to our lecture 18 notes, we see that "Defensive Rating" has a higher correlation (r = 0.89) with Points when compared to "Offensive Rating" (r = 0.76). The Washington Capitals being the best defensive team and finishing the 2016-17 NHL season with the most points provides strong anecdotal evidence towards the aforementioned point of defensive strength being strongly correlated to point totals.

Elo Ratings

Figure 13 below shows the start, end, and change of Elo ratings for every team throughout the 2016-2017 NHL season.

Team	***Start 2016***	***End 2016***	***Change***
Anaheim Ducks	1540.646	1554.906	14.259237
Arizona Coyotes	1451.923	1407.280	-44.643683
Boston Bruins	1510.224	1526.392	16.167585
Buffalo Sabres	1460.831	1440.723	-20.108175
Calgary Flames	1480.308	1494.613	14.305419
Carolina Hurricanes	1467.758	1466.338	-1.419408
Chicago Blackhawks	1533.997	1535.408	1.411188
Colorado Avalanche	1474.668	***1367.449 *****	***-107.219334*** **
Columbus Blue Jackets	1475.651	1530.109	54.458150
Dallas Stars	1527.667	1473.042	-54.625586
Detroit Red Wings	1497.587	1431.683	-65.904360
Edmonton Oilers	***1440.685*** **	1528.452	***87.767169*** *
Florida Panthers	1510.416	1468.978	-41.437770
Los Angeles Kings	1524.492	1499.976	-24.516125
Minnesota Wild	1497.455	1534.467	37.011770
Montreal Canadiens	1484.377	1511.832	27.455232
Nashville Predators	1507.331	1553.188	45.857412
New Jersey Devils	1480.213	1408.098	-72.114459
New York Islanders	1511.932	1519.784	7.852498
New York Rangers	1520.786	1544.083	23.296899
Ottawa Senators	1494.278	1520.887	26.608987
Philadelphia Flyers	1507.288	1490.177	-17.111819
Pittsburgh Penguins	***1562.413*** *	1598.527	36.114748
San Jose Sharks	1537.408	1526.253	-11.155268
St. Louis Blues	1536.320	1548.157	11.836380
Tampa Bay Lightning	1538.220	1526.111	-12.109446
Toronto Maple Leafs	1441.211	1497.307	56.096058
Vancouver Canucks	1453.582	1398.438	-55.143893
Washington Capitals	1553.660	***1608.988 ****	55.327743
Winnipeg Jets	1476.540	1488.223	11.682850

*Figure 13: Elo Ratings throughout the 2016-2017 NHL season. * denotes league high, ** denotes league low.*

In the chart above we see that the Pittsburgh Penguins started the 2016-2017 NHL season with the highest Elo rating in the league, this intuitively makes sense given that they were the Stanley Cup Champions at the end of the last season. It is also important to note the initial Elo ratings were based on the final ratings from the previous season with a ⅓ regression towards the mean, or 1500. One interesting takeaway from the Elo ratings is that the Washington Capitals finished the season with the highest Elo rating, despite losing in the second round of the playoffs to the Pittsburgh Penguins. This speaks to the strength of their regular season, as they were the President's Trophy winners. The Colorado Avalanche, once again, was the worst-ranked team in the NHL according to our Elo ratings. This is good to see that our statistical models are consistent in evaluating team performance.

The last interesting note from this season's Elo ratings is the impact of young talent on team performance. The Edmonton Oilers and Toronto Maple Leaf's gained the largest Elo boosts with an 87.77 and 56.10 Elo rating increase, respectively, from the start to the end of the season. I believe this can largely be explained by the addition of young talent through the NHL draft in Connor McDavid and Auston Matthews. Additionally, since these players were 1st overall draft picks, their teams were some of the worst in the NHL and had a lot of room for growth which their Elo rating improvements show.

Elo Ratings for One Team

Continuing our theme of reviewing the Pittsburgh Penguins, below in Figure 14 we took a look at the elo rating throughout the NHL season to detect any trends.

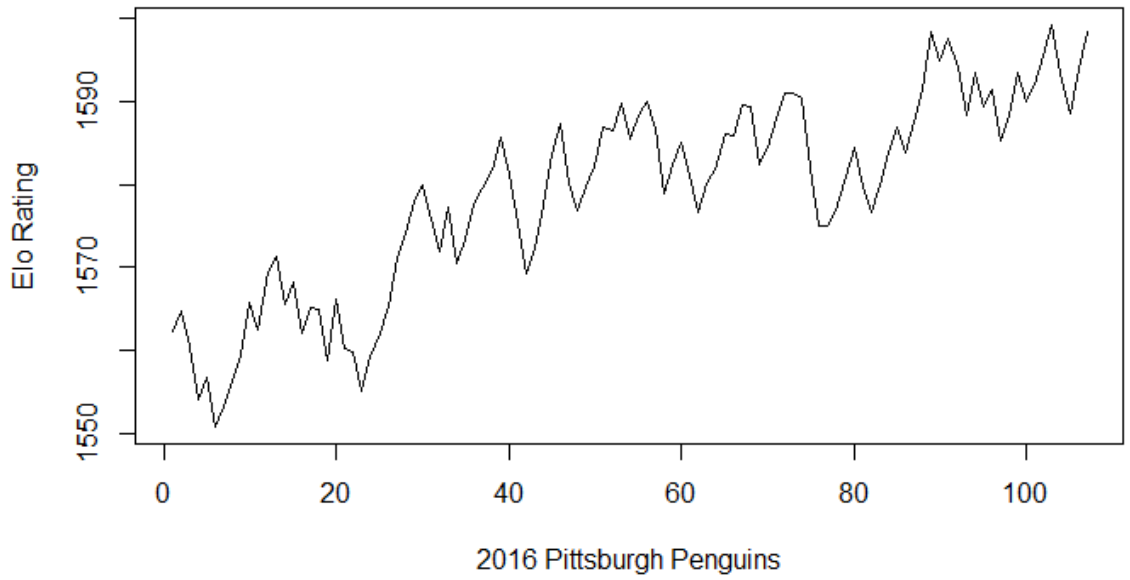

Figure 14: Pittsburgh Penguins Elo Rating throughout the 2016-17 NHL season.

Here we see the Pittsburgh Penguins had a very positive, consistent trend throughout the season. The season started on a little downturn, possibly due to the short offseason caused by a long playoff run the prior season. With that being said, overall, the season has its minor peaks and valleys such as a sharp run around game 22 and a dip around game 75 the overall trend is positive. One interesting note is the strong increase around game 85-90 which can be related to the Penguins defeating the Washington Capitals in round 2 of the playoffs. This large Elo jump can be explained by the Capital's high Elo rating from the regular season and the weight that beating a high Elo team carries. Lastly, it was interesting to see at the end of the season the Penguins had an Elo rating of 1598.53, which is very similar to prior years' finish of 1593.62, both years resulting in a Stanley Cup championship.

Simulated Regular Season

After running 10,000 simulations of the 2016-17 NHL season our model came up with the following results as seen in Figure 15 below:

Teams	*Actual Wins*	*Simulated Wins*	*Simulated Division Titles*	*Residuals*
San Jose Sharks	45.5	46.9022	***0.4889 ****	-1.4022
Washington Capitals	***56.5 ****	***50.7895 ****	0.4608	5.7105
Chicago Blackhawks	48.5	46.7699	0.3712	1.7301
Pittsburgh Penguins	50.5	49.6881	0.3390	0.8119
Tampa Bay Lightning	41.5	43.4697	0.2949	-1.9697
Minnesota Wild	48.5	46.0379	0.2945	2.4621
Anaheim Ducks	46.0	44.9719	0.2905	1.0281
Montreal Canadiens	46.5	42.5188	0.2140	3.9812
St. Louis Blues	46.0	44.7578	0.2083	1.2422
Boston Bruins	44.5	42.1981	0.1974	2.3019
Los Angeles Kings	40.0	42.9821	0.1547	-2.9821
Ottawa Senators	43.0	41.1141	0.1370	1.8859
New York Rangers	48.5	46.6022	0.1354	1.8978
Florida Panthers	35.5	39.9379	0.0902	-4.4379
Nashville Predators	42.0	41.8420	0.0760	0.1580
Columbus Blue Jackets	50.0	43.5983	0.0412	6.4017
Dallas Stars	34.5	40.0692	0.0408	-5.5692
Calgary Flames	44.0	39.1593	0.0363	4.8407
Toronto Maple Leafs	43.5	37.3626	0.0293	6.1374
Edmonton Oilers	47.5	38.5532	0.0271	***8.9468 ****
Detroit Red Wings	28.5	36.5732	0.0221	-8.0732
Buffalo Sabres	35.0	35.8128	0.0151	-0.8128
New York Islanders	42.0	41.1993	0.0146	0.8007
Winnipeg Jets	39.0	37.1190	0.0081	1.8810
Philadelphia Flyers	38.0	39.8142	0.0064	-1.8142
Vancouver Canucks	29.0	33.7687	0.0025	-4.7687
Carolina Hurricanes	37.5	36.8260	0.0020	0.6740
Colorado Avalanche	***22.5 *****	32.1273	0.0006	***-9.6273 *****
New Jersey Devils	28.0	35.4677	0.0006	-7.4677
Arizona Coyotes	28.0	***31.9670 *****	***0.0005 *****	-3.9670

*Figure 15: Results of 2016-2017 NHL Season via Monte Carlo simulation using Elo ratings. *denotes league high, ** denotes league low.*

Our simulation results provide us with lots of points of analysis. To start, we see that the simulation correctly predicted the Washington Capitals to 1) End the season with the most wins and 2) win the division title in the Metropolitan Division. Interestingly, the simulation underpredicted the Capital's win total by nearly 6 wins, yet they still were the model's favorite to win the division. This model also correctly predicted the division winner in the Central division with the Chicago Blackhawks but failed to do so in the Pacific division as the Sharks finished 3rd and interestingly selected the Tampa Bay Lightning to be the favorite in the Atlantic division despite them not making the playoffs this season.

Looking at Figure 16 below we can begin to have a better understanding of our models residuals and error tendencies. Here we see that the residuals are approximately normally distributed although we would need to run a Shapiro-Wilks test to formally confirm this observation. Additionally, our plot shows a strong, positive relationship between actual wins and our simulated wins. This relationship resulted in an r-value of 0.8702.

Looking at individual team residuals we once again see the Colorado Avalanche greatly underperforming expectations, with a residual of -9.623 representing losing nearly 10 more games than expected On the other end of the spectrum, we see the Edmonton Oilers greatly outperforming expectations, winning nearly 9 more games than expected. This seems to be a common theme this NHL season with Edmonton outperforming expectations and Colorado underperforming. This is something I will look into more depth in the next section. Lastly, we see that the Nashville Predators had the smallest residual this season of only 0.1580 showing us the model almost perfectly predicted their win total. This result is interesting considering Nashville made it all the way to the Stanley Cup Finals this season, although this connection seems it may only be by coincidence.

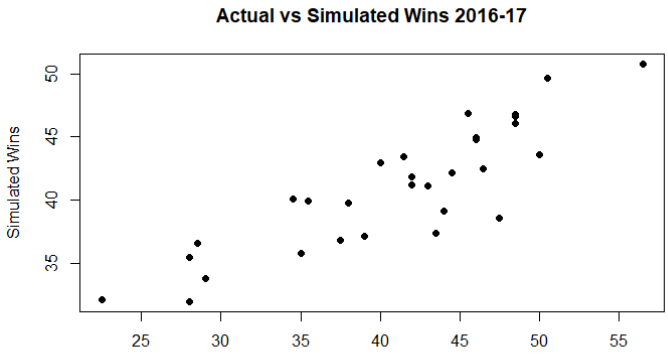

Figure 16a: Plot comparing actual wins and simulated wins from the

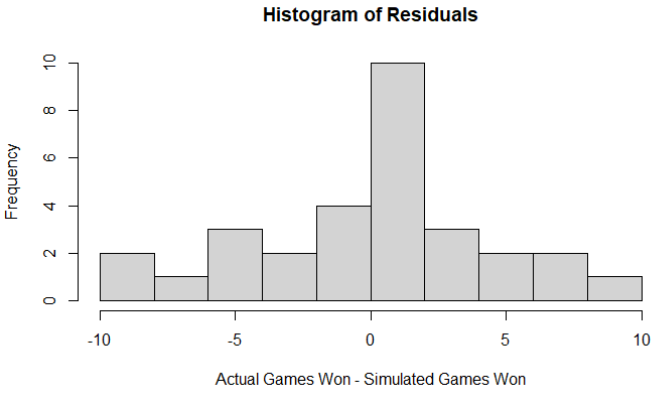

Figure 16b: Histogram of Monte Carlo Simulation residuals from

Analysis of Overachieving Team

As previously mentioned one team that consistently overachieves our statistical expectations for this season was the Edmonton Oilers. To get a better idea of why this might have happened it is important to

reference our summary statistics from before. First looking at expected goals we see that Edmonton was a middle-of-the-pack team but inevitability did score 6.39 goals above expectation for the season. Additionally, the Oilers were 6th in the NHL's PDO statistic showing they benefited greatly from high shooting percentages and high save percentages which isn't always sustainable. Next, looking at Pythagorean expectation we see that the Oilers had the 8th highest positive error term of 0.090, resulting in our simulation underpredicting their season point total by 14.8 points. One reason for this may be that the Edmonton Oilers performed exceedingly well in close games. Their strong performance in close games can be explained by their high-level star power in Connor McDavid and Leon Draisaitl, who often shine when the lights are the brightest. This can be further exemplified by looking at other teams who exceeded Pythagorean expectations. For example, the 3 teams that outperformed expectations the greatest were the Chicago Blackhawks, the Pittsburgh Penguins, and the Washington Capitals. Looking at scoring leaders from the 2016-2017 NHL season we see that Connor McDavid led the league but was followed subsequently in points by Sidney Crosby (Pittsburgh Penguins), Patrick Kane (Chicago Blackhawks), and Nicklas Backstrom (Washington Capitals) in 2nd, 3rd, and 4th place, respectively. This high-end talent on teams can explain what is often called the "x-factor" and these close games.

Figure 18 shows a histogram of the Edmonton Oilers Simulated Win Totals. Here we see a normally distributed plot with much of the data being between 35 and 45 wins, with a mean of 38.55 and a standard deviation of 4.41. Despite this, the Edmonton Oilers achieved 47 wins this season. Assuming normality, this results in a z-score of 1.92 and a corresponding probability of 0.0272 or 2.72% chance of the Edmonton Oilers achieving 47 wins or more this season, according to our simulation.

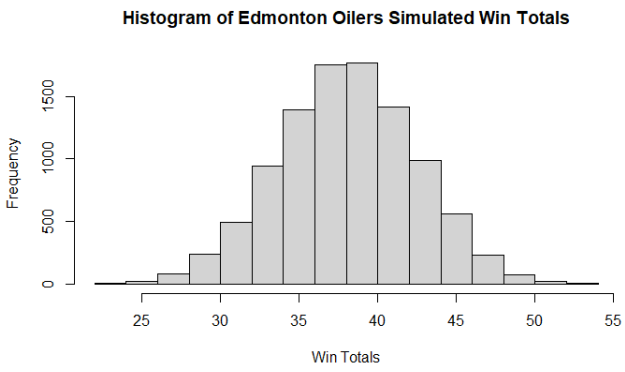

Figure 18: Histogram of simulated Edmonton Oiler win totals from 2016-17.

Analysis of Underachieving Team

One team in all of our statistical measures that seemed to underperform this season was the Colorado Avalanche. To begin analyzing their season we will look at Expected Goals for and PDO. Colorado ranked 2nd to last this season in goal-scoring performance relative to expectations. The Avalanche scored 19 fewer goals than what they were statistically projected to. This is further shown in the team's PDO which they ranked dead last in the league by a wide margin. These statistics show that their offense wasn't scoring goals that perhaps they should have and their defense/goaltending was also giving up goals that shouldn't have gone in.

Next, looking at the Avalanche through the lens of Pythagorean expectations we see that they had the greatest negative error. This resulted in them achieving 14.42 fewer points then they were expected. Once again this can be interpreted as losing close games, potentially due to lack of star power as Nathan Mackinnon seemed to be underwhelming expectations at this point in his career. Mackinnon led the Avalanche with only 53 points as their team struggled mightily offensively this season. It seems the Avalanche were missing the "x-factor" or "game-changing" qualities that Mackinnon has since possessed later in his career.

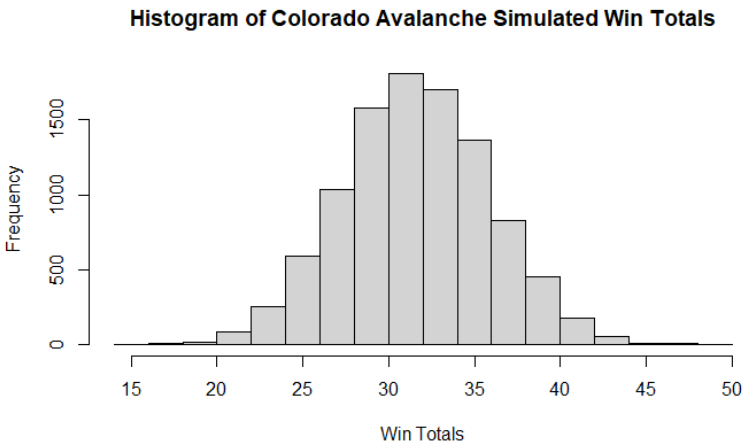

Figure 19: Histogram of Colorado Avalanche Simulated wins for 2016-17.

Moving forward, looking at our Monte Carlo Simulated season, we see the Avalanche also had the greatest negative residuals here of -9.63, projecting 32 wins despite only winning 22. Figure 19 shows a histogram of the simulated win totals. The histogram is approximately normal and has a mean of 32.13 and a Standard deviation of 4.31. Looking to calculate the probability of their lackluster win total we get a

z-score of -2.35, which results in a probability equal to 0.0094 or 0.94% chance they won that many or fewer games.

Conclusion / Takeaways

Overall, our ratings and simulation results seemed to be very consistent with actual team performance during the 2016-17 NHL season. Both the Pythagorean Win Percentage and Monte Carlo simulations predicted the Washington Capitals to achieve the most wins, which occurred during the actual 2016-17 season. Our model also predicted half of the division winners for this season, further showing evidence of the Monte Carlo simulation's predictive strength. Additionally, seeing the Colorado Avalanche's poor performance and large residual in both of our simulation models further exemplifies the historically bad season they had.

Our main team of interest, the Pittsburgh Penguins, seemed to perform up to expectations given that we knew they were the Stanley Cup Champions this season and the prior. The Penguins achieved the highest Offensive Poisson rating, had the 4th highest Pythagorean Win percentage, and the 2nd highest simulated win total in our Monte Carlo model. The residual results from our Pythagorean and Monte Carlo models give us a look at how teams perform in close games. The Pittsburgh Penguins exceeded expectations, leading to high residuals. As previously mentioned, I believe this can be explained by high-level talent and having an "x-factor" on the team. In the Penguin's case, they had multiple "x-factor" players this season.

These statistics combined with the 5th highest PDO rating and 5th highest Expected Goals differential show us that the 2016-17 Pittsburgh Penguins were exceedingly good at scoring goals above statistical expectation due–potentially due to high shooting percentages– and were also accompanied by strong goaltending.

To conclude, the models discussed in this paper seem to be very representative of actual team performance. While these models provide insight into the NHL it is very important to tie this information back to anecdotal evidence to provide a holistic view of the sport. Additionally, being able to hypothesize important factors based on hockey knowledge is important to build a strong model. Utilizing simulations, coupled with a thorough comprehension of key metrics like Expected Goals for and PDO, as well as leveraging prior hockey expertise, enables us to deliver a comprehensive and detailed analysis of the 2016-17 NHL season.