Statistical Analysis on the Impact of Rest Advantages on NHL Team Performance

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Abstract

In professional sports, rest is a critical issue. Playing too many games in a brief period of time can lead to fatigue, whereas periods of inactivity may hinder your performance due to "rust." This project aims to look at the impact of rest advantages in the National Hockey League (NHL).

Using data from Kaggle and augmented with data from Hockey Reference, we looked at regular season data spanning from the 2008-09 to the 2022-23 season, with the exception of the strike-shortened 2012-13 season. The dataset provided us with information about every game, including the home and away team, the date, final score, and how the game ended (regulation, overtime, or shootout). We also augmented the dataset with a simple measure of rest advantage or disadvantage for the home team and whether the home team won.

Interestingly, rest advantage appeared to become statistically significant in overtime games only after the NHL changed its overtime format from 4-on-4 to 3-on-3. In testing this hypothesis, we looked at all seasons since the change in the overtime format, which occurred before the 2015-16 season, as well as the seasons immediately prior to the rule change.

Introduction

In the NHL, schedulers need to fit 82 games for each team into a 6-month period. An obvious issue that must be addressed is how to do so without forcing any team to play too many games in a brief period of time. A question that arises is to what extent does a rest advantage benefit a team. This paper aims to answer that question and determine if rest provides an advantage to a team. If such an advantage does exist, we would also expect to see that the longer games go, for example overtime games, the more likely rest advantages would play a factor.

To test this hypothesis, we utilize logistic regression to check for an advantage based on the results of three distinct types of games:

i) Games that ended in regulation (i.e. after 60 minutes of play)
ii) Games that ended in overtime (i.e. during the 5-minute period after regulation ends)
iii) Games that ended in a shootout (i.e. after the 65 minutes of play)

The logistic regression was the preferred model, as it can be used to provide values for many parameters, thus giving us an estimate on the effects of potentially confounding factors.

Specifically, our logistic regression is calculated using the following equation[1]:

$$P_{ij}(Home\ Win) = \frac{e^{(\mu+\beta_i-\beta_j+\delta X_{i,j})}}{1+e^{(\mu+\beta_i-\beta_j+\delta X_{i,j})}},$$

where P_{ij} is the probability of a certain outcome, μ is the home team advantage for the season, β_i and β_j are the parameter coefficients for the 2 teams that are playing. The values of the beta's sum to zero for all teams in each season because doing so provides us with a unique estimate for each parameter, as well as a meaningful measure of home ice advantage and rest advantage. Had we not included this

[1] This is an expansion of the formula from *Applied Logistic Regression*, by Hosmer and Lemeshow, p. 6

constraint, we would have infinitely many identical fits in terms of fitted probabilities, but with different parameter values. δ is the rest advantage parameter value, and $X_{i,j}$ is the indicator of the home rest advantage. For the home rest advantage, the values are +1 if the home team has had more days off than the away team, -1 if the away team has had more days off than the home team, and 0 if they are equally rested.

Overall, a team's beta value should be higher than those of the teams they beat. Additionally, we can bring in additional factors that may impact the result of a game, such as rest advantage, or home ice advantage and measure the impact of such events. As a result, the model calculates team strengths based on who a team has beaten or lost to; therefore, the relative strengths of teams will help dictate impact of a game result. Losing to a good team will not impact a team's parameter estimate much, whereas losing to a bad team will heavily impact their estimate. The importance of such a feature is if, for example, most overtime ending games were won by the heavy favourites, who were also better rested, the overall score for rest would not be as significant and team strength would likely be the cause of victory. On the other hand, if the underdog team were better rested and won most of the overtime ending games, the rest parameter would be more significant, and the rest advantage would be a plausible explanation for such a discrepancy between the team strength and the result.

By fitting the model, for each season, we calculated the team strengths for each team and the overall home ice advantage. Additionally, we calculated a global rest advantage over all the seasons. Using a z-test, the p-value was calculated and analyzed using a 5% level of significance to see if the estimate differed from 0. In Figure 1, we view an example of the team strengths for games ending in regulation, overtime, and shootout.

From Figure 1, we observe that the shootout strength for each team somewhat matches the sign of the regulation strength of a team. We also observe that this trend does not hold nearly as well for overtime-ending games. This pattern appears to indicate that there is some other factor that impacts overtime performance that differs from regulation and shootouts.

We also observe that in the shootout strength graph, 2 teams have extremely high values. This anomaly is because the St. Louis Blues won each shootout they were in that season and thus had a large positive score, whereas the Vancouver Canucks lost every shootout game and had an extremely negative score.

Data and Methods

The dataset used was taken from Kaggle and consisted of all NHL games from 1917-2022[2]. We later augmented the dataset with data from Hockey Reference to include games from the 22-23 season[3]. This dataset was perfect for our analysis, as it clearly indicated the scores, home, and away teams, the

[2] Retrieved from https://www.kaggle.com/datasets/amandaloy/nhl-stats
[3] Retrieved from https://www.hockey-reference.com/leagues/NHL_2023_games.html

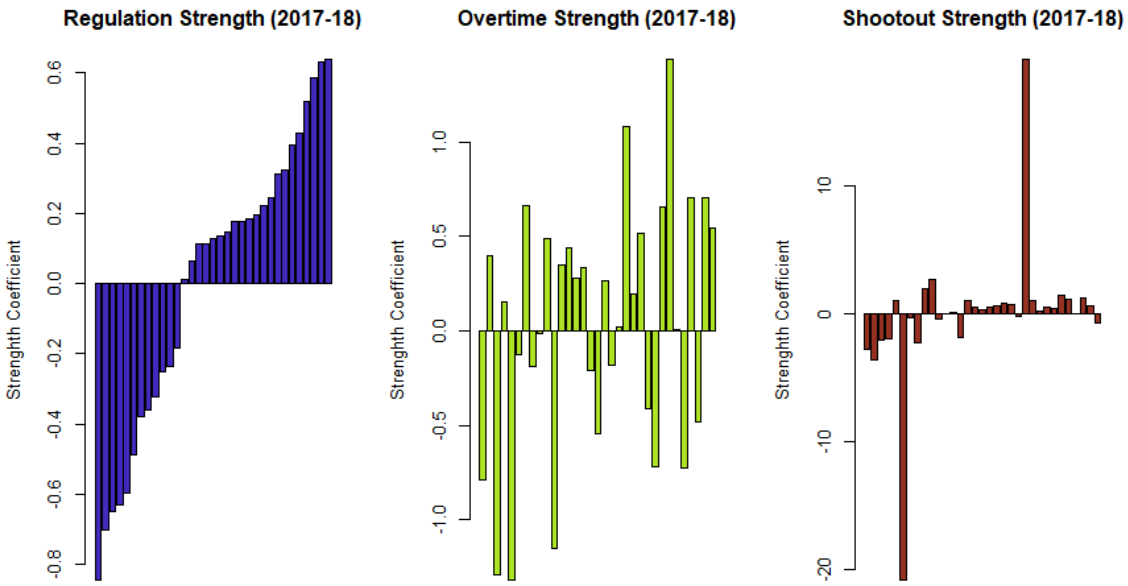

Figure 1: The team strength coefficients. In each plot, the team is ordered by their regulation strength, so all graphs have the same order of teams on the horizonatal axis.

dates of each game, and if the game ended in overtime or a shootout. Additionally, we created a column that showed how many days rest the home and away team had

In the 2015-16 season, the NHL changed its overtime rules so that the games would be 3-on-3 instead of 4-on-4[4]. We conjectured that the increase in skating required with fewer players would make fatigue a larger issue. We tested this by choosing 7 seasons from before and after the switch. For 3-on-3 overtime, we took all the seasons since the change, except for the 2020-21 season, as covid quarantine rules heavily impacted the season with many teams missing prolonged periods of time or needing to play without key players in games[5]. Additionally, the season was limited to 56 games per team and teams only played other teams in their division, making reliable league-wide comparisons impossible[6]. We did, however, keep the 2019-20 season, as sufficient games were played before the league shut down due to covid. The bubble games were not included in the analysis. Overall, we included 7 different seasons in our analysis.

For the 4-on-4 overtime games, we restricted the seasons to after the NHL introduced the shootout. We did not include the 2012-13 season since it was shortened due to a lockout and the graph of overtime games was not connected (See Figure 2). Once we had each set of seasons for the types of overtime, we trained the models on the data for each group and were able to extract the win

[4] https://www.nhl.com/news/board-of-governors-oks-3-on-3-ot-coachs-challenge/c-771982
[5] https://www.nhl.com/news/flyers-capitals-postponed-due-to-covid-19-protocol/c-321236564
[6] https://www.nhl.com/news/board-of-governors-oks-3-on-3-ot-coachs-challenge/c-771982

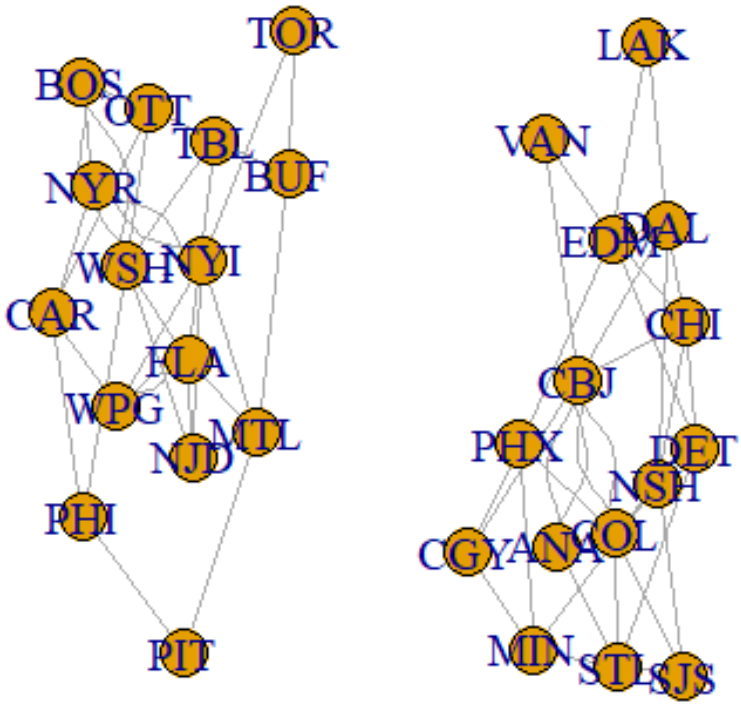

Figure 2: A graph of which teams played each other in overtime in the 2012-13 season. Notice how the graph is not connected, which means the model cannot give a reliable estimate for each team. For example, a team in one group cannot be reliably compared.

probabilities for a team, based on their strengths. The probabilities were conditional. For example, if a game ended in overtime, the win probability of a team in a particular game would be the probability of winning, given that the game ends in overtime (see Figure 3).

Results

The rest advantage in 3-on-3 overtime games was shown to be significant, so there is sufficient evidence to conclude that rest advantage is a considerable factor in 3-on-3 overtime games. More interestingly, however, is that the same could not be said for 4-on-4 overtime games. Rest does not appear to be a significant factor in 4-on-4 overtime games rest appears to have been immediate after making the rule change (see Table 1).

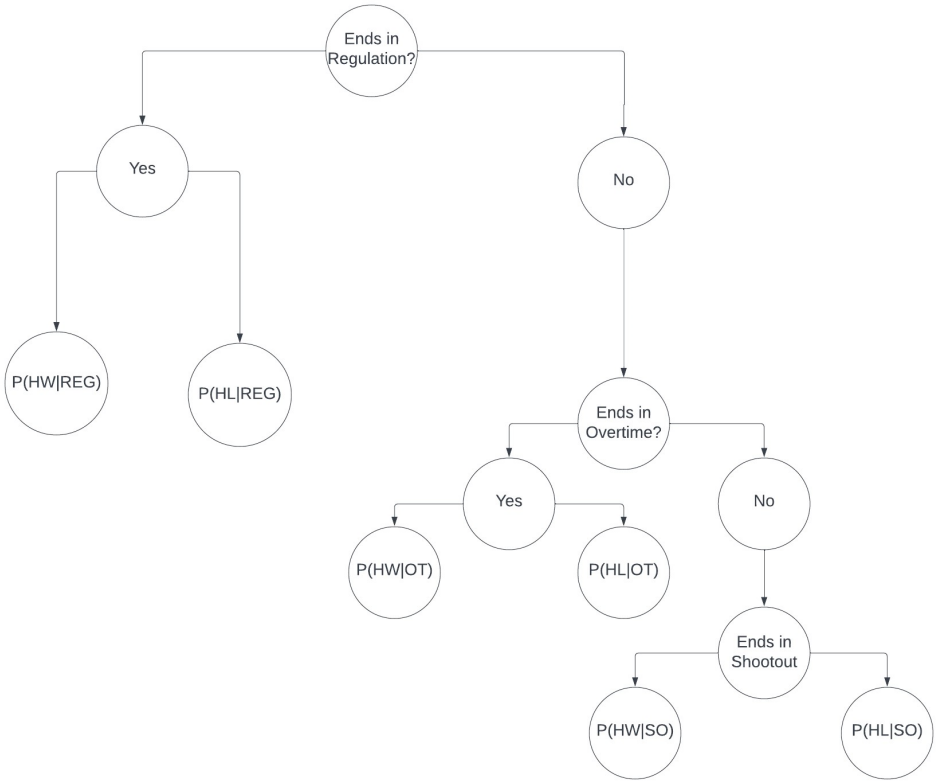

Figure 3: The decision tree showing how games end. All games start in regulation, then go to an overtime period if the score is tied and if the score is still tied, go on to a shootout where one team will win. In each game, the probability of a win is calculated based on the home team, so games either end in a home win (HW), or a home less (HL)

Regulation	**Estimate**	**Standard Error**	**P-Value**
3-on-3	0.0810850	0.0372751	0.029607
4-on-4	0.135947	0.036781	0.000213
Overtime			
3-on-3	0.295555	0.095598	0.00199
4-on-4	-0.195886	0.128934	0.1287
Shootout			
3-on-3	0.03998	0.1649	0.80842
4-on-4	0.047956	0.101998	0.63823

Table 1: The parameter estimates, standard error, and p-values from each test. Tests were done on all 3 ways a game could end and then repeated for each overtime type.

Although regulation and shootouts are not explicitly impacted by the overtime rule, the prospect of 3-on-3 overtime may cause a team to play differently at the end of a game if they are fatigued, to try

and avoid playing in overtime. This difference may impact the importance of the rest, as teams may play differently depending on their level of rest. Additionally, we do not know what the impact of 3-on-3 versus overtimes would be on shootouts, compared to 4-on-4 overtime, so we separated all three possible game endings into the two groups. Overall, there appears to be a statistically significant impact of rest advantages in regulation-ending games when looked at over larger sample of seasons. Evident also, is that 3-on-3 overtime games are significantly impacted by rest advantages, whereas 4-on-4 overtime games are not.

With these results, we can quantify the impact of rest advantages on the significant results by plotting logistic regression curves. In figures 4 and 5, we view the results for the seasons with the highest, lowest, and median home rest advantages in their respective test. The vertical lines show the win probabilities for if the home team has a rest advantage (on the right side), or a rest disadvantage (on the left side).

From figures 4 and 5, we observe that rest plays a much larger role in 3-on-3 overtime than in regulation. For the 4-on-4 overtime seasons, we observe that the overall difference in probability for an average team in regular time with a rest advantage compared to an average team with a rest disadvantage is about 0.06, or a 6% increase in win probability. For the 3-on-3 overtime seasons, increase in regulation win probability was around 0.04, or 4%. On the other hand, in 3-on-3 overtime, the win probability increased by about 0.1-0.2, or 10-20%. Therefore, although rest plays a statistically significant role in determining the outcome or a regulation-ending game, the increased probability of a team winning is much lower compared to 3-on-3 overtime.

Conclusion

We conclude that in most cases, based on the current scheduling practices, there is a significant, but numerically small impact of rest advantage on the results of games that end in regulation. There is, however, a rather significant impact on games that end in end in 3-on-3 overtime.

The difference in rest advantage between 4-on-4 and 3-on-3 overtime is fascinating, yet intuitive. 3-on-3 overtimes require much more skating as there are less players on the ice. With the extra effort required, previous fatigue can become a problem and help the better rested team win.

Limitations

The main limitation to this experiment was the small sample sizes. Especially for overtime games. Only a handful of games ending in overtime for each team in each season, problems can easily pop up, as we saw in the strike shortened season. The model relies on the connectivity of teams playing each other, which can become problematic if teams don't play many games that end in overtime, or if a team does exceedingly well or poorly in overtime.

We could have increased the sample size of overtime games by pooling teams over multiple seasons; however, this may have also been problematic. During the period of our analysis, the Las Vegas Golden Knights and the Seattle Kraken joined the league as expansion teams. Had we kept the teams the same throughout the experiment, those 2 teams would have much fewer games than the rest of the teams. Additionally, since there is a substantial turnaround in players on teams, which results in some level of leaguewide parity, team strengths will vary over the years. The result of this would be that

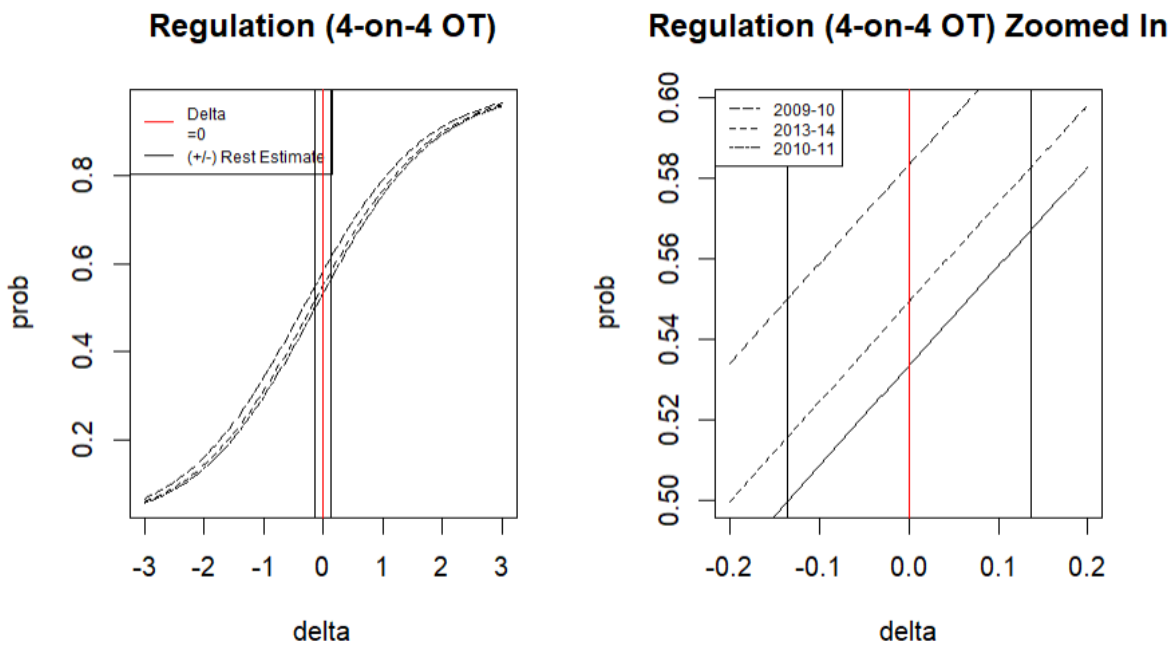

Figure 5: View of the plot for regulation games in 4-on-4 OT. The figure on the left shows the overall logistic regression curves, whereas the right shows a close-up of the win probability of a team with a rest advantage and disadvantage.

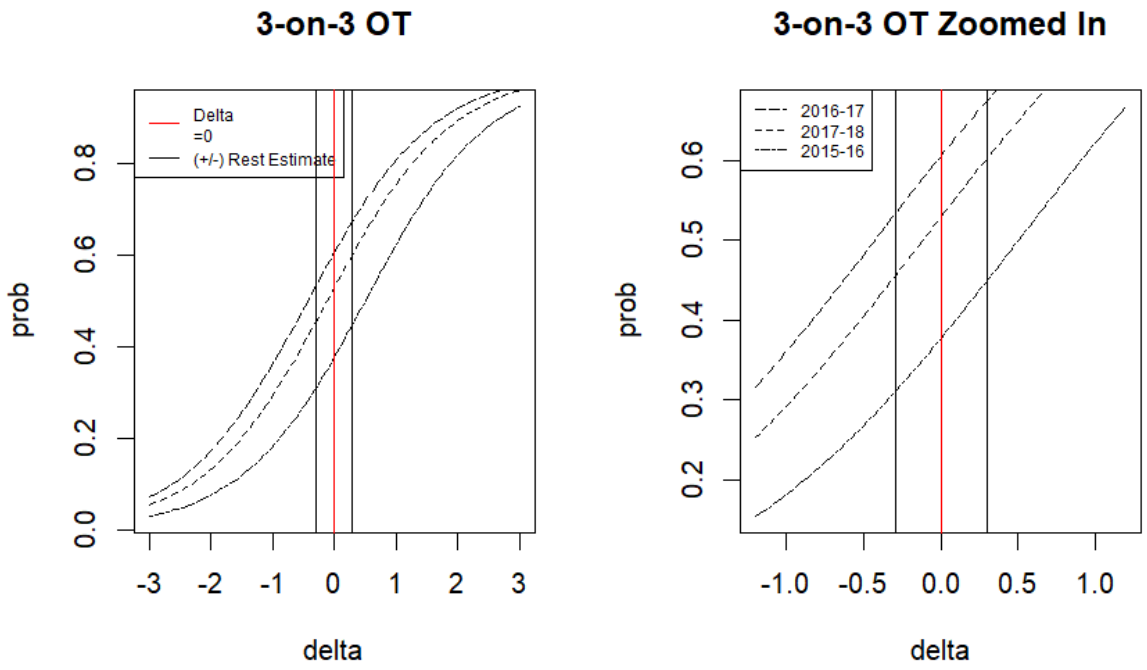

Figure 4: Plot of 3-on-3 OT results.

the strengths will be more equal, allowing for confounding factors to influence the results, as there will be much less separating the teams in terms of strength.

Another shortcoming of the small sample sizes is the fact that we had to classify rest advantages as either yes, no, or equal. In other words, a rest advantage of 3 days was classified the same as a rest advantage of 1 day. This classification system allowed us to have a larger number of observations in each category, but did not allow us to look at the impact of prolonged rest and whether or not rust had any impact on performance.

Finally, we assumed that every team's home advantage is the same. The arena size, facilities, and fan cultures differ from team-to-team and would likely have some impact on team performance. One way to remedy this in the future is to have a home and away team strength parameter for each team to quantify the difference for each team and better capture the effect of home ice advantage.